Influence of immersion and biofeedback on intrinsic motivation in the sport setting

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Award date:
2003

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Submitted to Philips Research Eindhoven,
Personal Care Institute,
in fulfilment of the requirements for the degree of
Master of Science
at the
Human-Technology Interaction group,
Techniek en Maatschappij,
Department of Technology Management,
Eindhoven University of Technology

October 2003

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Summary

Within the framework of a graduate project at the Eindhoven University of Technology, a way of increasing a person's motivation to do physical exercise was investigated. The investigation took place at the Personal Care Institute of Philips Research in Eindhoven.

Many people have difficulties with the motivation to do physical exercise. When people are finally doing physical exercises, then the next struggle is to stay motivated to continue doing physical exercises.

To solve this problem, possibilities are sought to develop a fitness device that will lead to an increase of intrinsic motivation. Two factors are found to be very important for people during the physical exercise. On the one hand getting feedback during the physical exercise and on the other hand the experience of enjoyment. To realize feedback, a virtual coach was presented to give feedback about the subjects' heart rate. To create enjoyment, presence was realized by presenting a virtual environment (VE) to the subjects.

A fitness device was put together to test whether feedback and/or enjoyment would lead to an increase in intrinsic motivation. The fitness device consisted of a sport bicycle placed on a training construction. Four different sessions were evaluated: 'without VE - without coach', 'without VE - with coach', 'with VE - without coach' and 'with VE - with coach'. The dependent variables were: intrinsic motivation, enjoyment, presence and attention to the screen. Standardized questionnaires were used to measure motivation and enjoyment (Intrinsic Motivation Inventory (IMI)) and presence (the ITC-Sense of Presence Inventory (ITC-SOPI). Every session existed of cycling for a few minutes and filling in the questionnaires. With the help of cameras, recordings of the experiments were made and the overall percentage of attention to the screen was calculated.

The four main conclusions that could be drawn are the following: (1) the use of VE increases motivation. (2) The use of VE causes presence. Three factors of presence (spatial presence, engagement and ecological validity) have a positive correlation with the interest/enjoyment factor of the IMI-questionnaire, which is considered the self-report measure of intrinsic motivation, so it can be concluded that these are the (dominant) factors of VE that lead to an increase of intrinsic motivation. (2) The coach causes less negative effects and less pressure/tension. So the coach leads to less chance of getting a headache, feeling dizzy or feeling disorientated. When given feedback, the coach may cause some distraction to the subjects. The result of this is that subjects 'step' out of the virtual world for a moment and this may lead to less negative effects and less pressure/tension. (3) The coach decreases perceived control. During the sessions with coach, subjects had, the feeling that they were less able to control the activity in comparison to the sessions without the coach. This could be due to the fact that the coach gave a 'command' to the subject, of which the subjects had the feeling they had to obey the 'commands'.

Despite the widely acknowledged public health burden and years of individually based intervention approaches, physical inactivity remains a growing concern among industrialized nations. Motivation is one of the biggest problems that arise for both new and regular physical active people. If people are motivated in any particular way, they will more likely start and continue the behavior.

1. Introduction

It is generally known that physical exercise is important for a good health (see McAuley, 1994; Tomporowski & Ellis, 1986; Yeung, 1996). The biggest problem is to remain physically active. For most of the people motivation appears to be a large problem with doing physical exercise. The ultimate goal is to make people do regular physical exercises and take care of their own health by adjusting their motivation. There are several possibilities to increase the motivation of people. The hypothesis of this study is that the motivation of people will be increased when, during the physical exercise: the user has the experience of presence and when the user gets biofeedback. To check the hypothesis, I explore how to increase motivation by making a fitness application that contains the features: immersion/VE and biofeedback from a coach.

How the user thinks about the physical activity is very important. When the user is thinking positively about the activity, he or she will have a higher motivation to accomplish the activity. The opposite is when the user is thinking negative about the physical activity. He or she will have a lower motivation to accomplish the activity. According to Bakker (1990), goal setting works presumably best and maybe only when there is feedback about the goals that are to be gained.

The positive thinking about an activity will be strengthened when the activity is considered enjoyable. People seek for enjoyment that they not (always) find in the real world. It is not hard to imagine how much enjoyment simulated experiences can bring. Consider the newest computer games for example. The environment, or the world where the main character of the game is in, has been becoming more convincing and realistic. The purpose of these virtual environments is to make the user think that he/she is in another environment. The experience of being in a place other than one's actual location is called presence. Many of the entertainment facilities nowadays are trying to create presence and thus enjoyment. Entertainment while exercising is thought to make the visit to a fitness club more enjoyable and increase the likelihood of repeat visits. The assumption is that the high degree of individualization in entertainment choice provides an environment conducive to exercising for above average periods of time at a higher level of intensity. The programming removes users from the sensation of discomfort inherent in strenuous stationary cardiovascular exercise. This technology is designed under the assumption that exercise adherence is directly linked to enjoyment and blocking of unpleasant sensations – basically resembling a distraction hypothesis (Nigg, 2003).

Because a fitness application containing feedback about the users' goals and the creation of presence does not exist at the moment, the approach is to design and build a fitness application based on these pro-motivational techniques. The target audience is generally healthy people who cannot bring up the motivation for doing regular physical exercise.

The report will be divided as follows. The theories about motivation and goal setting, feedback, and presence will be treated first. From the theory an experimental model can be formed and out of that the experiment can be developed. The results will be discussed after the experiment. Finally, out of the results will follow the discussion and conclusion. Because it is about the development of a fitness application by Philips, a closer look will be taken to the target groups and the backgrounds of the 'fitness world'. This chapter can be found in appendix A.

After wintertime, when the days become longer and the weather better, people are getting in the mood to do exercise. Physical exercise has a positive influence on the body condition. Important is that people are motivated to do physical exercise. Also goal setting and fun are of importance. This chapter turns out why

2. Motivation

Let us start to bring out what motivation really is. According to Petri (1981), motivation is the concept we use when we describe the forces acting on or within an organism to initiate and direct behavior. The concept of motivation is also used to explain differences in the intensity of behavior. More intense behaviors are considered to be the result of higher levels of motivation. Additionally, we often use the concept of motivation to indicate the direction of behavior. When you are hungry, you direct your behavior in ways to get food. When you have the idea that you do too little physical exercise, you direct your behavior in ways to get physical training. Receiving a reward or positive feedback for an action usually increases the likelihood that the action will be repeated.

It is important to understand what motivation is in the context of sport and participation. Brasile, Kleiber, and Harnisch (1991) state that motivation is "a process through which persons take available resources; time, talent, and energy and distribute them in a way they choose." This process is called the personal investment theory, and it incorporates a two-stage causal process. The first stage involves the effects of external factors and their influence on how an individual perceives a particular situation. In the second stage, the individual undertakes a personal investment in the situation. The personal investment involves an inner drive, an impulse, or an intention an individual possesses as a reaction to external influences. The key question is, what motivates people to dedicate themselves to sport?

What has to be changed to increase the motivation of people? There are in fact two ways of creating a change: through the person in question (intra-individual) or the person's surrounding (extra-individual) (Bronfenbrenner, 1977). Intra-individual influences might include individual attributes, beliefs, attitudes, and behaviors, while extra-individual influences might include environmental topography, social and cultural context and policies. For example, change at an intra individual level of influence might include improving attitudes toward physical activity, thereby increasing the probability that physical activity behavior might occur. Change at an extra-individual level of influence might include providing safe spaces to do physical activity, also increasing the probability that physical activity might occur (Bronfenbrenner, 1977).

A growing body of rhetoric and research argues that there may be synergy between individuals and environments that may exert influence on individuals beyond individual characteristics (Susser & Susser, 1996). Ecological models posit that this synergy is born out of a good "fit" between the individual and environment (Kelly, 1990). A good fit

refers to a matching of intra-individual attributes with environmental (extra-individual) attributes that produces positive human health behavior beyond the summation of the intra- plus extra-individual environment. Similarly, a poor individual-environment fit is a mismatch between individuals and environments that leads to poor health and disease. A good individual-environment fit can be improved by enhancing either side, the individual or the environment. It is easier to change the environment instead of the individual itself. In addition it is more efficient to enhance environments rather than change individuals, because enhancing one environment can have implications for many individuals.

2.1 Motivation in sport

To make people do more physical activities, one important thing is to make the activity itself seem to be enjoyable for the person. In other words, people have to experience the activity as enjoyable and so think positively about it. The way of thinking is very important. When a person thinks positive about an activity, he or she is more inclined to carry out this activity than when he or she thinks negative about the activity. The results of a study done by Lindner and Kerr (1999) indicated that the two principal reasons for participation or intended participation in sport or physical activity *were to become or stay fit and healthy, and for leisure and enjoyment.*

To reach a goal is a person's reason to start with physical exercise. To achieve the goal one must have a certain drive. A certain drive is already mentioned above, enjoyment and motivation. The motivation forms the spirit of the regular dedication, but is also partial based on the competence and self-confidence of ones own movements capacity. The two processes competence and self-confidence do not happen spontaneously.

Everyone has different reasons for participating in sports: enjoyment, physical fitness, and social relationships yet (as noticed in appendix A), feeling good after doing physical exercise is one of the mean motivations for males and females. Social integration incentives are another important factor. Many enjoy sports for the companionship, social interaction, recognition, respect, and feeling of belonging (Brasile et al., 1991). There are two types of motivation that enable people to accomplish a particular goal or task. First, extrinsic motivation in sports participation comes from outside influences or people (Deci & Ryan, 1985). People are extrinsically motivated to gain compensation, social approval, or rewards. Second, intrinsic motivation is an inherent characteristic that feeds off one's inner drive to accomplish a goal or objective. According to Seifriz, Duda, and Chi (1992), "focusing on a task for its own sake, having a sense of self-determination, and perceiving oneself as able to meet the demands of a task are all assumed to be fundamental to intrinsic motivation." These factors reinforce participation in sports and are often encouraged by friends, family, and health professionals.

According to Csikszentmihalyi (1975), people are motivated to participate for the purposes of improved competence, enjoyment, personal improvement, and mastery of a task. Research by Brasile (1989) and Brasile et al. (1991) revealed that individuals participated in sports for intrinsic and task-oriented reasons, which means they were

internally driven to accomplish performance goals rather than to win or compare themselves with others. Ego incentives are derived when comparing one's abilities, actions, or competence to the performance of another individual or group (Brasile & Hedrick, 1991; Brasile et al., 1991; White & Duda, 1993). The results of the comparison assist in the development of social realities. In competitive situations, it becomes important to be more competent. However, ego involvement can result in a negative response in achievement because of a lack of confidence in one's ability (White & Duda, 1993). When an athlete's abilities do not compare favorably with those of another, adverse effects may occur. Adolescents with low perceived competence have a tendency to foster maladaptive behaviors such as cheating, giving up, or risking health for success. Often, the effects of comparison can alter one's thinking about one's self, abilities, competence, or health.

2.2 Intrinsic and extrinsic motivation

Motivation is at the heart of many sport's most interesting problems, both as a developmental outcome of social environments such as competition and coaches' behaviors, and as a developmental influence on behavioral variables such as persistence, learning, and performance (Duda, 1989; Vallerand, Deci, & Ryan, 1987). Several conceptual perspectives have been proposed to better understand people's motivation (see Roberts, 1992). One perspective that has been found to be useful in this area posits that behavior can be intrinsically motivated, extrinsically motivated, or amotivated (Deci, 1975; Deci & Ryan, 1985, 1991). This theoretical approach has generated a considerable amount of research and appears pertinent to the field of sports (Brière, Vallerand, Blais, & Pelletier, in press; Vallerand, Deci, & Ryan, 1985, chap. 12; Fortier, Vallerand, Brière, & Provencher, in press; Vallerand, Deci, & Ryan, 1987).

In brief:

1. Intrinsic Motivation: Engaging in an activity purely for the pleasure and satisfaction derived from doing it; the activity is an end in and of itself. For example, "I am motivated to practice because I want to improve my skills".
2. Extrinsic Motivation: Engaging in the activity only as a means to an end. "I am motivated to get a medal" or "I want to please my parents/ coach".
3. Amotivation: There is no relationship between action and outcome. The athlete experiences no good reason to continue to train. "No matter how hard I train I do not get any better".

Social motivation can also be the reason for people to change their behavior. The presence of others can be of influence of a person's behavior. So a reason why people could do physical exercise is the presence of other people. Mostly these people who go to do physical exercise also have a goal. This goal setting or defining goals seems to be a very important motivational technique.

Intrinsic motivation

The concept of intrinsic motivation suggests that we may often be motivated in a task, not because of some external reward associated with the task, but because the

behavior itself is rewarding. In general, intrinsic motivation refers to engaging in an activity purely for the pleasure and satisfaction derived from doing the activity (Deci, 1975). Staw (1976) has, in fact, defined intrinsic motivation as the value or pleasure associated with an activity as opposed to the goal toward which the activity is directed. When someone experiences pleasure during the physical exercise this means that that person experiences physical exercise as a positive thing, and will be more probable to keep doing the exercise.

Although most researchers posit the presence of a global intrinsic motivation construct, certain theorists (Deci, 1975; White, 1959) have proposed that intrinsic motivation could differentiate into more specific reasons. A tripartite segmentation of intrinsic motivation has been made (Vallerand et al., 1992). This taxonomy is based in the intrinsic motivation literature that reveals the presence of three types of intrinsic motivation that have been researched on an independent basis. These three types of intrinsic motivation have been identified as intrinsic motivation to know, intrinsic motivation to accomplish things and intrinsic motivation to experience stimulation. From these three types of intrinsic motivation the intrinsic motivation to accomplish things is the most relevant of these three. This type of intrinsic motivation has been studied in developmental psychology, as well as in educational research, under such terms as mastery motivation, efficacy motivation, and task-orientation. In addition, other authors have postulated that individuals interact with the environment in order to feel competent and to create unique accomplishments (Deci, 1975; Deci & Ryan, 1985, 1991). Thus intrinsic motivation toward accomplishments can be defined as engaging in an activity for the pleasure and satisfaction experienced when one attempts to accomplish or create something. Trying to master a training schedule in order to experience personal satisfaction represents an example of intrinsic motivation to accomplish things in the sport domain.

Brodkin and Weiss (1990) have shown, in a study examining sport participation across a wide age range, that young and middle aged adults thought health and fitness reasons were the most important, but for younger children and older adults, enjoyment was rated as being most important. Enjoyment is usually associated with positive emotions, primarily joy. It is something that people are willing to do without a material reward, enjoy doing, and find amusing. Formal definitions of enjoyment usually link enjoyment to joy, amusement, recreation, but seem incomplete. Enjoyment is better to understand intuitively than formally. When something is enjoyable, the question whether the activity is necessary, important, or useless goes to the background. By focusing on the enjoyment, the sport environment can be improved and help to keep people interested in playing sports. Sport programs can positively impact people's lives by improving their self-esteem, their perceptions of their physical abilities, their interpersonal skills with other people, their stress coping skills, and their attitudes toward the value of physical activity. When people receive positive support from their coach, they are more likely to benefit from the sport experience. Supportive and positively engaged coaches are also easier to work with and contribute to a sport culture that maximizes positive outcomes for all those involved.

In a study reported in the Journal of Sport Psychology in 1985, Dr. Wankel noted that:

- Factors intrinsic to the sport activity (excitement, personal accomplishment, improving one's own skills, testing one's skills against others, just doing the skills of the sport, and so on) were most important to enjoyment.
- Social factors (being on a team and being with friends, for example) were of secondary importance.
- Outcome-oriented (extrinsic) factors like winning, getting rewards, and pleasing others were of least importance to enjoyment.

Studies done by other researchers have shown similar results. Factors found to be important to enjoyment include demonstration of personal ability, feelings of competence, involvement in the action of the game, opportunities to exercise control, and friendship.

A main reason why enjoyment could be very important while doing physical exercise is that one of the main reasons that people do not do physical exercise is because it is not enjoyable (see chapter 2). So, when making physical exercise enjoyable, this could mean that people have a reason less for not doing physical exercise. With pleasure, a sense of well-being is meant. People can experience enjoyment during the physical exercise, as well as after the exercise. When a person experiences enjoyment during the physical exercise this means that that person experiences the exercise as a positive thing, and will be more probable to keep doing the exercise. The experienced enjoyment can be due to several factors. Possibilities are the background music, the view out of a window or just knowing that you are doing something good. The enjoyment after the physical exercise can come from the idea that you have done something that is good for you. Besides this, there can be enjoyment in the fact that you are more active and less stressed in daily life.

Extrinsic motivation

Contrary to intrinsic motivation, extrinsic motivation pertains to a wide variety of behaviors that are engaged in as a means to an end and not for their own sake (Deci, 1975). It was originally thought that extrinsic motivation referred to non-self-determined behavior, behavior that could only be prompted by external contingencies (e.g., rewards). More recently however, Deci and Ryan, along with their colleagues (e.g., Ryan, Connell, & Grolnick, 1990), have proposed that they are, in fact, different types of extrinsic motivation that can be ordered along a self-determination continuum. From lower to higher levels of self-determination, they are: external regulation, introjection, and identification.

External regulation

This type of motivation corresponds to extrinsic motivation as it generally appears in the literature. That is, it refers to behavior that is controlled by external sources, such as material rewards or constraints imposed by others (Deci & Ryan, 1985). People who participate in sport in order to receive praise from their coach or because they feel urged to do so by their parents are motivated by external regulation. In this case, the sport is performed not for enjoyment but to obtain rewards (e.g., praise) or to avoid negative consequences (e.g., criticisms from parents).

Introjection

With introjection, the formerly external source of motivation has been internalized such that its actual presence is no longer needed to initiate behavior. Instead, these behaviors are reinforced through internal pressures such as guilt or anxiety. People, who participate in sport because they feel pressure to be in good shape for aesthetic reasons, and feel embarrassed or ashamed when they are not in form, represent an example of introjected regulation.

Identification

This last type of extrinsic motivation is in operation when the individual comes to value and judge the behavior as important and, therefore, performs it out of choice. The activity is still performed for extrinsic reasons (e.g., to achieve personal goals); however, it is internally regulated and self-determined. People who participate in sport because they feel their involvement contributes to a part of their growth and development as a person represent an example of identified motivation.

Amotivation

This form of motivation is quite similar to the concept of learned helplessness (Abramson, Seligman, & Teasdale, 1978). That is, amotivated individuals do not perceive contingencies between their actions and the outcomes of their actions. They experience feelings of incompetence and lack of control (Deci & Ryan, 1985). They are neither intrinsically motivated nor extrinsically motivated. When people are in such a state, they no longer identify any good reasons for why they continue to train. Eventually they may even decide to stop practicing their sport.

In short: intrinsic means innate or within; hence intrinsic motivation is the stimulation or drive stemming from within oneself. Intrinsic motivation is often associated with intrinsic rewards because the natural rewards of a task are the motivating forces that encourage an individual in the first place. In general, it can be said that people who derive pleasure from doing physical exercise are more likely to keep up training and be keener to start a workout than those who do not find pleasure in doing physical exercises (intrinsic motivation). Persons who go to practice because they find it interesting and satisfying to learn more about their sport, or persons who practice their sport for the pleasure of constantly trying to surpass themselves are considered intrinsically motivated toward their sport. The persons who do not find pleasure in the exercising itself, must be stimulated in other ways to keep on exercising. This could for instance be by a doctor's prescription (extrinsic motivation), or with the help of a cycling device that has the features to increase the intrinsic motivation of individuals.

Social motivation

Some theorists have pointed out that we are socially motivated. Around 1900 it was discovered that the presence of others sometimes has strong effects of on the behavior of individuals (Zajonc, 1972). It was found, for example, that bicycle racers performed better when competing against each other than against a clock. This social facilitation of behavior is probably one reason why people perform better in a

competitive situation. The presence of others energizes the behavior of the contestants to higher levels. The interaction with others can also be motivating. Research in social psychology has pointed to the power of the group in motivating us to conform and to the power of authority figures in motivating us to obey. We interact with others, and this interaction both generates and directs behavior. We often find it difficult to deviate from the wishes of our peer group; as we all know, this reason to conform can become quite strong. These social approaches point out the motivating properties of the presence of others. The reason why a lot of people make commitments with others to do their physical exercises can be explained with the fact that social situations have a large influence on our behavior because the presence of others alters our motivation. Outcomes of interviews with a fitness instructor and with a physical therapist in appendix A, demonstrate that a lot of people go to a fitness school for the social contacts.

2.5 Goal setting

When people want to reach something, they make goals. When a healthier lifestyle is desired, more physical exercise could be the goal. There are several motivational techniques to improve performance. Goal setting or defining goals is one of the most popular. According to Locke & Latham (1990) people must make a commitment (with themselves) to attain a goal because it will not affect performance without this commitment. "Goal setting works probably the best and maybe only when there is feedback about the progress by achieving the goals" (Bakker, 1990). "Goals enhance self-regulation through their effects on motivation, learning, self-efficacy (perceived capabilities for learning or performing actions at given levels), and self-evaluations of progress" (Bandura, 1997; Schunk, 1995). Goals direct individuals' attention to relevant task features, behaviors to be performed, and potential outcomes, and goals can affect how people process information. Goals help people focus on the task, select and apply appropriate strategies, and monitor goal progress. Goals also motivate people to exert effort necessary to meet task demands and persist over time.

However, just setting goals is not enough. The performance will not improve unless the person is told how he is doing. Goals without specific, concrete feedback are like a road trip without signs and landmarks along the way. The person will not be committed to a goal unless one sees it leading to what one wants. Feedback shows the way to the goal. Tracking and evaluating the progress toward a goal gives the person much needed feedback. Nothing motivates more to proceed to achieve the goal than getting feedback of concrete results. As people work on a task they compare their current performance with the goal. Self-evaluations of progress strengthen self-efficacy and sustain motivation. A perceived discrepancy between present performance and the goal may create dissatisfaction, which can enhance effort. Although dissatisfaction can lead to quitting, this will not happen if people believe they can succeed such as by changing their strategy or seeking assistance. Goal attainment builds self-efficacy and leads people to select new, challenging goals.

2.6 To summarize

In the beginning, the motivation of people has to be adjusted. An important issue hereby is the enjoyment that people have while doing physical exercise. People have to enjoy cycling or running through the park. The enjoyment part is very present in the intrinsic motivation, after all intrinsic motivation refers to engaging in an activity purely for the pleasure and satisfaction derived from doing the activity (Deci, 1975). So the aim is to increase the intrinsic motivation. Also the social theory plays a certain role. The social approaches point out the motivating properties of the presence of others, thus, that people are socially motivated. When people want to reach something they make goals. For succeeding in reaching one's goal, feedback appears to be an important factor. Goal setting is important, but works the best and maybe only when there is feedback.

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Before starting with physical exercise, the user has to form a goal. As appeared out of the second chapter it is very important to measure the activity of the user and reflect it to the user. With this feedback the user is able to compare the current data with the data of the goal. In what way will the feedback be important to the user? It appears that the acceptation of the feedback is dependent of the way feedback is given to the user.

3. Biofeedback

As written in the introduction, a fitness application might give feedback to the user during the exercise. Out of the previous chapter appears that feedback could lead to an increase of the person's motivation. There are many kinds of feedback to give. Speech, text, smells to name a few. Before deciding which kind of feedback could be the best to implement in the application, it has to be clear what the physical activity is, what kind of feedback are possible and useful, and which sensor can be used for it.

3.1 Feedback and motivation

The important thing about feedback is that it should be useful to and sensitive to the individual. The best kind of feedback is therefore feedback that the individual has asked for. Feedback can be given to accomplish three purposes: 1. error correction, 2. motivation, and 3. reinforcement. All three purposes are based on motivation but have their own emphasis. With error correction, feedback is meant to give information that will help the individual to perform better or execute a strategy more properly. Feedback can also serve as a form of motivation by giving direction to future attempts at the skill. It can help individuals focus their efforts and also lets the individual know that there is someone that cares about their level of performance and wants to help them improve. Feedback serves as a form of reinforcement by providing individuals with information about their progress towards goals that they are trying to achieve.

A study done by David Darvill et al. (1999) examined and investigated the various motivational factors in sport, and also assessed the relative impact of positive and negative feedback. Males who received positive feedback were producing scores significantly better than both females who received positive feedback, and females who received negative feedback. Whether they also producing scores significantly better than males who received negative feedback is not mentioned. Weinberg and Jackson (1979) gave subjects bogus success or failure feedback for their balancing ability by telling them that they had either exceeded the 82nd percentile (...very good...), or they had fallen below the 18th percentile (...not very good...). Success-feedback enhanced interest and enjoyment, and reduced boredom with the task and failure-feedback had the opposite effect. Vallerand and Reid (1984, 1988) manipulated feedback by making verbal comments to subjects suggesting that they were doing either well or poorly. Like Weinberg and Jackson (1979), the results showed that success-feedback led to an enhanced intrinsic motivation while lack of success-feedback reduced it. Additionally, a more in-depth analysis of the results allowed the experimenters to show that it was not the effect of the feedback per se, but rather it was the effect of feedback on the

subjects' perceptions of competence that moderated changes in intrinsic motivation. In other words, this study showed that it was not the feedback itself so much as the meaning or interpretation of the feedback to the subjects that produced the motivational outcome. So according to several studies, there can be concluded that positive feedback motivates the user.

3.2 Current situation

Some feedback is already given to the user in current fitness applications. During the exercise one can see the watt consumption, the users velocity, etcetera. These data are shown on a display, which is mostly assembled on the application. Most of the fitness applications have an option to measure the users heart rate. By means of gripping the handlebars, the heartbeat will be measured and depicted on the display. These data will be shown constantly in numbers and mostly nothing is done with this information by the fitness application. A lot of useful information, like the fitness and the condition of a person for example, can be gathered out of the given data by a combination of several physical parameters. Presenting a number to the user like watt, calorie consumption, heart rate, etcetera, has little meaning to the user. It is useless to present these data to the user when they have no or little knowledge of the interpretation of the given physiologic parameters. An alternative is to let the application do the calculation and inform the user about his or her fitness or condition on the basis of the measured parameters.

Some feedback systems include game elements to make (biofeedback) exercise less monotonous. Examples include biofeedback games developed by the MindGames group at Media Lab Europe, biofeedback visualizations developed at HeartMath Inc., and audio biofeedback developed by B. Gavitz (Gerasimov, 2003). A common problem of most of these systems is excessive focus on a single biofeedback parameter. It is hard to make an interesting game with a single dimension of control that also has to be shifted in only one direction. For example, some of those systems focus on continuous relaxation. The difference between the approach of this thesis and these systems is a higher emphasis on the game elements of the system. The goal is to make the activity enjoyable in the form of physical exercise that includes biofeedback rather than augment a biofeedback exercise with game elements.

With the expectation to find new feedback techniques, a visit to the FIBO 2003 in Essen was made. Surprisingly, a few fitness devices were found that contained some kind of interaction between the user and the fitness device. Showpieces of many suppliers were applications with a television screen built on it, where the user could watch television, dvd, surf on the internet or play computer games when exercising. Some applications were linked to computer devices, like the cyberrider of Reebok linked to the Sony Playstation, in which the speed of a racecar depends on the cycling speed. Another example is the Exertris cardiotraining where the user can play a computer game like Tetris or Solitaire during cycling. One treadmill was making use of virtual reality: on the Nurytec VR3000 the user can exercise with the interactivity display of a 3D avatar and computer-generated image or a real landscape image for various purposes.

In the end, it can be said that there are (still) only a few fitness application available on the market that have a real interaction with the user. Nevertheless, there is a movement noticeable from the common fitness application to applications with an accompanying function. But at the moment, these accompanying functions are restricted to make and keep up training schedules. No (bio)-feedback interaction during the exercise is applicable at the moment.

3.3 Kinds of biofeedback

There are several possibilities of giving feedback. The collection and the presentation of the feedback is a problem in itself. The kind of data that can be given as feedback is very varied. Numbers alone are meaningless to most of the users. Nevertheless, the feedback of the current fitness applications exists out of numbers, and besides that also graphics and illustrations for example are much obliging fillings. It is important to give feedback that the user understands directly. Some points of attention are to give feedback as soon as possible, give feedback only on things that learners can improve and control, comment only on important items ignore trivial points and focus on the performance rather than personal qualities. Also, the user should not become overloaded with information that is irrelevant. "You have done enough movement" is an example of feedback that could be useless for the user. The data that has been measured has to be translated to data that can become presented to the user, in order that the user understands what the content is of the feedback and what can be done with it. This can be realized to enable an interaction between the user and the fitness application. An example of a possibility of feedback that is understandable for the user is to depict a heart on a screen that becomes bigger and smaller all the time, which indicates the users heartbeat.

Humans can consume and process a certain amount of information. Too much information could lead to overload. Overload can be prevented by: noticing the amount of information that is presented; presenting the information not at the same moment; and make sure that the presented information is not too detailed. Another way is to make the information available on the background and when the user needs it, the information will appear on the foreground. Feedback of the exercise progress may add a feeling of control to the user. That feeling of control is a very important part within acceptation. According to Russoniello (2001) feedback is an excellent tool for assisting individuals to gain control over their health.

3.4 Which sensor and why

To give useful feedback about the individuals' state of fitness, sensors have to be used to measure certain data. There are several ways to measure components of fitness. In the 19th century it started with body measurement. Age, height, weight, chest circumference, arm circumference, forearm circumference and lung capacity were measured. Later muscular strength, endurance and power were included. At the beginning of the 20th century, heart rate and blood pressure were introduced in fitness measurements. Today, authorities, fitness centers, sports clubs and scientists all have slightly different ways to measure fitness. It depends very much on the goal of the

measurements, which parameters are included and which are not. Especially for athletic fitness measurement it depends very much on the discipline practiced which parameters are important (Stalman, 1998). The following parameters are commonly accepted in measuring health fitness (Maud, 1995).

Aerobe capacity: the maximum rate at which energy can be released from the oxidative process exclusively;
Anaerobe capacity: the ability of a muscle or muscle group to perform repeated contractions against a light load for an extended period of time;
Flexibility: the range of motion of a joint or related series of joints;
Body composition: the relative contents of lean body-mass, essential fat and nonessential fat mass;
Strength: the peak force or torque developed during maximal isometric voluntary contraction;
Power: the time rate at which mechanical work is performed.

Measuring fitness parameters is done for several reasons like evaluating a training program, predicting performance or selection for championships. Most of the fitness parameters are measured with specific tests. The sort of test also depends on the target. Another important aspect of tests is that before doing a test one must be sure that one is capable to do the exercise test. Because when people just start untrained with doing exercise it is more important to do a health examination when the person is less trained (Geysel, 1996). It is a little impractical to do a health examination every time a person starts to do exercise when one is less trained. A better way is to measure certain physical parameters, which can tell the user about the shape of one's body. According to Maud (1995) it becomes ultimately the responsibility of the individual to determine the value of different measurements that can be evaluated.

At a time of increasing awareness of one's own health and of decreasing public healthcare coverage, a market is developing for devices that allow individual customers to monitor aspects of their own health. This is becoming an important aspect especially in the fitness market. Such a device should be capable of monitoring body parameters that are known to be important indicators of physical health, or are perceived as such by customers. Some demands of the sensors are:

1. The values are physiologically relevant;
2. The user considers this information to be important and have a valuable addition to their experience of personal well-being;
3. The measurements are noninvasive.

To know which parameters are able to measure and to get a feeling of the sensors that are available on the market, a brief sensor study was done. Not all the sensors, but only these that could be interesting for this project. Meant are sensors which measure relative simple human physiologic parameters and which are non-invasive. Hereby is also looked at how the device works and to the purpose of the sensor. The sensors that have been studied and a briefly definition of them can be found in Philips memo RWB-570-RB-03040-rb.

Heartbeat and respiration are well-explored parameters and are the basis of health information for a generally healthy person. There are other signals that could be measured during the exercise, e.g. blood glucose level and cholesterol. These specialized sensors are necessary for comprehensive health monitoring of people with specific health problems such as diabetes and heart patients, but these sensors are more invasive and require more specialized electromechanical hardware. Since the target groups are people that do not do physical exercise, the design preferences were to choose a measurement system that is small and non-invasive. Furthermore it had to be non-intrusiveness, wireless and easy in use.

A great limitation in the acceptation of the application is privacy. People are very attached to their privacy. There are physical data that people prefer to keep to one self. The projection of someone's fat percentage for example, can be very shameful for some users. It is unwanted that the user gets obsessed due to the fat percentage that is been show constantly on the screen. The result of this can be the fact that the user does not make use of the application a second time. One of the most accepted, accessible and common classes of biosensors is a heart rate monitor. Non-invasive visualization techniques such as MRI can be used to obtain the most comprehensive analysis of heart activity. However, in most cases this method is neither feasible nor necessary. Pulse rate monitoring is usually sufficient for persons without a specific heart-failure risk. By means of the diagram that's depicted on most of the fitness applications nowadays, the user can see if the heartbeat stays in the desired trainings zone. The heartbeat is a well-known parameter in the world of fitness, despite any interaction between the user and the fitness application is missing. Another reason why heartbeat measurement is important is that the heart is the most important muscle in the human body. In fact, it serves as a barometer for the rest of the body, telling you how hard you are exercising.

Heartbeat measurement is already implemented in the most current fitness applications. The representation of the data is depicted simply and can be understand wrong or can be easily ignored by the user. Because it is the most known sensor of all the studied sensors and a suitable candidate for the aim of this project, it is a plausible choice to implement this sensor in the new application. Other sensors can be implemented in possible continuation studies.

3.5 To summarize

At the moment most of the current fitness applications will give some feedback to the user. However, this feedback is still hardly meaningful. Lately, the feedback is presented differently. Applications may force the user to interact with the device, in the form of a computer game. Many sensors could be used to measure certain data of the human body. The heart rate monitor is one of the most used and well-known sensor for measuring exertion.

A number of emerging technologies including virtual reality, simulation rides, video conferencing, home theater, and high definition television are designed to provide media users with an illusion that a mediated experience is not mediated, a perception defined here as presence. Traditional media such as the telephone, radio, television, film, and many others offers a lesser degree of presence as well. This chapter will explain the contribution of presence in this experiment. What is presence and what does it with people?

4. Presence

Nowadays there are many technologies on the market that give the user a mediated experience. Technologies like the IMAX films, home theater and simulation rides are some examples. There are some differences between these technologies but each of them is designed to give the user a type of mediated experience. A mediated experience that looks very much like the real world; a mediated experience that creates a strong sense of presence for the user. Meanwhile, traditional media including the telephone, radio, film, and television continue to offer us a lesser sense of presence as well (Lombard & Ditton, 1997). One of the two factors that were found to be very important for people during the physical exercise is enjoyment. To create enjoyment, presence will be used. A part of the hypothesis of this study is that the motivation of people will be increased when the user has the experience of presence during the physical exercise.

4.1 What is presence?

Singer (1997) refers presence as *"the subjective experience of being in one place or environment, even when one is physically situated in another"* (p. 885). The concept of presence is central to theorizing about advanced virtual environments such as immersive virtual reality (Barfield et al., 1995; Lombard & Ditton, 1997; Sheridan, 1992; Steuer, 1995). Tele-operators describe presence as the sensation of being at the remote worksite rather than at the operator's control station. In its more general use the term presence has referred to a widely reported sensation experienced during the use of virtual reality specifically, but also found during the use of other media. Users experiencing presence, report having a compelling sense of being in a mediated space other than where their physical body is located (Slater & Usoh, 1993). As applied to a virtual environment (VE), people experiencing the computer-generated environment rather than the actual physical environment where they are. However, presence is not limited to virtual reality applications; a sense of spatial presence can be achieved by e.g. multimedia applications. "Objects have a sense of presence," means that the objects seem to have a spatial location independent of both the user and the display technology (Bryson, (n.d.)). Presence in a VE depends on one's attention shifting from the physical to the virtual environment, but not all the attention needs to be in the virtual environment. How much presence users will report and how sharply users focus their attention on the VE partially determines the extent to which they will become involved in that environment. Presence depends upon a number of factors, as will be discussed later in the section of immersion and involvement. Both involvement and immersion are necessary for experiencing presence, while neither are sufficient.

Another factor that can be present during the experience of presence is flow. Flow is a psychological state that can be present while experiencing presence. During this experience the whole body, mind, and consciousness become ordered, focused and harmoniously directed. When being in a flow, everyday experience becomes a moment-by-moment opportunity for enjoyment and self-fulfillment. According to Rieber (1996), flow and enjoyment results when an activity meets one or more of the following components: (1) Challenge is optimized; (2) Attention is completely absorbed in the activity; (3) Clear goals; (4) Clear and consistent feedback as to whether one is reaching the goals; (5) Activities that free the individual from worries and frustrations, at least temporarily; (6) Feeling of control of the activity; (7) All feelings of self-consciousness disappear; (8) Time is changing during activity (e.g. hours pass without noticing). Not surprisingly, these components are quite consistent with characteristics of gaming.

4.2 Involvement

According to Witmer (1998), "Involvement is a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events" (p. 227). For many people, high levels of involvement can be obtained with media other than VE, such as movies, books, and video arcade games. Media experiences that evoke presence tend to be highly involving. Involvement depends on the degree of significance or meaning that the individual attaches to the stimuli, activities, or events. In general, as users focus more attention on the VE stimuli, they become more involved in the VE experience, which leads to an increased sense of presence in the VE. To the extent that users are preoccupied with personal problems or focused on activities occurring outside the VE, they will be less involved in the VE. "Presence implies a direct and natural experience rather than just the processing of symbolic data and is therefore likely to be more compelling" (Lombard, 1997). In an analysis of survey responses from 312 users of the BattleTech virtual reality game, Heeter (1995) found that involvement (made up of the items "fun," "exciting," "competitive," "addictive," and "intense") was the highest rated (8.7 out of 10) of several factors. Although part of the involvement effect is likely due to the interactive, and therefore active rather than passive, nature of high-presence media, there seems to be more at work. Individuals who have "passively" viewed an IMAX film can confirm that this effect of presence is not limited to interactive media. Obviously involvement also depends on the media content and the interests and experiences of the user. Involvement can occur in practically any setting or environment and with regard to a variety of activities or events; however, the amount of involvement will vary according to how well the activities and events attract and hold the observer's attention (Witmer, 1998).

4.3 Immersion

According to Witmer (1998), "Immersion is a psychological state characterized by perceiving oneself to be involved by, included in, and interacting with an environment that provides a continues stream of stimuli and experiences" (p. 227). When people are fully immersed, they perceive that they are interacting directly, not indirectly or remotely, with the environment. Because of this they feel that they are part of that

environment. In other media than VE, immersion is not common. But though strong identification with a character in a book, movie, or video game some immersion in those media may permit. A VE that produces a greater sense of immersion will produce higher levels of presence. Factors that increase immersion include: isolation from the physical environment, perception of self-inclusion in the VE, natural modes of interaction and control, and perception of self-movement. A VE that effectively isolates users from their physical environment, thus depriving them of sensations provided by that environment, will increase the degree to which they feel immersed in the VE. Typically, a helmet-mounted display (HMD) is instrumental in providing this isolation in a VE. If users perceive that they are outside of the simulated environment and looking in (e.g., while viewing the environment via a CRT display), the immersive aspect is lost, despite being involved through the presentation of a coherent and meaningful set of stimuli. For example, a standard arcade-style video game may lead to high levels of involvement, but have poor immersive characteristics. To the extent that users find interaction with (and control of) a VE awkward, immersion in that VE is reduced. When users interact naturally with a VE, able to both affect and be affected by the VE stimuli, they become more immersed in that environment. Perceiving oneself as moving inside a simulated environment or directly interacting with other entities in that environment will also increase one's sense of being immersed. Immersing people in a simulated environment is what VEs are designed to do, and that is why VEs have the potential to produce presence. High levels of immersion depend on the availability and perception of an encompassing stimulus stream (Singer, 1997).

There are some groups to distinguish with factors that may exert their influence on presence by affecting either involvement, immersion or both. Witmer and Singer (1998) have grouped these factors into the following major categories: control factors, sensory factors, distraction factors and realism factors. Witmer and Singer expect that control factors should affect involvement but not immersion. They believe sensory factors and distraction factors should affect both immersion and involvement. So, the better the experimental design fits with the factors the greater the perceived presence of the individual is.

4.4 Presence and enjoyment

Perhaps the most prominent psychological impact of presence is enjoyment and delight. Technologies that provide a strong sense of presence, including simulation rides, IMAX theaters, and virtual reality entertainment, are increasingly popular with the public and financially lucrative for those who design and market them. The reasons for this popularity seem to go beyond novelty and fad. The experiences these media provide are highly entertaining and, simply put, enjoyable. Hassenzahl et al. (2000) argue for criteria to promote enjoyment, and cite the many approaches that have been taken in an attempt to analyze how computer games achieve this. According to Riva et al. (2003), the purpose of being " there" in an environment has at least two reasons: entertainment and training. In the case of entertainment, people seek to experience for enjoyment something that they cannot or usually do not encounter in the real world. There is remarkably little research available concerning the effect of presence on enjoyment, perhaps because we tend to take this effect for granted. In one study (Heeter, 1995),

however, users of a virtual reality entertainment system reported that they enjoyed the experience and those who said they felt they had "entered another world" reported significantly greater enjoyment.

4.5 Measuring presence

A growing number of scholars have defined and attempted to measure "presence": Witmer-Singer, SUS, ITC-SOPI, as well as questionnaires specific to experiments, environments, and content. However, there is no standard technique or instrument for measuring presence responses. Most questionnaires have participants rate their responses to each question on a numerical scale, though some have examined free response questions. The ITC-SOPI questionnaire is an attempt at creating a questionnaire valid across media and content. This questionnaire attempts to measure presence by examining factors thought to underlie a person's sense of presence. Over 600 people completed the ITC-SOPI following an experience with one of a range of non-interactive and interactive media (Lessiter, Freeman, Keogh, & Davidoff, 2001). Exploratory analysis (Principal Axis Factoring) revealed four factors: 1. 'Sense of physical space', 2. 'Engagement', 3. 'Ecological validity', and 4. 'Negative effects'. Preliminary analyses have demonstrated that the measure is reliable and valid, but further, more rigorous testing of the ITC-SOPI's psychometric properties and its applicability to interactive virtual environments are required. While the development of the ITC-SOPI is still in progress, subject to satisfactory confirmatory analyses it will offer researchers using a range of media systems a tool with which to measure four facets of a media experience that are putatively related to presence.

4.6 To summarize

The theory confirms the fact that presence leads to enjoyment. Enjoyment is exactly the experience that is being tried to achieve in our fitness application using presence. To create presence, involvement, immersion and flow are factors that are necessary for experiencing enjoyment and presence. Where involvement in a VE depends on focusing one's attention and energy on a coherent set of VE stimuli, immersion depends on perceiving oneself as a part of the VE 'stimulus flow'. By 'stimulus flow' we mean the dynamic stream of available sensory inputs and events that are both influenced by those activities. A valid measure of presence should address factors that influence involvement as well as those that effect immersion. Though the factors underlying involvement and immersion may differ, the levels of immersion and involvement experienced in a VE are interdependent. That is, increased levels of involvement influence users to experience more immersion in an immersive environment and vice versa.

This chapter explains why the experiment is set up in a particular way, describes what the design of the experiment looks like. What kind of subjects were suitable to participate, what kind of questionnaires were used and why, etcetera.

5. Method

According to the theories, the presentation of the factors presence and coach might lead to an increase of the intrinsic motivation. Now that these several factors have been explored that might contribute to a successful application, it is time to translate these theories into an experiment that can test if the factors really contribute to an increase of intrinsic motivation.

The hypothesis of this study is that the intrinsic motivation of people will be increased when, during the physical exercise: the user has the experience of presence and when the user gets biofeedback. In chapter 2, the factors were discussed that could contribute to an increase of intrinsic motivation; presence and feedback. So the two questions of this thesis are:

1. Will the intrinsic motivation of the user increase when the user is immersed in a VE during the physical activity?
2. Will the intrinsic motivation of the user increase when the user gets feedback from a virtual coach during the physical activity?

Intrinsic motivation is the most important dependent variable. To provoke the dependent variable presence, the independent variable VE is offered to the subjects. From chapter 2, it appears that another dependent variables that is relevant to VE and feedback, is: enjoyment and presence. The attention the subject gives to the screen is a measure for the interest in the given stimuli. The mean velocity is a measure for the intensity the subjects provide. This will also be seen as a dependent variable and will also be taken into the experiment (see figure 5.1). The experiment will be set up as follows:

Independent variables:	- VE - Feedback from coach
Dependent variables:	- Intrinsic motivation - Enjoyment - Immersion - Attention to the screen - Mean velocity

There are two independent variables that can be presented. This results in totally four conditions, which gives 4 sessions:

- A session without VE and without coach;
- A session without VE and with coach;

- A session with VE and without coach;
- A session with VE and with coach.

To measure the attention the subjects give to the screen, cameras will be used. Questionnaires will be used to measure the intrinsic motivation, fun and presence. The four sessions will be done after each other, which gives a within-subject design. All possible orders of the sessions (24 different session ordering) will be evaluated, because the counter-balancing method will be used to prevent order-effects. This leads to 24 subjects, every subject gets a unique session ordering.

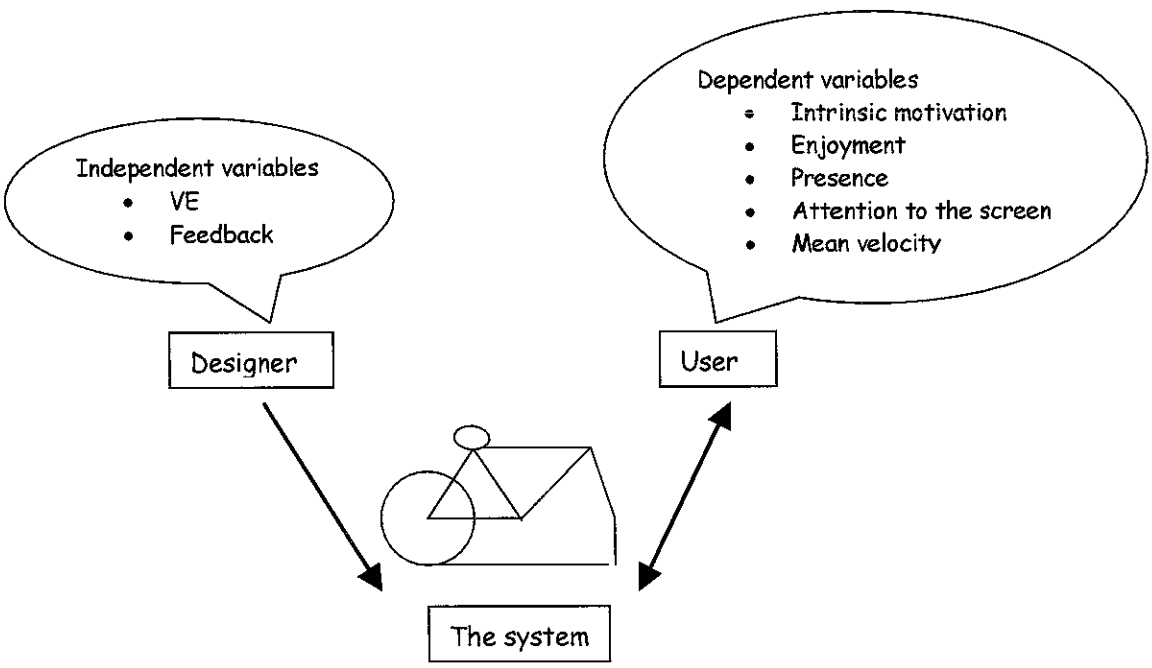


Figure 5.1 Conceptual model

5.1 Subjects

Twenty-four participants took part in the experiment: thirteen males and eleven females between 22 and 58 years of age (M = 43.3, SD = 10.2 for men; M = 39.2, SD = 11.8 for women). They participated for so-called PCI-points (a save system for Philips colleagues) or for a small present. Twenty-two of the participants were recruited from the Philips Natlab and the other two were acquaintances of another participant. Individuals that have a physically active life, have already a high intrinsic motivation at one's disposal. Because the greatest differences are expected with subjects who have a low intrinsic motivation, a requirement of participation is that the subjects were not having a physically active life. This means that the participants hardly or never sport in there leisure time. Notes were dispersed and a PCI-list of potential subjects was used to collect participants. Under the guise of first comes first serves, the subjects were categorized. Reckon has been taken with the distribution of males and females.

5.2 The environment

The room where the experiment took place was the adults' bedroom of the Homelab. The Homelab is a laboratory that looks like a normal house at the Philips Research Campus in Eindhoven. It is designed for feasibility and usability studies in ambient intelligence. For this experiment, the adults' bedroom contained no bed, which benefits the working space. The room contained two windows and despite the luxaflex that was present in the room, the two windows had to be taped with black paper to ensure the room was dark. Furthermore, the room had a closet, a chair, a small table and a stand up lamp (see picture 5.2 for a photo of the room).

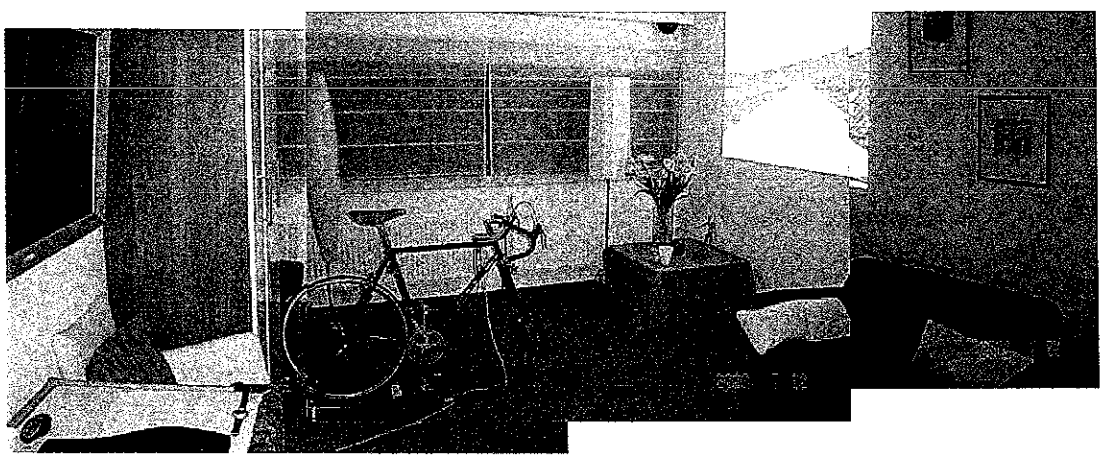


Figure 5.2 Photo of the room

The image was projected against a white wall of the bedroom (see appendix B for a picture of the depicted image). Through addition of a large screen with a virtual world depicted on it, we try to let the individual think he or she is in a different surrounding. The formal feature that has received the greatest attention from researchers concerned with presence is probably the size of the virtual world. Larger images have been shown to evoke a variety of more intense presence-related responses. That is why a big image was created using a beamer (Philips Beamer, cBright XG2i LC 4445). The dimensions of the image were 159 centimeter wide and 111 centimeter in height (see plan of the room, picture 5.3). The beamer was placed on top of the closet that was standing behind the bike. The beamer was aimed so that the horizon of the depicted image was as much as possible equal to the eye height of the subject. Also the beamer was not placed in a way that the subject was occluding in the projected image, so that the subject saw his/her shadow. To create more presence during the activity, the text of the coach was also presented aurally. The volume was at a level as if the coach was standing in front of the subject. The two Philips multimedia speakers 'A 1.2 Fun Power' were placed below the screen on the floor. The speakers were not visible for the subject.

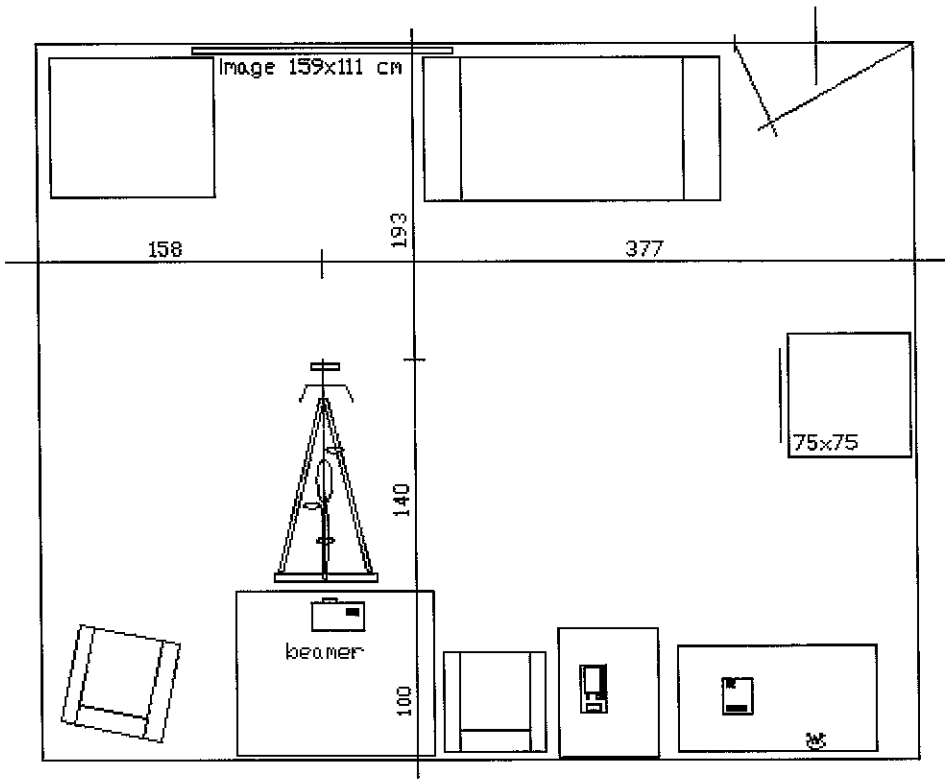


Figure 5.3 Plan of the room

The Homelab has been built with double walls; the rooms have a sort of side room to place some devices like computers. The computers that were necessary to produce the images were placed in a side room, out of sight of the subjects. One computer (DELL Pentium 4, 512 MB) produced the program that was responsible for the virtual environment, and the computer was also responsible for the not-virtual environment/graphic (Graphics Interchange Format (GIF)). A second computer (DELL Pentium 3, 1024 MB) was responsible for the coach. Due to technical reasons the signals had to be converted from SVGA-signal to PAL-signal before sending the images to the beamer. This was realized with the help of two Analog Way® Studioscan XTD 820-R. By means of cables via a so-called floating floor, the images were transported to the Panasonic Production Mixer WJ-MX 50 video mixer. From this video mixer the images could be sent to the beamer and ultimately depicted on the wall.

Cycle construction

The bike that was used for the experiment was standing in front of the closet (see picture 5.2 for pictures of the room and picture 5.3 for plan of the room). The bike was a normal sports bike with fourteen gears, of the brand Colner. The bike was placed on the T1670 Tacx Basic trainings constructions equipped with the T1905 steering wheel frame (http://www.tacx.nl). This gives the opportunity to steer because the front wheel was changed for a kind of joystick that sends the movements of the steering wheel to

the computer. Also, a cycle trainer and a virtual coach were used. This so-called cycle trainer is a steel frame on which the bike was assembled. The frame also contains an Eddy current brake with which the velocity of the subject could be measured. The Tacx trainer is connected to the computer via an USB-interface that can be operated via a device assembled on the steering wheel. The software on the computer is the Tacx T1900 I-Magic software, which is the basic software of the Tacx device.

5.3 Stimuli

Immersion

There were two different tracks. One track was a so-called GIF (Graphics Interchange Format). This is an animating image were the track and a black point was depicted. That black point traveled the track in 6 minutes. During this track there was no VE and no interaction was possible. The second track that the subjects had to cycle was a VE-track. This so-called Gemini track from the Tacx T1900 I-Magic software had a length of 2,6 km. The reason why this track was chosen is because this track is a flat one and it is the shortest track of the program. The short track was chosen to be sure that the whole experiment does not take too long. The track is ellipse shaped and the subjects had to turn left twice. See appendix C for images of the GIF and the VE-track.

Virtual coach

The coach's task was to give feedback to the subjects about their heart rate. Per session, there were six times that the coach gave feedback to the subject. In the beginning when the subjects started cycling she said a sort of welcome word. Every following 60 seconds the coach gave feedback (see appendix D for the sentences the coach gave) according to the subjects' heartbeat (see appendix E for the heart rate zones). The subjects never got the same feedback after each other. The last feedback the coach gave was a well-done word to end the session. See appendix G for pictures of the coach and the texts she could say. The Virtual Coach software was provided by Philips Digital Systems Lab (PDSL) Eindhoven (AIM-team) for use in this study. PDSL has four different virtual coaches. There are four typical characters, two ladies and two men. The most typical fitness instructor was chosen with the most neutral charisma. The coach was originally created using 3D Studio and then converted into a sequence of bitmaps. Visual C++ was used to create an animation out of this bitmap sequence. Originally, the coach had only text in a text balloon. For this experiment, a voice-over was created. A female colleague from Philips spoke the six sentences the virtual coach could say in, in a simple microphone.

5.4. Measurements

Presence questionnaire

There are three factors to measure: presence, motivation, and fun. One way to find out the meaning of the subjects is to fill in a questionnaire. For all the three factors, there are already standardized questionnaires developed. The first questionnaire subjects had to fill in, was the ITC-Sense of Presence Inventory (ITC-SOPI). This questionnaire is a

questionnaire measure whose development has been informed by previous research on the determinants of presence and current self-report measures. It focuses on user's experiences of media - with no reference to objective system parameters. This presence questionnaire had to be filling in immediately after the subjects had experienced the displayed environment. The questionnaire consists out of two parts. One part asks about the thoughts and feelings once the displayed environment was over. The second part refers to the thoughts and feelings while the subject was experiencing the displayed environment.

What do the four factors imply? First of all spatial presence. According to Biocca (1995), spatial presence is the sense of presence within a space. This space can be either a space visited via telepresence or a virtual space that only exists digitally. Examples of questions subjects were asked: "I had a sense of being in the scenes displayed"; "I felt I was visiting the places in the displayed environment"; "I felt that the characters and/or objects could almost touch me". Engagement is the tightness of interaction with the task, rather than the perceptual environment. Examples of questions subjects had to answer are: "I felt involved (in the displayed environment)"; "I enjoyed myself"; "My experience was intense". Naturalness (or "sensory presence", "perceptual realism", "ecological validity", or "tactile engagement) occurs when the person perceives that the objects, events, and/or people the person encounters in the VE look, sound, smell, feel, etcetera as they do or would in the physical world. Examples of questions subjects had to answer are: "The content seemed believable to me"; "I had a strong sense that the characters and objects were solid"; "The displayed environment seemed natural". Aftereffects that result from the user's adaptation to the VE in question are commonly referred as the negative (after) effects. Examples of questions subjects had to answer are: "I felt dizzy"; "I felt disorientated"; "I felt nauseous".

IMI questionnaire

In this experiment, the Intrinsic Motivation Inventory (IMI) has been used to measure motivation (see appendix F for the IMI). The IMI is a multidimensional measurement device intended to assess participants' subjective experience related to a target activity in laboratory experiments. It has been used in several experiments related to intrinsic motivation and self-regulation (e.g., Ryan, 1982; Ryan, Mims & Koestner, 1983; Plant & Ryan, 1985; Ryan, Connell, & Plant, 1990; Ryan, Koestner & Deci, 1991; Deci, Eghrari, Patrick, & Leone, 1994). The instrument assesses participants' interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice while performing a given activity, thus yielding six subscale scores. A seventh subscale has been added to tap the experiences of relatedness, although the validity of this subscale has yet to be established. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation; thus, although the overall questionnaire is called the Intrinsic Motivation Inventory, it is only the one subscale that assesses intrinsic motivation, per se. Because the interest/enjoyment subscale contains items about fun, this Intrinsic Motivation Inventory is also used to find out the amount of fun the subjects experience while cycling. As a result, the interest/enjoyment subscale often has more items (questions) on it than do the other subscales. The perceived choice and perceived competence

concepts are theorized to be positive predictors of both self-report and behavioral measures of intrinsic motivation, and pressure/tension is theorized to be a negative predictor of intrinsic motivation. Effort is a separate variable that is relevant to some motivation questions, so is used in its relevant. The value/usefulness subscale is used in internalization studies (e.g., Deci et al, 1994), the idea being that people internalize and become self-regulating with respect to activities that they experience as useful or valuable for themselves. Finally, the relatedness subscale is used in studies having to do with interpersonal interactions, friendship formation, and so on.

Eyes on screen

When comparing the time per session that was cycled with the time per session that was looked to the screen, the overall percentage of attention to the screen can be calculated. By means of a bicycle computer, the cycled time was measured during the experiments. Using the so-called Philips Behaviour Analysis System, recordings of the experiments were made. For each experiment, two recordings of the test person were made. One camera hung left above the subject so that a clear image of the subject was recorded. The other camera hung diagonally on the other side of the room so that an image of the subject and the depicted track was recorded (see appendix D for a plan of the experimental room). In this way, two recordings were created, with which the times were measured after the experiments. Measurements of the times happened through playing the video recordings and clock the time that the subject looked to the screen with a chronometer. The recordings are of a quality where even the eyes of the subject can be distinguished if they are directed to the screen. This was necessary because it was not a guarantee that the subject actually looked to the screen when they directed his or her head to the screen. Thanks to the good recordings this difference was distinguishable. Because the bicycle computer began to count as soon as the wheel was in motion, time measurements begun with clocking as the subjects began with cycling. As soon as the subject looked to the screen the time was running, every time the subjects' look directed somewhere else, the timer stopped. Through dividing the time looked to the screen through the time that the subject had cycled and multiplying this with 100%, the percentile value of attention to the screen could be calculated.

Time estimation

Two questions' concerning time estimation were added to the questionnaire. With these questions' we tried to found out if there is a difference in time estimation between the different sessions. The subjects had to fill in whether the task took a short time to complete and how long they thought they have cycled. To measure the actual cycle time and mean velocity a bicycle computer was used.

5.5 Procedure

The subjects were already informed about the clothes that they were advised to wear during the experiment. The subjects could come dressed in sport clothes or they had the chance to change clothes before the experiment begun. Before entering the experiment room, the subjects received a chest transmitter that they had to wear. The chest transmitter measures the heart rate and forwards the signal to the heart rate

monitor. When ready, the subjects entered the room and were asked to read the instructions (see appendix H) and ask questions about it. Then, the subjects took place on the bike to adjust the bike to the subjects' wishes. These wishes contained the height of the saddle and the choice of the gear. During the experiment, no changes could be made to the gear because the subjects might be distracted from looking to the screen. Before starting with the first session, the subjects' heart rate in rest was measured. When ready, the subject could begin with the first session. Every subject begins with cycling according to the unique order of sessions. After cycling the first session, the subjects had to fill in a questionnaire. This questionnaire was lying on a table, which was put down in a way that the subject was sitting with the back to the cycling position. This was of importance to allow the experimentator to start the next session without giving the subjects the possibility to look. To make sure the subject had enough light for filling in the questionnaire, a desk lamp was placed on the table. While filling in the questionnaire, the subject could take a rest and take a drink. Filling in the questionnaire for the first time would take about twenty minutes, because an extra form had to be filled in. Also the subject had to read the questionnaire instructions the first time, as the questionnaires were equal in each session.

Each session consisted of cycling and filling in a questionnaire (see figure 5.2 for the procedure of the experiment). All together, there are four sessions, which were done

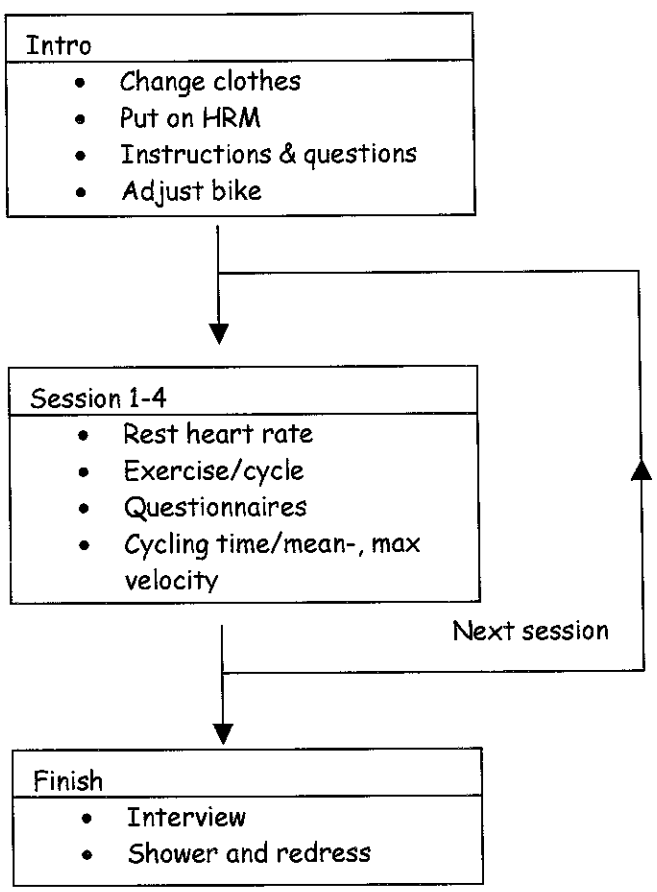


Figure 5.2 Procedure of the experiment

consecutively. Every time before starting the next session, the heart rate in rest was measured. That was directly after filling in the questionnaire. In this way a comparison can be made with the different heart rates to look if there is an effect of tiredness. An effect of tiredness could be of influence on the cycling performance. After every session, exercise/cycling time, mean velocity and maximum velocity were measured and noted with the help of the Cateye Velo 7 bike computer, model CC-FR7. Once the four sessions were done, a last interview was held with the subjects to give them the opportunity to ask and tell them about the coach, the bike, the questionnaires, the virtual environment and the experiment entirely. By doing this, conclusions can be made about certain questions which subjects did not understand or about the experimental design. After the experiment the subjects have the opportunity to take a shower. The whole experiment per subject will last maximum one and a half hour. This is excluding of taking a shower after the experiment.

After executing the experiment, rough data remains. These data need to be processed and analyzed before conclusions can be drawn.

6. Results

Analyzing the data was done with the help of the statistical program SPSS and the spreadsheet program MS Excel. Factor analysis was performed and correlation tests were done with SPSS. First, the presence and IMI questionnaires were analyzed to find significant differences in intrinsic motivation. The ITC-SOPI is a validated questionnaire that has been used more often, so the existing factors were used (a factor analysis was done in order to look if the factors that are given by the questionnaire corresponded to the factors from the executed factor analysis; similarities were found and in general they appeared to agree). The following factors are present: spatial presence, engagement, ecological validity and negative effects. In order to look whether there exist significant differences between the different averages, and because there are more than 2 variables, a full factorial ANOVA with a .05 significance level was executed. Second, the 'eyes on screen' time was analyzed, as it is interesting to find whether there is evidence to distinguish that one has looked to the screen more often in a particular session.

6.1 IMI questionnaire

The questionnaires consisted out of questions, which are to be categorized in the categories: interest/enjoyment, perceived competence, effort/importance, pressure/tension, perceived control and value/usefulness. The questionnaires for the sessions with coach contained some extra questions about the category relatedness. Because it is a validated questionnaire that has been used more often, the existing factors were be used (a factor analysis was done in order to look if the factors that are given by the questionnaire correspond to the factors from the executed factor analysis; similarities were found and in general they appeared to agree).

Interest/enjoyment

When looking to figure 6.2, a clear difference is noticeable between the sessions without VE and the sessions with VE. The interest/enjoyment is much higher at the VE session, in comparison with the session without VE. A univariate analysis of variance turned out that the VE factor brings up a significant difference in the interest/enjoyment factor ($F(1,92) = 40.726$, $p=.000$). This means that there is a difference between the sessions without VE and with VE. The coach has no influence on the factor. Further, no interactions were found.

Perceived competence

Looking to figure 6.2, it can be seen that the subjects had a small increase of perceived competence in the sessions with VE. A univariate analysis of variance turned out that the VE factor brings up a significant difference in the perceived competence factor ($F(1,92) = 5.310$, $p=.023$). This means that there is a difference between the sessions

without VE and with VE. The coach has no influence on the factor. Further, no interactions were found.

Effort/importance

Figure 6.2 shows that there are small differences between the different sessions. A univariate analysis of variance turned out that no factor brings up a significant difference in the effort/importance factor. This means that for all the sessions, the coach as well as the VE had no influence on the factor. Also, no interactions were found.

Pressure/tension

It appeared that the subjects felt less pressure and tension with the presence of the coach (see figure 6.2). A univariate analysis of variance yielded that the coach factor brings up a significant difference in the pressure/tension factor ($F(1,92) = 33.079$, $p=.000$). This means that there is a difference between the sessions without coach and with coach. The VE has no influence on the factor. Further, no interactions were found.

Perceived control

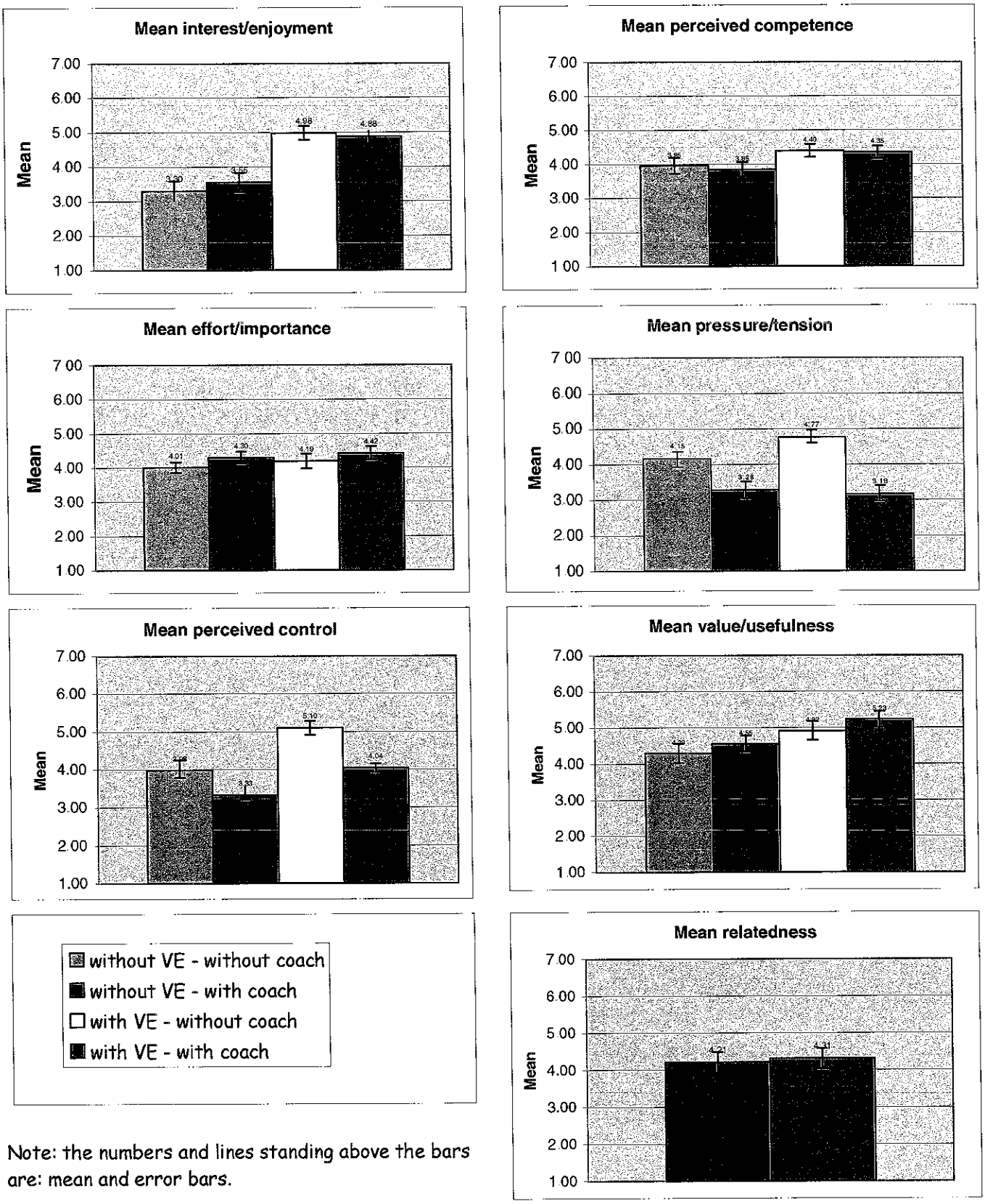
A univariate analysis of variance turned out that both the VE factor ($F(1,92) = 19.328$, $p=.000$) and the coach factor ($F(1,92) = 16.793$, $p=.000$) brings up a significant difference in the perceived control factor. This means that there is a difference between the sessions without VE and with VE and between the sessions without coach and with coach. It appears that the subjects perceive to have more control during the VE sessions and less control when the coach is present. Further, no interactions were found.

Value/usefulness

A small upward trend is noticeable when looking to figure 6.2. A univariate analysis of variance turned out that the VE factor brings up a significant difference in the value/usefulness factor ($F(1,92) = 7.095$, $p=.009$). This means that there is a difference between the sessions without VE and with VE. The coach has no influence on the factor. Further, no interactions were found.

Relatedness

This question was only asked for the sessions with the coach and no significant differences between the sessions without VE and with VE were found by the univariate analysis of variance.



Note: the numbers and lines standing above the bars are: mean and error bars.

Figure 6.2 Results of IMI questionnaire

6.2 Presence

Spatial presence

When looking to figure 6.1, a clear difference is noticeable between the sessions without VE and the sessions with VE. The spatial presence is much higher at the VE session, in comparison with the session without VE. At the sessions without VE, a small but insignificant difference is noticeable between with coach- and without coach session. A highly significant effect of VE was found for spatial presence ($F(1,92) = 34.54$, $p=0.000$) such that VE led to higher experience of spatial presence. The coach has no influence on spatial presence. Further, no interactions were found.

Engagement

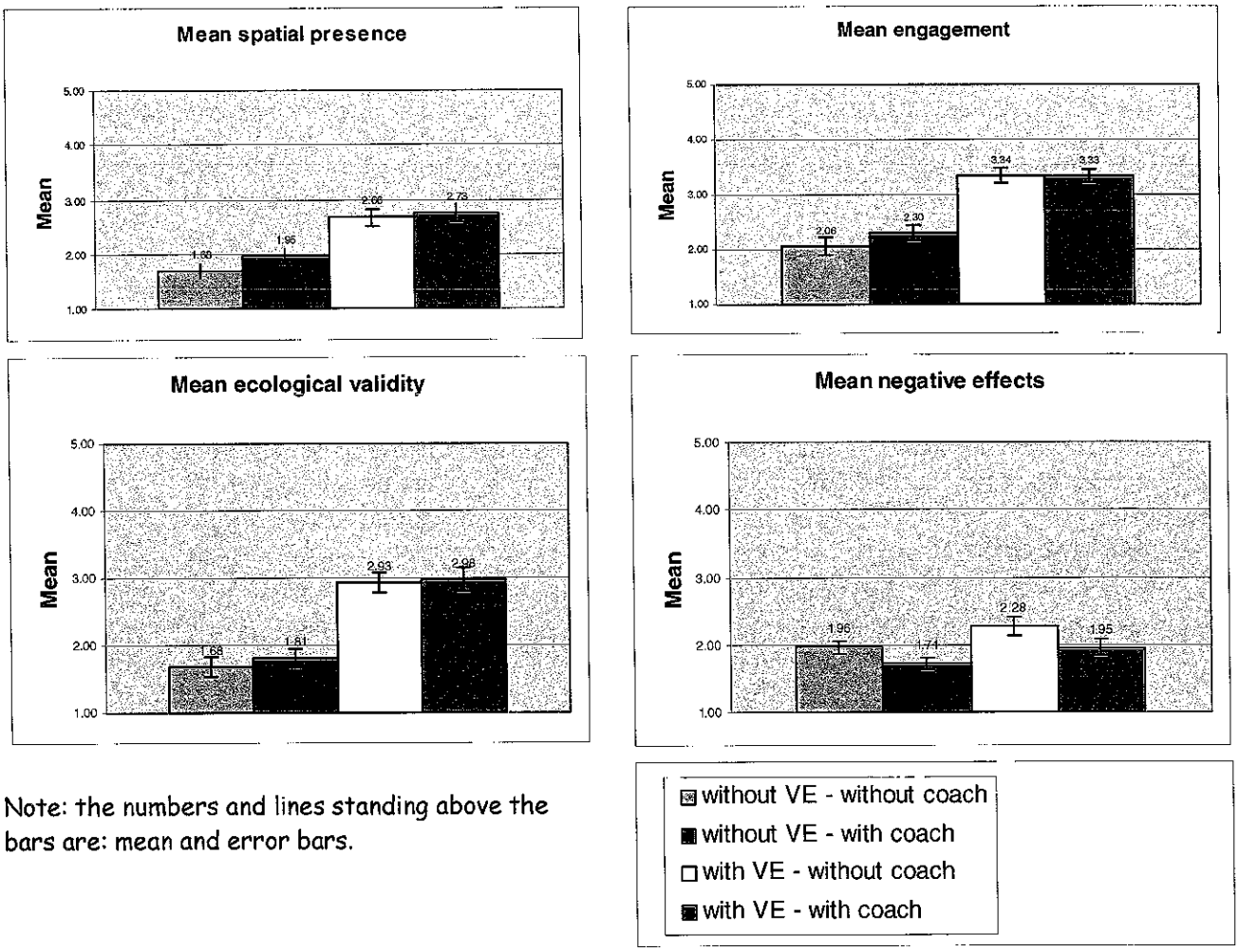
See figure 6.1 for a clear difference between the sessions with and without VE. The engagement is much higher at the VE sessions, in comparison with the sessions without VE. Without VE, a small difference is noticeable between with coach- and without coach session. A highly significant effect of VE was found for engagement ($F(1,92) = 67.719$, $p=.000$): such that VE led to higher engagement. The coach has no influence on the factor. Further, no interaction and significant differences were found.

Ecological validity/naturalness

Equal to spatial presence and engagement, we see a clear difference between the sessions without VE and the sessions with VE (see figure 6.1). A highly significant effect of VE was found for the ecological validity/naturalness factor ($F(1,92) = 61.866$, $p=.000$): such that VE led to higher ecological validity. The coach has no influence on the factor. Further, no interactions were found.

Negative effects

Looking to figure 6.1, it can be seen that the subjects experienced less negative effects in the sessions with the coach. Also the negative effects are higher in the VE sessions if compared with the sessions without VE. A significant effect of VE was found for the negative effects factor ($F(1,92) = 5.798$, $p=.018$). This means that there is a difference between the sessions without VE and with VE. Also the coach has influence on the factor. It turned out that the coach factor also brings up a significant difference in the negative effects factor ($F(1,92) = 6.092$, $p=.015$). With coach the negative effects are significantly smaller. Further, no interactions were found.



Note: the numbers and lines standing above the bars are: mean and error bars.

Figure 6 1 Results presence questionnaire

6.3 Other measurements

During the experiment some other variables were measured: eyes on screen, the heart rate, the time the subjects have cycled, the average cycling velocity and the maximal cycling velocity (see figure 6.4). With these data, it can be looked if there is a matter of tiredness phenomenon, and a comparison can be made between the subjective time and the real time the subjects have cycled.

Eyes on screen

During the experiment, the time that the subjects were looking to the screen was a measured variable. The expectation is that subjects will look more of the cycled time to the screen, as the screen becomes more 'rich'. This means that the 'eyes on screen' is expected to be less in the 'without VE - without coach' session compared to session 'with VE - with coach'.

From a Univariate Analysis of Variance and from the table with the percentile values (see figure 6.3) can be seen that there is a clear and significant difference between the two sessions without VE and the two sessions with VE ($F(1,91) = 174.10$, $p=0.000$). With VE, subjects looked at the screen almost all of the time; the means of the sessions with VE are nearly 100%. During the session without VE the subjects watched approximately half of the cycling time to the screen.

	without VE - without coach	without VE - with coach	with VE - without coach	with VE - with coach
mean	48%	57%	98%	95%

Figure 6 3 Percent eyes on screen

Heart rate

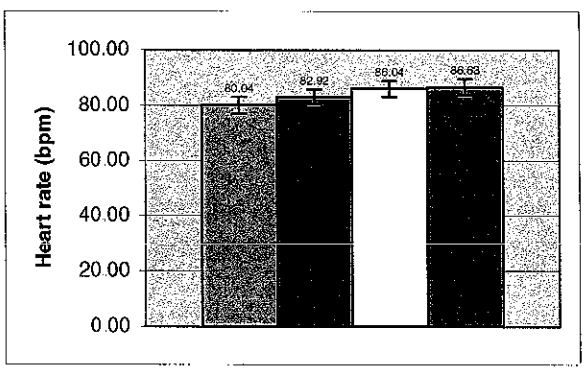
As can be inferred from figure 6.4, no significant differences were found between the different sessions. This means that on average subjects started each condition equally rested which underlines the validity of the condition order in the test set-up.

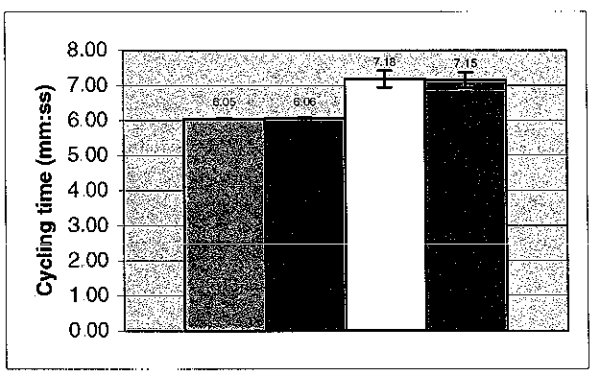
Average velocity

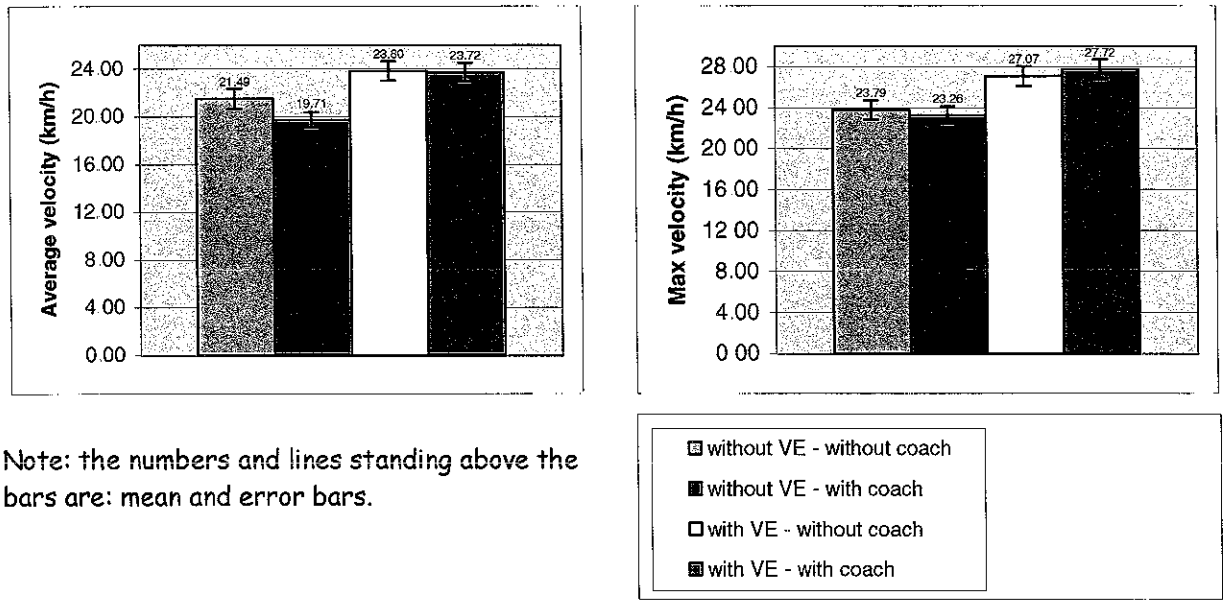
Figure 6.4 shows that there is a difference in average velocity between the sessions without VE and the sessions with VE: the average velocity in the sessions with VE is higher in comparison to the sessions without VE. This is confirmed by a univariate analysis of variance ($F(1,92) = 16.370$, $p=.000$). VE has a significant effect on the average velocity. Striking is the considerably but insignificantly lower average velocity in the session 'without VE – with coach'.

Maximum velocity

The univariate analysis of variance confirms that VE increases the maximum velocity ($F(1,92) = 17.360$, $p=0.000$).







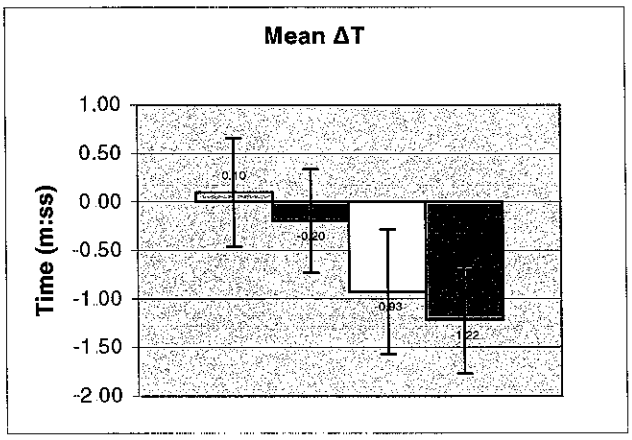
Note: the numbers and lines standing above the bars are: mean and error bars.

Figure 6.4 Heart rate, cycling time, mean velocity and maximal velocity

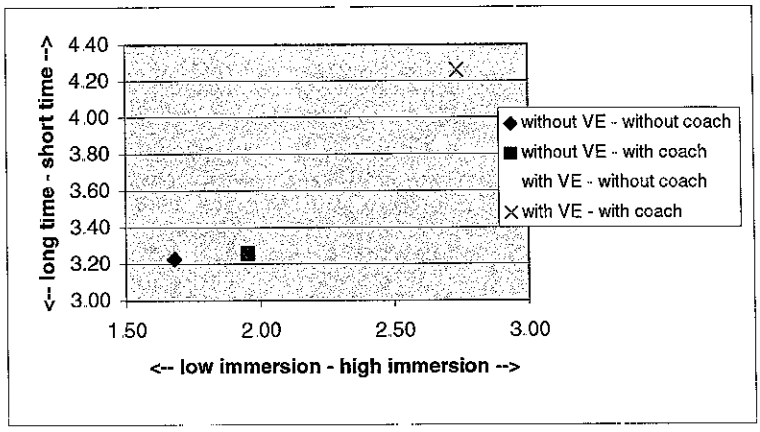
Estimated time

That there are differences between the cycling times is not a surprise. The session without VE existed out of a "GIF", which had a fixed time, so logically the cycling time for the sessions without VE is the same. The only significant difference that was found is between the sessions without VE and with VE. A univariate analysis of variance confirms this ($F(1,92) = 46.162$, $p=.000$). Two questions where added concerning estimated time. One question was about the awareness of time while cycling: "The task took a short time to complete". The second question was about how long the subjects thought they had cycled: "How long do you think you have cycled? (In minutes and seconds)".

Results are shown in figure 6.5, where it can be seen that the differences in estimated times between any sessions are small. This despite the fact that the actual times between without VE and with VE differs about one minute (see figure 6.4). Striking is that the subjects estimated all sessions of equal length, while the VE-sessions lasted a minute longer. When subtract the time the subjects have cycled from the estimated time, we get the delta-time (ΔT) (figure 6.5). This value is the most interesting of these questions. A univariate analysis of variance results in insignificant differences between the different sessions, for both presence ($F(1,92) = 0.023$, $p=.880$) and coach ($F(1,92) = 0.281$, $p=.597$). What does results in significant differences between the different sessions for the "the task took a short time to complete"-question is VE ($F(1,86) = 10.85$, $p=.001$) (see figure 6.5).



Note: the numbers and lines standing above the bars are mean and error bars.



Note: the higher the value for time estimation, the shorter the task took to complete.

Figure 6.5 Estimated time

6.4 Correlations

Pearson's correlations were run between all the presence- and motivation factors. Also the average velocity and the estimated time factor were included. Three presence-related scales were strongly positively intercorrelated, negative effects smaller but still significant (spatial presence and engagement: $r = 0.829$; $p < 0.01$; spatial presence and ecological validity: $r = 0.868$; $p < 0.01$; spatial presence and negative effects: $r = 0.381$; $p < 0.01$; engagement and ecological validity: $r = 0.851$; $p < 0.01$; engagement and negative effects: $r = 0.328$; $p < 0.01$; ecological validity and negative effects: $r = 0.440$; $p < 0.01$). Three out of the four presence-related scales were strongly positively correlated with the factor interest/enjoyment (spatial presence and interest/enjoyment: $r = 0.757$; $p < 0.01$ (see figure 6.6); engagement and interest/enjoyment: $r = 0.832$; $p < 0.01$; ecological validity and interest/enjoyment: $r = 0.679$; $p < 0.01$). Negative effects did not correlate with interest/enjoyment ($r = 0.182$; n.s.), but did correlate with pressure/tension ($r = 0.371$; $p < 0.01$). Another interesting positive correlation is found between time estimation and spatial presence ($r = 0.260$; $p < 0.05$) and time estimation and interest/enjoyment ($r = 0.306$; $p < 0.01$).

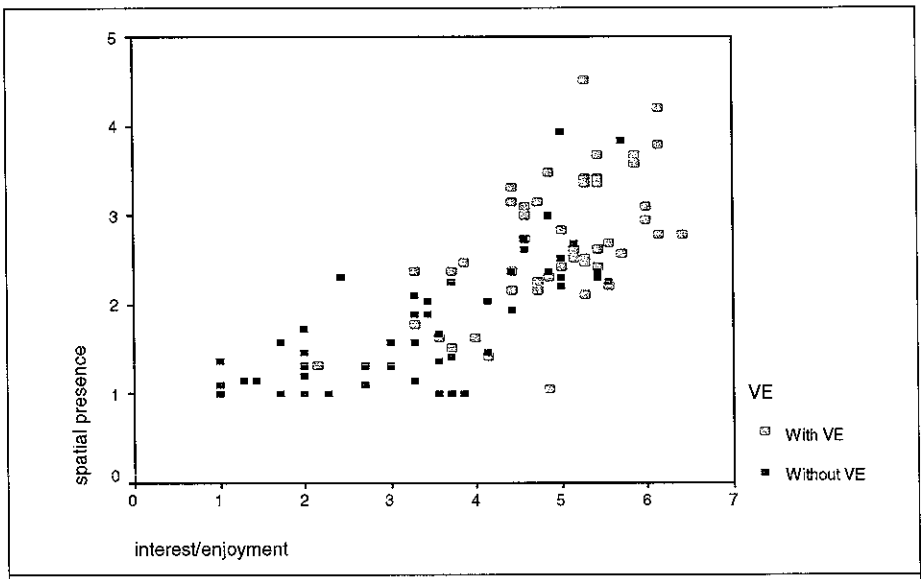


Figure 6.6 Scatter plot: spatial presence - interest/enjoyment

6.5 To summarize

In the table below an overview is made of the effects of VE and the coach on the different factors. For all cases no interactions between VE and the coach were found.

	Factor	Immersion		Coach	
Presence	Spatial presence	+	p=0.000		
	Engagement	+	p=0.000		
	Ecological validity	+	p=0.000		
	Negative effects	+	p=0.018	-	p=0.015
Motivation	Interest/enjoyment	+	p=0.000		
	Perceived competence	+	p=0.023		
	Effort/importance				
	Pressure/tension			-	p=0.000
	Perceived control	+	p=0.000	-	p=0.000
	Value/usefulness	+	p=0.009		
	Relatedness				
Other	Heart rate				
	Average velocity	+	p=0.000		
	Maximal velocity	+	p=0.000		
	Δ time				
	Eyes on screen	+	p=0.000		

+ : VE or coach has a significant increasing influence on factor
- : VE or coach has a significant decreasing influence on factor (although this may be a positive effect)

From the presence questionnaires, it can be concluded that the VE has a positive effect on/increases the factors: spatial presence, engagement, ecological validity and negative

effects. From the presence questionnaires, the coach has a negative effect on/reduces the factor negative effects. From the motivation questionnaires, it can be concluded that the VE has a positive effect on/increases the factors: interest/enjoyment, perceived competence, perceived control and value/usefulness. From the motivation questionnaires, the coach has a negative effect on/reduces the factors: pressure/tension and perceived control. From the other factors, it can be concluded that only VE has an effect on the factors. It is a positive effect on/increases the factors: average velocity and maximum velocity. No significant differences were found by the dependent variable effort/importance, relatedness, heart rate and Δ time.

In this chapter, the results from among other things the questionnaires, user comments and the eyes on screen measure will be discussed. A critical look will pass over the resulting data and in the end conclusions can be drawn and recommendations can be made

7. Discussion and conclusion

7.1 Effects of VE on motivation and presence

The first hypothesis was that the intrinsic motivation, especially interest and enjoyment, of the user increases when the user is immersed in a VE during activity. Results of the IMI-questionnaire confirm this hypothesis in this experiment. In addition, from the results of the presence questionnaire, we found that VE has a positive effect on presence. This is in line with the literature in chapter 4, which confirms that presence leads to enjoyment and it is the enjoyment that is associated with intrinsic motivation. The experience of spatial presence, engagement and ecological validity are significantly higher for the sessions with VE. These results are in line with earlier results found in the presence literature, discussed in chapter 4, that enhancing the extent and fidelity of sensory information offered to participants will increase their sense of presence. Correlations between interest and enjoyment and each of the factors spatial presence, engagement and ecological validity are strong and positive. This suggests a relation between presence and motivation. When presence is experienced, this will lead to a higher motivation. This corresponds with the results of an experiment done by J. Porcari (1998) that VE or interactive exercise equipment may provide the type of feedback and enjoyment necessary to help some people not only stay with an exercise program, but to reap greater benefits once they get started.

7.2 Effects of the coach on motivation and presence

Contrary to expectations, we found that the coach did not have a direct influence on interest and enjoyment, which is considered the most important measure of intrinsic motivation. However, when looking at the pressure/tension factor of the IMI questionnaire we see that pressure/tension is significantly less during the sessions with coach, which is good. When looking to the four presence factors, the coach only results in less negative effects. One interpretation of these results could be that the subjects see the coach as independent from the virtual environment, thereby drawing their attention away from the VE and thus preventing potential negative effects such as getting a headache, feeling dizzy or feeling disorientated. It further appears that there is a significant positive correlation between negative effects and pressure/tension. This correlation is not so strange because these are both negative experiences of the subjects.

Also the presence of the coach lowered the perceived control dimension of the IMI. This was not in line with our expectations as we hypothesized that control would increase with feedback. This could be due to the fact that the coach gives 'commands'

like "cycle faster!" to the subjects from which the subjects maybe get the feeling of having to obey these orders.

7.3 Other effects

The two velocity measurements (average and maximum velocity) might be very interesting behavioral indicators for motivation. Significant changes were found: subjects cycle on average faster during the sessions with VE and their maximum velocity is higher. This might be related tot the fact that subjects experience the sessions without VE as the least enjoyable. When the motivation is high, subjects will do one's best, and this might result in a higher average-and maximum velocity. This supports the central finding of this experiment, which is that presenting participants with a VE during a workout on a stationary exercise bike will have a positive effect on their intrinsic motivation, as it heightens the enjoyment of the exercise.

When looking to the estimation of the cycling time, the subjects estimated the sessions as equal in length. The feeling that the task took a short time to complete is much higher in the sessions with VE, despite that the VE sessions took about 1 minute longer to complete on average. Saying "time flies when you are having fun" seems adequate here. When looking to the mean estimated ΔT, the same conclusion can be taken. This is presumably due to the large variation in the ΔT-results. Time estimation appears to be difficult.

Briefly, subjects cycled more and experienced it as less time consuming which benefits the motivation.

7.4 Recommendations

In this experiment the coach was depicted as part of the screen (see appendix G). To optimize the impact of VE, the environment could be depicted bigger. In that case a higher immersion is expected to be caused. So, when the depicted VE will be larger and the coach will be depicted at the side of the screen, then the experience of presence might probably be even higher and according to the results of this thesis that might result in an increase of the motivation. Maybe other variables like the combination of exercise and computer games instead of presenting VE will also lead to enjoyment.

A coach that would give more neutral 'commands' would possibly score better on 'perceived control'. To find out to what extent these different effects have an impact, further research has to be done where the directivity, frequency, commands, of the coach's feedback and appearance of the coach itself is varied which should affect the perceived control dimension.

7.5 To summarize

The overall conclusion in the end is that presenting home fitness users with a VE that provides feedback on their activity has a strong positive effect on their intrinsic motivation. Three of the four factors of the presence questionnaire have a strong

positive correlation with the interest/enjoyment factor of the IMI questionnaire. VE has an increased effect on the following factors:

From the presence questionnaire:

- Spatial presence;
- Engagement;
- Ecological validity.

From the IMI questionnaire:

- Interest/enjoyment;
- Perceived competence;
- Perceived control;
- Value/usefulness.

Others:

- Average and maximum speed.

Another conclusion is that three of the four factors of the presence questionnaire have a strong positive correlation with the interest/enjoyment factor of the IMI questionnaire. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation.

The coach has no influence on motivation (interest/enjoyment), but appears to have a relaxing effect on the subjects, because it reduces pressure and negative effects. On the other hand, the coach resulted in for less control in the activity. So, it can be concluded that the coach reduces:

- Negative effects;
- Pressure/tension;
- Perceived control.

So, the four main conclusions that can be made are:

- VE has a positive effect on motivation;
- VE increases presence;
- The coach reduces pressure and negative effects;
- The coach decreases perceived control.

Acknowledgements

Though it is my graduate project, the design of the new fitness application is accomplished by the knowledge of several experts. I would thank the people of the Natlab, in special dr. ir. Marko de Jager and dr. Joyce Westerink. They give me the information and motivation to bring this to a good end. Furthermore, thanks to drs. Wijnand Ijsselsteijn and dr. ir. Yvonne de Kort for their critical view on the project.

Further my thanks go out to the AIM-team of PDSL Eindhoven, in special Rohan Lobo for using and modifying their virtual coach, Jan van Herk for knowing the right persons, Vic Teeven for making it possible to use the Homelab, Jettie Hoonhout for lending me her funquest, and last but not least my subjects. Without them it never could succeed.

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Appendix A - target group

Which target group will be interested in the fitness application and which target group will find benefit by the fitness application? Before we can design a fitness application, these questions have to be answered. The target groups are those people who would like to use the fitness application. Another target group can also be the people who use common fitness applications at the moment.

A. Target group

The target groups can be defined according to purpose of the fitness application. This purpose has already been described: by means of the fitness application the pleasure, the presence and ultimately the motivation of doing physical exercise will be tried to increase. It may be clear at first that the application is not developed for people that have already a high motivation to do physical exercise. The target groups are mainly those people with a motivation that is not high enough to fulfill the minimal weekly physical exercises.

A.1 Less physical activity

Since industrialization, we have gradually been working to make physical labor redundant. Now we are slowly beginning to realize that some kind of physical activity is still needed. It almost looks like physical activity is turning into a luxury thing. As if physical activity is for those who have the time (Galema, 1997). In general people do not move enough. Physical inactivity is currently acknowledged as a serious public health burden throughout the industrialized world (US Department of Health & Human Services, 1996; Villeneuve, Morrison, Craig, & Schaubel, 1998; World Health Organization, 1997). Our physical activity is too low. Several studies have confirmed this (CBS webmagazine (29 mei 2000), Bauman (2001)). According to the GBW (Centrum GezondheidsBevordering op de Werkplek) the standard is at least five (but preferably all) days a week thirty minutes of moderate intensive movement. Moderate movement is for example like cycling with a speed of at least sixteen kilometers per hour. Many organizations agree with this (e.g. World Health Organization (WHO), Nederlandse Norm Gezond Bewegen; NNGB)).

Approximately 30% of the Dutch population is physical inactive. Almost half of the Dutch population is physical active, but does not reach the norm. The other 20% of our fellow countrymen is doing physical exercises for at least 30 minutes during five days a week (see figure a.1). It is generally known that insufficient physical exercise leads to "prosperity-diseases". The risk to get cardiac-and vascular diseases, depressions, osteoporosis, geriatric diabetics, low back trouble, high blood pressure, stroke and overweight will increase fast. Doing sufficient exercises and sports will on the other hand increase the mental condition, the alertness and introspection. The defense against diseases, the stamina, muscle power, blood pressure en heartbeat get better.

Attention paid to the dangers that coincide with a lifestyle without body movement, our public health is worrisome (Trendrapport Bewegen en Gezondheid 1998-1999). The latest Trendrapport Bewegen en Gezondheid 2000-2001 conforms these data, which means that nothing has changed during the past decade.

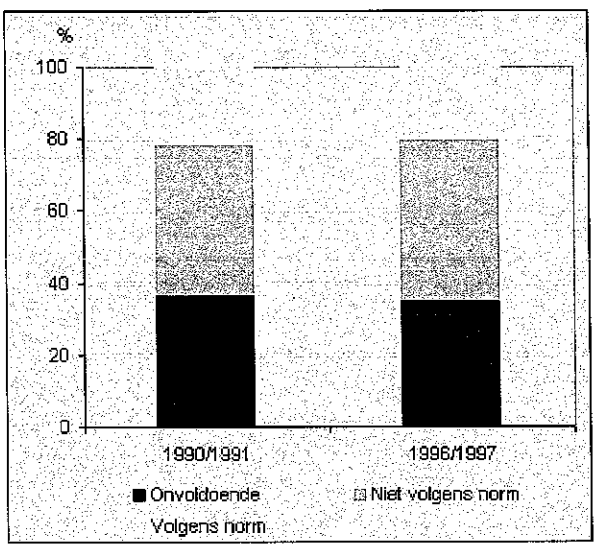

Figure a.1: physical exercise

In the previous decade the percentage adults remained high that does not sport or does other forms of physical exercise. Dutchmen have even become something less physically active: the number of compatriots that moves according to the standard between 1990 and 1997 has decreased of 22% to 20%. From TNO investigation it appears in addition that 12% of the Dutch (approximately 2 millions people) even not obtain one day the 30 minutes body movement that is according to the standard. Research of the Free University Amsterdam indicates that especially young people do less and less body movement.

According to most of the literature half of the Dutch population does not reach the norm, which is worrisome!

A.2 Reasons and trends

A lack of drive or motivation to do physical exercise is being present with half of the Dutch population. The people that succeed in complying the norm must have already a high motivation. That motivation has to come from somewhere, which is different for each individual. There can be many reasons why people want to do physical exercise. The motivation is dependent of the individuals' target. From literature examination and interviews with sport instructors of different fitness school, a number of categories can be distinguished. Besides that there are also different training targets, all kinds of fitness and exercises to distinguish. These training targets are the aim that people want to reach by doing physical exercise.

There are many fitness goals. Fitness programs are designed depending on background and future goals. Every fitness program has its own purpose. A combination of strength training, aerobics, core strength and flexibility are utilized to safely and efficiently improve overall health and give each person the opportunity to accomplish personal goals. Some examples of the most important personal goals are: general condition, weight loss and muscle power, but also health improvement for the elderly and revalidation are some of the many different personal goals. In appendix AA is an extensive list of target groups, training targets and all kinds of fitness and exercises. The ultimate goal of the person has to be fulfilled when choosing a kind of fitness. That exercise has to fit with the training target. When using a fitness application to help with reaching the goal, that fitness application has to fulfill the users aim. This can be done on several ways. First of all, the fitness application has to fit with the users' target, which means that the fitness application has to be able to do the exercise what will reach the users' target. Other helping 'hands' could be an exercise program, other people with the same target or a coach. I will get back on this later.

Reasons for exercising

Studies have shown that practically everyone knows that exercise will make you feel better, stronger, healthier and probably even happier. Even so, people remain inactive. Knowledge, then, is not the problem; that battle has been won. It is motivation now that matters. The next reduced list shows different reasons for males and females. Percent of participants of fitness activities, age eighteen and older who said the goal was somewhat to very important (http://www.rebound-aerobics.com/aerobics.htm).

Females:		Males:
1	Weight control (88%)	1 Muscle tone (85%)
2	Feeling good after (87%)	2 Increased energy (83%)
3	Increased energy (86%)	3 Cardio vascular benefits (82%)
4	Muscle tone (84%)	4 Weight control (82%)

From this list there can be concluded that the weight control is generally the most important reason for most people to do physical exercise. This also turns out the result of the interviews with a number of fitness instructors. In total seven fitness instructors were interviewed and the outcomes are very similar to each other. The most given purpose of the visitors of the fitness schools, in fact the reason why people do physical exercise, are:

- Weight control;
- Aesthetics;
- Condition;
- Social contacts.

Two interviews have been conducted within the framework of MTI Design Project Part 2, one with a physical therapist, and one with a fitness instructor. Outcomes of these interviews appreciate the fact that a lot of people go to a fitness school for the social contacts. The physical therapist emphasizes the importance of good motivation to keep up doing physical exercise. The social factor with this is a very important motivational

factor. For the fitness instructor, the social factor is the most important motivational factor. In addition to this, his opinion is that for a home fitness system, to be used frequently, it is necessary that it stimulate the motivation of the user. A questionnaire filled out by twenty students at the Technical University of Eindhoven (MTI Design Project Part 2 (2003) appreciate that most people thought that social contacts form an important part of doing the physical exercise.

To get motivated is an often-mentioned reason why people go to a fitness school instead of doing the exercise by itself. Privation of motivation has been given as the reason why people don't do physical exercises at home. Therefore they go approximately twice a week to a fitness school. With 'they' are mentioned the biggest group of people that visit a fitness school. These are people aged from 20 till approximately 50 years old.

On the other hand also reasons for not doing exercising are present. According to The American Institute of Reboundology, Inc. (1999) these are the four main reasons. Percent of participants of fitness activities, age eighteen and older who said the goal was somewhat to very important (http://www.rebound-aerobics.com/aerobics.htm).

1 No time in my busy schedule!
2 No energy, I'm too tired, lack of discipline
3 Discouraging, not enjoyable
4 Expense of equipment, clothes, memberships

Except the time and money problem, the other reasons have to do with motivation. When manage to chance at least one of the two reasons, this can be a great progress in making physical exercise interesting. The most obvious reason to chance is the third one; make the exercises more fun to do, in order to encourage the person to do physical exercise.

Trends in sporting habits and participation

Why are people doing physical exercise at this moment and what are the trends. According to Jos de Haan and Koen Breedveld (1999) the sport participation in The Netherlands has increased since 1995. A slightly bigger part of the people takes part in two or more sports, but the share of people that sport weekly went down. Compared to 1995, only the solo-play sports grew in size, sports for which, outside formal competitions, no direct adversary has been required. This increase is also to be written at new sports as fitness/aerobics and roller blade/skating. Also the University of Twente sees that individualization is becoming more and more popular. Some examples of sports are: climbing, run disciplines like marathon and triathlon, squash and fitness. Everybody can practice these sports on a moment whenever he or she wants. These in contrast to the team sports by which that freedom is limited because trainings are planned all year through, and because the dependence of a definite number of team members to practice the sport. The individualization translates itself clear in the participation by the various sports. At the moment one on the five students on the University of Twente is in the possession of a fitness card (Beleidsnota Sportraad UT, 2003).

Not only in the Netherlands is the trend of doing physical exercise increasing, but also in other countries a similar trend has been noticed. The following trends come from American Marketing reports. They give some relevant information about how people deal with physical activity in general. This research has been done in America but can be seen as equal as Europe (SMGA, 1996). The trends are:

1. *More Americans will exercise more;*
2. *Over the last two decades there has been a trend towards healthy living, eating right and exercising;*
3. *Older Americans are expected to be the most important consumers of home exercise equipment;*
4. *A trend away from strenuous fitness activities like jogging and high impact aerobics to activities using equipment;*
5. *More efficient and more fun;*
6. *Heart rate training;*
7. *Lighter exercise;*
8. *Emphasis on stretching;*
9. *Efficient calorie burning.*

Like tastes in foods, fashions and popular music, exercise habits have undergone significant shifts in the past decade. Here are key trends uncovered by a national survey that has been conducted every year since 1987 by American Sports Data, Inc., Hartsdale, NY, for the Sporting Goods Manufacturers Association. The study measures participation in some 60 sports, fitness and outdoor activities. Two self-administered questionnaires are sent to a national sample of 15,000 households asking about participation the year before. In 1998, a total of 16,831 usable questionnaires were returned. The sample is then balanced to reflect the population of the 48 contiguous states.

- **Health clubs flourish.** The number of health club members increased from 13.8 million to 22.5 million, a gain of 63%. Fitness facilities have become commonplace in hotels, colleges, corporations, apartment complexes, hospitals, fire houses and police stations.

- **Home exercise habit.** "The growth in health club memberships obviously contributes to the increased use of fitness equipment," said Gregg Hartley, executive director of the Fitness Products Council, a sponsor of the study. "Meanwhile, other research confirms there has been a huge increase in home ownership and use of exercise equipment as well." A 1997 FPC-sponsored survey of 1,600 households found that equipment was owned and used regularly in 32.3 million American homes, almost one-third of the total.

- **Serious exercisers increase.** The number of individuals age six and older who said they participated "frequently" (100 times a year for most activities) in one or more of the fitness activities measured increased from 39.6 million to 47.6 million, a gain of 20%. However, the total population increased about 12% over the study period.

Thus, in 1987, about 18,5% of all those six and over participated frequently in fitness activities; in 1997, 19,75% did so. Many others, of course, participated in sports, outdoor pursuits and other activities.

- **Exercising population ages**. In 1987, 18,49 million frequent fitness participants were aged 35 and older, 47% of all frequent participants. By 1997 the number had risen to 25,94 million, or 54% of the total. "For a growing portion of the population, vanity is no longer the dominant motivation for exercising. Equally important goals are health and quality of life," Hartley said.

- **New exercise forms proliferate**. In 1987, the study measured 12 fitness activities; in 1997 the number had grown to 18. Step aerobics, stair-climbing machines, elliptical cross trainers, cross-country ski machines, aerobic riders and aquatic exercise were in their infancy or had not been invented when the study was first conducted.

"Taken as a whole, the study confirms that the fitness movement has broadened significantly in the past decade, reaching more people in more places," Hartley said. "The inescapable conclusion is that more people are exercising than ever before, but many of them may not be exercising frequently enough to significantly affect their health, weight or appearance." Striking is that more and more people are exercising while it is still not enough according to the norm.

A.3 To summarize

There are still too much people that must do more physical exercise. This huge mass of people can make a profit of new motivational techniques. Considering the enormous offer of different forms of fitness and physical exercise, this has to be managed. Fortunately there is an improvement going on. There is a trend noticeable that the sports world is growing; people do more and more physical exercises. Not only in the Netherlands the trend of doing physical exercise is increasing, but also in other countries a similar trend has been noticed. There are countless of reasons to think of why people most do physical exercise. So the sports world is growing, people do more and more physical exercises, but these characteristics are not noticeable when taking a look to the numbers of people that do physical exercise. Still, half of the Dutch population does not reach the norm. This cannot be due to the offer of fitness or sport schools, considering the trend. So there must be something why people don not manage to reach the norm of physical exercise.

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http://users.pandora.be/thierry.de.rouck/doelgericht_trainen.htm

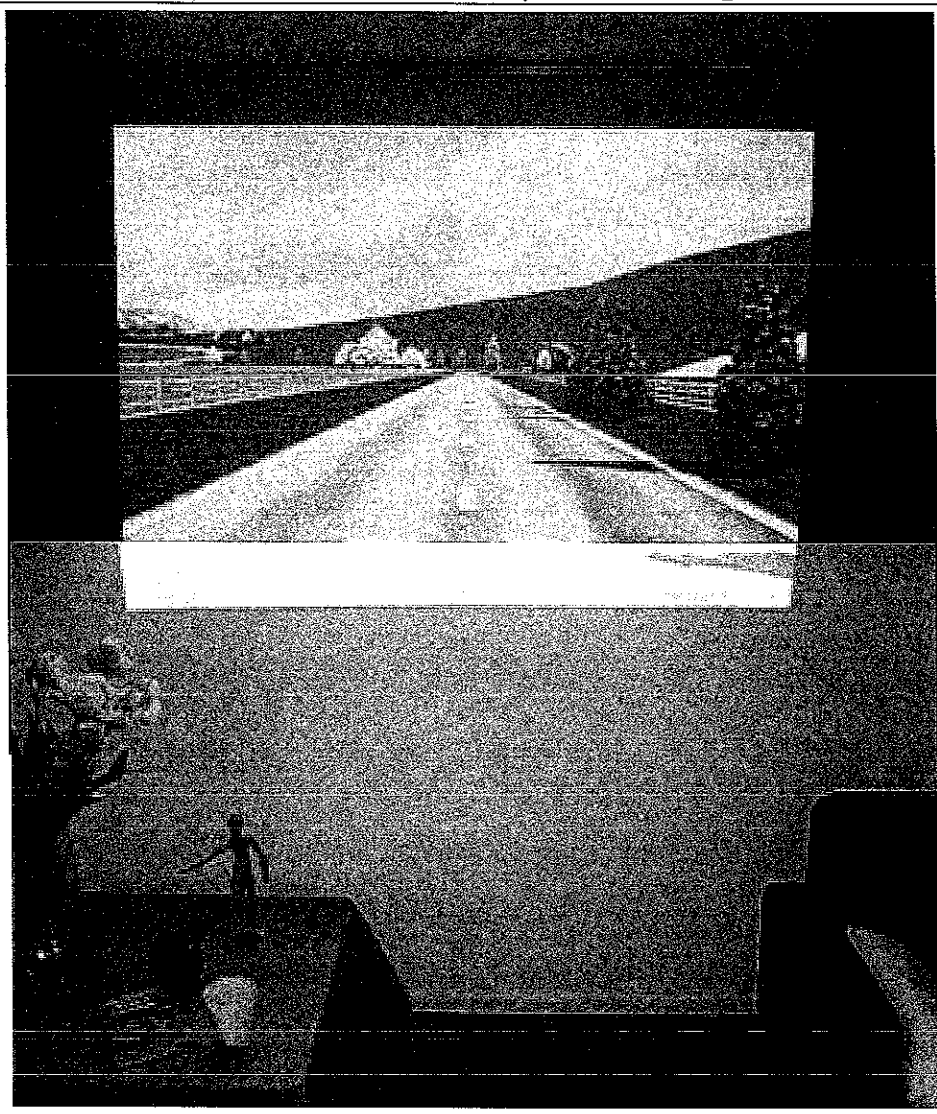
(http://www.rebound-aerobics.com/aerobics.htm).

Appendix AA

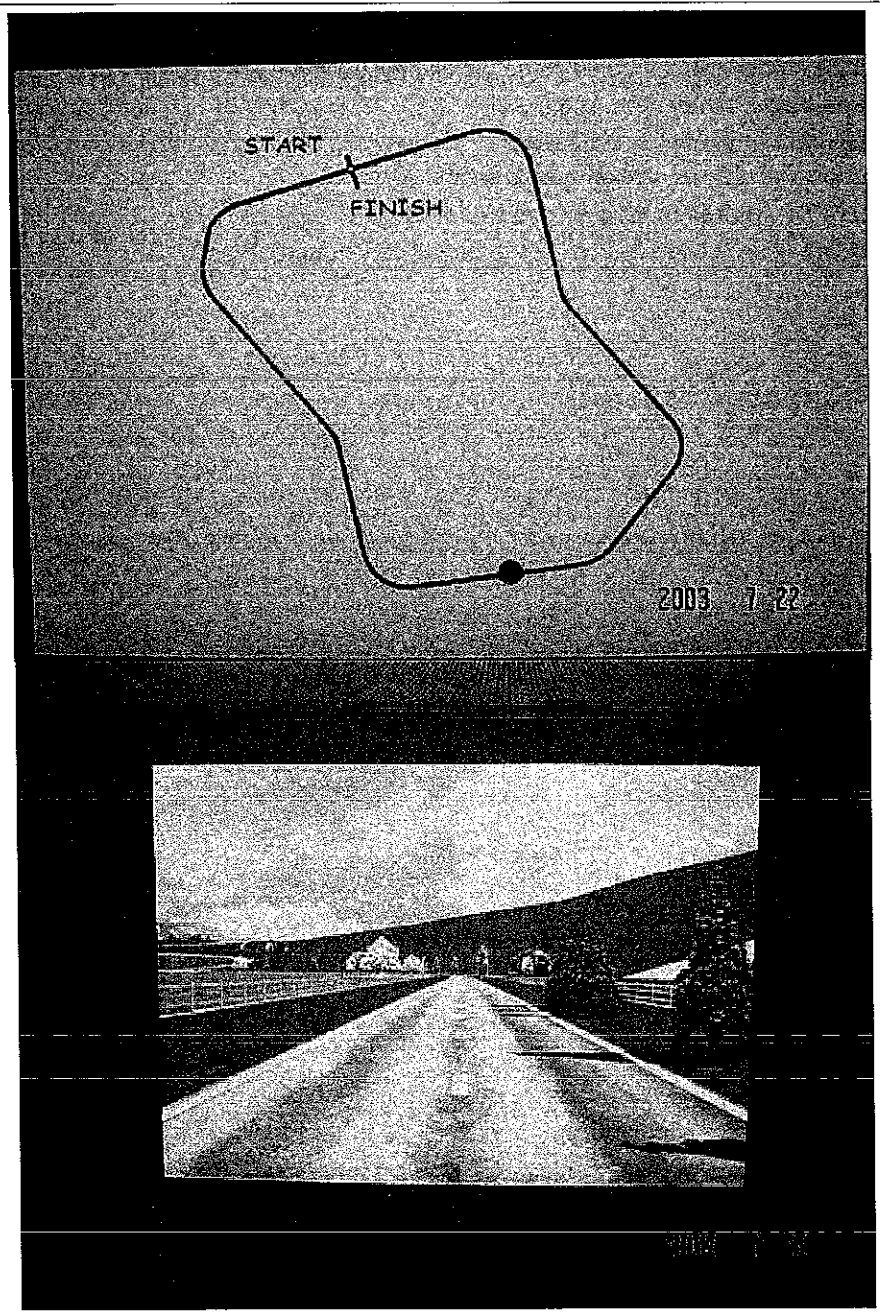
Trainingsdoelen	**Soort fitness – ontspanning**	**Doelgroepen**
Algemene versterking spiergroepen	Algemeen fitness	Bedrijven
Belastbaarheid	Bedrijfs fitness	Bejaarden
Bescherming gewrichten (artritis)	Body balance	Gehandicapten
Bewegingsvaardigheden	Body combat	Gezette mensen
Conditieverbetering	Body pump	Huisvrouwen
Coordinatie	Body sculpting	Jeugd
Estethisch	Cardio fitness	Kinderen
Figuurcorrigerende oefeningen	Conditie training	Mannen
Flexibel blijven	Duur training	Mensen met Chronische ziekte
Gewichtscontrole	Figuurverbetering	Revaliderenden
Goed gevoel aan over houden	Groepstraining	Senioren
Hartfrequentie in rust verlagen	Hi-Lo Aerobic	Volwassenen
Herstel	Individuele training	Vrouwen
Herstel blessure	Jeugd fitness	
Herstel lichaamsklachten	Kracht training	
Kwijtraken overtollige kilo's	Low shape	
Medische/fysische therapie	Medische fitness	
Normalisering bloeddruk	Mind surfer	
Opbouw goede basisconditie	Paramedische fitness	
Persoonlijke uitdaging	Quick-fit	
Positieve invloed op allerlei ziektes	Revalidatie	
Preventieve bescherming tegen blessures	Senioren fitness	
Preventieve workshop (RSI)	Short track fitness	
Snelheid	Spinning	
Sociale redenen	Steps	
Souplesse training (ouderen)	Tae Bo	
Specifieke krachttraining voor andere sporten		
Specifieke versterking spiergroepen		
Spieruithoudingsvermogen		
Stimulering stofwisseling/verbranding		
Stressvermindering		
Tijd voor jezelf		

Toenemende energy
Vanwege lichaamlijke klachten
Verbeteren algehele lichaamsconditie
Verbeteren fysieke/psychische/emotionele toestand (zorg)
Verbeteren sportieve prestatie
Verbetering zelfvertrouwen
Verbeteringen in het bewegingsapparaat
Verlaging cholesterolgehalte
Vermindering depressie
Vermindering vermoeidheid
Vermindering vetpercentage
Voor het plezier
Voorkomen blessures
Voorkomen gewichtsproblemen
Voorkoming houdingafwijking
Welzijn van de mens

Appendix B – picture of the depicted image



Appendix C - images of the GIF and the VE-track



Appendix D - sentences of the coach

1 = Hi, welcome, today we are going to do a training, with a light intensity
2 = You can do better than this...come on!!
3 = Your hear rate is to low, cycle faster
4 = You are doing great, try to keep this heart rate
5 = Your heart rate is too high, slow down a little
6 = Yes, good work. You are finished for today. See you next time!

Appendix E - heart rate zones

Age	60-70% Maximum heart rate
20	124-144
25	120-140
30	116-136
35	112-132
40	108-128
45	104-124
50	100-120
55	96-116
60	92-114

Appendix F - Intrinsic Motivation Inventory

The following questions refer only to the recently done activity. For each of the following statements, please indicate how true it is for you by circling just ONE number using the following scale:

1	2	3	4	5	6	7
not at all true			somewhat true			very true

1. I enjoyed doing this activity very much.
   1 2 3 4 5 6 7

2. I think I am pretty good at this activity.
   1 2 3 4 5 6 7

3. I put a lot of effort into this.
   1 2 3 4 5 6 7

4. I felt very tense while doing this activity.
   1 2 3 4 5 6 7

5. I believe I had some control in doing this activity.
   1 2 3 4 5 6 7

6. I believe this activity could be of some value to me.
   1 2 3 4 5 6 7

7. I felt really distant to the coach.
   1 2 3 4 5 6 7

8. I think this is an important activity.
   1 2 3 4 5 6 7

9. It was important to me to do well at this task.
   1 2 3 4 5 6 7

10. This was an activity that I couldn't do very well.
    1 2 3 4 5 6 7

11. While I was doing this activity, I was thinking about how much I enjoyed it.
    1 2 3 4 5 6 7

12. I felt like I could control this task.

1 2 3 4 5 6 7

1	2	3	4	5	6	7
not at all true			somewhat true			very true

13. I thought this activity was quite enjoyable.

1 2 3 4 5 6 7

14. I was very relaxed in doing this.

1 2 3 4 5 6 7

15. I think doing this activity could help me to improve my physical condition.

1 2 3 4 5 6 7

16. I'd really prefer not to interact with the coach in the future.

1 2 3 4 5 6 7

17. I am satisfied with my performance at this task.

1 2 3 4 5 6 7

18. I think I did pretty well at this activity, compared to other participants.

1 2 3 4 5 6 7

19. I thought this was a boring activity.

1 2 3 4 5 6 7

20. I didn't really have control in doing this task.

1 2 3 4 5 6 7

21. I was anxious while working on this task.

1 2 3 4 5 6 7

22. I tried very hard on this activity.

1 2 3 4 5 6 7

23. I think this is important to do because it can be beneficial for my lifestyle.

1 2 3 4 5 6 7

24. I'd like a chance to interact with the coach more often.

1 2 3 4 5 6 7

25. I didn't put much energy into this.

1 2 3 4 5 6 7

26. I believe doing this activity could be beneficial to me.
1 2 3 4 5 6 7

1	2	3	4	5	6	7
not at all true			somewhat true			very true

27. This activity was fun to do.
1 2 3 4 5 6 7

28. After working at this activity for a while, I felt pretty competent.
1 2 3 4 5 6 7

29. I felt pressured while doing this.
1 2 3 4 5 6 7

30. I think that doing this activity is useful for my health.
1 2 3 4 5 6 7

31. I felt like I could really trust the coach.
1 2 3 4 5 6 7

32. I would describe this activity as very interesting.
1 2 3 4 5 6 7

33. I did this activity because I wanted to.
1 2 3 4 5 6 7

34. I was pretty skilled at this activity.
1 2 3 4 5 6 7

35. This activity did not hold my attention at all.
1 2 3 4 5 6 7

36. I didn't try very hard to do well at this activity.
1 2 3 4 5 6 7

37. I did not feel nervous at all while doing this.
1 2 3 4 5 6 7

38. I would be willing to do this again because it has some value to me.
1 2 3 4 5 6 7

39. Once involved in this activity, you keep going on automatically.
1 2 3 4 5 6 7

1	2	3	4	5	6	7
not at all true			somewhat true			very true

40. I was quickly fed up doing this activity.
1 2 3 4 5 6 7

41. The time passed by quickly when I was doing the activity.
1 2 3 4 5 6 7

42. I would not want to have this device.
1 2 3 4 5 6 7

43. Once busy doing this activity, it was hard to stop with it.
1 2 3 4 5 6 7

44. While doing the activity, I was feeling great.
1 2 3 4 5 6 7

45. I think my friends also would like this activity.
1 2 3 4 5 6 7

46. I would surely like to do this activity again.
1 2 3 4 5 6 7

47. I was feeling a little insecure while doing the activity.
1 2 3 4 5 6 7

48. Doing the activity took too much time.
1 2 3 4 5 6 7

49. I found the activity very unattractive.
1 2 3 4 5 6 7

50. When doing the activity, you forget everything around you.
1 2 3 4 5 6 7

51. The task took a short time to complete.

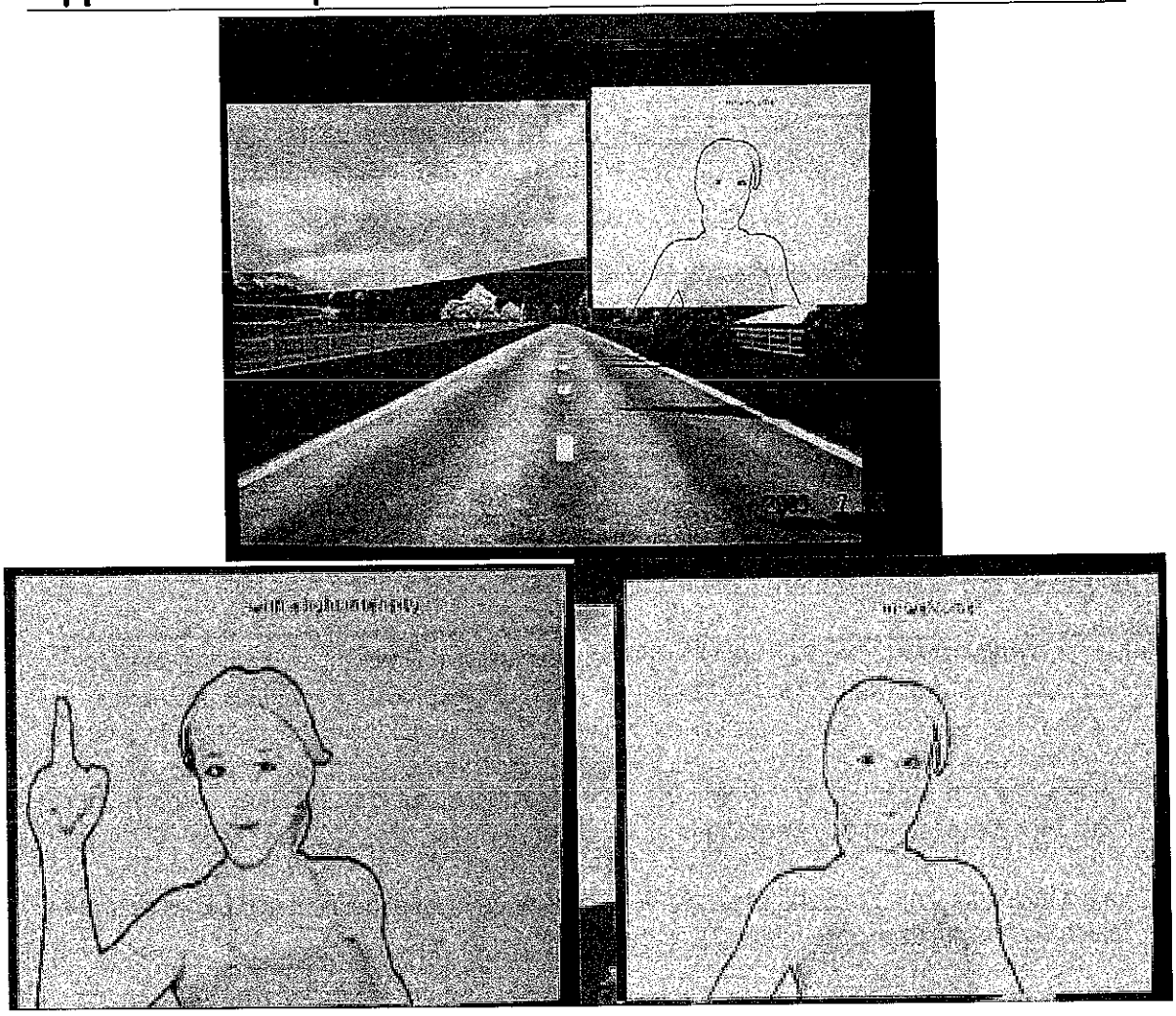
totally disagree - mostly disagree - somewhat disagree - somewhat agree - mostly agree - totally agree

52. How long do you think you have cycled (In minutes and seconds)?
(mm:ss)_____

Technical note:

- The questions: 7, 16, 24 and 31 are related to the coach. These questions were only asked after the sessions with coach.
- The questions 39 through 50 are questions from FunQuest© Hoonhout, Philips Research 2003. These questions were finally not been taken into the analyze process because these questions were very similar to the questions of the interest/enjoyment factor of the IMI.

Appendix G - pictures of the coach



Appendix H - instructions

Instructies

Als het goed is heeft U nu sportieve kleding en een borstband aan en bent U klaar om wat aan lichamelijke beweging te gaan doen. Voor U ziet U een fiets staan waarvan U zometeen gebruik zult gaan maken.

Bij dit experiment is het de bedoeling dat U telkens een stukje gaat fietsen. Wij vragen U in een constant tempo te fietsen op een lichte tot gemiddelde intensiteit. Dit is ongeveer 60-70% van de maximale hartslag. Voordat het experiment begint krijgt U de mogelijkheid om even een stukje voor uzelf te fietsen zodat U aan de fiets kunt wennen en om de fiets goed te kunnen instellen. U kiest een versnelling die U het meest bevalt, deze versnelling verandert niet meer tijdens het experiment.

Het parcours dat U moet fietsen wordt voor U op een scherm afgebeeld. U fietst telkens één rondje. Tijdens het fietsen kan het zijn dat U aanwijzingen krijgt van een coach welke op de hoogte is van de trainingszone.

Na één rondje gefietst te hebben vragen wij U een vragenlijst in te vullen.. De vragenlijsten zijn in het engels, mocht U een vraag niet begrijpen vraag het de proefleider. Tijdens het invullen van de vragenlijst kunt U tevens gebruik maken van de gelegenheid om uit te rusten. Als U de vragenlijst ingevuld heeft en voldoende uitgerust bent, gaan we verder met de volgende ronde. Deze sessie van fietsen en het invullen van een vragenlijst wordt in totaal 4 keer gedaan. In totaal zal het experiment ongeveer anderhalf uur duren.

Na het experiment mag U de borstband af doen en is er de mogelijkheid om gebruik te maken van de douche om uzelf op te frissen en om te kleden.

Als er geen vragen zijn mag U plaats nemen op de fiets en beginnen we met de eerste sessie. Succes!!