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Playing Cool – Winter Weather’s Influence on Location-based Gaming

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Location-based games are highly dependent on the physical environment. One important but often overlooked factor is weather. In this paper we focus on winter weather, as this is a common weather that is often not designed for specifically. By performing a qualitative observation, interview, and questionnaire study of families during and after playing a GPS-based mobile game in a winter setting, this paper studies how winter conditions affected the gaming experience. Three main factors were observed to have a big impact on the gaming experience: snow, ice and cold. We outline ways these weather conditions were found to be both obstacles, and adding value to the game. Finally, we suggest design implications for winter weather, mainly; the need for short games due to cold, adaption of gameplay for movement in snow, to avoid interactions based on handling the phone, and to adapt maps to the effects of snow and ice. By explaining how winter conditions affect the gaming experience, location-based games can be better adapted for these weather conditions, and thereby help in making better design decisions.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)** → Empirical studies in HCI • **Human-centered computing** → **Interaction design** → Empirical studies in interaction design • **Applied computing** → **Arts and humanities** → Media arts

KEYWORDS: location-based games; game design; outdoors; outdoor play; winter; winter weather; playful design; game experience; snow; ice; cold

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1 INTRODUCTION

Location-based games are usually played outdoors, and that outdoor environment is therefore an important part of the experience. When playing location-based games outdoors the weather affects the experience. While there are several successful location-based games on the market (e.g. Pokémon GO [34], Ingress [33], and Zombies run! [32]), as well as older, more traditional, games such as Killer and Assassin [12, 26], and there is an abundance of research on location-based games, as witnessed by a large number of publications on the topic (e.g. [5–8, 19, 27, 29–31]), and research on games and outdoor conditions [2–4, 24, 31]), the focus is mostly on how to integrate outdoor conditions into mobile games, rather than how to integrate the games with the local conditions. While awareness of weather conditions is important in all climates, it is of course more visible in extreme weather.

In this paper we focus on one specific type of weather condition, namely sub-arctic winter, as this is a common type of weather that many experience, while also quite different from what we usually consider everyday conditions for use. When we in this paper refer to ‘winter’, this is the type of winter we mean. More specifically we ask, how can (sub-arctic) winter conditions affect the gaming experience for families playing a location-based outdoor mobile game?

We observed, and interviewed 11 players, divided among 5 family groups, playing a location-based game in outdoor winter conditions. Further, the participants got to fill out a questionnaire to further debrief them of the game experience. The data was inductively bottom-up coded to find common themes. We focused on what the weather did to the playing of the game. Based on the results, we suggest design implications for winter weather.

While it may be noted that not all GPS-based games are played outdoors, and even those intended for outdoor use, such as Pokémon GO, are used in a variety of situations both indoors and outdoors [1], in this paper, we are focusing solely on outdoor settings.

1 BACKGROUND

1.1 Weather and Designing GPS-Based Games

GPS-based mobile games are very popular, Pokémon Go for instance has had as much as 45 million daily users [21]. With a strong digital focus in areas such as Silicon Valley, it is common for games to be developed in certain regions of the world, with certain climates and environments. When considering the everyday use of a phone app, it is easy to forget to take the surroundings into account, and thereby developers tend to design for their own concept of normal [e.g. 14], which in many cases, like the one mentioned above, is something like a warm (but not hot), semi-dry environment with car roads, walking paths, and easily accessible public areas. However, many parts of the globe do not have those conditions.

As these GPS-based games are built on an interplay between the outdoor surroundings and what is happening in the phone, many users face big challenges that are not caused by the game, but by environmental conditions, often overlooked by developers. These conditions can include things such as extreme humidity, hot and dry weather, and as in the case of our study, cold winter weather.

At the sub-arctic locations of the tests the winters are long, dark, and cold. The temperature is often well below freezing almost half the year, and in the winter months there is daylight only a few hours per day. The ground is covered in snow and it is also often snowing. It is important to note that even though this can seem like extreme circumstances, it is the everyday environment for the people living there. The families observed in this study are all local, and used to the weather. When observing how they handle the game in winter condition, this is their normal. It is the act of playing GPS-based games that is their 'different', not the winter.

1.2 Playing together

GPS-based games are in many ways suited to play together. Going outdoors is often done together with others. This can for example be seen in how Pokémon GO raids gather people to certain spots for collaborative play. Therefore, the way the games are played are interesting to view from an interpersonal perspective. The interaction between the players is also affected by the environment and climate. As a group, families are an interesting unit to focus on, for several reasons: The debate about screen time in families have been a concern for a long time [e.g. 10, 11, 16]. Also spending time outdoors has been in focus, especially concerning children [e.g. 9, 20]. Younger kids seldom have power over the mobile devices themselves, but the interaction and negotiation between family members is an important factor for if a game will be played,

and how. How families interact and use GPS-based games together outdoors in winter conditions allow us to see both children’s and parents’ behaviors, as well as the interactions between them.

1.3 Environment and Outdoor play

Playing outside, with or without technology, comes with special challenges and opportunities. Nature and surroundings take part in, and shape what is happening in the games. When mobiles are used by children in play, they use the technology to both enhance existing play activities as well as invent new ones [13]. In this way the visual and the physical coexist, and help form each other. In studies of pervasive gaming, this has been referred to as the world having ‘unlimited affordances’ [18]. As the world is used as part of the game, and creates large portions of the game, the actual game system can be minimized.

Even though all games played outdoors will be affected by their surroundings, from a design perspective a more common way to integrate the outdoor environment, and especially weather, is to let the current weather affect the virtual game state. This can for example be achieved by connecting the game to a weather service, to let the game know the current weather and let it have effects on the gameplay. This can be seen in academic games such as ‘Weather Wizards’ [23] and ‘Free all Monsters!’ [15], as well as being added to the commercial game ‘Pokémon Go’, as of December 2017. Research shows that a connection between the real-world weather and a digital game can contribute positively to the experience for the player [22]. Montola [17] describes weather as a potential factor under the type ‘adaptronic games’, borrowing the term from Walther [28], who describes adaptronic games as a subcategory to pervasive games that “simulate life processes observed in nature”. Still, the focus is on adapting the digital content, and not on forming the game experience in accordance with the actual situation. This despite the fact that the games are designed to be played outdoors and therefore the weather conditions will affect the gameplay and experience for the players, whether the designer intended for it or not.

2 THE GAME - DESCRIPTION AND IMPLEMENTATION

In the larger project this study was a part of, a location-based game named ‘Oknytt’ was developed. This game was used for the tests. The game is situated in specific, pre-defined, locations (for example a nature reserve, a square in the outskirts of the city, and a sports training area), where a play area with digital game elements are prepared in the game. Players need to be in one of these locations in order for the game to work.

It can be debated whether it was better to design a game, or if it would have been better to work with an already existing game. While an existing game would have simplified comparisons to other studies of that game, and the development of a new game may have introduced bias towards the types of behaviours the researchers *wanted* to see, the development of a new game opened up possibilities that were not available if we would have used something else. First, as we were more interested in how people act in certain situations, rather than in how they act in general, a new game gave the possibility to design for that specific situation of moving outdoors. Second, we wanted to study how participants developed strategies for playing, as our experience tells us this is often a good way of understanding why they act in a

certain way. If using a game already on the market, this means some of the participants would probably already have played the game, thus already having developed strategies for playing. We believe this would have meant missing the opportunity to study how participants together developed those strategies, and taking the weather into account when doing so. While the exact game chosen for the study was not crucial, the type of game was. While most location-based games do include movement, the actual gameplay often mean standing still, swiping. We wanted the focus to be on movement in itself, and therefore we needed a game that encourages movement between locations.

Before the game starts, the player can choose for how long they want to play, 10, 30, or 60 minutes. In the tests the 10 minute session was used. As the game starts, a voice shortly explains the rules and give some flavour to the game. After this, a map showing the player location is displayed on the screen. The map also displays ‘amulets’ in some nearby locations. Those amulets are of three different colors, representing different values. Further, the player can see clouds with angry red eyes. Some clouds are still, and one cloud moves toward the player’s location on the map, and hunts them; this is to encourage walking at a fast pace (see Figure 1). There are background sounds of nature playing throughout the game.

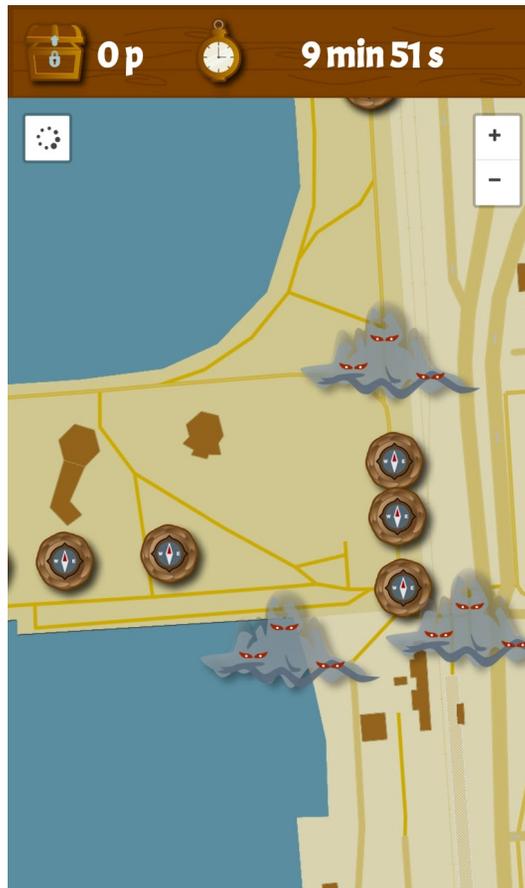


Figure 1. A screenshot of the game running. Clouds and medallions are visible in the location.

As the player starts walking the marker on the map follows. When the player reaches the destination of an amulet, a sound is played, indicating that the amulet has been taken. The amulet disappears from the screen and another appears in a new location. To take an amulet the player just has to stand close to it; no actual interaction with the screen is required. New amulets keep popping up for as long as the game is played. The higher value amulets are more unusual than the lower value ones.

Once the game is over a page is shown with the player’s points, how many amulets were taken of each type, how many times the player was taken by the clouds, and how long a distance the player moved during the game.

3 METHOD

The observations were conducted in a large town in the northern part of Sweden. This is an area with regular winter weather, and usually large amounts of snow in the wintertime. At the time of the tests, it had snowed during the night and day before, and there was about 10 cm of powdery newly fallen snow on top of the previous snow. On the ground there was about 40 cm of snow in total. The tests were conducted during daytime, it was -7° Celsius and it did not snow during the tests but it was cloudy.

The study used a convenience sample, as the families were invited through a call on social media. The invitation asked for (self-defining) families consisting of at least one child and one adult, the children being at least 6 years old and preferably under the age of 12. While this is likely to create a bias, as not all will see or be able to answer such a call, the focus of the study was not to have a representative sample. To broaden the sample somewhat, the tests were conducted during a school winter break, to make it easier to find different families that could take part in the study. Most participants were used to technology, and also fond of being outdoors in the snow. All participants were informed about the research and the purpose of the tests. As they participated as family groups, all children had at least one legal guardian present.

3.1 Conducting the Observations and Interviews

The tests were conducted in two different locations: The first one, a park by the water in the middle of town (Figure 2). The park is next to a big lake. Some people are moving about in the park but it is not in high use. The walkways were plowed and easily accessible. There is a huge snow fort by the side of the park, where a group of children were playing. Some children had snow mobiles that they were pedaling around on a snow track in the park, on the ice of the lake some people were ice skating. In the park there is a café that is closed, a small wooden scene and a small playground with swings. The park is surrounded by water on two sides, and then by a small road and a railway track.



Figure 2. The playing field by the park in town.

The second location was a recreation area in a residential area with apartment buildings (Figure 3). The area consists of a soccer field that has partly been turned into an ice rink during winter, a (now snowed over) meadow, and some forest. The area is surrounded by walkways, a parking lot, a school and apartment buildings as well as villas. There are not many people out in the area. The forest is dense and mainly consists of spruce trees.



Figure 3. The playing field by the recreation area.

A total of 11 persons participated in the tests, 6 at the first location and 5 at the second. In both locations, participants were divided into the natural family groups they arrived as. In the first location the participants consisted of two groups, the first one two girls (7 and 10 yo) and the second two boys (11 and 12 yo). Both groups were accompanied by their mothers. In the second location the participants were organised into three groups: one mother and daughter (10 yo), the second a lone boy (8 yo), and third a girl (6 yo) with two accompanying adults.

After the families were informed about the study, they got a link to the game (as short-url and qr-code). They used their own phones and chose themselves how to use them. It turned out all groups decided to share one phone within the group. Except being asked to use the games 10 minute play option, they did not get any further instructions on how to play, and had to

intuitively and through the built in game instructions understand how to play the game. After the first session of 10 minutes they returned to the starting point. The researchers then asked them to play another round for 10 minutes.

During the playing, researchers followed and took notes while keeping distance (around 10 meters) to not interfere or interrupt the participants. Notes were taken on what the participants did, how they moved, who held the phone and, when within hearing distance, also what they said. Some players were also given a go-pro camera placed on their torso, to capture samples of the playing and the discussion from a first-person perspective (see Figure 4). After the test the participants answered a shorter written survey (see Table 1 for questions), and the researchers then held a semi structured group interview, loosely following the following questions: *How did it feel when you played? Did you freeze? What was hardest? What was the most fun? Was the whole family active? and What would make you go out and play this at a weekend?*

Table 1: Questions form the questionnaire

Questionnaire
<ul style="list-style-type: none"> • How old are you? • Gender • Where did you play the game? (multiple choice: the two locations) • here do you live? (multiple choice: town center/neighbourhood) • How much would you like to play this game again? (1-5 from uninterested to very keen) • How much would you like to come back to this location if the game was not here? (multiple choice 1-5 from uninterested to very keen) • How much would you like to come back to this location if the game is still here? (multiple choice 1-5 from uninterested to very keen) • Comments about the game and the location: (open answer) • Was the location more interesting because of the game? (multiple choice 1-5. boring - very interesting) • How hard/easy was it to play the game? (multiple choice 1-5. easy - hard) • Why was it hard/easy to play? (open answer) • How long did you play the game? (answer: duration in minutes) • What was most fun with playing? (open answer) • How could it be more fun to play the game? (open answer) • Tell us about something that you discovered at the location! (open answer) • Where would you like this game to be available? (open answer)

Afterwards, all data was coded through a bottom-up process, and qualitatively clustered to find relevant categories related to the research question.



Figure 4. One of the participants carrying a Go-Pro camera for recording a first-person view of the experience. The image also shows the amount of clothing required for the weather.

3.2 Analysing the Data

The data from interviews, survey, and observations were coded through an inductive bottom-up coding process, focused on experiences as observed by the researchers and vocalised by the participants. Keywords were identified and tagged in the data material, studying videos, observation notes, survey responses and interview transcripts as one corpus. The keywords were then clustered into themes, and the themes were finally clustered into larger themes until three main factors were identified.

In the keyword identification process, three main type of keywords were searched for in the data:

- Weather - Words, phrases, and observations about weather conditions.
- Emotion - Words, phrases, and observations about emotions and feelings.
- Movement - Words, phrases, and observations about movement and patterns of movement.

Weather keywords were all words mentioning weather or weather conditions in any form. Words such as *snow*, *cold*, *freezing*. Words and short phrases that could be read as secondary effects of weather conditions were also highlighted. This included words such as *gloves*. An example of a weather phrase would be something like “[*my*] *hands were freezing*.”

Emotion keywords were all words and phrases revolving around the feelings and experience of the participants. Example of such keywords are *tired*, *laughing*, *exhausted*, *eager*. An example of an emotion phrase would be “*Dad, I am tired*”.

Finally, keywords connected to movement and change of patterns of movement were also identified. This could be phrases like *move along the paths*, *running away from the roads* and similar. An example of a movement phrase would be “*Shall we try and go around [it]*”.

The keywords were cross-checked across the three types, to identify if certain emotional keywords could be connected to certain weather and/or movement keywords by being used in the same sentences or by referencing each other.

3.3 Ethical Considerations

Playing a game is usually not a very sensitive or dangerous activity in itself, even if playing outdoors. Still, the participants included children and ethical considerations thereby become extra important. All participants were accompanied by adults, and informed consent was asked from both children and grown-ups, part of this included directly addressing the children and making it clear that this was a voluntary activity, and they may change their mind at any time. No sensitive data was asked of the participants, and all recorded data was handled using the university guidelines, and following GDPR regulations. In the paper, as well as any accompanying presentations, we are deliberately anonymizing participants, and especially children, not only in text, but also in images.

4 FINDINGS

Analysing the data, we identified three distinct weather factors that were found to have an impact on the gaming experience and the behavior of the players. Those factors are *snow*, *ice*, and *cold*. Each of them affects the playing of the game in their own way. They will be described below.

4.1 Snow as a Factor

All participants lived in a snow-rich area. We could observe coping strategies to handle the snow they met; as this could be seen already when greeting people welcome to the test, this seemed to be a natural behaviour in their everyday life, rather than something created by the game. In the test, these strategies could be observed, and further the strategies could be seen changing as the playing continued.

4.1.1 Snow as an Obstacle

Among the strongest coping mechanisms, often noticed in both observations and interviews, was how the participants used paths and walkways to avoid the deeper snow (see Figure 5). In interviews participants told they would never walk out into the snowdrifts and snow banks if it wasn't for the game. It could be observed that the participants avoided the snow and treated it as an obstacle. As for example, when one group of players were heard saying “*Oups, here comes the fog, we have to flee! No, not that way; it is faster to go around the snowbank!*” or in another case “*The snow is too deep, maybe we should go around it?*”.



Figure 5. Players choosing the plowed roads over the unplowed fields.

This was also worded in the interviews; the snow makes progress slow and it also takes more energy to move through deep snow. “*You know what an obstacle snow is when you are used to snow.*” This directly seemed to have affected the gameplay. In several observations, as well as in the interviews, the snow is described as tough. A majority of the time during observation the participants moved along the walkways. This is also reflected in the interviews, e.g. where one of the participants said “*When you had to run out in the snow, [it was] very difficult.*”

4.1.2 Snow and Fun

Snow is an obstacle, but it can also be fun to move in the snow. It was observed that when participants were forced by the game mechanics to tread out into the deep snow, they often laughed at their troubles. This seemed to be a big step to overcome, but was fun once it happened. In the observations of one of the groups it took 8 minutes (in a 10 minute long game) before they first walked into the deeper snow. Once they did, they all started giggling. Similar observations could be made also in the other groups.

4.1.3 Changing Behavioral Patterns Concerning Snow

The participants all lived in snow rich areas. It was clear that participants were used to snow and had adapted behavioral patterns accordingly. Among those behavioural patterns it could be observed that they tended to avoid snow. It is simply easier to walk along cleared paths than in the snow.

The game clearly changed the behavioral patterns of the participants. After a while it could be observed that participants went out in the deep snow. It was also commented that they reflected upon doing this, as something that was not part of their usual behavior. For example, during one of the sessions a player could be heard saying “*Now we know we have to leave the paths [and go out in the snow]*”, and in the follow-up interview, one of the participants answered to a question about walking in the snow: “*It is difficult, duh!*”. It could be observed that several of the participants were very tired after having played the game, and they attributed this to a large extent to the snow.

4.2 Ice as a Factor

Ice appears in many forms, it makes roads and walkways slippery, fountains become rigid. However, here we will focus on larger bodies of ice. In the tests these were found in two different places. The first test location was located in a park next to a lake. The second included an ice-hockey rink.

It became obvious that the map service, as well as some of the game functions, were constructed around summer weather. In the first location, no amulets appeared on the water (marked blue on the map), even though it was clearly possible to walk on, and many people did. In the second location the ice-rink was not shown on the map, which instead showed a larger soccer field that was there in the summers. This way, the ice became a discrepancy between the physical and the virtual; it became something that the participants had to interpret and handle both ‘in the real’ and on-screen.

For example, one player was observed staring into her phone as she climbed over a snowbank next to the water, as she passed over and almost climbed out on the ice she looked up, surprised. At this moment she says “*oups, there’s water!*”, and walks back in the same direction she came from, even though the ice was actually walkable.

In the second location, the youngest girl in the study stopped playing together with her parent and older sibling. Instead she played on the ice rink. She was running and slipping around, and spinning on the ice, mainly near one of the locations where an amulet was located in the game. She was observed talking to another group of players (walking cautiously over the ice), saying she pretended to be an amulet.

4.3 Cold as a factor

4.3.1 Living in Cold Winter Conditions

Just like with snow and ice the participants were all used to cold weather. It was clear that the participants had adapted behavioral patterns accordingly. They were all dressed for winter weather. They had jackets, padded trousers, overalls, gloves and woolly hats, thick boots and such. The clothing affected mobility and motorics. This meant larger athletic movements were hindered, but it also, for instance, made it hard to use a touchscreen with gloves on. And removing the gloves made you cold quick.

4.3.2 Cold as an Obstacle

After the game had been played several participants voiced the need to go inside. It is simply tough to stay outdoors for extended periods of time in cold weather. Unlike snow and ice, we did not find any observations of participants enjoying the fact that it was cold. The cold in itself did not seem to enhance the experience in any way. Instead it was viewed as a problem or an obstacle. Mainly it seemed to decrease the amount of time the participants conveniently could stay outdoors. It could also be observed that when the participants stood still, before and after the game when receiving instructions for instance, they moved their body, stamped their feet, and showed signs of trying to stay warm. Some also voiced the wish to become warm and go inside. It could be observed that none of the participants sat down while outside, even when

seating was easily available. We interpreted this as an adaption to the cold. Everyone, including the youngest children, stood up during interviews, instructions and so on.

4.3.3 How the Low Temperature Affected the Gaming Experience

As previously stated, we found no evidence for the cold to in any way enhance the experience. The cold made it hard to use touchscreen, something that was already taken into consideration in that the game was designed to work with a minimum of touch interactions. To be able to use the phone the gloves needs to be taken off (and in this weather, gloves that can be used with the phone while on are too cold), and as soon as the gloves go off, the hands start getting colder. Therefore, when using the touch screen gloves could be seen going on and off multiple times, to minimize the cold.

Both observations and interviews showed another important aspect when using technology outdoors in the cold: the batteries discharged very fast. This seemed to be something the participants were aware of and strategies to handle this could be observed. In one example one of the players had an external battery plugged in, and she kept this battery inside her gloves (see Figure 6). When asked about it she said “*One knows how fast a phone with a cold battery discharges*”, pointing to this as common knowledge.



Figure 6. Player with an extra battery placed in her glove.

5 DISCUSSION

In this paper we have put our focus on non-typical weather conditions and their effect in location-based gaming. More specifically we have chosen the example of sub-arctic winter conditions, and we ask how these winter conditions affect the gaming experience for families playing a mobile game outdoors.

As shown in the background, it is not uncommon to include weather data into games. As games start to move outside of the screens, with pervasive games, mixed reality games, location-based games, and other types of outdoor technology, enhanced gaming needs to also start taking the effect of outdoor conditions, and especially weather, into account.

Game design is unique in that it can choose its problems. It is not meant to be effective, but rather create its own obstacles and challenges for the player to tackle. To play a game can be seen as “the voluntary attempt to overcome unnecessary obstacles” [25]. By being aware of the surrounding situation and obstacles, and design in accordance with technological and spatial preconditions, a game can use something that can be seen as a problematic situation to make it into a deliberate in-game struggle, thereby using e.g. snowy hills as a game-problem to

overcome. Taking this approach to the observations, we here present a list of implications for designing, that can be taken into account when designing for cold snowy winter weather.

5.1 Design for Gloves-on Gaming

One of the features that was implemented in the tested game was that players did not need to touch the screen during active gameplay. The screen was still used in setting up the game, but once it started, it was enough to follow the screen, and interaction was done through the players movement in the game space, through reading the GPS-position. This design made it possible to play the game without taking the gloves off. While this of course is limiting in possible interactions, and may seem like a small difference, it seems to have been crucial in making the game playable at all in cold conditions.

5.2 Design for Short Game Sessions

The cold made it hard to stay outdoors for longer periods of time. As long as the players kept moving, they also kept warm, and since the snow made it difficult to move effectively, they also got tired quickly. This could be remedied by balancing the game play for slower play with shorter bursts of fast running, or to design for shorter game challenges, with the ability to go inside to get warm in between. This also means the game design needs to consider aspects of how the game works before and after a session, as the playing of a session will include elements such as putting on and off heavy clothing, quitting because someone is freezing and so on.

5.3 Be Aware of the Lacking Snow and Ice on the Map

Snow is slowing you down. A lot! It is also not always obvious where a pile of snow will be. What was an open field in the summer may be a real problem to pass in the winter. Further, this is not just dependent on weather and the landscape, but also on such things as where the plow-truck decides to dump the gathered snow (see Figure 7), thereby making it hard to predict.

In addition to this, the winter does not only make things harder to reach, sometimes it is the other way around. The map can work differently in winter time, with what was water now being ice, and thereby becoming accessible. While ice can be treacherous, as long as it is a known place, it can also be safe and trusted, in places becoming so rigid that you can drive a car over it. However, if designing for leading people onto the ice, safety needs to be taken into account to not lead someone into a dangerous area.



Figure 7. Snow-pile created by chance by a snow-plow clearing the walking area. They will be put wherever there is place for them, and they are out of the way for ordinary traffic. The photo is taken from the location of the second test.

While this does not give a clear answer on exactly *how* to design for it, since this will be different in different situations, it points to the importance of adjusting the map and the pacing of the game to winter conditions. This might need to be specific for each location, as different locations can behave differently.

5.4 Design for Short Battery Lifetime in Winter Weather

Batteries discharge quickly in low temperatures. This means a game can only be played for a short period of time before the phone is discharged. It is also something the population used to cold weather are aware of, meaning they will avoid getting their phones cold, and may deliberately avoid a game where this will happen. To save batteries, the phone would need to be kept warm. Commonly this is accomplished by keeping the phone in a warm inner pocket when not using it. Of course, the phone could still be active in this state, even though this makes looking at the screen very hard. Therefore, one design solution could be to not make the game dependent on screen-based interaction, but instead build it around sound or vibration for feedback. Such a solution would have the extra benefit of making it easier for the participants to take in the surroundings, for instance looking at nature or be aware of cars and other dangers instead of focusing on the screen.

6 CONCLUSION

In this study, we ask how sub-arctic winter conditions can affect the gaming experience for families playing a location-based outdoor mobile game. Data was collected via observations, a survey, and group interviews with invited families. The study found several factors that have a big impact on gaming experience. The main factors identified were *snow*, *ice*, and *cold*. Those weather conditions could both have the possibility to enhance and lessen the gaming experience.

The three identified weather conditions have a huge impact for the players. Therefore, it can be valuable to take into consideration the effects of those weather conditions when designing a

game that is supposed to be played outdoors. In the discussion section, design implications tied to these three winter conditions are presented:

- Design for Gloves On Gaming
- Design for Short Game Sessions
- Be Aware of the Lacking Snow and Ice on the Map
- Design for Short Battery Lifetime in Winter Weather

It is important to note that, while each of these would be worthy to focus on and investigate deeper in future work, they are also specific to cold sub-arctic winter weather, to this specific game, and to the weather conditions during this single study. There can be many types of winter; there can be ice, snowfall, different types of snow, varying snow depth, and so on. There can also be many other environmental factors that affect the game. The values suggested by this paper should not be read as a generalized and complete list, but rather as one example of environmental impact on location-based games, opening up for more weather-related design reflections also in future cases. Other factors that could be worth studying in sub-arctic winter include snowfall, sun reflection, different snow types (crust, powder, packing snow, slush, and so on), and the darkness.

Similarly, studying non-ordinary weather is of course not limited to winter. While winter conditions are the focus of this paper, the paper can also be read as an inspiration and point of comparison for taking other weather conditions into consideration when designing games. This way weather conditions become an important consideration when making design choices. Heavy rain, moist, extreme heat, and so on would all be interesting for different reasons. It’s not just about adding weather data into the game, but to in a meaningful way design the game for the actual weather conditions the players will be experiencing.

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REFERENCES

- [1] Alavesa, P. and Xu, Y. 2020. Unblurring the boundary between daily life and gameplay in location-based mobile games, visual online ethnography on Pokémon GO. *Behaviour & Information Technology*. 0, 0 (Sep. 2020), 1–13. DOI:<https://doi.org/10.1080/0144929X.2020.1825810>.
- [2] Back, J., Heeffer, C., Paget, S., Rau, A., Sallnäs Pysander, E.-L. and Waern, A. 2016. Designing Children’s Digital-Physical Play in Natural Outdoors Settings. *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (2016)*, 1359–1366.
- [3] Back, J., Heeffer, C., Paget, S., Rau, A., Sallnäs Pysander, E.L. and Waern, A. 2016. Designing for Children’s Outdoor Play. *Proceedings of the 2016 ACM Conference on Designing Interactive Systems (New York, NY, USA, 2016)*, 28–38.
- [4] Back, J., Turmo Vidal, L., Waern, A., Paget, S. and Sallnäs Pysander, E.-L. 2018. Playing Close to Home: Interaction and Emerging Play in Outdoor Play Installations. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (New York, NY, USA, 2018)*, 156:1-156:11.
- [5] Benford, S., Crabtree, A., Flintham, M., Drozd, A., Anastasi, R., Paxton, M., Tandavanitj, N., Adams, M. and Row-Farr, J. 2006. Can You See Me Now? *ACM Transactions on Computer-Human Interaction*. 13, 1 (Mar. 2006), 100–133. DOI:<https://doi.org/10.1145/1143518.1143522>.

- [6] Benford, S., Flintham, M., Drozd, A., Anastasi, R., Rowland, D., Tandavanitj, N., Adams, M., Row-Farr, J., Oldroyd, A. and Sutton, J. 2004. Uncle Roy All Around You: Implicating the City in a Location-Based Performance. *Proc. ACE 2004*. (2004).
- [7] Benford, S. and Giannachi, G. 2011. *Performing Mixed Reality*. MIT Press.
- [8] Benford, S., Magerkurth, C. and Ljungstrand, P. 2005. Bridging the physical and digital in pervasive gaming. *Commun. ACM*. 48, 3 (Mar. 2005), 54–57. DOI:<https://doi.org/10.1145/1047671.1047704>.
- [9] Clements, R. 2004. An Investigation of the Status of Outdoor Play. *Contemporary Issues in Early Childhood*. 5, 1 (Mar. 2004), 68–80. DOI:<https://doi.org/10.2304/ciec.2004.5.1.10>.
- [10] Forsler, I. and Guyard, C. 2020. Screen Time and the Young Brain - A Contemporary Moral Panic? Making Time for Digital Lives: Beyond Chronotopia. A. Kaun, C. Pentzold, and C. Lohmeier, eds. Rowman & Littlefield. 25–42.
- [11] Hiniker, A., Radesky, J.S., Livingstone, S. and Blum-Ross, A. 2019. Moving Beyond “The Great Screen Time Debate” in the Design of Technology for Children. *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (New York, NY, USA, May 2019), 1–6.
- [12] Jackson, S. 1981. *Killer – The Game of Assassination*. Steve Jackson Games.
- [13] Jarkiewicz, P., Frankhammar, M. and Fernaeus, Y. 2008. In the hands of children: exploring the use of mobile phone functionality in casual play settings. *Proceedings of the 10th international conference on Human computer interaction with mobile devices and services (2008)*, 375–378.
- [14] Liedtka, J. 2015. Perspective: Linking Design Thinking with Innovation Outcomes through Cognitive Bias Reduction. *Journal of Product Innovation Management*. 32, 6 (2015), 925–938. DOI:<https://doi.org/10.1111/jpim.12163>.
- [15] Lund, K., Coulton, P. and Wilson, A. 2011. Participation inequality in mobile location games. *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology* (New York, NY, USA, Nov. 2011), 1–8.
- [16] Maniccia, D.M., Davison, K.K., Marshall, S.J., Manganello, J.A. and Dennison, B.A. 2011. A Meta-analysis of Interventions That Target Children’s Screen Time for Reduction. *Pediatrics*. 128, 1 (Jul. 2011), e193–e210. DOI:<https://doi.org/10.1542/peds.2010-2353>.
- [17] Montola, M. *Exploring the Edge of the Magic Circle: Defining Pervasive Games*. 4.
- [18] Montola, M. 2009. *Games and Pervasive Games*. Pervasive Games. Elsevier. 7–23.
- [19] Montola, M., Stenros, J. and Waern, A. 2009. *Pervasive Games: Theory and Design*. Morgan Kaufmann Publishers Inc.
- [20] Muñoz, S.-A. 2009. *Children in the Outdoors - A Literature Review*. Sustainable Development Research Centre.
- [21] Pokémon GO Revenue and Usage Statistics (2020): 2017. <https://www.businessofapps.com/data/pokemon-go-statistics/>. Accessed: 2020-09-13.
- [22] Reis, S. and Correia, N. 2012. Playing with the Weather. *Entertainment Computing - ICEC 2012* (Berlin, Heidelberg, 2012), 172–184.
- [23] Reis, S., Romão, T. and Correia, N. 2010. Pervasive play for everyone using the weather. *Proceedings of the 7th International Conference on Advances in Computer Entertainment Technology - ACE ’10* (Taipei, Taiwan, 2010), 104.
- [24] Sallnäs Pysander, E.-L., Back, J., Waern, A. and Paget, S. 2020. The DigiPhysical Playscape. *Making Smart Cities More Playable: Exploring Playable Cities*. A. Nijholt, ed. Springer. 207–234.
- [25] Suits, B. 2005. *The Grasshopper: Games, Life and Utopia*. Broadview Press.
- [26] *Traditional Assassin*.
- [27] Waern, A., Balan, E. and Nevelsteen, K. 2012. Athletes and street acrobats: designing for play as a community value in parkour. *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems (2012)*, 869–878.
- [28] Walther, B.K. 2005. Atomic actions -- molecular experience: theory of pervasive gaming. *Computers in Entertainment*. 3, 3 (Jul. 2005), 4. DOI:<https://doi.org/10.1145/1077246.1077258>.
- [29] Wetzel, R., Blum, L., Feng, F., Oppermann, L. and Straeubig, M. 2011. Tidy City: A Location-based Game for City Exploration Based on User-created Content. *Proceedings of Mensch & Computer (2011)*.
- [30] Wood, G. 2014. Using play as a lens to bridge the physical with the digital. *Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play* (Toronto, Ontario, Canada, Oct. 2014), 307–310.
- [31] Wood, G., Back, J., Choi, J.H., Dylan, T. and Louw, M. 2019. Designing for Outdoor Play. *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (New York, NY, USA, May 2019), 1–8.
- [32] *Zombies, Run!* <https://www.zombiesrungame.com>. Accessed: 2013-02-20.
- [33] 2013. *Ingress*. Niantic Labs.
- [34] 2016. *Pokémon GO*. Niantic, Inc., The Pokémon Company.