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Final Project

"Understanding Engagement with Educational Handheld Games"

Introduction

Handheld computers (or personal digital assistants, PDAs) are becoming increasingly popular in education because of their low cost, flexibility, accessibility, wireless capability, portability, and ease of use (Klopfer, et al. 2003, Dede 2004). As a result, educators and researchers have been actively seeking creative ways to use handhelds in education (Dieterle 2004, **http://k12handhelds.com/101list**). A growing number of educational games and "playful learning" activities have been designed for handhelds; for example, MIT's Environmental Detectives (Klopfer, et al. 2003), Outbreak at MIT (2004), and Charles River City (2004). While there has been extensive research on computers and games in education (Papert 1980, Resnick 1996, Gee 2003), constructivist and playful learning technological activities (Resnick, et al. 1996, Resnick 2004), general video game and interface design (Laurel (1990), Salen and Zimmerman 2004), there has been less research on the design and efficacy of handheld games in education. Also, while there has been research on emotional response patterns of video game play and related design elements (Ravaja, et al. 2004), there has not been research specifically on handheld games. Moreover, most of the research on handheld games has been largely anecdotal (Squire, et al 2003). Also, it has focused on the users' overall enjoyment of the game and its general pedagogical value, rather than the users' physiological, mental, and emotional states during the handheld game experience.

Further, discussions in the Deep Engagement seminar have suggested that deep engagement with an activity, such as a game, can foster deeper learning and learning of more complex ideas. Moreover, discussions have also suggested a connection between social interaction, collaboration and deep engagement. Participating in an activity where you can learn from, teach, and share ideas with others helps foster deeper learning, as well as encourages deeper engagement with that activity (Papert 1994). Thus, engagement and learning may actually reciprocally promote each other. By understanding their relationship, we can harness and create deeper and more meaningful educational and life experiences.

In this paper, I specifically want to explore the use of handheld games in collaborative learning. Recent research has suggested that handhelds are uniquely positioned to support collaboration, particularly in educational activities (Cole and Stanton 2003, Danesh, et al. 2001). To do so, I seek to understand the users' engagement during a collaborative handheld game experience. I want to assess their physical, mental, and emotional state during game play, particularly with regard to learning and sharing of ideas and their interactions with other users. Further, I will use this to reflect on the relationship between a users' engagement with a handheld game and their learning of complex ideas.

In this study, I will observe and assess their level of participation of the user; their responses and interactions; and their perceived emotional/physical state. I will compare these results to that of a Bluetooth Galvactivator, an instrument that measures skin conductivity.

Thus, my goals are three-fold: a) I wish to better understand the relationship between deep engagement and learning; b) I wish to study engagement to understand how a handheld game can best support complex learning and c) I wish to evaluate whether the Bluetooth Galvactivator is an appropriate tool to measure engagement in a handheld game experience.

The Galvactivator

The Bluetooth Galvactivator was developed in Rosalind Picard's Affective Computing Laboratory at MIT. It is based on the Galvactivator, a "glove that senses and communicates skin conductivity," also developed in Picard's laboratory. According to Picard and Scheirer, skin conductivity response measures whether a stimuli is "physiologically arousing" and thus, an indicator of "emotional activation" (2000). Studies, cited by Picard, indicate that arousal is also implicated as a “predictor of two important aspects of cognition: attention and memory” (Reeves and Nass, 1996). Attention, according to Czsentmihalyi, is integral to achieving “flow” or immersion in an experience (1990).

Since arousal, enhanced emotional states, attention, and cognitive activity may all be indicators of a person’s engagement in an activity, the Galvactivator may provide some insight into the aspects of a game that are more engaging.

The Galvactivator does not indicate exact measures of arousal; rather, it suggests changes in levels of arousal. This is how I will use it in this study.

Methodology

To examine the engagement of the user in a handheld game experience, I used four different educational games developed by Eric Klopfer’s research group in the Teacher Education Program at MIT. In this study, I use four short, iterative, collaborative handheld games that are not location-dependent and are designed to be used anywhere, including a classroom. The four games (Tit-for-Tat, Debate, Sugar and Spice, Genes; see brief descriptions below), at least in theory, were designed to support a variety of educational content; however, in this paper I am assessing whether they were actually educational or whether they taught specific concepts. Rather, I studied the users’ physiological, emotional, and mental states over the duration of the handheld games. Specifically, I looked at the following:

a) The users’ verbal and physical participation in the game, including the content of their interactions. What types of concepts were they expressing? Were they problem-solving? Were they working in a group? One-on-one? By themselves? Were they offering opinions? Who were they talking to? What were they doing with the handheld? These measures were observed in-person and later, via videotape.
b) The users’ perceived emotional and mental state and attention. I observed their facial expression; where they were looking; whether their body language or movements indicated that they were speaking, listening, or thinking. These measures were observed in-person and later, via videotape. User feedback on the experience after the game gave further illustration to my observations and measurements.
c) The users’ skin conductivity, as measured by the Bluetooth Galvactivator. The Bluetooth Galvactivator apparatus was connected to the users’ wrist and measured skin conductivity from the users’ palm. The apparatus took readings of skin conductivity approximately 7-12 times per second and sent them wirelessly to my laptop computer.

In my analysis of the data, since each participant had different baselines and different variance levels throughout the game, I tried to focus on places where there were changes in skin conductivity levels, with consideration to the users’ variance. I looked at sharp peaks and valleys, as well as times when the conductivity levels were more stable.

Also, because there is so much rich data in this experiment, I chose to highlight four snapshots of the data (one from each game) to illustrate and focus my analysis.

Participants

The participants in this study were three graduate students who were invited to play a variety of handheld games in a group setting. There were seven different students playing these games at different times; however, only three were tested with the Bluetooth Galvactivator and videotaped. None of the students who were tested had even played these games before. They were each at least a little familiar with handheld technology.

I tested three different users (designated as Alexis, Betty, and Chris) across four different games. I tested Betty across two different games. Alexis was tested during Tit-for-Tat; Betty for Debate and Sugar and Spice; and Chris for Genes. I began the Galvactivator measurements and qualitative measures of the users during the entire duration of the games: preliminary instructions, actual game play, and then post-game discussion.

Game #1: Tit for Tat

In this handheld version of "the prisoner's dilemma," the participants need to "meet" every other participant three times in a row (meeting involves synching up their handhelds). Each time before a participant meets the others, s/he needs to choose whether s/he will cooperate or defect. If both participants cooperate, they get three points; if they both defect, they get one point; if they defect and the other person cooperates, they get six points. In this game, the participants tried to get as many points as they could, and to test out different strategies. Since participants need to meet the others each three times, they have to choose wisely.

Thus, there are three components to this game: a) choosing whether to cooperate or defect in each "meet"; b) actually "meeting"; and c) discovering how many points you earned after each "meet."

Results and Analysis of Game #1

I tested and observed Alexis over the course of "Tit for Tat." Figure 1 shows the skin conductivity readings over the entire 22 minutes of the experience. The instructions and preparations lasted for the first 7 minutes. During this time, except for the very beginning when she first received the handheld and typed in her name, Alexis had the lowest skin conductivity readings over the entire game experience. She also appeared bored, did not speak to the other participants, and was not physically active. Instead, she quietly looked down at the handheld (which was not providing any new information) and not at other people, or passively listened to the instructions. At least superficially, these results seem to indicate that my observations of her external state (boredom, restlessness), and the activity level of the task (low-level, passive), correspond to relatively low skin conductivity levels. (See Video Clip of Game 1: Lower Conductivity Levels).

When I adjusted her Galvactivator, her skin conductivity sharply increased. Also, once the game started, however, her skin conductivity levels rose to above 4500, almost triple what they were during the instructions (1500-2,000). During the actual game play, in general, Alexis's readings higher than in either the instruction or discussion phase. There was also greater variability during this time, often going up or down by 1,000 to 2,000 over a minute. During the discussion period, Alexis's readings were consistently in the 2,500-3,500 range. Concurrently, she was actively speaking to other participants, listening to others, thinking about the game, and offering opinions on how it could be used in a classroom. She was looking at other participants and not the handheld. From these readings, it seems that Alexis was more engaged during the discussion period, rather than the instructional phase, because she was an active participant, invited to express her opinions, and involved in dialogue with other participants.

Figure 1-A is a more detailed snapshot of Figure 1, as indicated by the square in Figure 1. When the leader says that the game has begun, she immediately seems happy and excited, as suggested by her laugh and physical movement. Concomitantly, her skin conductivity reading increases to just under 4,500 from 2,500. The level decreases slightly, however as she patiently waits for her turn to "meet" someone. Her highest level comes after the others experience some difficulty and she offers a solution. Alexis reaches 4,500 just as the entire group reaches consensus on the problem and how to solve it. At this moment, she is talking to others, has increased energy, seems happy, enthusiastic, and motivated, and appears involved in mentally solving the problem, as well as sharing the solution with others. Following this "aha" moment, her skin conductivity decreases again as she passively receives some more instructions. Each time she "meets" someone, her skin conductivity levels increase by at least 1,000. During each meet, she physically moves to the person, smiles, has an expectation of a result, and looks at her handheld for the result.

Interestingly, when Alexis first meet this other participant, she increases to ~3,400 when she discovers that they both are cooperating. She peaks even higher, to almost 4,000, when she sees that they both have defected; laughter follows this. Then, in the final meeting, she increases to the highest level, ~4,700, when she discovers that she has defected, but he has cooperated (thereby winning the maximum number of points). It seems that her surprise and excitement at winning points, and her increased emotional response due to her "win," may correspond to her higher levels of skin conductivity. Skin conductivity may not just be measuring engagement, but other factors that could be related to engagement (but not fully reflect engagement), such as excitement, stress, anxiety, satisfaction, and humiliation. (See Video Clip of Game 1: Higher Conductivity Levels).

Overall, the skin conductivity measurements, combined with the observations of Alexis's activity and perceived emotional/mental state seem to suggest that she is more engaged in the actual game play than during the other phases (instruction, discussion) of the game experience. In particular, interactions with other participants (whether verbal or by using the handheld), seem to enhance Alexis's physiological responses (skin conductivity), attention, and verbal and facial expressions of emotion. Also, novel information, such as when she discovers whether a person defected or cooperated, combines with interpersonal interactions to increase signs of engagement.

Game #2: Debate

In "Debate," two participants need to type a statement into their handhelds and then choose how much they agree or disagree with the statement. Then, each person has to explain his/her side and try to convince the other person to change their opinion. Then, after they each tell their side, they need to each input their new opinion.

Results and Analysis of Game #2

I tested and observed Betty over the course of this game. She debated two topics with a partner: the first was "That rocks are better building blocks than Legos," (topic 1) and that "Harry Potter can be seen as good literature" (topic 2, chosen by Betty) The first 10 minutes of the trial had very low skin conductivity levels (below 2,000). During this time, Betty was passively waiting for the game to begin, listening to the instructions, and not speaking to anyone. As shown in Figure 2, her skin conductivity levels suddenly began to increase at 10 1/2 minutes, about the same time as she was began thinking of the question to type into the handheld, and then increases more when she actually types it in. She appeared to be actively thinking and creating a topic, and filled with anticipation as she actually types it in. Over the next 10 minutes, she is waiting for the debate to begin and listens to more instructions; her skin conductivity levels remain around 3,000, except for a few mini peaks where she and some other participants retype in the topics. Again, like Alexis, the skin conductivity levels and observations of Betty suggest that she is less engaged during the instruction phase of the game, and while waiting for it to begin. As soon as she is required to perform creative thinking, such as coming up with a topic, however, she becomes more engaged.

The next large peak (8,500), at twenty minutes, comes right after I adjust her Galvactivator, and right before the game is about to start. As the game begins, Betty's skin conductivity levels remain high, particularly when she makes the first decision to agree or not agree to the first topic (her partner's topic, so it is novel). She quietly looks at the handheld, intent on thinking about whether she agrees, and then makes her decision. As Betty's partner argues her side of the statement, and Betty quietly listens, Betty's skin conductivity decreases to about 4,300, but not as low as it was in the beginning. During this time Betty looks at her partner, but does not speak. Just before Betty speaks, at about 24 minutes, she nods and her skin conductivity levels begin to rise again. As she speaks, her levels steadily rise.

This pattern continues throughout the debate over topic 1. Betty's skin conductivity levels increase even more drastically when they laugh and input their new choices about how much they agree or disagree with the statement.

Betty's levels rise to a high peak (9,000) when they go the next topic—the one that she had composed. It is possibly higher because she has higher anticipation about the topic—both more investment in the topic and her partner's response to it. This seems to make sense: if Betty is already more engaged with a topic, because of personal, emotional, and/or intellectual reasons, she will exhibit deeper engagement than with a different topic.

Again, when Betty is speaking, as opposed to her partner, her skin conductivity levels are generally higher. Overall, however, Betty's skin conductivity levels are consistently higher than for topic 1. During topic 2, Betty appears more enthusiastic while she is speaking, and more actively listening to her partner. There is more of a back-and-forth of ideas and experiences.

Betty shares more personal information, as well as past academic experiences. She often stops and tries to think about names of characters or terms in philosophy to support her point.

The difference in skin conductivity levels between topic 1 and topic 2, thus, could relate to Betty's level of personal interest and passion in the question that she chose to discuss. The topic sparks more memories, and invites her to think about, and then share, her experience, background, ideas about the topic. Even when her partner is talking, Betty is more actively listening. Not surprisingly, she talks more during this topic, and interrupts her partner more frequently. Her skin conductivity levels do not decrease as much when her partner is talking, because she is either anticipating talking again, or emotionally and intellectually moved by her partner's ideas. This has important implications for a game experience. By sparking familiar concepts and personally-meaningful stories that a user can share, it becomes a much more deeply engaging experience.

Finally, after the game ends, there is a steady decrease in skin conductivity levels as Betty waits for the others to finish, followed by an extremely sharp peak (almost 13,000). This occurs when Betty offers her opinion on the game to the entire group of participants. Before then she had been quietly listening to others; at this moment she appears very alert. Her skin conductivity levels increase again (10,000) while she offers a couple secondary comments once others react (positively) to her primary statement. This is seen more clearly in the detailed Figure 2-A (as indicated by the box in Figure 2). Once the group reacts positively to Betty's statement, her levels do not increase as much during her follow-up statement. She already feels comfortable sharing her ideas. Again, while anxiety or sudden changes in physical activity, such as that caused by offering one's opinion in a group, could be related to deep engagement, it is not the only way of describing engagement. Factors like stress and anxiety might be confounding the Galvactivator's role as a sole measure of deep engagement. This is further complicated by factors like comfort and ease, which could also be related to deep immersion and engagement. These results suggest that it may be important to only use the Galvactivator in tandem with other instruments to gauge engagement.

Game #3: Sugar and Spice

In "Sugar and Spice," participants are either spice producers (and sugar consumers) or sugar producers (and spice consumers). They need to buy or sell sugar and spice to the other participants to remain "alive" (i.e., the participant "dies" when s/he runs out of sugar or spice). On the handheld, the participants can watch their sugar and spice levels rise and decrease over time. To "trade" with other participants, they need to sync their handheld to another's handheld.

Results and Analysis of Game #3

I also tested and observed Betty in "Sugar and Spice." As seen in Figure 3, her skin conductivity levels were lower during the short instruction phase of the game (~3,000). As Figure 3-A suggests, as the game began, and she began to solve problems, and interact with other people and with the handheld, her levels began to increase. First, she figures out whether she is offering sugar or spice, whom to trade with for the spice she needs, and then how to conduct a "trade." At first, as her spice levels decrease, and she starts to exhibit more anxiety, but also enthusiasm, physical movement, and interactions with others and the handheld, her skin conductivity levels increase (over 12,000). As her spice levels become dangerously low, though, she still has higher levels of skin conductivity, but not as high as earlier (slightly above 11,000). She seems less happy, and more disappointed, frustrated, and helpless, but still actively talking to others, when she realizes her game has ended (11,000). Afterward, her skin conductivity levels steadily drop. When she is out of the game, and has to wait for others to finish the game, she appears bored and restless, and does not talk to anyone. Her levels are consistently low, until she begins a new game.

As seen in Figure 3, during the second game, she exhibits a similar pattern of skin conductivity. As the game begins, and she starts to interact with other people, her levels steadily increase. The conductivity levels peak (~11,000) when her spice levels are dramatically low and she is able to get spice from another participant. As the game goes on, and she continues to "trade" with others, her levels of conductivity decrease. Although she is still interacting with people, it is at a slower pace, and she waits a while between turns. Also, the content of the game starts to become repetitive—there is less novelty of activity. It could also be, however, that she becomes more comfortable with the game, suggesting again that the Galvactivator may not be the only measure of deep engagement, especially after an individual has been doing the same activity over a period of time. It is difficult to parse whether she is actually less engaged, or whether she is just more comfortable. In Czsentmihayli's concept of flow, for example, "sense of time is altered, and sense of self is lost," (Brown and Cairns 2004), so physiological measurements may in fact drop in total engagement. On the other hand, deep engagement, and concomitantly, attention, may instead require a variety of activities and increasing challenges, which would instead pull you out of this state of flow.

Thus, when there is a sudden variety of activity, created by the participants and their collective dropping spice levels, Betty's skin conductivity levels increase again (to above 12,000). At this moment, she is also cheering and much more verbally expressive. Interactions with other participants seem to have raised her engagement in the game, as indicated by the quantitative and qualitative measures of skin conductivity levels, verbal statements, and her perceived emotional state.

Finally, Betty's levels decrease dramatically to ~3,000 after her game ends and she begins answering a survey while the others finish the game. During the post-game discussion, when making an observation or answering questions, her skin conductivity only increases to about 6,000. Otherwise, it stays relatively low. This suggests that even though she is interacting with people, the handheld game is arousing her physiological state even more, perhaps because it is heightening her interactions with people. Instead of merely sharing ideas with others, she is depending on them for the outcome of her game. The stress of the game—the perceived fear that she is going to "die"—may also be causing the higher skin conductivity levels during the game. Since the game has an element of stress and anxiety, it is difficult again to tell whether the Galvactivator is measuring stress levels or emotional states, or level of engagement in the activity.

Game #4: Genes

Genes is a group problem-solving game, where each participant begins with a person, as represented by three pairs of DNA, each strand of which could be dark, patterned, or light. As time progresses, the person ages, and can possibly die. The object of the game is to keep "mating" with others before your person dies, and to figure out what each of the pairs of DNA means. The participants "mate" with other participants by synching their handhelds together. If the two can "mate," then each handheld will generate an offspring with a brand new set of three genes. The participants work together to solve problems and create tactics to understand what each of the DNA pairs mean.

Results and Analysis of Game #4

I tested and observed Chris in the Genes game. As seen in Figure 4, Chris was relatively low (below 5,000) in terms of skin conductivity before the game started. He was sitting, passively, waiting for the game to start and not talking to anyone. In Figure 4-A, the detail of Figure 4 as indicated by the box, Chris's skin conductivity levels dramatically increase when he prepares to start and then told to start the game (to around 15,000). As he plays the game, and interacts with other participants, he stays consistently around 15,000. During the game, he is standing up, moving around, looking at his handheld's information, "mating" with other participants, and then receiving information following the mating. There is a lot of back-and-forth dialogue in terms of ideas, tactics, and observations among the participants. Also, there is a lot of physical interaction, since the matings, and subsequent investigations of the results of the mating on the handheld are constantly happening. Also, the participant's games are often ending (because their virtual people die before they can "mate," so they need to continually restart the game and figure out why they just died. The game is also fast-paced, because there is a constant age increasing. Thus, while there are little changes in skin conductivity during the duration of the game, the levels are consistently high in Chris.

In fact, the highest peaks during this game occur because of social interactions and verbal and facial expressions of happiness and enthusiasm. For example, at one point, someone makes a joke that we are "all mating in here." During that moment, at about 22 minutes in, Chris laughs, and his skin conductivity levels increase to above 20,000. The other times are when he is problem solving with other participants—going through possibilities for the genes, offers data to support his ideas, and trying to come up with ways to test out his hypotheses (e.g., above 20,000 at 28 minutes and 22,000 at 34 minutes). Thus, though there is a lot of constant activity, novel data, and social interaction in this game, which may relate to the consistently high skin conductivity levels. Furthermore, the highest levels of skin conductivity do not necessarily just occur during higher stress or emotional moments, but also when those moments occur during interactions with other people and when actively conducting higher level reasoning and problem-solving.

Conclusions and Next Steps

The data suggest that there is a strong relationship between my observations of users' mental and emotional state, physical activity, and skin conductivity levels, as measured by the Galvactivator. In general, during periods of passive activity, boredom, and waiting, skin conductivity levels were relatively low. At the start of a game, and during different novel moments of a game, skin conductivity levels peaked. Levels also increased when there was more mental activity, social contact, physical activity, or a more intense focus on mental processing (e.g., creating a question). Interestingly, though, even when there was similar activity, the results suggested that when there was a perceived negative or positive consequence, due to gameplay, the skin conductivity readings increased even higher.

Game activity and information (e.g., mental processing, problem-solving, typing, scores), along with the stress and anxiety regarding a game outcome, and interactions with other participants, seemed to work together to increase skin conductivity levels. These, however, were not the only instances that levels peaked. Higher emotional states caused not just by the game, but by other circumstances, such as talking to a group, or laughing at a joke, were related to social interactions. Also, high level problem-solving and the sharing of ideas and experiences with other participants seemed to work in tandem with elevated emotional states to further increase skin conductivity levels. It is difficult to parse out whether it was the game play or game information, or the social interactions of the game, that related to having higher skin conductivity levels, and possibly, a more deeply engaging experience. The handheld-supported gameplay and social interaction literally went hand-in-hand.

Thus, it was difficult to understand whether it was collaborations or one-on-one interactions, or the acquisition of novel information, or the combination of them (e.g., teaching or learning concepts from others), that was increasing the measured engagement in the game. Moreover, as Picard explains "many different kinds of events can elevate skin conductivity…it is impossible for an outsider to tell what made your [skin conductivity increase] unless several potentially confounding factors are controlled" (2000). Future research will need to examine how to control such factors in a game environment.

Furthermore, lower skin conductivity levels may be explained by a participant feeling more comfortable and relaxed, not a lack of engagement. Such a state--closer, perhaps, to the flow state--as well as more repetition than what would be in a game, may be integral for the type of reflection on and internalization of new ideas that is an essential component of deeper learning. Deep engagement in an ideal game (as opposed to an ideal educational experience) may require a different type of balance between challenge and mastery, and familiarity and novelty. Thus, the relationship between changing arousal states and learning needs to be studied further.

The evidence suggests that Galvactivator's readings should not be used as the only measurement of deep engagement, but as one, compelling indicator. Although skin conductivity and the other measures are not each, on their own, ideal measures of engagement, my analysis of their interrelations provided insight into the most engaging features of the games. My results suggest, however, that the following aspects of the handheld games were related to higher skin conductivity levels, increased perceived mental activity, and/or enhanced expression of emotion. These elements, thus, may be related to overall deep engagement in a game and the learning of new information.

Games should support:

1. Collaborations and multiple, diverse interactions with people
2. A personally-meaningful topic; or activities that support sharing of topics that are already of interest
3. Storytelling or sharing of ideas with others
4. Fast-pace or increased interactions between people and with the handheld
5. The discovery of new information at an appropriate pace
6. Complex problem-solving tasks, particularly with others; and, especially, finding solutions to a problem
7. Perceived consequences; fear of an outcome or possibility of “losing”
8. Expression of personal opinions and critiques to a group or person
9. Activities that encourage the user to generate hypotheses
10. Active dialogue among participants vs. passive diatribes from one person
11. Learning by doing, rather than from spoken or written instructions
12. Everyone has a role—no one can completely die out and then have to leave the game
13. Clear, established goal
14. Perceived and appropriate level of competition

More research should be conducted to further examine the relationship between the Galvactivator, emotional states, and deep engagement. Concomitant to this, there needs to be more research on the interaction of emotion with cognitive function. Future research should be conducted on handheld games that non-collaborative, to further explore the question of the relationship between social interactions and engagement. Also, location-specific handheld games, which turn typical environments into virtual game boards, should be studied. It is important to also look at how physical information (e.g., interacting with a monument), as compared to virtual information (e.g., interacting with a handheld to get information about the monument), affects an individual’s engagement in a game experience and their learning of new concepts. Moreover, it would be beneficial to compare this Galvactivator research to measurements and observations of participants playing the same types of games without handhelds (e.g., playing tit-for-tat against the computer, or playing the prisoner's dilemma game without handhelds), to further understand how handhelds, specifically, can enhance deep engagement of a learning experience. Finally, another research question to consider is the relationship among "appeal" or "fun," skin conductivity levels, and deep engagement. Participant self-reported enjoyment, as revealed in the post-game discussions, seemed to be generally highest for the Genes game. The skin conductivity levels were consistently the highest during this gameplay. It supported constant social interaction, collaborative exercises, multiple iterations of the game, and higher level problem solving skills. I did not, however, test each participant across all of the games, so it is difficult to compare on the basis of the specific skin conductivity readings. More research would need to be conducted to look at a series of games for each participant, and to compare the readings to their reported and observed enjoyment of a game.

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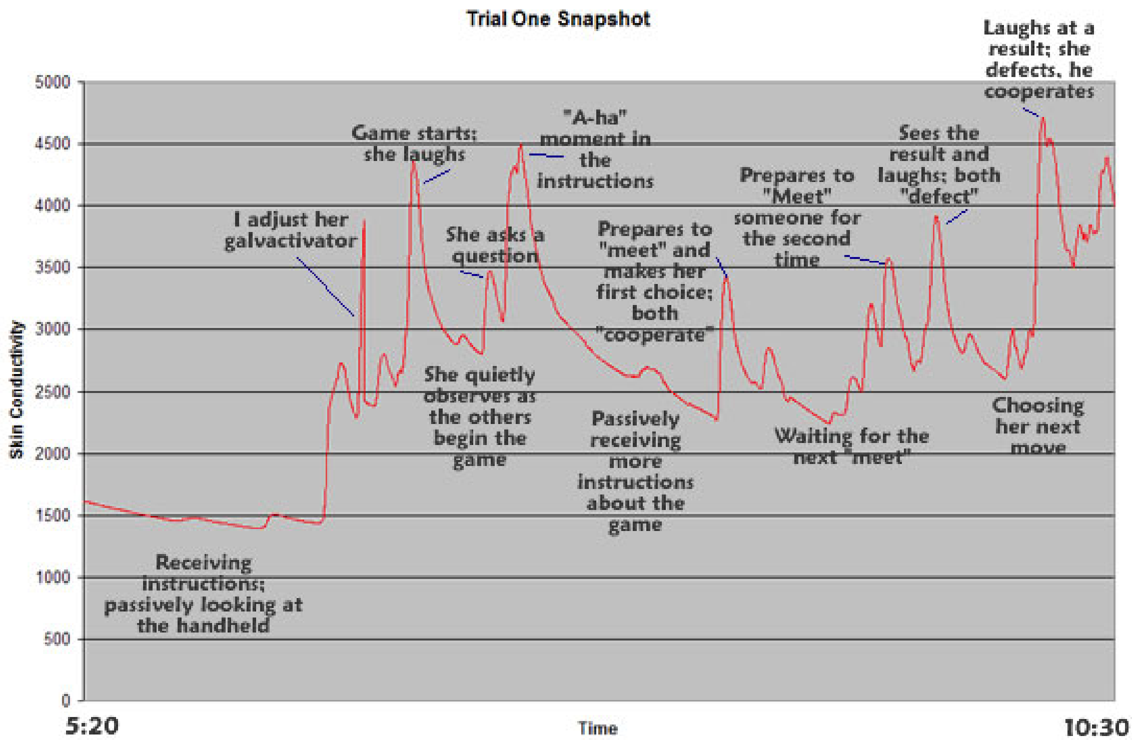
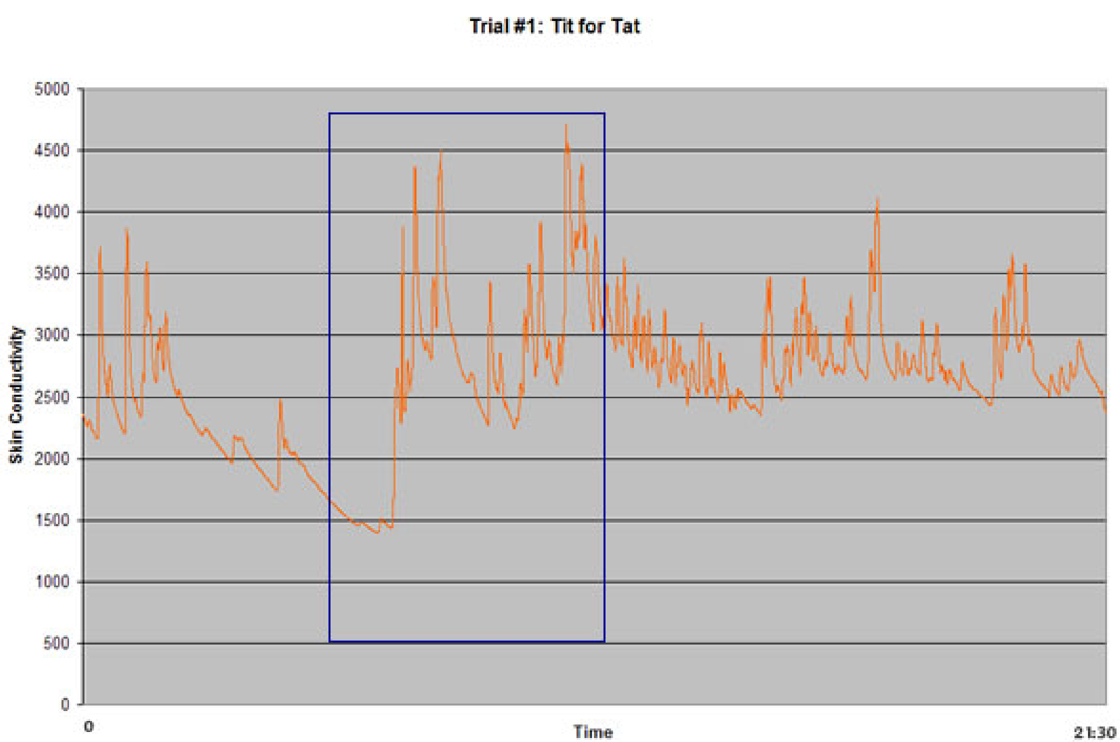
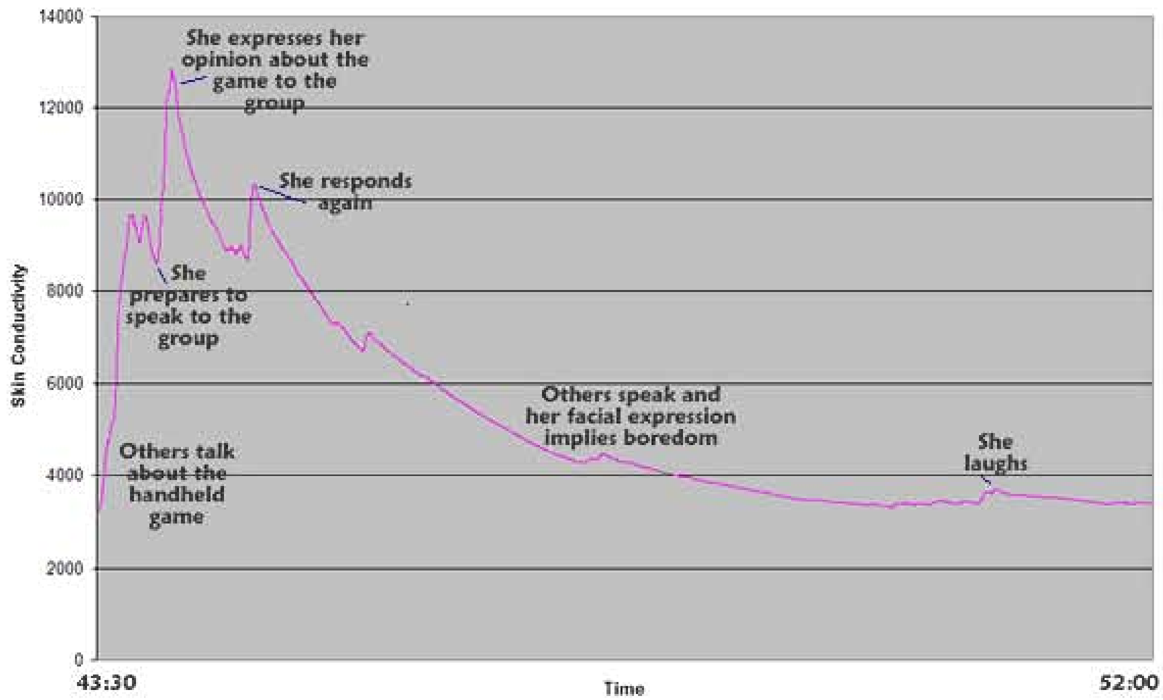
Appendix A: Data

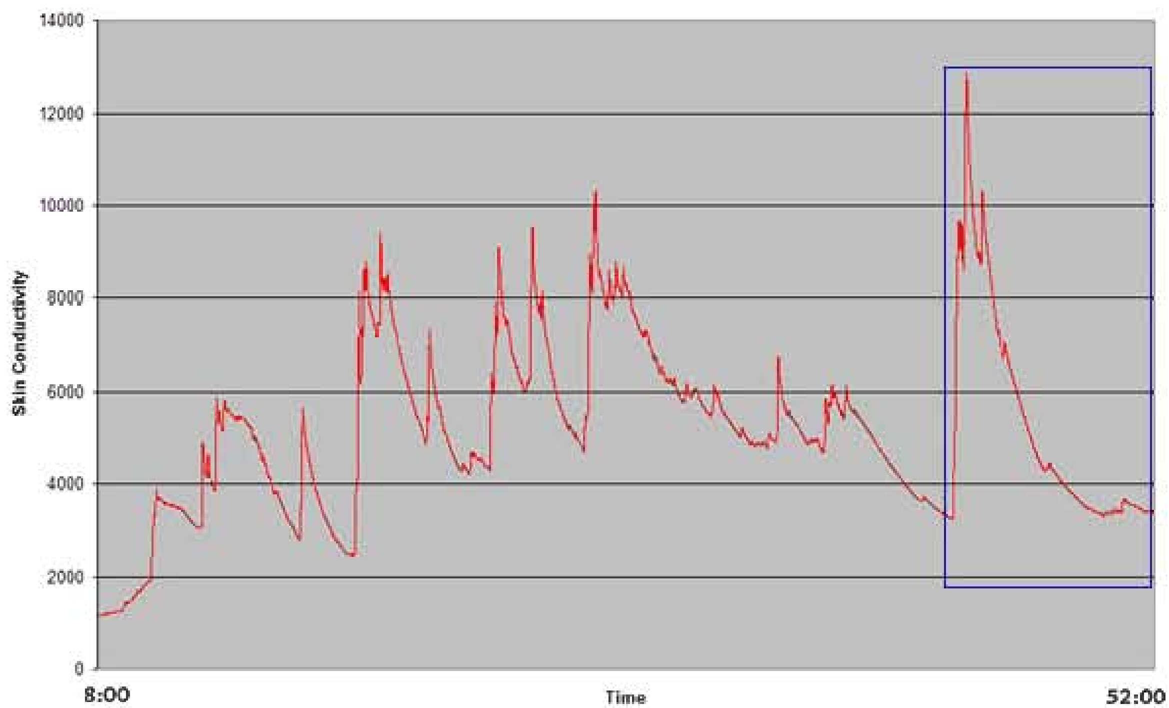




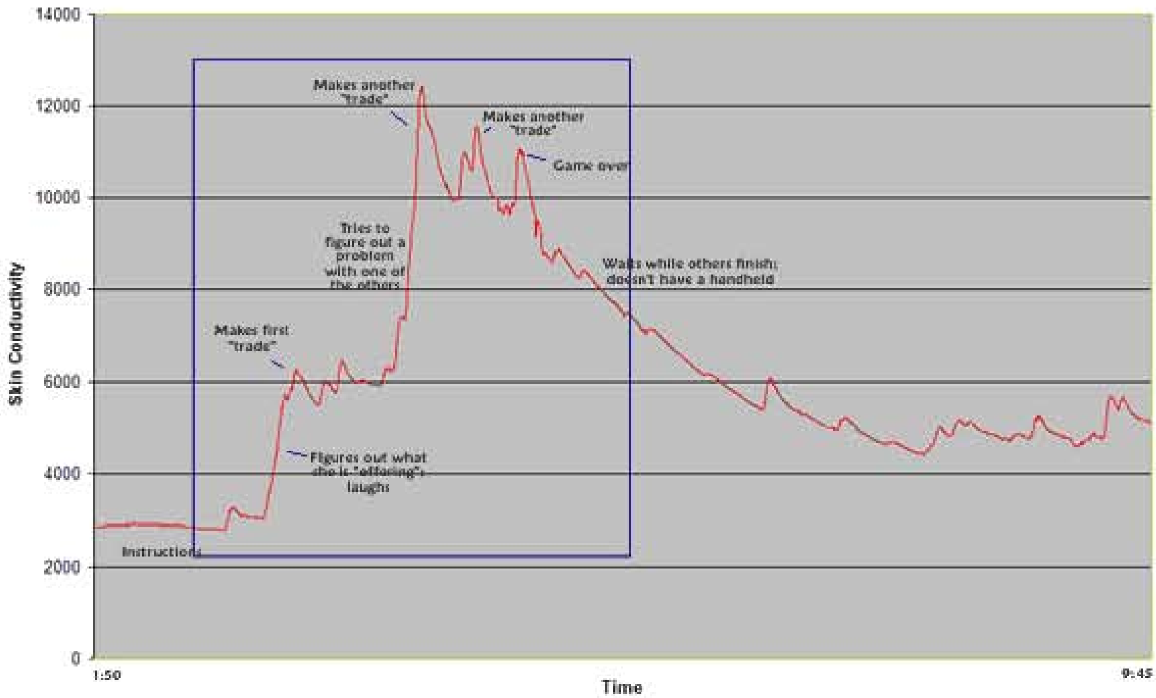
Trial Two Snapshot



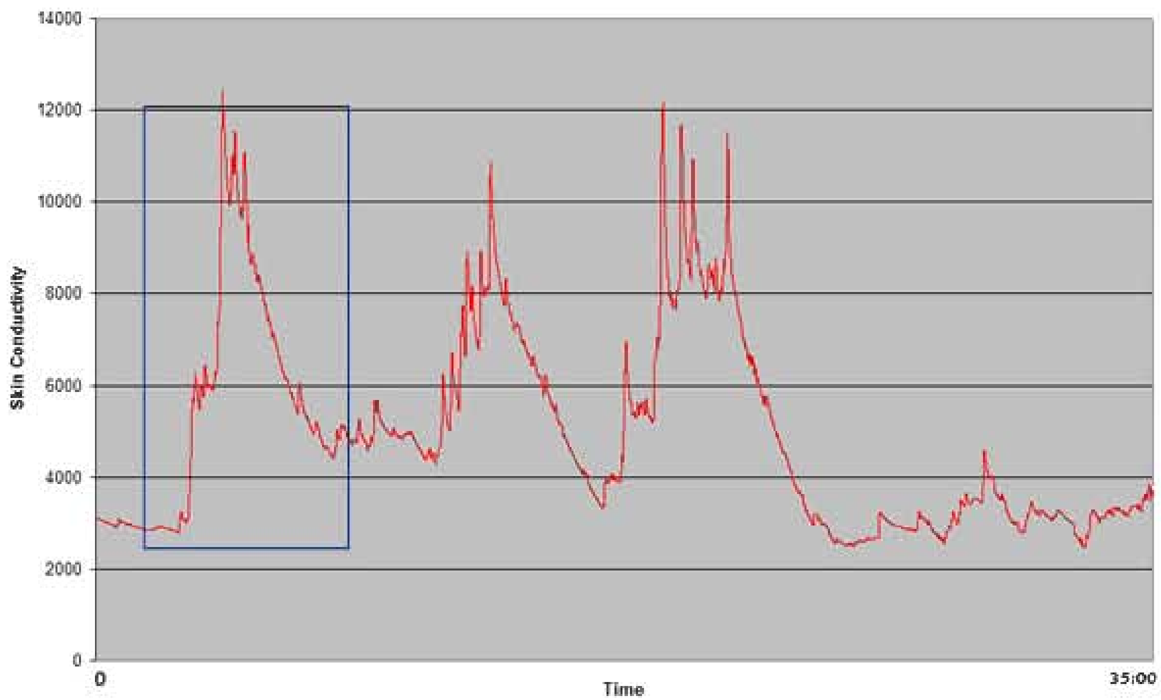
Trial Two (Debate)



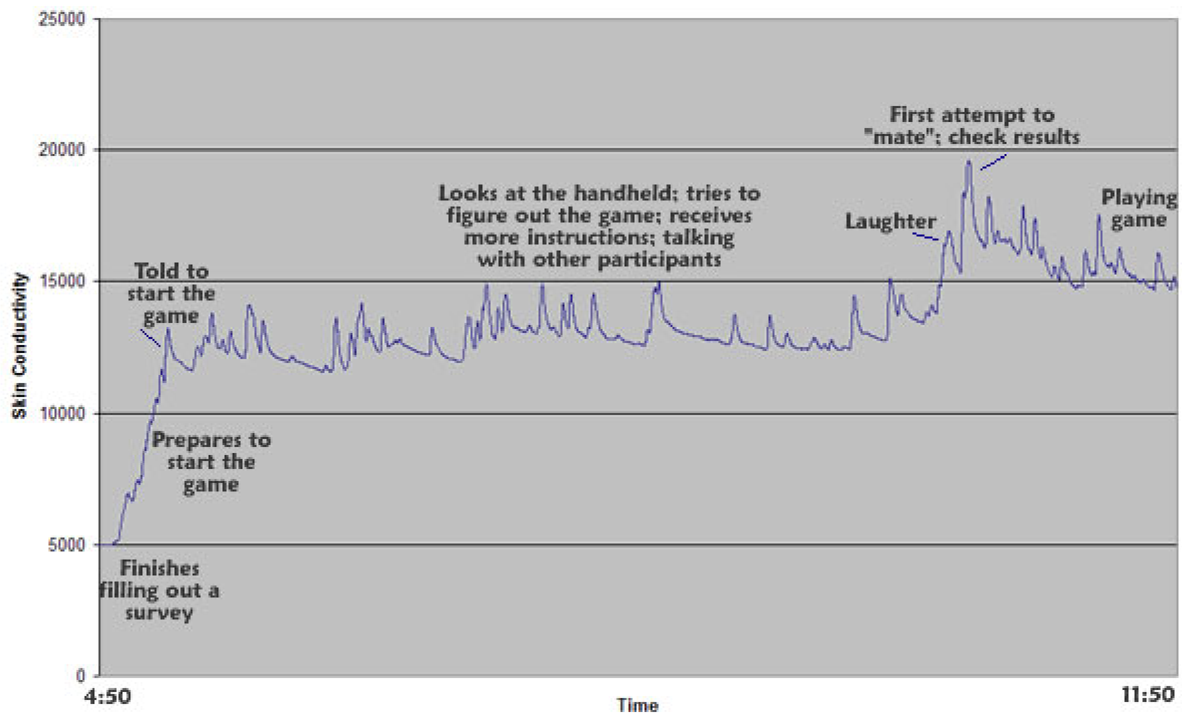
Trial #3 Snapshot



Trial #3: Sugar and Spice



Trial Four (Snapshot)



Trial Four: Genes