Sound-kinetic feedback for virtual therapeutic environments

I Tarnanas[1] and V Kikis[2]

[1]Aristotle University of Thessaloniki, Greece

[2]Kozani University of Applied Science, Greece

[1]*ioannist@ccf.auth.gr*, [2]*kikis@kozani.teikoz.gr*

ABSTRACT

This paper reports on the results of a pilot study on comparing auditory feedback to visual and kinesthetic only feedback as the more consistent feedback type that leads to developments in kinesthesia, motor planning, sequencing and timing capabilities. Development of kinesthesia, motor planning, sequencing and timing capabilities is tested through a learning and transfer of learning of a new unusual movement skill task. We defined as new unusual movement skill a target oriented movement performed under specific conditions that do not match real life movements. The participants were 28 learning deficient children 10-12 years of age randomly spread across 3 groups. There was the same number of participants across groups and gender balance within groups. All 3 groups went through two (2) Phases. In Phase I, Learning, the participant practiced the new movement across 8 trials using his/her not prevalent hand. In each trial the target was situated at different positions on the surface. In Phase I, each group performed in a different feedback Condition. In Condition A, the Visual Feedback Condition (VFC), Condition B, the Auditory Feedback Condition (AFC), Condition C, No Feedback Condition, (NFC1) In Phase II, Transfer of Learning, all three groups exercise the task with their prevalent hands in a No Feedback Condition(NFC2). The number of trials available was 4 so as training effects could be inhibited. The results showed that the VFC group performed notably better than the other two groups in Phase I (VFC: 95%, AFC: 15%, NFC: 12%). In Phase II, though, the AFC group performed better than the other two. These results indicate that auditory feedback seems to be a consistent feedback type leading to developments in kinesthesia, motor planning, sequencing and timing capabilities. Kinesthesia, motor planning, sequencing and timing capabilities are associated with mental processing and the development of mental structures on both a conscious and subconscious level developed in conditions where sound information is provided as feedback for movement. Even if the sound feedback ceases to exist the user can navigate his/her movement with the aid of these mental structures. The VE consists of a SGI Octane MXI system, a midi output, a digital camera and two laser pointers. The system was programmed in C and it creates an artificial environment that encodes the user's motion and can translate it into music in real time.

1. INTRODUCTION

According to modern neuropsychological studies (Baudbovy, Bridgeman, 1998), the practice of new kinetic dexterities is achieved through complicated cognitive processes of control and feedback (Willingham, 1998). According to the model of COBALT (Control - based learning theory), the usual kinetic dexterities are observed unprincipled from experiences of movements and their modeling base of kinesthesia, while in new type - extraordinary movements, where there is an observed disagreement between the objective of movement and the intellectual representation of her muscular activity, the practice is conscious and cognitively guided (Newell, 1991). Practiced in a dynamic, the new kinetic dexterity shapes a new model of movement depending on the precision of intellectual representation of his kinesthesia in this particular movement (Willngham, in press). Moreover, researches have shown that exists a positive cross-correlation between the musical perception and the kinetic record in a determined kinetic ordeal in the space (Rauscher, Shaw, Levine and Ky, 1994).

Previous researches in the region of sound-kinetik environments have shown the connection of musical perception with the visual perception. The originality of this research concerns those particular pieces of motor planning, sequencing and timing capabilities that has relation with the kinesthesia. More precisely it is our interest to show any relation between the development of kinesthesia, motor planning, sequencing and timing capabilities through a learning of a new unusual movement skill task accompanied with a musical perception.

Learning problems associated with memory and attention are seen in a wide range of diagnoses across the human lifespan. Most notably, attention difficulties are seen in persons with Attention Deficit Hyperactivity Disorders (ADHD), Traumatic Brain Injury (TBI), and as a feature of Autism. More effective assessment and rehabilitation tools are needed to address attention abilities for a variety of reasons. In children, attention skills are the necessary foundation for future educational activities. Accurate cognitive assessment is also vital for decision making regarding special educational placement concerns, the possible use of pharmacological treatments, and for treatment efficacy and outcome measurement. The conclusions of this study will be used for a better comprehension of mechanisms that is activated in motor planning, sequencing and timing capabilities inside sound-kinetik environments.

2. METHODOLOGY

2.1 Tools

a) two computers with computational sound analysis software: Big - Eye (Steim) for the recognition of movement and 2) MAX - MSP for the production of sound,
b) video camera for the digitalisation of movement,
c) a mirror,
d) surface of aiming - parallelogram leaf of Plexiglass, white colour.
e) objective - ring of diameter 10 cm, from colourful cardboard.
f) body of aiming - manufacture with piece of plastic pipe in the interior of which are 3 laser pointers, that gives common distinct trace in the surface of aiming. Externally exists switch of operation (on/off).
g) sound system (amplifier and speakers)
h) special glasses
i) questionnaire on the control of Noeri's representation (MIQ)

2.2 Description of the experimental environment

The experimental environment was shaped in a room of dimensions of 4 meters width and 3,5 length. In one wall was placed a mirror, in the opposite wall the surface of aiming and between them a chair turned to the mirror so that a person seated in the chair sees from the mirror the surface of aiming behind him. A video camera was placed next to the chair turned to the surface of aiming and a pair of speakers at both sides mirror. In the floor near in the chair was placed a pedal that would be controlled from the leg of the seated in the chair. The surface of aiming (smaller than the wall) was delimited with film of different colour from the wall.

When we a beam of laser is activated and we aim with this in the surface of aiming, information of movement, from the trace of the beam laser, it is transmitted in the computer with which the camera is connected. Then this information is transported in a second computer where it activates the production of sound that follows in real time the movement. The process of information transmitting and movement encoding can be seen at the figure 1.

2.3 Sample

The choice of sample became with accidental sampling from the region of Thessalonica. The attendance was voluntary. The sample of pilot research is constituted by 28 learning deficient children of age of 10-12 years and was shared in 3 teams (Visual Feedback Condition, Auditory Feedback Condition and No Feedback Condition) of 10 individuals.

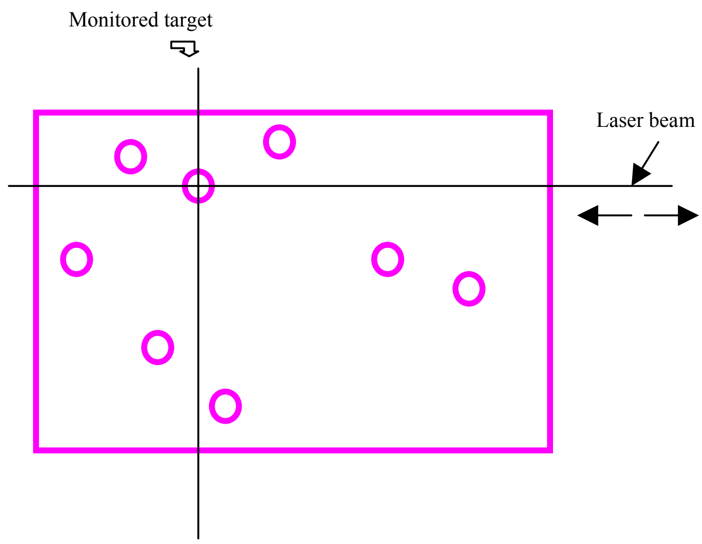

Figure 1. *The sound-kinetic environment was created in real time in 2D space. Any movement that is performed from the subjects is converted into sound.*

3. PROCEDURE

The participants arrived individually in the place of the experiment, where they were given specialized directives depending on their team. They practiced a supplemented questionnaire on the control of mental representation (MIQ) in Greek and then they were sited in the forecasted place, in front of the mirror so that they can check optically the space where they will be presented with the objective. Using the non-dominant hand in the same shoulder, they tried to aim. In the leg there existed a pedal-switch, which they could step whenever they consider that they achieved the objective, in order to stop the effort. The experimental process was completed in two phases. In the 1st phase of the experiment all the three teams took part, as a stage of the actual practice. In the 2nd phase of experiment the three teams took part, realizing the kinetic ordeal with the dominant hand, as a stage of transfer of learning.

3.1 Phase I

The efforts in the first phase are 4 measurable and two test, for each subject of teams (A), (V) and (G).

3.1.1 Team A (VFC). The feedback that helps the subjects of team (A) to direct the movement of their hand (not dominant) it will be exclusively optics that is to say, the subjects will see, the trace of the luminous beam above in the surface of projection in the place of the objectives, without no sound stimulus that could guide them through.

3.1.2 Team B (AFC). The feedback that will help the team (B) in order to they direct the luminous beam with their hand (not dominant), was exclusively sound. The participants could not see the trace of the luminous beam that they directed above in the surface of projection. We used glasses with chromatic filters that prevented the view of the luminous trace, while they aimed at the target. The sound signal that is shaped depending on the relation of luminous beam and objective, constitutes the only source of information (for the subject) and for the result of the movement.

3.1.3 Team C (NFC). The participants of the third team (C) would try to direct the movement of their hand (not dominant) without feedback, guided only from their conscious kineshtesis perception for the place of their hand (arm - shoulder) and the intellectual representation of direction in which the luminous beam would hit the visible objective.

3.2 Phase II

In the 2nd phase all the three teams are executing precisely the same procedure, but with the dominant hand and with just 2 trials. Participants are called to aim as good as possible better, and to declare the achievement of the target with the step of pedal in the flooring.

4. RESULTS

The results were connected with the answers in the questionnaire on the control of mental representation (MIQ) via qualitative analysis. In the phase of the actual practice the results showed statistically important differences in the yield practised (F (df = 1)=8,024, p < 0,05). In the phase of transfer of learning with regard to the distance by the objective, and the time of completion, were not presented statistically important differences.

With regard to the absolute success for the objective, an analysis of fluctuation of direction was used in order to examine the differences between the three teams (sound, optics, locus of control) in the phase of the actual practice and in the phase of transfer of learning. The results showed that there existed a statistically important difference in the actual practice (F(df=2)=66,309, p<0,0001) in favor of the audio team and in the transfer of learning (F(df=2)=1,009, p>0,05). The no feedback team (M=1,7975, SD=2,144) had evidently better performance than the visual team (M=0,862, SD=0,611), but was not however statistically important. The better "performer" was the sound team with a 100% of successes "4" (four efforts), which achieved a mean 0,4636 (SD=0,889). Second, with null difference were the team of no feedback control (M=0,4578, SD=0,1180) and last optical team (0,1180, SD=0,315).

5. CONCLUSION

The occurrence of pure attention vs. pure hyperactive vs. mixed subtypes may be better assessed in a Artificial Environment where, in addition to cognitive performance, motor activity levels can be recorded via the position tracking system. This might also be of particular value for assessing the effects of medications on performance. While pharmacological treatment may produce a measurable decline in motor "fidgetiness", it may be found through measurement within a Artificial Environment, that concurrent attention does not improve. This may also be of value for examining gender differences in the diagnosis of this disorder since the male predominance reported in incidence statistics have ranged from between 4:1 and 9:1 depending on the setting where the data was collected. Perhaps boys are more commonly diagnosed due partly to differences in occurrence of the more "observable" hyperactive component. By contrast, girls who do not manifest the hyperactive component may be less "noticed" yet may still have attention deficits that go undiagnosed.

The special young experience cognitive/functional impairments due to various developmental and learning disabilities. Estimates place the number of children receiving special education services at between 2.5 to 4 million (estimated from CORDIS database, 1999). Rates of other childhood learning disorders, such as Attention Deficit Hyperactivity Disorder (ADHD) and reading disorders, push estimates even higher. Methodological complications preclude precise estimates of the cost of ADHD to society, but according to 1995 statistics, additional national public school costs for these students may have exceeded 3 billion Euros.

The cognitive process of attention is well suited for a comprehensive Sonic Movement assessment and rehabilitation approach. Within the SM environment, the interactivity between sound and movement was realized through one camera and two computers using the BigEye (Steim) for movement recognition and MAX-Msp for sound production. Current methods for assessing attention difficulties include traditional paper and pencil tests, motor reaction time tasks in response to various signalling stimuli, flatscreen computer delivered approaches, and behavioral observation techniques. These methods have limitations regarding issues of reliability and validity, and behavioral observation methods are additionally time consuming and costly. Rehabilitation approaches for this cognitive process also suffer similar obstacles.

Students with severe learning difficulties can use experiential learning programs to access a rich set of environments, both in terms of objects and situations, to interact with them in appropriate contexts and in ways they are restricted from doing so in the real world. Similarly, learning experiences can be structured for children with learning difficulties to break down complex tasks into more simple components until the child masters the necessary skills. Another advantage of SM described by Wilson, Foreman & Stanton is that the need for semantics, symbols or language is virtually eliminated, due to the experiential nature of the learning process. This means that SM is more accessible to different categories of users who may benefit from learning a task in SM without the restrictions of traditional teaching methods.

It is this freedom of exploration and expression which may go some way in restoring the disparity that exists in real world learning systems; to give easy and frequent access to environments that are not so in the real world, and to accommodate experiential ways of learning rather than concentration on the abstract learning systems that prevail in mainstream education.

The superiority of SM as compared to traditional educational tools is based on rather well-understood factors such as physical and psychological involvement – known as “presence” – free interaction, and buildup of knowledge as a result of direct experience with information presented in precisely contextualised ways, yet modifiable and adapted to the individual’s level of comprehension (Lewis, 1998). Because mobility aims at overcoming the effect of spatial and temporal distances on human activities and social interaction, it is a highly contextualised activity and its patterns depend on the environment as well as on other factors, such as previous experience, availability of transportation means, weather conditions, time limitations, physical and other types of resources, etc. The SM system will utilize interface technology that renders computer information onto multiple human sensory systems to give a sustained perceptual effect (i.e., a sensation with a context). Perception and expression of greater quantities of complex information will be the end value to expert knowledge users.

6. REFERENCES

Baudbovy, G. (1998). Pointing to kinesthetic targets in space, Journal of Neuroscience, Vol. 18, No. 4, 1528-1545.

Bridgeman, B. (1997). Interaction of cognitive and sensorimotor maps of visual space, Perception and Psychophysics, Vol. 59, No. 3, 456-469.

Burgess, P. R. and Clark, F. J. (1969). Characteristics of knee joint receptors in the cat, Journal of Physiology, 203, 317-335.

Craske, B. and Bolli, M. (1985). Localized distortion of the human kinesthetic map.

Craske, B. and Crawshaw, M. (1975). Shifts in kinaesthesis through time and after active and passive movement, Perceptual and Motor Skills, 40, 755-761.

Darling, W. G. (1995). Perception of arm orientation in 3-dimensional space, Experimental Brain Research, 102, 3, 495-502.

Edin, B. B. (1996). Strain-sensitive mechanoreceptors in the human skin provide kinaesthetic information. In Somesthesis and the Neurobiology of the somatosensory cortex (pp. 283-295). Birkenhauser: Basel.

Ferrell, W. R. and Craske, B. (1992). Contribution of joint and muscle afferents to position sense at the human proximal interphalangeal joint, Experimental Physiology, 77, 331-342.

Gandevia, S. C., McCloskey, D. I., Burke, D. (1992). Kinaesthetic signals and muscle contraction, Trends in Neuroscience.

Golton, C. (1996). The role of manual kinaesthesis in building and in using mental representations of bidimensional objects, Travail Humain, Vol. 59, No. 2, 137-153.

McCloskey, D.L. (1981). Corollary discharges: motor commands and perception, Handbook of Physiology, 1415-1447.

Melzack, R. (1989). Phantom limbs, the self and the brain (the D. O. Hebb memorial lecture), Canadian Psychology, 30, 1-15.

Melzack, R. (1992). Phantom limbs, Scientific American, April, 120-126.

Von Békésy, G. (1967). Sensory Inhibition.

Walker, J. T. and Shea, K. S. (1974). A tactual size aftereffect contingent on hand position, Journal of Experimental Psychology, Vol. 103, No. 4, 668-674.

Baily, J. (1985) Music structure and human movement. In: Howell, P., Cross, I., (editors), Musical structure and cognition, 237-258. London, UK: Academic Press.

Pressing, J. (1990) "Cybernetic issues in interactive performance systems." *Computer Music Journal*, 14(1), 12-25.

McAdams, S., Bigand**,** E. (ed.) (1993) *Thinking in sound: cognitive perspectives on human audition*. Oxford, UK ; New York: Clarendon Press.