How to Stay in the Emotional Rollercoaster: Lessons Learnt from Designing EmRoll

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ABSTRACT
Bodily expressions can be used to involve players in intense experiences with games. By physically moving, breathing, or increasing your pulse, you may start emotional processes that help create for a stronger experience of the narrative in the game. We have designed a system named EmRoll that poses riddles to pairs of players. The riddles can only be solved if the players are, or at least pretend to be, moving according to different emotional states: dancing happily, relaxed breathing and being scared. The system measures movement, breathing and sweat reactions from the two players. Lessons learnt were: playing in pairs is an important aspect as the two players influenced one-another, pulling each other into stronger experiences; getting excited through intense movement when involving your whole body worked well, as did relaxing through deep breathing; using the sweat response as an input mechanism worked less well; and finally, putting a Wizard (a human operator) into the loop can help bootstrap difficulty balancing and thereby increase emotional involvement.

Author Keywords
Affective loop, designing for experience, full body interaction, body tracking, biological sensors

ACM Classification Keywords
H.5.2 Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Intense emotional experiences often involve our whole bodies [25]. By moving in certain ways, rhythmic movements, tensing or relaxing different muscles, you can initiate emotional processes, as when having a massage, doing yoga, taking a deep breath, or dancing wildly on the dance floor [15].

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Our aim here was to design for a rich emotional journey through a game of riddles. The riddles were posed to pairs of players. In order to solve the riddles, they had to move, breathe in a certain way or show other forms of physical reactions to what was portrayed in the interaction with the game. To design this game named *EmRoll* (Emotional Rollercoaster), we embarked on an iterative user-centered design journey. The game bases its interaction on bodily movement, respiration rate and spontaneous Galvanic Skin Response (GSR)[1] frequency [1].

Obviously an emotional process is not something we can command users to have by forcing them to move, tense their muscles or breathe in certain ways. We can 'stage the scene' for certain experiences to happen through the ways we design a system, but in the end, the user will decide whether to play along or not. They will filter their experience through their individual preferences and prior experiences [19]. Becoming crazy happy will more likely happen if we stage the interaction to involve players' whole body, jumping up and down in intense dancing movement, than if the system makes people sit still on a chair.

In addition, making players collaborate and do physical movements together may strengthen their experience. Others have shown that collaborative play has some interesting advantages [24]. By sharing a goal or a character in a game, players have to interact more with one another. In earlier studies we observed that players usually feel embarrassed when performing intense gestures. They preferred to express their happiness through only moving their hands or sometimes their heads. However when the same people were asked to express their happiness together with someone else, they motivated one another and went as far as dancing happily together. These are the reasons why we decided to make players interact with EmRoll in pairs, synchronizing their movements or breathing.

Below we will go through the design process behind EmRoll to show some of the pitfalls and potentials for engaging interaction we encountered. We will also reveal insights from the iterative prototype testing with users to

[1] GSR measures sweating activity, known to be related to physical, mental and emotional arousal.

show how users get involved, or, in some cases, fail to get involved. But let us start by providing some background to how to design for *affective loops*, the design concept behind our work [10].

BACKGROUND

Ever since the work by Darwin [7], it has been known that certain movements are closely related to emotional processes and vice-versa. Philosophers such as Sheets-Johnstone [25] and Shusterman [26], have shown that movement can be seen as the basis of our whole way of being in the world. Choreographers and dancers, such as Laban [15], and theater movements, such as *method acting*, have made similar points: by portraying emotions in movements, we can come to experiences that we would not have otherwise. Sheets-Janstone [25] claims that emotional experiences are impossible without the corresponding physical state in terms of muscle tensions and body postures. As Sheets-Johnstone said, there is *"a generative as well as expressive relationship between movement and emotion"* [25].

But the step from noticing that certain movements coincide with certain emotional processes to designing systems that actively involve users at all levels is not easy. Results of some prior projects, such as SenToy [22] and eMoto [28] have shown that using the body and gestures in interaction tends to be far more vulnerable to the slightest delay or mistake in interaction compared to more traditional interaction. It is only when the interactive system can be designed to work without creases or cracks in the interaction that it reaches the kind of experience sought. The emotional involvement through physical movement, we have tried to capture by the idea of an affective loop, where:

- emotions are seen as processes, constructed in the interaction, starting from everyday bodily, cognitive or social experiences
- the system responds in ways that pulls users into the interaction, touching upon their physical experiences
- throughout the interaction the user is an active, meaning-making individual choosing how to express themselves – the interpretation responsibility does not lie with the system

Several other systems have been built that attempt to create affective loop experiences with more or less successful results. For example, eMoto lets users send text messages between mobile phones, but in addition to text, the messages also have colorful and animated shapes in the background chosen through emotion-gestures with a sensor-enabled stylus pen. The gestures are designed to resemble our bodily experiences of different emotion processes, and the graphical, animated shapes in turn resemble the gestures – allowing for an affective loop experience.

Overall, bodily imitation between people is a fundamental skill and a powerful mechanism. Alan Kay [14] used it when he designed the desktop-metaphor and the physical acts "point and click" and "drag and drop". He was inspired by a tennis teacher who promised that he could teach anyone how to play tennis in 20 minutes. The tennis teacher simply distracted players by making them sing or talk, which allowed them to relax and simply imitate his bodily behaviors for backhand, forehand and serve. Our idea in EmRoll is that our two players would both imitate one-another but also be inspired by the behaviors of the avatar on the screen in front of them.

Physically involving games

We are not the first to design games that require physical involvement. There is a whole wave of such games going back to Dance Dance Revolution [6] and emWave. Today we are all impressed by the successes by the Nintendo Wii-games [21]. In academia, games like Wriggle, SenToy , and Ghost in the Cave , have mapped out a space of games that require physical interaction.

Wriggle [12] uses a Wii-mote placed inside a knitted hat tied to users' heads. By moving their head, they control their avatar picking up on falling objects. Ghost in the Cave [23] requires that a whole audience move together, creating a wave of activity picked up by a camera. The more the audience moves, the faster a fish swims from one cave to an-other, searching for a ghost. SenToy [22] was an early game where the avatar in a game was controlled by a plush toy that the player could manipulate. By dancing happily with the toy, they made their avatar happy, by shaking it angrily, their avatar became angry, etc. Depending on the emotion of the avatar, it would act differently in the game. Several other systems have used plush toys as a way for users to interact [16, 13].

There are also relaxation games, like Brainball [11], where measurements of brain activity determine who of the two players is more relaxed and therefore wins the game. "The Journey to Wild Divine" [29] is another relaxation game in which player proceeds through different levels of the game by breathing, meditating and laughing.

DESIGNING EMROLL

Let us start by describing EmRoll, the game we have designed and implemented, before we go back and discuss some of the considerations, problems and pitfalls that lead to this particular design.

EmRoll

EmRoll is played by pairs of kids, 8 – 12 year olds. They dress up in the costumes that can be seen in Figure 1. The color markers on head, arm and leg are picked up by two cameras placed in front of them on the floor. Around their chest (over or under the costume), a breathing sensor is placed. On their fingers (on the hand without the color marker) a GSR-sensor is placed. These sensors are connecting them to an avatar on a big screen. The avatar has two arms, two legs, and two heads. One player controls one arm, one leg and one head. The other player controls the other arm, leg and head. Their respiration affects half of the avatar's belly – expanding and reducing with their respective breathing. That is, if one player breathes fast and the other slow, one half of the belly will move quickly in and out, while the other moves more slowly – making the avatar asymmetrically shaped.

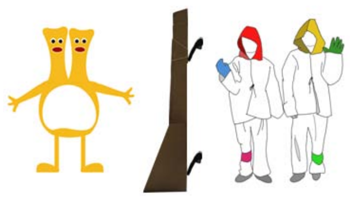

Figure 1 Dressed up for playing EmRoll . A 'tower' of cameras placed in front of the two players, picking up on their movements. The two-headed avatar called Gamboo.

The pair of players is faced with riddles, or challenges, that require that they perform physical actions together, in a synchronized fashion. The overall narrative they are introduced to goes as follows:

"On a sunny day, Gamboo and his friend were playing in the garden. Suddenly, however, a hungry eagle attacked them and took Gamboo into the sky! The eagle wanted to take Gamboo to his nest to make a delicious meal for his babies!!! Fortunately, Gamboo managed to release himself. But now he is far away from his home…"

Figure 2 Gamboo's friend is captured.

Their challenge is to make Gamboo (the two-headed avatar) walk across the island and to help him return home to his friend, see Figure 2. The first challenge they meet is simply how to make the avatar walk. They have to move one leg each in turn in a synchronized fashion to make the avatar move across the scene.

After learning how to walk, the first riddle they need to solve is how to make a sulky guy happy. The solution is to dance together, moving arms, legs and body energetically – forming a happy dance (from now on we refer to this as the *Happy Dance* scene). By moving their heads, arm and legs, each player can make their half of the avatar jump up and down, which in turn makes the sulky guy less grumpy, even starting to dance and finally becoming happy. If he is really happy, he opens the gate and the two players can move on to the next riddle. See Figure 3.

Figure 3 The sulky guy who needs cheering up in order to open the gate.

The second riddle, involves a spider slowly approaching the avatar (from now on named the *Spider* scene), see Figure 4. The players have to shake it off their body and stomp on it in order to get out of this scary situation. But to succeed and not have yet another spider arriving on the scene, their GSR-readings have to go up – that is their emotional arousal needs to rise. Originally, we were hoping that the players would really get scared and that this would be seen from the GSR, but in reality, the spiders were too cute, and any changes in GSR came from their energetic movement (causing them to sweat) rather than emotional arousal – a problem we will come back to below.

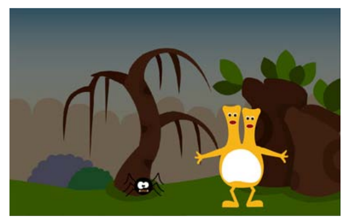

Figure 4 Scary spiders attack Gamboo.

Finally, the third riddle that we have implemented so far happens when Gamboo accidentally falls into the water (from now on the *Underwater* scene). The two players have to breathe deep, slow and synchronized with one another, to make their avatar slowly rise to the surface, see Figure 5.

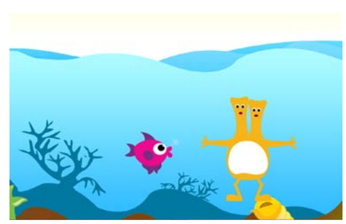

Figure 5. Gamboo falls into the water. A helpful fish gives hints on how to breathe to rise out of the water.

The intention behind these three riddles is to take the pair of players from an intense, aroused, happy peak in the Happy Dance scene, through a scary experience in the Spider scene, into a relaxed, deep breathing, experience in the Underwater scene.

As the two players have to act synchronized to move their avatar and solve the different riddles, we also wanted to create a strong sense of imitation and influence between the two players.

DESIGN PROCESS

Before we arrived at the current implementation of the game, we performed several technical explorations to figure out which biosensors and motion sensors to use. At the same time, we explored the design space and our ideas of the *dynamic gestalt* [18] of the interaction unfolding over time. The version of EmRoll presented above is the third iteration in a tight user-centered design process, intermingling technical investigations, designs and user testing. Below we describe the technical, design and user-testing phases separately even though in reality they were mixed.

To analyze our design and player behavior we made use of two concepts: *trajectories* as defined by [2] and *aesthetic experience* as discussed by [8]. Let us describe these before we describe our design explorations.

Analytical lenses: Trajectories and Aesthetics

As discussed by Benford et al. [2, 3], an interactive narrative (or riddle game) as EmRoll takes users on a journey in time, space, narrative and experience. It provides a *trajectory* that keeps the story and experience coherent. Designing this coherent trajectory is a challenge, and as we shall see below, we ran into several issues arising from problems with the trajectory. Sometimes these issues threw players "off the emotional rollercoaster". Benford and Giannachi [2] point to the importance of continuity in these trajectories. The experience of a game comes to nothing if players experience the interaction as singular, disconnected events. As they say, we need to go "beyond the 'discrete but connected' towards the 'continuous and interwoven'".

We use the concept of, in particular, *temporal* trajectories as a lens through which we analyze some of the design problems and possibilities we encountered when creating EmRoll. That is, the movement through the game over time, linking one scene or activity to the next.

Another important framework for our analysis is *aesthetic experience* as defined by Dewey [8], later picked up by, amongst others, McCarthy and Wright [19]. In short, Dewey says that:

- An aesthetic experience typically has a clear beginning and end. It is something that we can refer to afterwards in quite definite terms: "*An experience has a unity that gives it its name, that meal, that storm, that rupture of a friendship. The existence of this unity is constituted by a single quality that pervades the entire experience in spite of the variation of its constituent parts.*"
- An aesthetic experience is characterized by an emotion that works as its congruent unity. It gives shape to all the different parts.
- A high quality aesthetic experience will "empty" the material on all its potential. In other words, a high quality aesthetic experience benefits from the fullest potential of all the accessible materials. In a game, the material consisting of the narrative, the roles players take on, the graphics, the music, all need to be used to their fullest potential.

Technical explorations

In any design process, the design team needs to properly explore the properties of the material [27]. Initially we tested a range of games involving users bodily, such as The Journey to Wild Divine mentioned above, and Wii Sports [30]. We were also inspired by the smooth and playful movements of the avatar in LocoRoco [17]. We noted that most tried to address one kind of experience, or, to simplify, one emotion. Rather than taking the user through a range of different bodily/emotional experiences, they would typically address a dramatic curve of increased tension and then relief.

Apart from testing a range of games involving the users' bodies, we needed to figure out which bio-sensors and motion capture models we could use to involve our players into an affective loop experience. After testing some biosensor solutions, we decided to use an off-the-shelf sensor named Nexus-10 [20].

A rough comparison made from the results of different biosensors, showed that GSR and heart rate sensors were the most useful signals in distinguishing between the emotion processes we were interested in. The GSR-sensor in our toolkit was easier to attach tighter to the players' finger, which made it more convenient to use than other available GSR-sensors. The GSR measurements are analyzed into different levels of arousal based upon the derivative of the signal and categorized into a five-grade scale, where the extremes on the scale represent a fast change (up or down) in arousal. An extremely fast increase is interpreted as getting enormously scared and fast decrease as getting highly relaxed, see Figure 6.

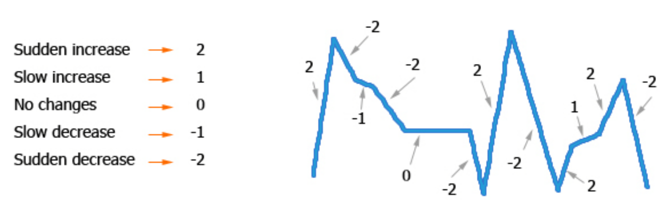

Figure 6 five-grade scale for signal coming from GSR sensor

The breathing sensor intrigued us as it seemed to provide a strong, very physical, experience of being in contact with the game. To validate the use of this bio-sensor as a means to control a game in real time, we decided to develop a small side-scroller game where you control the altitude of an airplane with your breathing to pass between a set of obstacles (clouds). This game 'probe' made it clear to us that it would be possible to use breathing in an interesting way in interaction and we got a feel for what kind of variables we needed to control to create for an interesting experience. In the end, we used the tempo of breathing – quick, medium or slow – as input.

As for the motion capture sensor, we first tried to use the Wiimote accelerometer. But since it became uncomfortable to attach Wiimotes to the players' bodies, we chose to work with image processing from live video streams. Again, after exploring different image processing solutions, we ended up using the freely available software named CamSpace [4]. Each module can track up to 4 colored markers which we used for capturing the two players' heads and one hand each. But we also wanted to capture their leg movements. We first tried Dance Mat, a mattress equipped with pressure sensors. But Dance Mat could only give us footsteps, while we needed the position of the leg in order to animate Gamboo's legs. Putting two Dance Mats next to one-another to be able to differentiate the two players' feet also meant that they stood too far apart. Therefore we added another Capspace module to track colored markers on the feet of the players.

We also needed to find a way to model the body movements and sensor data into states that the game could act upon. Inspired by the analysis of movement into *shape*, *effort*, and *valence* done by [10] we looked at the shape of movements and the level of effort to perform them, to map different body movements to different states of arousal. Sundström and colleagues showed that shape of the movements related to excitement and happiness is *extremely spreading*, *rising* and *advancing* [10] (according to the Laban-terminology). Waving with your hands and moving your torso rapidly results in higher level of effort and thereby higher arousal. We measured and categorized movements based upon their direction (downwards/upwards) and into three levels of speed.

For each riddle in the game, we defined a set of movement and/or breathing/GSR characteristics to be met in order to progress in the game. For example, the measurement of happiness needs to be high for both players in order makes the purple guy starts his happy dance with them. Otherwise he only smiles or waves his head but the door does not open.

Design explorations

As mentioned earlier our aim in EmRoll was to take users through several different emotional experiences. For the first phase of this project we chose happiness, calmness and fear as these are clearly distinguishable emotional processes with very different arousal levels. Our aim is to later extend EmRoll with more riddles relating to other emotional processes.

Our design materials for creating EmRoll were graphical objects, animations, colors, music and narrations. During the design process we recognized that careful, well-designed usage of each of these materials would lead players to stronger, more immersive emotional experience. We found Dewey's idea of emptying the material on all its potential quite useful. Every aspect of the design had to be geared towards the same aesthetics for it to work. The design process behind the Spider scene is a good example of how we worked from a design methodology to find a good interaction [31]. In the beginning, the spider scene had neither sound nor any narration. The colors were bright just like the colors in the other scenes. With this design, the scene was nowhere near being scary. After changing the colors to darker ones and adding scary sounds to the background we made the scene a bit scarier, see Figure 7. We also added a narration to the beginning of this scene which said *"OH NO, BIG DANGER AHEAD!!"*

Figure 7 Spider scene before (left) and after redesign (right)

At first there were a bunch of spiders that entered the scene from left to right. As they were too small to induce any apprehension, we replaced them with one spider that jumped down from a tree and performed erratic, jumpy movements. The spider frequently changed in size and with frightening laughs climbed all over the avatar's body.

ITERATIVE USER-TESTING

Three versions of the EmRoll game were tested with players.

Testing the first version of EmRoll

The first version did not have any narrative or music when it was tested with five pairs of players. The players were all adults, six males and four females, who interacted with the game during, in average, fifteen minutes. This first study revealed some issues with the technological set-up that needed fixing. But more importantly, it gave us some clues as to how the temporal trajectory had to build up the right tension at the right time.

In this first version of EmRoll, there was no narration telling the players what they were supposed to do. We had hoped that they would experiment with moving and breathing in various ways, and by seeing the graphical feedback, they would slowly get the point. But it took way too long for them to figure out what to do, and they lost interest in the experience. One of the players called the happy dance scene a really tiring one as the activity needed in order to make the purple guy happy forced him to dance and move way beyond the time span for feeling happy by dancing around.

In this first version of EmRoll, players found the avatar's movements to be too slow. They expected a one-to-one mapping between their movements and the avatar's. As we did not provide a perfect synch, they felt less as "one" with their avatar. There were also some other issues with understanding how the breathing interaction worked – a player suggested that the breathing animations should be present throughout all scenarios to make it easier to link the avatar's belly movements to their breathing.

Testing the second version of EmRoll

In the second version, we added a narration to the game, giving away some clues to what the bodily riddle was supposed to be:

"Wow! Look at this purple guy! He looks so sad. I wonder if he lets you pass the door with such a sad face...Oh come on! Why not cheer him up a bit?"

"Oh! You should have been more careful! Relax, go with the flow and you'll reach the surface...You're getting there, but try to learn more from the fish..."

This version of EmRoll was then tested with two pairs of players, all male kids (three 10 year olds and one 11 year old). We found that the story line was key-important in helping users to get on track towards solving the riddles. We also noted that the children more easily interacted enthusiastically with the game than the adults testing the prior version. The children moved their whole bodies. The somewhat naïve or cute graphics also seemed to work better for children. When they were asked about the whole graphical environment, they mostly mentioned that they enjoyed the color combination and the shape of the two-headed avatar. In this second study, we again noted that players were extremely sensitive to any mismatch between their behavior and what the avatar did on the screen. It became obvious that we needed to provide many more avatar animations that could mirror players' movements and breathing. This coupling between player behavior and avatar animation had to be near real-time so that players could more strongly identify with the avatar – or as one of our players expressed it when it was working well: "*It felt like I was really inside the game*". But the animations should not only mirror player behavior, they also needed to convey whether players' actions were either leading or not leading towards solving the riddle. The wrong movement needed to be animated as an awkward avatar movement, obviously not leading anywhere. In a sense, this redesign of graphics and mapping from player behavior to graphics was again, a means to "emptying the material to its fullest". Thus, we realized that only when we would really built up the right tension, the right graphical response from the system in relationship to motion recognition, we would achieve the kind of aesthetic experience that we intent.

Testing the third version of EmRoll

In the third version of EmRoll, we therefore added many more avatar animations to better mirror players' behavior: showing players' breathing more clearly, adding many animations for low, medium and high levels of movements of legs, arms, torso and head, as well as position of arms based on whether the arm gesture is done closer to the hip, waist or above the shoulder level. We also added sounds to indicate when they got the synchronized walking right or wrong.

In all three versions of the Underwater scene, players often started by trying to swim out of the water. We therefore added animations that made the avatar to desperately wave his arms and legs, when players produced swimming gestures. If the players still did not get the point that swimming did not work, but breathing would do the trick, an animated fish showed breathing gestures and the narrator would say "*You're getting there, but try to learn more from the fish*". The fish was breathing in a slow manner, letting out bubbles at the pace they should be breathing. To further motivate players to synchronize their breathing and make it slow, we added some animations, in which the avatar turns to his sides if the depth and the speed of the two players' breathings are not (almost) synchronized.

We also added music to the different scenarios, strengthening the intended emotional experience.

The third version of EmRoll was tested with four pairs of users – only children (all male). Their age ranged between 8 and 15, and the game worked best with children between 8 and 12. Teenagers commented that the graphics looked a bit childish.

To find the solutions and solve the riddles each scene were supposed to take less than 5 minutes. While in third iteration even after adding narrations and sound, each scene took players around 10 minutes to be solved. We observed that kids from 8 to 12 could solve the riddles more quickly than kids from 12 to 15 or even adults. They mostly listened to the narrations rather than looking for logic behind each riddle. While the older kids or adults were the other way around.

Below we go through the main results from these three iterations.

RESULTS

Successes – situations when the affective loop works

Let us start by describing a situation in which the affective loop worked and how that relates to our use of full body interaction, playing together, and tight interaction loop with the avatar.

Excitement through full body interaction

The studies confirmed that the Happy Dance scene worked really well in terms of implementing an affective loop. Players got very excited by performing the gestures and seeing the effect on the sulky guy – who started smiling, dancing and finally happily opened the door. In particular, players seemed to start smiling when they involved not only arms and legs, but also moved their head and torso, rhythmically. Some even continued to dance after the door was opened in pure excitement, see Figure 8.

Figure 8 Players continued to dance in pure excitement even after the door was opened.

The interaction between the two players also seemed to be important to the experience of this scene. The two players imitated each other's behaviors. For example if one player started moving his head or jumping up and down, the other usually followed. Or in a negative way, if one player got tired of the interaction and stopped moving, the other one more or less did the same.

Relaxing through deep breathing – needs calibration

The Underwater scene often made players get back into a more relaxed state – even if they did not really go into a deep relaxation. Their breathing became synchronized with the animations of the belly of the avatar, the animation of the fish, as well as with each other's breathing – sometimes creating a sense of unity between the two players. In the interviews after the test, players repeatedly told us that found the breathing to be an interesting interaction with the game.

A problem though, was that some users, in particular small children, needed an adjusted threshold for the breathing rate in order to not become dizzy. As we had, at this point, inserted a Wizard (a human operator) [5] into the loop, we could sometime quickly adjust the threshold to fit with the child's breathing capacity. It was also important to place the breathing sensor at exactly the right location on the players' bodies. If placed too high up on the chest, it would pick up a more shallow breathing rhythm.

Playing in pairs

Playing in pairs was another appreciated feature of this game. It became easier to behave silly and dance around like crazy when doing it together with a friend. And this relationship probably contributed to moving players from faking an emotional reaction to actually experiencing it.

In Figure 9 (left), we see how two players look at each other and smile, confirming their joint experience of trying to breathe together. This confirms the result from Seif El-Nasr et al. [24], showing how cooperative play can be much appreciated. In our view, it becomes extra important if the game is trying to interact with a range of emotional responses – not only the typical dramatic curve of a game with rising and falling tension.

At one occasion, one player in the pair became too dominating, 'commanding' the other to perform actions or breathe. This killed the experience for the other player. Likewise, difference in height between the two players, or unwillingness to stand really close to one-another, was also a complicating factor, see Figure 9 (right). If the physical contact between them was low, it was less likely that they could coordinate their breathing and movements. In a future development of the game, we might want to create costumes that force players to be even closer to one-another.

Figure 9 Two players smiling at one-another, confirming their joint experience (left). Differences in size make it more difficult to experience the game together (right).

Identification with avatar

With the changes of the mapping from player behavior to avatar animations between version 2 to 3, the identification with the avatar became much stronger. This identification was highly important in creating an affective loop. When the feedback from the animations of the avatar were perfectly responsive to players' movements and breathing, they felt as "one" with their avatar, despite the fact that the avatar portrayed them as a double person.

Failures – killing the experience

While the successes of the Happy and Underwater scenes confirmed that we could get a good trajectory through the game, involving users in an affective loop experience, there were also some failures in the interaction that threw users out of the trajectory, and out of their affective loop experience. These failures are perhaps even more interesting to document as they help us form a design case knowledge-base that Benford and Giannachi asked for when setting up their agenda for studying trajectories [2].

Using GSR in the Scary scene

The Spider scene was not the same success as the Happy and Underwater scenes. The spider itself perhaps looked a bit too nice (see Figure 10 below) and even though we added some scary laughter to his behavior, he was still more amusing than scary.

What was more problematic with our spider scenario was the use of the GSR-sensor. Our initial idea was that if players did not get scared, as indicated by the GSR signal, the spider's erratic movements, its growth in size and scary laughter would continue. Only if the GSR showed some indication of arousal there would be less scary laughter and a decrease in size of spider. But GSR-sensors measure many different kinds of arousal: arousal resulting from bodily movement, excitement, fear and anger. It is known that fear is associated with a particular pattern in GSR-measurements – typically a very strong, short peak. But given the complexity of the situation, with breathing sensors, special clothes and the two players standing close, we could not determine whether the a rise in GSR came from energetic movements or emotional arousal.

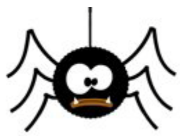

Figure 10 Not so scary spider

On top of that, GSR-measurements are hard to use as an input mechanism since users cannot voluntarily control their sweat glands, and perhaps not even sense them. While you can pretend to be happy by dancing or pretend to be relaxed by breathing deeply, you cannot pretend to be scared and thereby raise your sweat level in a peak-formed shape. In effect, the Spider scene became an uncontrollable part of the game, where the spider moved in, for the players, unpredictable movement patterns. This does not mean that GSR could never be used as part of game. But in the games we have looked at (e.g., The journey to Wild Divine) a different game genre is applied. While ours was intended to be a side-scroll, real time, adventure game, "The journey to Wild Divine" was designed to help players to get relaxed, and to feel less stressed. In that context, GSR-sensors might very well work much better.

Timing

First of all, when the timing of an overall experience is off, players easily fall out of their emotional experience. When, for example, it takes too long to open the door by excitedly jumping around, the experience dies and it stops being fun and exciting, see Figure 11 left.

Likewise, in the Underwater scene, if the breathing sensor threshold is not properly adjusted to the individual player, the player might have to breath too slow, which makes him/her dizzy.

These kinds of timing issues are good examples of both what prior research has said about timing in affective loops and the temporal trajectories discussed by Benford and Giannachi. While timings have been discussed in the design of affective loops, they mainly concern the tight, real-time, interaction between players and game [28]. Movement has to render response in exactly the right moment for exactly the right kind of length of time in order to create for a particular experience [28]. But the overall temporal trajectory of the whole game also needed fine-tuning. There has to be 'transportation' time between the different emotional experiences in the rollercoaster. Otherwise one experience will be spill into the next. After being exhilarated in the Happy Dance scene, jumping energetically up and down, it is hard to become scared in the Spider-scene. Some kind of interesting, but calming, transportation between the two riddles is needed to give room for the new experience.

Figure 11 Players got tired of jumping up and down and stopped moving while the door was still closed (left). One of the players felt really dizzy after breathing deeply for a long time (right).

The only way we could get the timings and thresholds right was by repeatedly testing EmRoll with players – and through putting a Wizard into the loop, controlling the threshold levels dynamically. This is similar to reports from others who have attempted to design for emotional involvement in games [12].

Failures of motion tracker

In order to 'see' the players we use colored object tracking together with ordinary Webcams. During our tests it turned out that the system sometimes lost track of the markers due to too fast movements, changes in lighting condition, or improper calibration. In most cases, an error detection mechanism using some experimental rules to detect invalid marker positions (e.g. detecting too fast movements or impossible body positions), fixed the problem. But in second and third versions of EmRoll to give more control, we set up a screen facing the two players so that they could see how the system was tracking their markers.

Yet revealing the interior workings to the players is of course not without risks. Players started to pay too much attention to this screen in order to make sure that their markers had not been lost.

Solutions

While some aspects of our set-up obliterated players' experience, we also found some solutions to how to, on the fly, adjust the game so that it would create for an interesting experience in the moment even when our implementation's timing was slightly off.

Solutions - Putting a Wizard into the loop

Others have made use of the so-called Wizard of Oz method as a means to bootstrap the functionality of a system during the design process [5]. This can be extra useful if the interaction requires exploring entirely new kind of functionality.

From the very beginning of this project, to recognize the level of intensity of each of expressed emotions and to provide players with proper feedbacks, we intended to track their facial expressions, bodily movements, vocal intonations, and the changes in their bio-data. However due to the limits on the budget dedicated to this project, and the time limit, we decided a human being plays the role of Wizard (a human operator, who mediates the interaction) in Wizard of Oz method for the recognition of facial expressions and vocal intonation among the mentioned list. However during the third user study iteration, we noticed that some players "cheated" the game and solved the riddles without really getting emotionally involved. This is similar to how you can fake interaction with a Wiimote, only moving the wrist of your hand rather than your whole body. To motivate them to express their emotions more intensely we added a Wizard to the system. The Wizard's responsibility during the game was to check players' facial expressions and body postures, and based on them to adjust the thresholds on the fly (1) for how fast players needed to breath to make the avatar come up to the surface in the Underwater scene (2) to change the difficulty level how much dancing was required in order to open the gates in the Happy scene. In effect, we added a dynamic difficulty balancing feature through this Wizard-interaction.

The Wizard interface was also used to compensate for motion detection failure by applying a simulator. The Wizard could watch players' movements and easily put in their hand, leg and body movements into the system if the motion detection was off. This way, we could more easily make sure that each pair had an interesting and less error-prone experience.

We used the Wizard involvement as a means to explore the design space, figuring out how to set thresholds and fix bugs in the system interaction. Our insights were then fed into our implementation process, altering aspects of the system. Others have made the Wizard a permanent part of the design [9], which is an interesting alternative solution.

CONCLUSION

Our EmRoll design process and iterative testing with users show how bodily expressions can be used to involve players in intense experiences with games. In particular, physical movement and breathing, helped start emotional processes that created for a stronger experience of the narrative in the game. The overall story in EmRoll was a simple, quite naïve story, and still, especially our younger players, got very involved. They mostly complained about how short the game was – they had wanted to play it longer. Some of the kids also asked for more adventures.

Based on our technical and design explorations together with our iterative user testing's, we learnt some lessons that may be useful to other game designers. In particular, we want to pick out four of the lessons learnt.

First, playing in pairs is an important aspect in the intensity and fun of the emotional experience. The two players influenced one-another, pulling each other into stronger experiences. In those pairs where there were inequalities, such as one player being physically bigger than the other, or one player dominating the activity, those experiences did not work out equally well.

Second, getting excited through intense movement when involving whole body worked well as did relaxing through deep breathing, but using GSR as an input mechanism to indicate fear worked less well. In parts, this may be explained by the design that lacked really scary spiders, but the problem also came from the indirect control that GSR offers. Players cannot control their autonomous reactions, and they might not even feel them. This means that they cannot create any proper mapping between what they do and what then happens in the game. In different genres of games, autonomous reactions may well work better, but here they failed.

Third, putting a Wizard into the loop can help bootstrap difficulty balancing and thereby increase emotional involvement even if the system is slightly off. This in turn makes it possible to perform user studies early on.

Fourth, to analyze our data and iteratively changing our design, we made use of Benford's and Giannachi's trajectory concept. The idea of temporal and narrative trajectories were perhaps most useful to us when it came to getting feedback on the overall story progressing in the game. Emotional experiences have their ebbs and flows, and the progression of the game in time and space has to smoothly mirror player behavior, while gently steering them through the process.

In our analysis, we also used the concept of aesthetic experience as discussed by Dewey. In particular, in the Spider scenario, we found Dewey's idea of emptying the material on all its potential quite useful. The scenario did not come anywhere near a scary experience until we added both music, a darker color scheme, as well more erratic, scary movements of the spiders.

In summary, our explorative research shows that we can put players in an emotional rollercoaster through carefully crafting the interaction between player movements and game design. It requires fine-tuning of the animations, the narrative, the difficulty level and the timing of events, but when it works, the experience is exhilarating.

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