Humanics 2

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Humanics 2: Human Computer Interaction in Acquired Brain Injury Rehabilitation

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Abstract

The Humanics project goal was to produce a home based telehealth training and reporting device for the client that had an acquired brain injury. Initial feasibility testing was successfully undertaken at the Centre for Rehabilitation of Brain Injury (CRBI), Copenhagen and this led to the creation of a research protocol that centered on key issues of *creativity* and resulting *motivation* for implementation in a full project. The core body of research utilized for the feasibility study was applied as a new supplementary therapeutic aid. The subsequent full project, which is the subject of this paper, however, ran into detrimental problems in the collaboration with the commercial partner resulting in a curtailed project that did not realize its goal. The issues appertaining to the failure of the main project are discussed in context of a reflection on the report with questions asked of the strategies and decisions of those involved towards a refinement of future protocol.

1 Introduction

Interactions through movement empowered by technology to control multimedia feedback opens up new possibilities in rehabilitation to optimize training potentials, and thereby offering new opportunities to improve the patient's quality of life in different ways depending on their needs and desires. The multimodal character of the interaction – i.e. a selected mixture of sounds, music, image, vibration, etc., controlled by gesture - center on key issues of *creativity* and resulting *motivation*. The body of research is founded upon an earlier research system design titled SoundScapes (Brooks, 1999), used together with handicapped, elderly, and in rehabilitation, so as to offer accessibility to appealing technology for improvement of their physical and cognitive skills (Brooks & Hasselblad, 2004). Furthermore, SoundScapes has inherent design aspects to specifically accommodate adaptation as an Interactive Home Telehealth system[1], based on utilizing the Internet for observed training progress and reporting. As an iteration of the SoundScapes system being successfully facilitated in the feasibility investigation (Brooks, 2004b) the research presented in this paper[2] was dedicated to the production of the concept as a marketable product. It is important to note that the eventual system that was developed as a prototype in the main project research differed from SoundScapes which was used in the earlier successful study. A commercial company, titled Personics attained the contract for the production.

2 Background

2.1 Personics: Baseline, Prototype, and Promises

The company Personics was created in the year 2000 as a result of the successful bid for the contract with Centre for Rehabilitation of Brain Injury (CRBI). The company were contracted to create a system to fulfill aspects of the

[1] In 1999 the author Brooks won a top European prize for his design of this system at the Brokerage Event on Applied Multimedia (B.A.M.) held in Stockholm, Sweden.
[2] The research presented in this paper is founded upon collaboration with the Centre for Rehabilitation for Brain Injury (CRBI) in Copenhagen, Denmark.

feasibility study and to extend the results from that investigation into a product for the home and clinic where communication of patient progress was monitored and reported by an internet connection. The product was to be used in home training of rehabilitation for acquired brain injury. The training was to be enjoyable, fun and creative so that motivation was optimized. This design (see footnote 1; and Brooks, 2004b), based on using an adaptation to the common home theatre system, was to give direct multimedia feedback – sound and image – that was controlled through movement within an activated air space.

In the feasibility study the space of capture was achieved through volumetric 3D sensors and this was to be the baseline for the new system. The requirement to establish test bed sites through a network of recognized training research establishments was included in the design. This was instigated in cooperation with CRBI in the early stages of the project with key centers 'standing by' awaiting the prototype development.

The Personics prototype system consisted of three low cost infrared movement sensors connected by telephone wire to a small plastic computer interface box. The sensors registered movements obtained from the physical training. The data was routed to various animated basic child-like games created in the software Flash[3] that visibly responded to the input from the patient. Sounds, which had been instrumental in the earlier studies and used as a reinforcement of patient awareness to proprioception were promised to be responsive - if not an improvement - as the original system.

The aim of the research was to obtain increased motivation and creativity in connection with physical training, but also to affect the motivation and creativity in the everyday life of brain injured people. Thus, it was hoped that brain injured people would initiate more activities, together with family and friends as well as alone. At the same time it was hoped that they would increase their creativity in everyday life. The subject of this paper is to critically reflect upon the results from this research, which is to say a meta-analysis on the fact that the Personics system did not fulfill the aim of developing a new, different, and motivating rehabilitation aid.

2.2 SoundScapes: A unique phenomenon

The core of the SoundScapes phenomenon was to create a space that was fun and enjoyable to be in, and that it was a place where the participant's creativity and motivation was stimulated through a form of play and enjoyment. Furthermore it was to be adaptable so as to be accessible by all, no matter ability or limitation, preferences or desires, gender or creed. Beneath this fun "user-perceived accessed-by-all" layer, the information captured from the participant that is empowered to have control of the environmental feedback stimuli is the analytical data which gives an indication of training progress and session presence.

This concept and methodology is applied as a new supplementary therapeutic concept and methodology across distinct borders in the field and as such has been stated by neuropsychologist Lyon (2002, p.7) as being unique: "*Der er mange andre metoder til fysisk rehabilitering. Men det umikke ved Soundscapes så ud til at være, at de kunne vække – og udvikle – en høj grad af motivation, glæde og kreativitet hos patienterne*" [There are many other methods for physical rehabilitation available. But the uniqueness with SoundScapes, it seems to be, that it could awaken - and develop - a high degree of motivation, enjoyment and creativity among the patients].

From its initial seeding around the mid eighties SoundScapes was developed throughout the nineties finally evolving into an open platform for new inter-disciplinary investigations into various human performance aspects. Throughout these years the research has been applied at various disability institutes and special centers in respect of those who may benefit within special needs. Tri-weekly sessions at these centers led to the establishment of inductive grounded theories being developed where the parameter of human movement, communication and expression became the main focus and indicator. These theories developed into a phenomenon called *Aesthetic Resonance* (see next page).

These theories are the topic of ongoing inquiry in the field through various research initiatives which have resulted in a number of publications (see Brooks, 1999 – present), degrees based on the design and concept (e.g. Lyon, 2002) and research citations in studies (e.g. Kjær 1999, p. 11-12).

[3] http://www.macromedia.com

2.3 Aesthetic Resonance

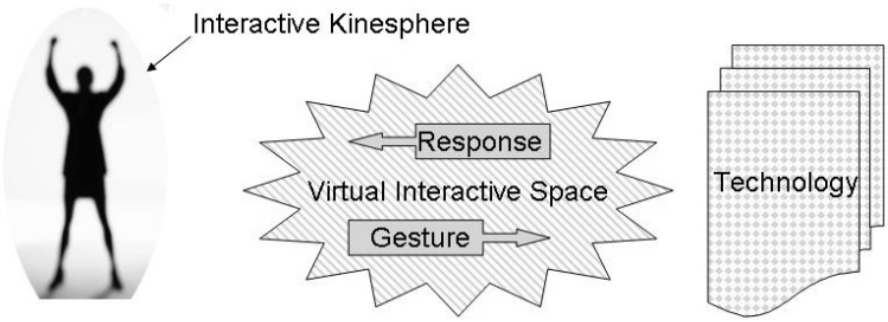

Figure 1: Interactive Kinesphere created with sensors to explore Aesthetic Resonance.

Aesthetic Resonance refers to a situation when the response to intent is so immediate and aesthetically pleasing as to make one forget the physical movement (and often effort) involved in the conveying of the intention (Brooks *et al* 2002, Brooks 2003; 2004c; 2004d, 2004e). This situation arises within the space that we all carry around with us and which Laban titled our Kinesphere (see Laban, 1963, p. 85). Figure 1 depicts a participant in their own *Kinesphere* where a gesture is captured and translated by an interface as control data for the technology (usually a personal computer) to interpret and respond with selectable multimedia content manipulation in an immediate and direct manner.

Aesthetic Resonance was targeted in the Humanics 2 project such as in Figure 2 which illustrates a 3D animated dolphin that navigates through human body/limb movement in the Kinesphere to catch fish. In this training exercise in Humanics 2 the participants also generated a chart with scores so as to compete from day to day. In hindsight this is suggested as to substantiate the social bonding that is discussed later in the paper and which is suggested as a main positive outcome as far as the actual participants were concerned.

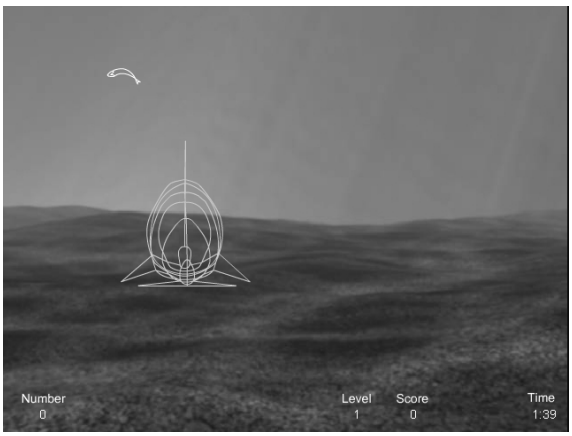

Figure 2: Immediate and aesthetically pleasing response[4]

In a similar way an earlier European funded future probe titled Twi-aysi[5] based upon this interpretation of the term aesthetic resonance presented the findings, relative to the investigation of (1) control of robots through gesture and (2) control of animated 3D artifacts in a Virtual Reality (VR) environment with children between the ages of three and six years and having a severe disability. The research with the robots (Brooks, 2004c) presented similar findings to the VR (Brooks, et al 2002) in so much that the children were totally absorbed by the empowered control through their bodies and reaching an aesthetic resonant state.

[4] Animated dolphin game credit Pete Strømberg: http://www.stromberglarsen.dk/
[5] www.bris.ac.uk/Twi-aysi.html

3 Method

The objective of the project was to develop a home Human-Computer-Interaction (HCI) based telehealth system that utilized the internet to communicate user data to the therapist located at the clinic. The system was designed to be a sensor system that captures body function (movement) and should give controlled manipulation of selected multimedia feedback that should be pleasing to the user.

Following a user profile creation built by the therapist team through initial study sessions at the clinic, the progress data received from the user's home is logged and compared with expected information so as to distance monitor user progress during self training.

The stated objectives in the research protocol were:

- Does Personics give patients with acquired brain injury with physical injuries, an increased physical level of activity and function?
- Does the Personics System have the potential to become a relevant and novel system, and can it increase motivation for physical rehabilitation?
- When training in the system: Is a more free style of training (e.g. no specific physiotherapeutic exercise or goal) preferable to a more restricted type of training (e.g. specific physiotherapeutic measures and aims, comparing achieved goals, etc.) or vice versa?
- Can results from the Personics System be shown to correlate with functional change measured by traditional physiotherapeutic tests? And if it can; which functions will it be possible / desirable to measure?
- Working with the Personics System: Are creative and motivational aspects of specific activities outside the training sessions affected?
- Is implementation of the Personics System as a training measurement system in private homes a viable prospect?

3.1 Participants

The single-case study strategy was selected so as to include 12 adult participants selected among patients formerly enrolled in the traditional post-acute rehabilitation program at the CRBI. At a very general level patients enrolled in this program are typically half a year to three years post-injury and are able to handle most essential ADL at a reasonable level. A total of 51 adults, 26 male and 25 female former patients with acquired brain injury (stroke or trauma) aged 24-62 years were selected as potential participants. Exclusion criterions were inherent cerebral dysfunction, any history of psychiatric disease and substance abuse. All participants continue to have physical impairment following their injury (this means that a reduced function of one or more body parts is observed by means of common clinical, neurological assessment). Time post-injury for most patients was two to seven years having participated in the rehabilitation program zero to four years ago. Since the patients of the Centre (CRBI) are among the best functioning 30 per cent of all Danish people with brain injuries, many of them will be occupied in jobs in some measure. Homogenous groups of patients in relation to age, gender and localization / degree of injury were created. Focus was put on the largest possible variation of physical after-effects from the injury/the illness.

Offers to participate were sent out to all potential participants, after which they were invited to an information meeting with a demonstration of the system and a presentation of the staff. Those who were interested could then volunteer for a test period with two to three sessions lasting one (1) hour, in order to get to know the system better. On the basis of this test period, the twelve participants and four reserve participants were finally selected. At the same time, a draft was made for the particular exercises in the Personics System which was expected to be pertinent for each participant. An equal division of age and sex has been a conscious aim, and also as large a spread as possible in terms of time of injury, localization of injury, and degree of injury.

The session research team consisted of a physiotherapist, a neuropsychologist, and a psychologist. They were all employed at CRBI. The SoundScapes founder, conceptualist and designer of the methodology (author Brooks) was based at the CRBI for the duration of feasibility and main project.

3.2 Procedure

For the full project a makeshift laboratory was set up in a large room under CRBI offices. A screen of dimensions: 1 meter high x 1.2 meters wide was hung from the ceiling at one end of the room with a LCD projector arranged for back projection. Figure 3 illustrates the set up where a patient uses his balance to control an animation of a glass containing liquid on a tray.

The prototype Personics passive infrared sensor system was arranged according to physiotherapist desires, however this was not a strictly adhered to position (needing to be changed for each individual session) thus establishing an unforeseen difficulty in post session corroboration between sessions where consistent data is required. A video camera was also set up to record the sessions.

Figure 3: Personics exercise: A game where the balance of the patient adjusts to keep the glass on the tray.

Each participant was instructed in one or more of the jointly chosen exercises, and together with the physiotherapist, he/she selected a feedback that was deemed motivating for the participant as well as useful in terms of the exercise. The actual training with the Personics system, and the accompanying tests were carried out over two ten weeks periods. Six patients were trained in each period.

During the training period all patients were to be individually trained by the experienced CRBI rehabilitation physiotherapist in one hour duration sessions that took place two to three times weekly (depending on patient availability). Each session consisted of 20 minutes of free movement and 40 minutes of physiotherapist directed activity directed towards the patients' needs, which in most cases was a form of endurance training for this target group. It also demanded much concentration from the participants. The entire session utilized the Personics System[6]. At first, it was foreseen that typically there would be a need of physiotherapeutic involvement in the form of correction, guiding and changes of initial positions, but it was the plan that this involvement was to decrease gradually towards the goal of a self-training tool which can be used by the patient in their own homes.

3.2.1 Test Procedure Overview

For each 10-week period all patients were individually tested following the schedule below:

- At inclusion: User Interface Questionnaire / Prior experience with computers.
- Immediately before and after each 10-week period: Physiotherapeutic testing included tests of general fitness, balance, level of activity, and quality of movement. Psychological testing of creativity and motivation.
- At two and six and ten weeks into the training period: Focus group. (Video recorded open group-session with all participants). User interface questionnaire / Personics System interface.
- At every training session: Video recordings and audio comments taped by the physiotherapist.
- Where possible, results from tests carried out immediately after the traditional rehabilitation program at CRBI were used as reference points.

[6] Before the study was carried out the system was made available to the staff involved for one and a half month accommodation period. This period included the before mentioned trials with patients using the system.

4 Results

The results are presented as they were interpreted within the research. The meta-analysis will be reflected in the following section. Results from almost all physiotherapeutic tests showed that there were no achievements among the participants. It was underlined that these results should be seen in the light of the concentrated training efforts the participants have carried out during ten weeks period, which should have shown measurable achievements. Especially since the project intervention level was higher than the participant's normal level of training.

The creativity tests indicated a correlation between the test results and the diversity of ideas related to use of the system within the "free movement part". The two participants, who had the highest level of creativity, also were those who said that they benefit from working with the "free movement part"[7]. At the physiotherapeutic directed part of the training all participants seemed to be motivated to participate, though their engagement was affected of the problems with calibration and correction of the system.

The motivation tests showed that the participants primarily were directed by intrinsic motivation, and less by external factors. During the physiotherapist directed sessions and according to the feedback from the system, age seemed to be a factor that mattered. Fewer efforts were needed to attract the older generation of participants, and, thereby, less efforts were needed to motivate them.

Results from the focus group interviews showed the participant's creativity and motivation through their many suggestions of concrete ideas about how the system could be used. The participants also showed a strong wish to continue the training even though there were a lot of technical problems when using the system. The participants' valuation of the user interface showed that the participants in general had positive expectations on the system before the use of it. The high expectations were related to the short presentation of the system that was given to the participants utilizing the SoundScapes system by author Brooks prior to sessions start. The questionnaire was answered after the 10 weeks of training with the Personics system. The main results showed that all participants did not think that the feedback (sound/video) of the Personics system was usable in a long term perspective as it was not inspiring enough for further training.

5 Conclusions

The aim of the system was that it should be able to give motivating feedback during free movement sessions and during physiotherapist directed sessions, which, in turn, was planned to facilitate an increase in the participants' everyday movements. So, for example, he or she would be able to open a door even though this should almost not be possible to achieve due to the participant's physical limitations. However, during the realization of the project it was shown that it was only possible to work within limited restrictions due to an unwillingness and/or perhaps incompetence of the Personics company to satisfy requirements as promised.

The prototypes that were developed during the realization of the project, supposedly (as stated by the company) with a correcting feedback, showed to be unusable do to their inability to register at a sufficient resolution without problematic noise and false triggering. The results showed that the participants from a rehabilitation perspective reached a low degree of exchange when they were training with the system. It was hard to value the few physiotherapist positive results as this could be related to the high level of involvement and support from the physiotherapist (placebo effect) as well as to the training with the system. The former were considered to be the case. Thereby, the Personics System was considered not to have fulfilled the aim of developing a new, different and motivating rehabilitation aid, which should have stimulated the participant's creativity.

The training situation and the testing were evaluated from a strict individual, physiotherapeutic and psychological perspective. Nevertheless, the results point toward possible social and contextual interpretations, which open up for opportunities to broaden the understanding of the result of the project. The meaning of *inter-subjectivity* and the *environment* suggest that the training basically is situated, material and social when, and if, it is useful.

[7] During the "free movement part" the participants themselves can choose tasks/movements, instead of focusing of specific therapeutic goals.

Working with the system during the free movement parts of the project, immediately showed that there was a need for a much higher degree of involvement by the physiotherapists than was expected from the start of the project. Consequently, there were just very few exercises that the participants could come up with without support from the physiotherapists in the form of corrections and evaluations. However, this could be understood as the training with the system not only seemed to be an individual matter, and not only related to the interaction between the system and the user. The training also required social interaction and inter-subjectivity to be meaningful. Inter-subjectivity is about sharing of purpose and knowledge and is central to motivation and creativity (Rogoff, 1990; Tikhomirov, 1999). Petersson and Bengtsson (2004) underline the importance of sharing purpose to develop trust among group members and facilitators and concern a central aspect of participation (Petersson, 2004). This trust includes authentic creation of belief in other people's ability to come up with suitable solutions to problems. Furthermore, inter-subjective experiences and knowledge sharing are connecting the user's internal and external worlds (Vygotsky, 1978) and can change perceptions and expectations (Wenger, 1998).

These matters also stress a learning fact that the participants, as novices in using the system, accommodate to the understanding through underpinned joint activities with the physiotherapist who is considered as being more expert than them, which underline the importance of *scaffolding performance* (Wood, Bruner and Ross, 1976) in training situations. If the training with the system should be active, motivating, and creative, the participant must be empowered to, at least unconsciously, visualize the kinetic space, and understand the use of the system on their own terms. Through scaffolding performance the participant can learn and internalize the 'rules' of the system in order to make own creative contribution. Thus the user achieves clarity of the structure and accessibility of the system (Csikszentmihalyi, 1996). In line with Petersson (1999a; 1999b; 2004) the system by this should constitute a resource that through its design articulates and offers a network of choices for use (e.g. play and interaction), and the use of it could be connected to 'actability' rather than functionality (Petersson, 2004).

However, if the training always operates well within the participant's competence resources, then what happens is that the participant continues to experience success by doing the same things. This is good for masterful performance, but it is not good for developing newer and higher skills. But, as has been noticed from the results of the project, if the training operates outside the participant's resources, the user will be frustrated and perhaps give up[8]. In other words, the training should be balanced between 'fun' and 'difficult' aspects - this being both frustrating and enhancing, which in terms of Petersson (2000) means to increase the task in line with increased skills. 'Within' the participant's area of competence, should, from the described viewpoint, be understood as being at the outer edge of the participant's resources so that the system is experienced as challenging, but not unachievable[9]. This is also part of what characterize an open-ended system (Petersson, 2000). The criteria of open-endedness concern the complexity and flexibility of the system, which, for example, means that it is hard to predict exactly how to handle a task in order to proceed playing with the system. This, in turn, mean that an open-ended system embeds the aspect of surprise, which concern that it should not be easy to predict different situations, for example, if the child handle a part of the system the same way as the child did before, this is not a guarantee for the same thing to happen again. The system should surprise (a.a.). As such a *masterful performance* should encourage explorations without immediate goals as in play or curious discovery (Berg, 1992) so as to facilitate creative achievements. These 'masterings' could in line with Bigün, Petersson and Dahiya (2003), be characterized as *non-formal learning processes* in form of exploration and curiosity, rather than traditional formal physiotherapy.

The results and focus of the project emphasized the system merely as a training aid, alongside with the fact that the training took place at an institution, could have affected how the participants viewed the system. If the system to a greater extent would have been emphasized as a (complementary) tool for enjoyment and if the testing had been carried out in a home-environment, the results might have been slightly different. The way we name and contextualize *our doings* have an impact on how we approach and apprehend them. In a traditional physiotherapeutic training situation it is probably natural that the physiotherapist provides and guides the participant through the training. In this case the participant is more or less viewed as a passive recipient. That is, due to the aims of the project, a distorted view, as the future use of the system should not be in form of a traditional training situation, but rather in a non-formal creative and enjoying situation.

[8] This parallels Csikszentmihalyi's theory of flow (1991; 1996).
[9] This reflection is related to Vygotsky's notion of the Zone of Proximal Development in learning situations (1978).

It may seem like a small change, but the words used can make a big difference in how we think and what we do. In fact, it was thought that the participant was supposed to train the most, and enjoy the most, to be engaged as an active participant. But, in a traditional and formal context it might be easy to fall back on training and thinking only what is simple and easy. The key is to find ways to make hard things *life enhancing* so that people are motivated to actively experience the world in a new way.

From the documented results it would appear that there were differences of the qualities related to what the different types of personalities gained from training with the system. The indication was that creative personalities gained a lot of possibilities, or at least potentials, to work "free". Typical for individuals with brain injury is also that they merely think in a concrete way. For this type of persons it is necessary with far more unequivocal, direct, encouraging and challenging feedback on their movements. From a technical point of view it has been shown that it has been difficult to *register* and *process* movement pattern in "real time", which has relevance for the training of this group of patients. Because of that, this task should be focused, instead on the entertainment value, in future developments of the system. However, from a critical and holistic point of view, it is a danger to separate the technical and the entertaining parts in such future developments of the system[10], they should walk hand in hand. Neither of the parts should be a later 'add-on', but should be central to the future development process from the beginning. These aspects put forward the fact that integration of perspectives and aims as well as inter-disciplinary collaboration in general is not an easy task. It is not only the aims of the specific project that have to be known, shared, and internalized by the project partners and participants. It is also a matter of making every partner's and participant's agenda to join the project clear to everyone, especially the so called hidden agendas, if the project should have a chance to be successful. In consideration of the dimensions above and the issue of *flow* (Csikszentmihalyi, 1991; 1996; and Brooks 2002, p. 841) one design factor planned for the future SoundScapes is where machine intelligence plays a role so as to adapt according to user input. This depiction can also be considered related to Vygotsky's theories in respect of learning and development (see footnote 9) and have intrinsic entertainment value.

Finally we state that the potential of the initial design (SoundScapes) is still sound accounting for the dimensions listed above. The home telehealth concept that was originally formulated upon musical peer to peer exchange of digital protocol information from remote locations and interacted to locally is seen as viable. The increasing speed of data exchange and accessibility of online networking stimulated the design of an advanced system that was to take advantage of the internet so that users would have the benefit of selecting their practitioner/therapist/clinic without restriction of distance; be able to train at home with family support; be alleviated the stress, economic and time burden of traveling to the clinic for sessions; and to assist the ever growing burden of time management for clinicians.

To conclude we reiterate the point that "SoundScapes revolves around the creation of a 'play' experience that is stimulating and entertaining for the user" (Brooks 2004a) this point reflects the final comment from the interview with the physiotherapist in Humanics 2 with the Personics system where she was asked 'If you should start the whole project again, what would you have done differently – suggest improvements to the system, concept, and methodology based on this'.

> *I would make it the most important that the users had fun while using the system. That the movement itself was more important than how the movement was performed. The system would be like a play or game tool rather than a physiotherapeutic rehabilitation tool.*
> J. Sørensen, physiotherapist, Center for Rehabilitation of Brain Injury (CRBI) interview,
> (personal communication, March 7, 2005)

Acknowledgements (from author Brooks):

Acknowledgement is given to the CRBI and the agreed credit is stated under the authors names. Elements of this paper are subject of the project report submitted in Denmark[11]. SoundScapes is a not for profit company based in Denmark – the potential conflict of interest in respect of my contribution that could be surmised is considered as being at an impartial level with the inclusion of author Petersson who has no such association to any of the parties.

[10] Lessons learnt from the project will be implemented in future development of the SoundScapes system.
[11] http://vfhj.dk/projekter/detaljer/filer/d7/Research_%20GB-version.pdf?OpenDocument%20

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