Affective Tabletop Game: A New Gaming Experience for Children

Abdullah Al Mahmud[1], Omar Mubin[1], Johanna Renny Octavia[1], Suleman Shahid[1], LeeChin Yeo[1], Panos Markopoulos[2], Jean-Bernard Martens[2], Dima Aliakseyeu[2]
[1]User-System Interaction Program, [2]Department of Industrial Design
Eindhoven University of Technology, Den Dolech 2, 5600 MB Eindhoven, The Netherlands
{a.al-mahmud, o.mubin, j.r.octavia, s.shahid, l.c.yeo, p.markopolous, j.b.o.s. martens, d.aliakseyeu} @ tue.nl

Abstract

In this paper, we discuss various options for enhancing the gaming experience in augmented tabletop games. More specifically, we propose to incorporate psychophysiological measurements as a part of the gaming experience, and to integrate a desktop game within its real surrounding (i.e., the entire room) in order to promote more physical activity. Such design options, together with other game rules, aim at promoting social interaction between participating players, as this is considered to be a major characteristic of any good multi-player game. We concretized and informally evaluated the above aspects within a specific tabletop game that we designed for children aged 7 to 11 years. Our findings indicate that psychophysiological feedback in a tabletop game does indeed facilitate social interaction and adds to the fun element. Our results also reveal that children appreciate the involvement of the real world environment in a tabletop game.

1. Introduction

Augmented tabletop technology is an approach towards multi-player gaming that combines traditional board games with computing technology. It is a way of offering richer gaming experiences that are well-established in the realm of computing technology [8], and presenting them in a context that is more socially binding, as is for instance evidenced by the popularity of traditional board games. Tabletop games provide co-located, collaborative and face-to-face interaction, while the tangible interaction elements that are often part of such an environment provide an enjoyable user experience through more natural interactions. However, the static nature of conventional tabletop games limits the scope of realizable games [7], so that further extensions of the augmented tabletop concept are worth exploring.

The potential of tabletop gaming has been well substantiated within several research prototypes [15]. Most existing applications are however targeted towards adult (experienced) players. In order to better illustrate the potential impact of augmented tabletop gaming, and in order to improve accessibility for a broader audience, more applications that appeal to non-expert users, such as children, are required. There are some recent examples of tabletop applications for children within research prototypes such as READ-It [16] or SIDES [10]. The READ-It game was created to enhance the development of reading skills of five-to-seven-year-old children. The SIDES tool was designed to provide social group therapy for adolescents having Asperger's syndrome. It is evident that most tabletop games have been built either for educational purposes or for social skills development within special groups of children. We are aware of relatively less established work in the area of tabletop gaming for children, solely for the purpose of entertainment and fun. Therefore, we feel that there is uncharted potential for utilizing tabletop technology within such a context.

In traditional games where players sit face-to-face, individual players interpret the facial expressions and physical behavior of their co-players. It could be beneficial if, as part of the gaming experience, this subjective judgment could be complemented by a prediction of the other player's emotional state, for instance based on breathing or heart rate. The use of skin conductance response (SCR) for lie detection within the polygraph is of course well-known [2, 3]. It has been established that psychophysiological signals are also potentially useful within entertainment computing [14]. More specifically, physiological data have been used to objectively measure human enjoyment and fun when playing games [9], i.e., as an evaluation metric. We however do not know of any examples where physiological signals have been used as explicit input into a game environment [7], i.e., as an extra input modality that can augment the interaction and hence the overall game experience. Currently, there is no existing research in the game domain that analyzes the use of real time physiology as an element of fun. Most of the work focuses on game metrics or applications for adults whereas computer games for children that incorporate real-time physiological feedback are yet to be explored.

The goal of the reported study was to explore novel ways of designing a game for children, based on the technical options afforded by augmented tabletop technology that could lead to a more engaging and social gaming experience. Early on in the study it was suggested that social interaction and fun could possibly be promoted by using bluff in combination with physiological feedback, as bluff and deception in theory should be influential to physiological data. This was motivated by a wish to capture how an individual player is feeling at any given moment and to integrate this very personal representation of the context into the game. From the start, the target users in our design were children aged 7-11. It is known from child development literature that, children at this stage start structured learning; they are able to understand rules and engage in structural game play [17].

The prototype that we built has a three-fold contribution towards children's game design. First, designing a tabletop game for children using psychophysiological feedback is, as far as we know, new. Second, our study reveals that bluff enhances fun and social interaction in collaborative tabletop game play. Last but not least, the study provides evidence for the fact that integration of the real world within the context of a tabletop environment leads to a more absorbing gaming experience.

The structure of the paper reflects and reports on the different stages in the design process. After an initial enquiry into game play, several rounds of iterative conceptual design ensued. The resulting prototype, its implementation and evaluation will all be described in detail. The major lessons learned from developing and evaluating the design will be explained at the end in conjunction with possible directions for future work.

2. Game design process

2.1. Conceptual design

The game concept was developed as a result of several user studies with children [13]. Next to the game rules, the roles of bluffing and physical activities had to be developed in depth. Bluffing is an obvious attempt to mislead opponents in hope of gaining an advantage over them. Bluffing can potentially add tension and animosity to a game and seems to be widely appreciated as an exciting aspect of games. Physical Incorporation of the real world within the game environment is highly promising as well. This is especially evident in young children, who like to be physically active, adding activities away from the gaming environment was also considered potentially interesting. The rules of the game were drawn up in a participatory manner, which meant that feedback and suggestions from the children guided the design choices. The game rules also needed to be outlined in such a manner that an appropriate level of difficulty was maintained throughout the game.

The design process started with a sequence of sessions that aimed at establishing the key aspects that we wanted to incorporate into our tabletop game. Bluff, the use of pyschophysiology and various modes of social interaction were therefore analyzed with several groups of children. This was done by slightly altering the rules of traditional and common games such as Ludo, Liar's Dice [6], Pacman 3D [19], Journey of the Wild Divine [18] and Snakes and Ladders. Various insights were gained in this initial phase that further led to new conceptual designs that were subsequently evaluated with the children via a peer tutoring strategy [4]. The concepts were extensions of the games that we had tested in the earlier round. They included Ludo supplemented with bluffing and physiology and a new mobile game called Save the Princess. In Save the Princess the children had to retrieve resources from the environment.

An intermediate game concept, called Pachisi, was composed by synthesizing the rules from Ludo and Save the Princess. The rationale was that both games comprised of elements that the kids enjoyed. A brief evaluation session was conducted with four kids. The objective of the session was two-fold. One was to test this refined game concept and the other one was to test the 'ping' concept for physiological measurements. To know the physiological measurement of a player's opponent he/she could 'ping' a limited number of times for his/her opponent's physiological data. The test revealed that the game-board in Pachisi was perceived as too linear by the children and they expressed a desire for an overall greater challenge in the game board path. Therefore, a new game concept called aMaze was developed that included pictures of various mazes and labyrinths.

The aMaze game concept was tested against Pachisi before settling on the final game concept SaP: Save aMazed Princess. This new game SaP shares the game rules composed for Pachisi, including the aspect of bluffing, but, inspired by the aMaze game, the game board was more challenging in order to incite some puzzle solving skills in the children. A session was also arranged in which the SaP game concept was evaluated (prior to final implementation) with children. The children rated the SaP game positively in terms of the difficulty level in comparison with earlier game concepts. They reported that the SaP game is more challenging, as they have to think and logically decide which path to choose.

2.2. Game rules of SaP

The game rules of the SaP game are intended to encourage individual effort and involvement as well as teamwork amongst members. The game is played with four players, using two dice. Each team is divided into two players; with teammates sitting opposite each other (see Figure 1, where Player 1 and Player 3 constitute one team).

Movement of a player's token on the game board is enabled by throwing two dice. Player 1 starts the game with the first throw of the dice. He or she hides the dice during the throw and calls out aloud the total score on the dice. Starting from the second round in the game, a player is allowed to bluff about his/her score on the dice. A physiological device that continuously records and interprets physiological data is attached to the player that is throwing the dice. In the context of our game, two types of physiological readings, the galvanic skin response (GSR) and the heart rate, are used. The opponent player that is next in line (player 2, in case player 1 has thrown the dice) is given the option of calling the opponent's bluff. If the player who threw the dice is caught bluffing, a penalty is inflicted. As a rule, the penalty is to retreat the player's token back five positions (the last five squares in the path followed up till then, as there is no orientation due to the game board being a maze). If this is not possible (for example, the throw is only the second throw and/or the player hasn't advanced far enough yet), then the penalty is to move the player back to the starting position. If the player is not caught bluffing (for example his/her opponent does not wish to challenge the throw, or the reported number on the dice is actually correct, i.e., the current player is not bluffing), the player can take whatever number of steps based on the number he/she had reported out loud in any direction he/she desires.

Figure 1. The game board

In order to judge whether or not a player is bluffing, the challenging player can acquire the assistance of physiological feedback by pinging the player who threw the dice. This is simply done by activating one of two possible menu buttons on the game board, which gives feedback on the current state of the physiological measurements (either GSR or heart rate). The result is an overall estimate from the system of the likelihood of the throw being a bluff. Pinging is only allowed for a fixed number of eight tries and hence cannot be used on every turn. There is no penalty for the player who uses the physiological device when challenging the throw, besides losing one of his tries (wildcards).

The game is structured as a story, having stages (or chapters). The rules of the complete game are as follows. In the first stage of the game, each player has to reach an iconic resource on the maze board (for example, for the first team, player 1 needs to find a river, while player 3 needs to find a mountain). The dice throwing annex bluffing process discussed above is used to move across the board. In order for a player to progress pass a resource; a key that is hidden within the environment is required. Players hence need to leave the game board and retrieve resources from the real world in order to proceed past their current position on the game board. While a player is locating a resource, other players may continue with the game. If Player 1 is looking for a resource, the game can continue until Player 4 throws a dice. Once a player has found the relevant resource he/she can register the retrieval of the resource key, with the system by placing activating a designated menu button on the game board. To create a degree of uncertainty and surprise, the game board supported hidden resources. If a player arrived at certain squares on the game board, a hidden resource popped up. The player would then have to retrieve that resource from the environment before being allowed to move ahead.

In the second stage of the game, both players in a team are given a common target resource (a palace). This means that both players from a team have to meet somewhere on the maze and coexist, after which they can head off together towards the resource target (the palace). The aim of the last stage in the game is to find a princess, in a manner similar to finding the palace. The first team to find the princess is declared the winner. Needless to say that the resources required in a particular stage of the game are only displayed on the game board after the previous stage has been successfully conquered. The flexible way of controlling resources and changing the layout of the game board (to another maze in every round) were of course made possible by the fact that the game was implemented as a virtual tabletop game.

3. Implementation

3.1. Gaming platform

The prototype was implemented on the Build-It [12] hardware platform, using the Visual Interaction Platform (VIP) software [1] (see Figure 2). The setup consists of several artifacts: a data projector, a table supplemented with several tangible checkers (used to represent player's tokens, and for activating the menu buttons on the game board). The light from a data projector mounted above the table is directed towards the table surface, using a mirror. The projector has a resolution of 1024 X 768 pixels and is bright enough for projecting the maze on the table. Interaction on the game board is primarily a selection task. The interaction devices used are square tiles with infrared reflecting tape. A pattern of holes in the reflecting tape provides each tile with a unique identity (and orientation). The center coordinates of the tiles are used as the localization parameters in the selection task. Corner coordinates can be used to track individual checker pieces on top of the intelligent game board, e.g. in order to find out if hidden resources need to be displayed.

Figure 2. The gaming platform

3.2. Software

The tracking system is provided by the VIP platform. Existing software libraries (implemented in C++) that offer vision-based tracking in 2D are incorporated into our application. The VIP platform is designed in order to support a server-client architecture. The server is the tracking system and it sends reports to the client application whenever they become available. Such reports include various parameters and attributes of the tangible checkers, such as their ID, the coordinates of the center and corners of the checker, height, width, etc.

The game engine was visualized in OpenGL (see: http://www.opengl.org/) and C++, and developed using Visual Studio.NET IDE. Animated 2D/3D sounds were implemented using OpenAL (see http://www.openal.org/). The entire system was a multithreaded application as the tracking and game engine were executing concurrently. In order to generate the maze the Depth First Search (DFS) algorithm was used. It was slightly adapted to render mazes that were a) sufficiently simple and b) had four starting points, one for each player. For each game session a new random maze was generated.

Images and icons in the game were simple bitmap images designed externally in Macromedia Fireworks and texture mapped in OpenGL. The images and icons were primarily comical depictions or caricatures. These images were attached to menu buttons, resource pictures and outputs of physiological measures (see Figure 3).

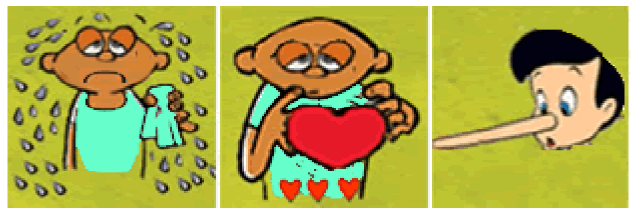

Figure 3. The representation of sweating, heart rate and bluff probability by Pinocchio on the game board

3.3. Game interface

Each player had a personal interface that was rendered into his or her corner of the maze/tabletop (see Figure 4). This interface included 5 buttons. By employing the tangible tiles, players could activate those buttons. From these 5 buttons, only 3 could actually be activated. Those 3 buttons were pinging for heart rate ("Show me heart rate"), GSR ("Show me sweating") and reporting the retrieval of a physical resource from the environment ("Team A or B found resource"). The other two buttons were meant to be for information display purposes only. One of them was the resultant output of the bluff estimate: a corresponding image of Pinocchio. This same button would display the number of ping tries left when it was not activated. The last button was an image of the current resource target.

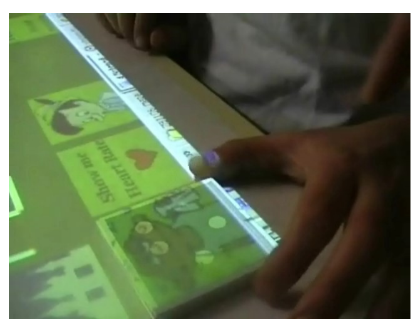

Figure 4. Psychophysiological ping output, use of the Tangible Tile, and the interface corner

3.4. Communicating with the Mobi device

For measuring the two physiological readings (GSR and heart rate), the Mobi system is used [11] (see Figure 5). The Mobi system is a multi-channel system that can measure different (electro)-physiological signals such as GSR, ECG, EEG, EMG, temperature, force, movements, respiration etc. For viewing and processing the real-time physiological data captured by the Mobi system, the Portilab signal processing software, which is delivered together with the Mobi system, can be used. It can assist in viewing and processing data in real-time and can store data in a database for offline analysis. We for instance used it to apply filters on the GSR and heart rate signals and to categorize the filtered signals based on signal strength.

Communication between the Mobi device (see Figure 6) and the Portilab software is accomplished using a Bluetooth connection. The processed signals are transmitted by the Portilab software to the game engine, so that this information is available whenever a player wants to "ping" for it.

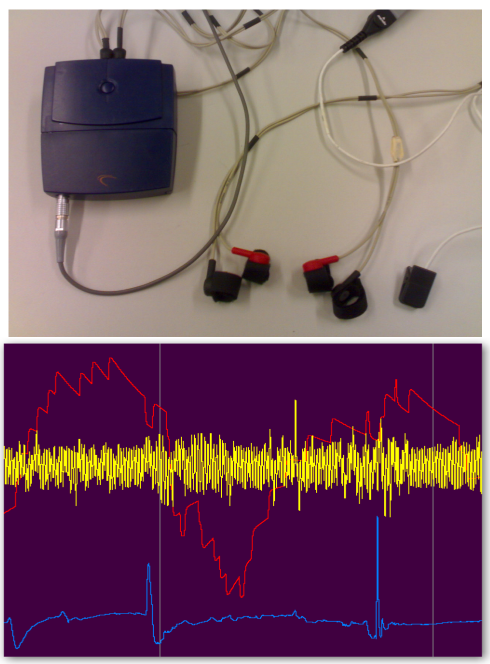

Figure 5. The Mobi system (top) and some psychophysiological outputs in Portilab (bottom)

3.5. Visualizing psychophysiological data

Baseline readings for each player were recorded prior to the start of the game. Players were instructed to be calm and inactive while baseline readings were collected. The physiological data was categorized into three levels (low, medium and high). For heart rate, the most recent five readings were averaged out and compared to the baseline reading. Based on a simple threshold scheme, a low, medium or high level was determined. For GSR, however, the most recent readings were compared amongst each other and similarly a corresponding level was established. The level of physiological arousal was derived either based on the prevailing heart rate or skin response. The level of physiological arousal was directly mapped and a corresponding low, medium or high-level Pinocchio image was displayed as a result.

The icons in Figure 4 depict a high probability of the throw being a bluff, given the length of the nose of Pinocchio and the corresponding high levels of the physiological data. The image of Pinocchio was a pictorial description of the likelihood of the concerned throw being a bluff. The longer the nose of Pinocchio, the more likely was that the other player bluffed. The renderings of the two physiological measures were intended to be equally intuitive.

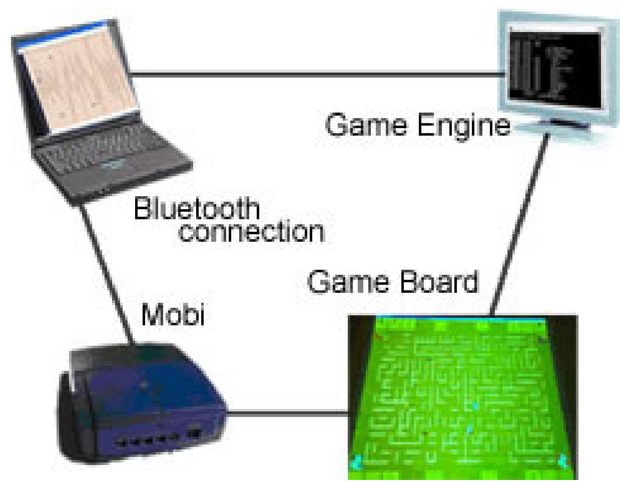

Figure 6. System architecture

4. Prototype evaluation

The final step in the design process was an evaluation of the implemented prototype. The game was evaluated with 8 children within two sessions. Each session lasted for 30 minutes and the teams of children were formed randomly. All the children were acquainted with their teammates before the study and none of them had prior experience in tabletop gaming. Each child in the sessions was given a game board as a gift for their participation.

We aimed to evaluate the usability of the tabletop game, as well as ascertain the impact of our three fold add-ons to tabletop gaming. The key issues were as follows. Would psychophysiological input be understood as a part of the game by children? Would psychophysiological feedback add fun to the game and contribute to a new gaming experience? Would it enhance social communication and social bonding, across and within teams? How would children react to bluff and psychophysiological measurement? How would children react to leaving the game board and carrying out some game play in the environment?

To minimize the risk of technical problems, such as with the calibration of the tracking system, we tested the game in the same laboratory where the prototype was developed. The game table was set in one corner of the lab. The children were seated on two sides of the table (see Figure 7). The physical resources were hidden in different parts of the lab inside paper cups. There were more cups than number of resources. Inside some cups, pictures of resources taped to door keys were hidden. Children were instructed to quickly retrieve the correct resource from the environment and return to the game board.

Each evaluation session comprised of two phases, where we evaluated our game with and without psychophysiological input. Each evaluation session had several parts: training on how to play the game, a free play session, followed by group and individual interviews with card sorting. Physiological baseline measurements were taken for each player before the game started.

One of the experimenters explained how to play the game, the rules and interaction with the game board with respect to the tangible tile and activating the various menu buttons on the game board. The others were video recording, observing, note taking and managing data from the Mobi device.

Figure 7. A play session

5. Results and discussion

5.1 Subjective impressions

We report our analysis based on observations, interviews and videos. It is evident that the children understood that the psychophysiological output and bluff are important and crucial components of the game. They mentioned that they grasped the (ordinal) mapping of physiological data to cartoon drawings. The image of Pinocchio, which was the summarized representation of the current psychological condition (heart rate, sweating), was ranked higher than the other features/drawings in card sorting by most children. One child said 'Pinocchio helped a lot more than heart rate and sweating because it's the conclusion of both. Most of the time I only see the picture of Pinocchio'. Overall, the gaming experience was enthralling for the children and they appreciated the visualization of the game. Their fascination with the game was evident when one child commented: "The game came from the sky" (referring to the projection). The children also expressed satisfaction with the fact that the game was based on a story with stages or chapters.

In the session when children were playing the game without psychophysiological measurement, children reported that they either looked into the eyes of their opponent or blindly guessed if the other player was bluffing. Later, they expressed during interview that in the game with psychopsychological enhancement it was easier to guess when a player was bluffing. There were more excited during the game with psychophysiological measurement. One child said 'knowing heart rate and nervousness is new and fun' and 'I can see into the heart and body of the others and its cool'. The children also expressed that to ensure sufficient challenge and interest within the game, there should not be too many ping tries. The figure of eight possible tries were deemed to be adequate by the children.

When the psychophysiological measurement device was working properly children had dependency on it and one player said 'sometimes it's too good'. The children reported that psychophysiological measure should not be entirely accurate. It was obvious that there is a need for maintaining a delicate balance between the guessing element and the accuracy of the reading. Moreover, it should not be too easy to fool the system. On the other hand, the system should not be too accurate since this would ruin the challenge in the game, as players would be caught bluffing rather easily. We found out that the data from the Mobi device was partially noisy at times, which would mean that it would not always be accurate.

We only collected qualitative observations on how children compared the two game variations, i.e., with and without psychophysiological feedback. It was evident from their remarks and comments that they enjoyed the version of the game which incorporated the Mobi device and the physiological elements of the game. However, they did at times criticize the Mobi device since it was not ergonomically suited for them, and the earplug for measuring heartbeat was a bit painful and uncomfortable.

Tabletop games today are mostly restricted to audiovisual means, up and around the table [7]. Our evaluation shows that finding resources in the environment, triggered by clues in the tabletop game, is exciting for the children. Children all agreed that collecting resources is a real part of the game and this activity matched with the theme of the game (see Figure 9). During the interviews, children appreciated the game and, interestingly, immediately recognized that it was a combination of technology and other artifacts in the real world. One child stated: “This game is different from others, because you not only use the computer; you also use the real world”. Another team said: ‘finding the keys is like hunting and that’s why we liked it’. The children appreciated the fact that the surrounding environment of the game board was also used as a part of the game. Their approval is validated from the following quote: ‘The nice part is clues that are on the board and then you actually move to find the keys in the room on the basis of the clues’.

5.2. Technical observations

From the technological perspective, there were some limitations in the prototype. Tracking of the square tile that was used as the main interaction device in the game was sometimes insufficiently accurate to guarantee successful activation. This was especially a problem when positioning tiles in the corner of the game board. Several children for instance experienced problems when “pinging” (i.e., calling another player’s bluff). They sometimes needed several attempts before being successful (see Figure 8). The (unwanted) consequence was that they lost some of their tries (wildcards). The children were able to adjust to this, since they made fewer placement errors in the second game session. We had to compensate for this and for one of the game sessions, we removed the limit of eight tries, consequently providing the children with unlimited tries.

Figure 8. Using tangible tile to check psychophysiological reading

A constraint on the game play was the limited set of GSR electrodes of the Mobi device. During the test, we had only four electrodes, two for each player. Therefore, children had to swap their electrodes with other players, when their turn was over. However, it did not introduce any delay in the game play.

Since the tabletop was not very big, throwing dice on the table was a problem for the children as the dice would occasionally drop from the table and they would have to repeat their throw. Implementing digital dice could help to solve this issue. This could also aid in preventing children from cheating and/or accidentally turning the dice at the time of revealing them to other players. However, there is a trade off, as tangible dice provide children with physical game-play. The children were observed to exhibit peculiar traits with respect to throwing the dice. At times, children would blow into their palms before throwing the dice (as a good luck charm), or extensively shake the dice before throwing it on the table.

Handling and processing of physiological data from the Mobi device was a challenge. The Mobi device was able to record data when it was operating in stationary mode. However, we observed that at times, the device produced noisy data that had to be normalized during transmission to identify which part corresponded to a peak. The peak would then directly represent and determine the bluff probability. Though it is possible to reduce noise by using appropriate filters; yet the transmission of real time psychophysiological data into any game engine faces considerable challenges, primarily due to the limitation of technology. This would be an important direction of future exploration, especially in terms of incorporating physiology in a real time and mobile setting.

Figure 9. Winning (left) and finding resources on the ground (right)

It is common in tabletop systems that the orientation of a shared object causes problems for its users who are located differently around the table [5]. While projecting and designing the game and images we tried to overcome the orientation issue. The maze game board was projected as it is, whereas the interaction buttons on the game board were oriented based on a player’s point of reference. The only text that appears during the game is at the start. Here players have to choose the difficultly level of the maze, number of players etc. The children who were seated on the wrong side of the table did not report any problems in interpreting the startup text. Overall children did not mention any problems that could be attributed to the orientation of any of the representations.

6. Conclusion and future work

We have investigated how to design and build an affective tabletop game for children. The evaluation of the designed prototype revealed that children appreciated it as a new gaming experience. The addition of psychophysiologiacal data into a tabletop application provided an extra modality for the game environment. From a research perspective, this work could inspire other ways of utilizing psychophysiological measurements, especially in mobile gaming environments. We also explored the potential of incorporating a tabletop game within a broader context, with the intention of enhancing social interaction and fun within and around the game. The implications for game design of this latter aspect also need to be developed further.

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