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Research + design: the making of Brainball

Sara Ilstedt Hjelm

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The Interactive Institute was founded in 1998 and performs research within art, design, and interactive media. One important part of this "new" research approach was its inclusion of multi-disciplinary teams that would create objects to communicate the research and subsequently develop a marketable product.

Brainball was one of the first large projects to be completed at the Interactive Institute and the one that has received the most media attention. It embodies the guiding ideas of the institute as something new, multidisciplinary, fun, and technically pioneering. As a result, it became an icon for the "new" research performed at the institute.

Brainball is an ambiguous object. It dwells in the realm between art and research, entertainment and science, method and object. It has received honorary mention at Ars Electronica 2000 and was ranked the seventh most interesting attraction at the World Exhibition in Hanover. It was shown twice at BBC's "Tomorrow's World" as well as on 100 other televised and live occasions. Brainball has been played by more than 300,000 people, including yoga gurus, artist/musician Brian Eno, children with attention-deficit disorders, and the king and prime minister of Sweden. Dutch journalist Robert van Weperen called Brainball "the best invention since Internet." A few months ago a company was formed to produce Brainball games for an estimated worldwide market of 74 million households. (This reveals more about marketing plans than about Brainball.)

Brainball can best be described as an anti-game. In most games success is achieved as a result of activity, decision-making, and physical coordination. In Brainball none of these capabilities counts. Here the goal of the players is to achieve—nothing. This was echoed in the cult nerd Web site Slashdot.org, which enthusiastically described Brainball as "a slacker's game if I ever saw one."

Unlike ordinary games, Brainball uses something that is invisible—the electrical activity of the brain—and transmits it to a ball moving on a table. You cannot use common game abilities such as concentration or winning instinct, to achieve your goal. As BBC reporter Peter Snow commented, "What makes this game so very different is that all the old skills, like tactical thinking and hand-eye coordination, count for nothing." But Brainball is also very unusual for an information technology-based gaming device. Unlike other games, it is devoid of sounds, blinking lights, action, and sensual stimuli. The emptiness of Brainball makes it open to interpretation and reflections on what it is and how to use it. It has come to embody issues about stress and burnout and the complex task in contemporary life of having to be able to simultaneously relax and compete.

Relaxation is Key

Brainball consists of a headband with electrodes that reads a player's brain activity using an electroencephalogram (EEG). Two players sit opposite each other at a table, each wearing a headband. In the middle of the table from one short end to the other is a clear plastic surface with a small steel ball rolling on top of it. When either of the players presses the Start button, the ball rolls away from the person who is most relaxed and toward the other player; the only way for the other player to defend is to become more relaxed. When the ball reaches one end the game is over. Next to the table is a display of the players' brain activity and the current state of the game. The display gives the players feedback on their brain activity and allows the audience to follow the game and watch the players' EEG levels.

The task of relaxing very quickly in a competitive situation is regarded as difficult but fun.

Despite its tranquility, Brainball is a very public game. It always attracts large groups of people watching the game and following the brain activity of the players. The task of relaxing very quickly in a competitive situation is regarded as difficult but fun. As one devoted player remarked, "You must not be afraid to lose! That's the trick!"

We have noticed that people trained in relaxation techniques and meditation are superior at playing Brainball. On one television program two yoga masters competed and the ball did not move at all. Conversely, giggling, fidgeting, and changing position makes you a hopeless loser. People that have suffered from burnout or nervous exhaustion have difficulty relaxing but are fascinated by the possibility of seeing their own brain activity.

Humble Beginnings

Brainball began as a workshop in the Smart Studio at the Interactive Institute. The institute had been set up only six months earlier with the Smart Studio as one of four research groups (currently there are 12 studios). Smart Studio was then a group of eight people with backgrounds in visual arts, product design, engineering, and computer science who were searching for relevant research questions and working methods. One of the important visions for the institute was to have multidisciplinary teams producing new and exciting research. The goal of the workshop was therefore to do something where everybody in the studio could take part and contribute equally.

The workshop was led by one member who had worked with creativity methods. We started with a brainstorm session at which we came up with different ideas or areas we could develop. Themes such as awareness, emotional communication, physical interfaces, light, office parties (the artist's contribution), and biosensors emerged.

We then screened these ideas to identify practical limitations such as time, technology, cost, or interest. Finally we had a voting system in which each of us had five balls that we were to distribute in plastic mugs, one for each suggestion. Two of the group members put all their balls in the biosensors mug (which was not considered fair play by the others). As a result,biosensors won.

The next step was to decide what we could do with biosensors of which none of us had previous knowledge. The two designers who thought of the idea had only vague suggestions, obviously influenced by science-fiction movies, of products that were like pets and that you wore like an extension of the body. The computer scientist of our group knew about Ross Picard, a computer scientist at the Massachusetts Institute of Technology who had done work with biosensors. Biosensors could measure physical data from breathing, pulse, temperature, and conductance.

On the basis of this knowledge we decided to create a game in which players competed in relaxation. Here, the key elements to Brainball began to appear: the biosensors, the game, and the central motivation for the game.

A month later we held a one-week workshop in which the prototype for the game was built using a borrowed set of biosensors, including an EEG and an old plotter that would move the ball using data from the EEG. During the workshop weexperimented with the EEG and different biofeedback, suchas sound and became aware of its inherent attraction.

We discussed how we would present it and how to play it, but in the end we did not have time to develop it. By the end of the week we had an open house and a small party where we showed our work to colleagues and guests. Only five minutes before the guests arrived, Brainball actually worked and we were able to try it ourselves. Brainball became an immediate success at the party. Lots of people gathered around the table and watched this rather slow game with enthusiasm and fascination. We were amazed ourselves at how public and fun the game was and how well the game concept worked.

Word of the game spread and people kept dropping by to play a set or two. Instead of packing it up and putting it in the cellar, as we had planned, Brainball was being permanently displayed in our research lab.

A Measure of Activity

The concept of measuring the electrical activity in the brain is called electroencephalography. Signals are measured in microvolts using electrodes positioned on the scalp. The analysis of continuous EEG signals or brain waves is complex. Different waves are categorized by the frequency of their emanation and can be seen to correspond to certain types of brain activity. Beta waves lie typically in the range of 14 to 30 Hz and are associated with an alert state of mind. They can reach frequencies of up to 50 Hz during stress or intense mental activity. Alpha waves, in the frequency of 8 to 13 Hz, are usually quite strong in a relaxed state; they diminish in amplitude when a person is stimulated by light or attempts mental efforts. Theta waves, at 4 to 7 Hz, rise during drowsiness or mental stress. These waves are usually strong in children withattention-deficit disorders. Delta waves, below 3.5 Hz, occur during deep sleep.

Brainball may have widespread future possibilities in various applications related to stress and relaxation.

For medical purposes, EEG machines have been used since the 1970s to trace brain activity and brain function deficit. In clinical psychology, biofeedback using EEG machines has been used to treat neuroses, panic disorders, and attention disorders (ADHD and ADD) with good results. Some children with mild attention disorders can attain good results with as few as five to 10 sessions. Research has also been carried out using EEG as an input device for computers and for the physically disabled. Mind Mouse from Leapfrog Technologies uses EEG and electromyography (EMG) to elicit tiny muscular movements on the forehead to control the movements of a mouse cursor on a screen. Disabled or injured people can learn how to control a mouse cursor just by thinking about a word or a movement. The U.S. firm IBVA has explored EEG as an input device for various manipulation of abstract forms on a screen, for example, to change colors and forms of graphic patterns or to light up a building. Recently Sony worked with EEG as a game input device.

The relatively high expense of EEG makes it difficult to obtain for private use. There are also few examples of artists using EEG. One exception, however, is the Swedish artist Ola Persson, who has used EEG on plants. Plants also exhibit electrical activity at very low frequencies, which appear in human beings during deep sleep and coma. In the piece Yucca Invest, Persson placed electrodes on yucca palms and connected them to a program that sells and buys stock. Touching and talking to the yucca palm create a stimulus that affects the program. One yucca palm has been very successful on the stock market, with a mean far above the stock index.

User Evaluations

We conducted user studies on Brainball with a researcher from a business faculty. The aim of the test was to study the use of Brainball, subjective and objective times during games (which will not be presented here), stress levels, and how the subjects perceived the game. During the test, stress was measured by using a galvanic skin response (GSR) sensor.

The test was divided into two parts:

1. Competition: Three games are played in which the goal is to be the most relaxed and score on the opponent's side.

2. Cooperation: One game is played in which the players must cooperate in moving the ball from one side of the table to the other by alternating stress and relaxation and finally placing it in the middle. Finally, players fill out a form, answering questions about gender, age, perceived time of the game, and attitudes toward the game. The questions were assessed on a Likert scale between 1 and 7.

It turned out that playing Brainball did make users more relaxed. Both the GSR values and the evaluations showed great significance in the result.

General attitudes toward Brainball were very positive; it was considered interesting, exciting, and more than 90 percent of the subjects wanted to try the game again. Women were significantly more enthusiastic about Brainball than men. Though women stated that they were more stressed than the men, the GSR and competition results showed no differences between the sexes. In face the GSR showed that stress levels were lower during competition than during cooperation. Women found competition more fun and men liked cooperation better.

The results suggest that the male preference for competition is neither biological nor normative. *How* you compete and in *what* play a significant role. If the quantitative results questioned traditional gender thinking, the qualitative results supported them. When losing, women tended to blame themselves; they were stressed, nervous, had a lot on their mind, or experienced difficulty in relaxing. The men, however, tended to blame the equipment: it did not work, biofeedback was not clear, or the outcome was predestined. When winning, however, both sexes said that they were good at relaxing and many mentioned that they practiced relaxation techniques. This might support the concept of gender as something cultural, transmitted, and cultivated within a social group.

Having to compete in relaxation is a contradiction in terms and thought provoking. Can we compete and relax at the same time? According to the user test the answer is yes. The main issue Brainball raises is connected to stress and relief. Stress is becoming a widespread problem, a *mal de temps*, a typical disorder of the late 20th century. Burnout was adopted as a clinical description in 1998 in Sweden. Since then the number of people suffering from this syndrome has increased dramatically. This is a probable cause for the interest in Brainball and suggests a course for further development. User tests show that subjects relate to Brainball as an interesting way of practicing control over brain activity and of learning how to relax. The tests also show that motivation to keep on playing Brainball is very high. This attempt to combine relaxation with a game is an interesting aspect for future development. The high level of interest shown in Brainball by users and the media suggests that it may have widespread future possibilities in various applications related to stress and relaxation.

When the first Brainball prototype was built we had no idea it would attract so much attention. We thought that it was an interesting game idea to compete in relaxation but could not foresee how interesting it could be. Above all, Brainball is an experience. This is something we noticed many times afterwards when we built prototypes. Until you actually do something, you can't tell what it's going to be like. An idea is one thing, but an embodiment of it is something completely different. Artists and designers work with manipulating the material world and are used to giving form to ideas and concepts; art and design, however, are unusual in experimental research.

A Mix of Disciplines

We are confident that Brainball owes its value to the multidisciplinary team that stood behind it. The project is a mixture of technical naivete, conceptual sharpness, and prototype-building efficiency that is not found in only one profession. Software designers alone would not have had the knowledge and the persistence to go through the difficulties of translating a two-dimensional interface to a three-dimensional one. After all, an image of a ball moving on a screen would not have been as fascinating as a real ball rolling on a real table. Only artists and designers would have been naïve and courageous enough to believe in the idea of biosensors as product input for a one-week workshop.

The "aesthetic intuition" is not at all intuitive— it's based on long and deep intellectual knowledge of the subject.

Entering design into research raises the issue of what precisely is the core of design research? A great deal of research has been conducted on design from various angles: the value of design from a business perspective, ergonomic and cognitive design, design methods for product development, design and material culture.

None of these areas includes designing artifacts themselves; researchers from economics, behavioral sciences, engineering, or sociology merely use the artifacts as an object for their study. For a practicing designer entering research, it seems difficult to imagine how the field would be advanced without including the central activity of design.

The Grand Design

Research is presented as a rational activity in which a number of questions are answered by applying a set of methods and proceeding in an orderly fashion, and in the end the result will answer the questions. This approach has been criticized by many areas since research includes a number of less rational decisions and actions. Design problems that occur in real life are often "messy," that is, not simple and ordered as in an experimental situation. They are not likely to be repeatable, and there is not one answer to the problem. A solution to the problem might often come from playing around with and arranging the facts in new ways and not from deducing objective facts. The process of creating something new is not a matter of calculated choice, argues Claude Lévi-Strauss. Rather, it involves "a dialogue with materials and means of execution" [2] where the materials that are at hand "suggest" the course of action. Donald Schön describes the design process as "reflection in action," whereby the designer works with a design model in dialogue with the context and the problem at hand. The solution usually appears in this process of arranging design elements in different patterns and structures [3].

In aesthetic practice, it is common that working with the materials at hand provides a way into the subject. A designer might know of all the criteria for a product but still not be sure how to execute it. Sketching or making mock-ups (3-D sketches) is usually a way of visualizing and embodying these implicit ideas. A painter, for example, does not always start a new painting with a clear idea of what to do. The artist starts putting paint on the canvas to let the action itself bring him or her to a desired expression. When the work is done it often points to a clear question that would otherwise not have been asked. This does not imply that the artist does not know what he or she is doing or that the work is based on some vague "feeling." Artists and designers rely on long, intense training in their respective subject and material. The "aesthetic intuition" is not at all intuitive, but rather based on long and deep intellectual as well as practical knowledge of the subject and a "repertoire" [3] of similar problems and inquiries. This knowledge differs from scientific knowledge in that it is not verbal or explicit but mainly tacit, implicit, and based on the activity itself. Several professions are based on such situated knowledge, among them nurses judging patients, architects, musicians, and actors. What these professions have in common is that they are not taught by explaining how to do but by showing how it's done.

Conceptually Speaking

Since Plato, the material world has had a subordinate position in the Western mind. For Plato the idea or concept was always superior to the actual object. Roland Barthes observed that in classic writing, "the writer is always supposed to go from signified to signifier, from content to form, from idea to text, from passion to expression." Speech has been regarded as the utmost sign of truth and authenticity. Speech has become so thoroughly naturalized that, according to Derrida, "not only do the signifier and signified seem to unite, but also in this confusion, the signifier seems to erase itself and become transparent" [1]. In seeking to establish "grammatology," or the study of textuality, Derrida claimed the primacy of the material world.

Aesthetical practices have the possibility to embody and materialize issues that previously have not been raised.

Aesthetical practices involve a certain amount of starting with the material world and letting the content appear out of that. Is there a knowledge that is unique for this activity? And how can we combine it with traditional verbal analyses?

My thesis is that aesthetical practices have the possibility to embody and materialize issues that previously have not been raised. By doing so, they can point at ideas or solutions in ways that are different from textual or verbal analyses, especially since the nonverbal communication in an artifact might be difficult to discuss or present in a verbal form. A piece of art can be magnificent to experience and be a milestone in art history and still reject analysis or slip away from being described with words. This is one of the great problems of research in art and design. What role shall the artifact have and what role the text? Some art institutions claim that art and verbal communication are so far apart from each other that a textual companion to the artifact is unnecessary. At Helsinki's University of Art and Design, the doctorate in design consist of two parts that are judged by two juries: one for the artifact and one for the text. An infamous example is the dissertation by the well-known textile designer Riitta Nelimarkka. She created a practical piece that was approved by the design jury, while the textual companion to her piece—a dialogue with herself—failed on the grounds that it was unacademic. Nelimarkka appealed and finally received a passing grade on her text.

Brainball itself defies description. We tried in different situations to write about it, but failed. At one time the Interactive Institute planned to write a book about multidisciplinary work and three members—including I—from the Smart Studio were asked to collaborate. After days of discussion and of transcribing tapes (on my account), we managed to send in a text that the editor thought was frightfully boring. We were on the verge of giving up when a colleague suggested that we should not "write about it," but rather "give shape to it" in the form of a play. And that is what we did. My colleague had a background as a playwright and helped me with some basic structure. The play almost wrote itself—it was that easy—and the editor was very pleased.

Our experience and that of Riitta Nelimarkka point to the difficulties of making an objective and true account of creative development, because it is more appropriate to make another "design" or interpretation. The logical verbalization of an interpretation is another interpretation until perhaps you have distanced yourself from the process so much that you can relate to it. The conclusions to be drawn on this for research in art and design still need to be considered.

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