Raw emotional signalling, vi expressive behaviour

Brooks, Tony; Petersson, Eva

Published in:
The 15th International Conference on Artificial Reality and Telexistence ICAT2005

Publication date:
2005

Document Version
Publisher's PDF, also known as Version of record

Raw emotional signalling, via expressive behaviour

A. Brooks
Aalborg University Esbjerg
Niels Bohrs vej 8
6700 ESBJERG, DENMARK
tonybrooks@cs.aaue.dk

E. Petersson
Aalborg University Esbjerg
Niels Bohrs vej 8
6700 ESBJERG, DENMARK
ep@cs.aaue.dk

Abstract

The paper reports on an initial explorative study that inquired to the response of persons with profound and multiple disabilities in an interactive environment. Our goal was to explore the potentials of interactive environments for improving quality of life for people with special needs and those around them. In the study they were empowered within a volumetric non-invasive interface to actively experience gestural control of sonic events. Case studies exemplify the findings indicating a potential that can encourage social interaction and benefit user, carers, and family. Conclusions highlight evaluand significance to other interactive research such that when a state of *flow* is achieved both a new reality and state of consciousness are opportune.

Key words: Disabled, flow, quality of life.

1. Introduction

Persons with disabilities enjoy interaction as much as the next person. This may be more so for those with profound and multiple disabilities, and those challenged developmentally, as their social contact is limited. This has been suggested by Clegg (et al., 1991) as because carers are unsure how to interact with these people. Others point to the violence from those with challenged behaviour as the reason of the limited contact and interactions (Emerson & Hatton, 2000).

Previous research (Davies, 2005) emphasizes difficulties in regard to traditional strategies of measurement, replicability and objectivity, regarding the sector of the special needs community. Understandably then, in terms of research, this group may be "considered too complex and diverse in character to tackle, and in terms of healthcare, not necessarily able to make their voices heard" /…/ "often overlooked in both research and even healthcare funding" (Davies, 2005, p. 285).

In creating adaptive environments that encourage interaction for these groups of people within the special needs sector, we believe new opportunities in improved quality of life is a distinct potential, for them and even more so for the staff caring for the people. Having enjoyable experiences together in interactive play scenarios alone - with staff supervision passive-, or with active staff intervention, is in our experience conducive to improving relationships and in the long term could improve the work place for careers.

2. Intersubjectivity and individual processes

The actions and interactions in interactive play scenarios are, in this study, characterized as non-formal learning processes (Petersson, 2000; Petersson, 2004; Bigün, Petersson, and Dahiya, 2003) in an intersubjective manner (Aderklou, Fritzdorf, and Petersson, 2001), as important basis for individual processes. Convergent references to the notion of intersubjectivity are described as "mutual understanding", "symmetrical dialogue", "sharing situation", and "joint participation" (Rommetveit, 1979; Trevarthen, 1979; Rogoff, 1990). Vygotsky (1978, 1981) states that intersubjective experiences and knowledge sharing connects the individual's internal and external worlds. Wood, Bruner, and Ross (1976) describe this process as a "scaffolding" performance. Furthermore, the shared situations are negotiated through semiotic mediation (Wertsch, 1985), in this study including mainly gestures, and sounds.

2.1 Capacities of action

We suggest that the basic understanding of intersubjectivity needs to be modified beyond harmonious processes. Interactions that are not conforming to the traditional understanding of intersubjectivity plays a vital role in the formation of the individual. We define divergent moments as part of intersubjective functioning.

In doing so we draw on Burke's (1969) notion of dramatic action, which, according to Gusfield (1989), includes "conflict, purpose, reflection, and choice" (p.

10). Burke (1969) introduces a pentad to provide a dynamic tension of the action. From this perspective, action is expanded into further explanation as ambiguities emerge when taking asymmetric interacting elements into account. This paper states that these ambiguities are resources worth taking into account when analyzing beyond intersubjectivity relative to one basic form of action (e.g. Rogoff, 1990).

Burke (1969) delineates his dramatic pentad in terms of *act*, *agent*, *scene*, *agency*, and *purpose*. In the pentad framework 'agency' is the corresponding item of mediation, and furthermore in respect of the emotional signalling via expressive behaviour (Scherer, 2000) which we focus upon, it can be seen (section 3.4) how *action tendency* is a component of the emotional reaction triad (Scherer, 2000) and thus pertinent to Burke's theories as presented here.

2.2 Capacities of mediation

Mediation, in terms of Vygotsky (1981) provides a link between the actions carried out by the individual, on the one hand, and the institutional context, on the other. Wertsch (1991) expands upon this framework by adding analysis of the artefact as a mediator. Artefacts are essential as they shape actions. Thus, mediation is an active process (Wertsch, 1991). Accordingly, mediation is seen as a *process* involving the potential of artefacts to shape action, on the one hand, and the use of these artefacts, on the other.

The use of the non invasive interface and content is empowering as well as constraining, and, thereby, it opens up new avenues of action for the people with profound multiple disabilities. The kind of constraints that we have in mind is often recognized by the facilitator, and often retrospective. How to use and overcome these constraints is a concern for the facilitator in the immediate situation. In view of that, we have coined the Zone of Optimized Motivation - ZOOM (Brooks and Petersson, 2005b), which refers to an interactive space that encourages and supports immersion, engagement and concentration through machine controlled intervention.

The Zone of Optimized Motivation is important as it encourage the user's unintentional and/or intentional explorations and expressing of him- or herself. By this, the expression has an immediate character, which places the participant in the midst of the experience; as in a *flow* state (Csikszentmihalyi, 1996). In this paper the state of flow is creating both a new reality and state of consciousness and where non-formal and unintentional learning occurs. Accordingly, the state of flow creates a new form of reality. A main point we would like to make here is that this is an area where rehabilitation and education has an opportunity to expand children's skills substantially, particularly so, as play is so closely related to intrinsic motivation. Optimally, this matching is intrinsically rewarding (Csikszentmihalyi, 1996) and the enjoyment derives from the use in itself.

3. Case studies

This paper presents a qualitative study undertaken with persons having profound multiple disability where the individual is empowered to actively control selected content by body gesture. The warranted strategy of utilising qualitative research as the methodological paradigm for the study is substantiated by Patton (1990) who offers the four traits (i) the emphasis on individual outcome; (ii) the detailed in-depth information about the phenomena under inquiry; (iii) the study's focus on diversity and unique qualities of individuals; (iv) no available standardized, valid, and reliable instrument.

We selected four case studies from our sample of 18 (see section 4).

3.1 Equipment

The system used for the study was based on non wearable devices that did not encumber the body of the participant, i.e. wireless. The system consisted of sensors[1] that created a volumetric information space which in prior research has been coined as Virtual Interactive Space (VIS) (Brooks, 1999) and which is more recently referred to commonly as a Virtual Environment (VE). Movement in the information space generated output signal data from the sensor. This data was routed to a computer and a sound module/synthesizer. The output of the sound module was routed to a playback system for the participant to audition the sonic response to the participant's gestures.

3.2 Set up

In setting up the system there were two main zones of volumetric information capture available for the facilitator to place the participant. Established around a perpendicular axis emitted from the small sensor head were two 3D zones that were defined by the sensitivity programming of the onboard circuitry. The first zone was defined initially for size and sensitivity. The second zone was enhanced through retro-reflective microprism technology which activates an additional zone having a trait of reverse polarity. Each zone polarity information output could be reversed in the sensor but they had to remain opposite to each other (Brooks, 2005). This enhanced information space – the additional second zone – offered a freer environment for motion to data capture as it can extend up to over 14 meters and thereby offers and encourages a direct contact with the content feedback rather than a fixation on the mediating technology. In other words the interaction becomes more intuitive as body weight change, rotation, or other activities trigger events

[1] The term sensor relates to cameras, microphones and various devices using ultrasonic or infrared technologies.

3.3 Design and procedure

The participants in the case studies had sessions individually over a two year period. The participants had no prior experience of interactive environments. The time frame varied due to illness one of the participants.

The participants experienced a situation where movement created an event from movement in free space. Thus a limb, head, torso, or whole body was sourced for information to make music. Initial sessions were in establishing an understanding of the interactive space through facilitator guidance. This meant actively taking the hand of the participant and guiding it through the sound space. Tactile response that was exchanged between facilitator and participant guided the participant's understanding of the space and subsequently the space was explored by the participant through hand and head movement without guidance. A silent space – i.e. no interaction - was always available which also indicated to the facilitator an interpreted understanding through use as a pause place.

All sessions were video taped. The analysis of the sessions involved rigorous manual observation technique. The video data was analysed for defining peaks and lulls of emotive indices and labelled through cross reference to the field notes and memos from the sessions (Appendix 1).

Ethical considerations were taken. Parents and facilitators were approached about the study, informed of the goals, and gave their permission beforehand.

3.4 Annotation

Usually three types of annotation of emotion are implemented (1) appraisal dimensions (2) abstract dimensions (3) verbal categories, the latter being the most common (Abrilian, et al., 2005). However given that we did not have any verbal expression from our sample we focused on the subjective emotional signalling, via expressive behaviour (Scherer, 2000). In this respect we were influenced by Efron (1972), Ekman (1982), and Knapp and Hall (1992).

Other components of emotion also have a bearing for our study – namely: feeling; motor expression in face and gesture; neurophysiologic response patterns (in the central and autonomous nervous system); cognitive evaluation; and action tendency which is referred to as the "behavioural consequence" of emotion. The first three of these – feeling, physiology, and expression are referred to as the emotional reaction triad (Scherer, 2000, p.156).

Segmented video annotation analysis was instrumental (e.g. appendix 2) and again influenced directly by nonverbal strategies of investigation as listed above.

4. Results

Four case studies were selected to best illustrate the exploratory inquiry of people with profound multiple disabilities and response in interactive environments. The four individuals were John, Mats, Beata, and Hans. The unit of analysis was the artefact-mediated-action. In particular, and inspired by Burke (1969), we focused on qualitatively different transformations in action when using the artefact. Basic coding was to look at transformations in form of conflict, shared situation, reflection, and choice related to the participant's facial and other nonverbal semiotics gestures. In John's case of significance was a suggested coupling between the facial and hands signalling that prompts further investigation.

4.1 Semiotic interplay

Appendix 1 shows a sequence from a single session with the agent John, which constitute a visual example of semiotic interplay during sessions. The semiotic interplay involves individual, social, and material processes, which are based on that the artefact (agency) in question shapes actions in use. The facilitator was also a part of the scene as he/she challenged John through empowering and constraining the different on-going processes. However, focus of the results in this section is merely on individual internal and external processes, rather than on results based on intersubjectivity, which is the theme of the results presented below in section 4.3. Average length of sessions was around 27 minutes. The six segmented images in Appendix 2 illustrate how focus on the facial expression is in accordance with the hands.

The image sequence constitutes an action cycle within one (1) session. Each action cycle lasted on average around 3-4 minutes segmented by a distinct pause. The <start> image, tagged 'pensive anticipation', was where John indicated recognition that a VIS was being set up with a sensor for him to manipulate sounds with his head. Following the registration of the sounds he joyfully explored; got a surprise; and, focused on the feedback – his face and hand expressed a *concentrated effort*. His final phrase in the initial session phase was defined head realignment where his vocal utterance was recognized by parents in the video interview as related to the pitch change of the sound patch he was manipulating. This achievement – accompanied by a *relaxation* of the hands - was followed by a state of rest <End>. Intervention strategies were also incorporated with John whereby a volumetric sensor was positioned immediately in front of his face so as to source his cheek muscle. The facilitator informed that this was his only perceived controllable body part in an effort to play drums.

These behaviour signals were relative to the components of emotion (Scherer, 2000) for each individual case and with obvious variance had a commonality. The

transformation between inner to outer processes had temporal variance between cases but in all cases the interactive technology was as a mediator to the process. The technology was also used by the facilitator to challenge the agent through improvised play within the knowledge boundaries, e.g. from the functional abilities profile – i.e. abilities, limitations, preferences and desires.

At all times it was important to challenge from the perspective of play and not a user perceived 'therapy session' mindset so that an intrinsic motivation or interest was achieved (e.g. Taylor, 1960; Hunt, 1965). Notably, with the cases presented in this paper the extrinsic or non-autotelic attributes of interaction were not as prevalent as with for example acquired brain injured (Brooks, 2004a, Brooks & Petersson, 2005a).

4.2 Optimized intersubjectivity

Figures 1 to 4 show images from three different single sessions with the agents Mats, Beata, and Hans. The duration of the sessions with Mats, Beata, and Hans was approximately 14 minutes. Optimized intersubjectivity involved a scene with the participant as the main agent. However, the facilitator was as important in this section as an active inter-agent who actively reflected and interpreted the scene to make conscious choices to overcome constraints and encourage empowerment.

Figure 1 and 2 shows Mats. His optimized interaction was achieved in sessions when he was able to interact with the sounds that he himself generated: a grating of the teeth and a constant humming of musical tone that had been sampled and assigned mappings from the movement data. This as opposed to mapping the movement signals to a synthesizer or digital sound module.

The early sessions had instances of significance where Mats' behaviour would signal his desire to participate more fully with increasingly extended instances of hand gesture raised to either side of his head being the obvious indicator of "in" – however, care with intervention had to be taken as it was a case that Mats individually had to locate and explore the space. The facilitator could only hint to location of the active space as Mats would signal direct dislike to too much intervention.

Figure 3 shows Beata. She did not require any intervention to discover the interactive environment. Once she entered the space she immediately signalled recognition when her behaviour was affecting the sounds and subsequently she physically explored the space through rocking back and forth in her wheelchair over long extended periods until she was stopped by the facilitator. In the sessions the wheels of the chair often had to be secured because she was so engrossed and physically expressive of the empowerment. The role of the facilitator with Beata was as an observer and note taker as various sound patches were explored. Her functional abilities profile was referenced mostly to determine preferences in cooperation with her long-term facilitator.

Figure 1 Mats

Figure 2 Mats

Figure 3 Beata

Figure 4 Hans

Figure 4 shows Hans trained by an external facilitator in front on a 3D infrared sensor that played sounds as their hands moved in front of it. In the picture he is guiding his facilitators hand as if he had learnt a new 'thing' (sensor space plays music) and wanted to guide her in sharing the understanding. The role play was motivating Hans and was optimal with his own personal facilitator.

Another case study, John, is the focus of appendix 1 and 2 which features video segmentation analysis and a more detailed explanation of the process of enquiry.

5. Conclusions

This initial exploratory qualitative inquiry has presented the feasibility of a non-quantifying strategy where transformation between components of emotional valence in response to feedback from within an interactive environment can be represented by facial expression and other nonverbal signals through behaviour.

We also pointed out a correspondence with hand gesticulation though at a more visceral level. The findings in the study reflect on a conscious use of non-intrusive interfaces that are applied in consideration of the participant's specific needs. The use in real-time interactive virtual environments present how digital technologies can be used to enhance life quality opportunities through empowering creative expression for people with special needs through embodied interaction. The work consciously applies non-intrusive/invasive technologies so as to target freedom of person and freedom of creative expression rather than what traditional state of the art presents; utilizing HMDs, body suits etc.

Relative to Burke (1969) (section 2.1) and the system used in the study, we suggest the *act* as a gesticulation sourced by the interface with the *agent* as the human participant. The *scene* is the interactive environment mapped via the interface with the feedback as *agency*. The *purpose* is manifold.

For the agent the purpose is to enjoy, play and have fun. For the facilitator whose role it is to encourage the agent enjoyment, there is the additional role of awareness of data capture for progress analysis, be it video recording or computer data archiving. For the system the purpose is to source the motion data from the interface and map it to preferred feedback content, whilst simultaneously archiving for session to session analysis. Reflecting upon the inter-, intra- and mediating statements referenced to Vygotsky (1978), Rommetveit (1979), Trevarthen (1979), Rogoff (1990), Wertsch (1985) in section 2, the 'here and now' flow state of Csikszentmihalyi (1991) (section 2.3), and then cross reference to artist inventor Rokeby (1998) who gives insight to the shared interactive space of art and his observation of the public within his pieces, we can see that an intrinsic motivation where play itself mediates without extrinsic goal of control, or apparent ego, is the cumulative optimal state for development and interaction, which relates to the concept of the Zone of Optimized Motivation - ZOOM (Brooks & Petersson, 2005b).

5.1 Implications and further research

The findings from this study suggest that interactive environments can have benefit within the field of special needs. Our study, working within a specific sector of this community, suggests at a more generalised potential. One aspect of the outcomes from the study is that the increased social interaction element gives an opportunity to alleviate the violence shown by those with challenged behaviour. This is by encouraging shared enjoyment, and hence improved social contact between carers and agents so that working conditions are improved. Additional, this improved social contact offers the agent greater opportunities for improved quality of life.

In prior research we have explored non-wearable and marker-less tracking in Virtual Reality with profound and severe disabled children (Brooks, et al., 2002). We have also used the same system to empower the children to control 'intelligent' robotic feedback (Brooks, 2004b), and investigated use of the system with acquired brain injured rehabilitation (Brooks, 2004a; Brooks and Petersson, 2005a). In summary, this paper has presented the raw unbiased response of those who are experiencing the interactive environments that were created with the clear purpose of enjoyment. The state of flow that was achieved by the participants is suggested as superseding the 'presence' state which is targeted in existing VE research. In other words, as an explored state relating consciousness to 'human experienced reality of the virtual' we suggest that flow takes precedence. Furthermore, we suggest that the Zone of Optimized Motivation – ZOOM - is a fruitful base for play, learning and development and that the design of virtual environments advantageously should rest upon these theoretical foundations (see Petersson, 2004).

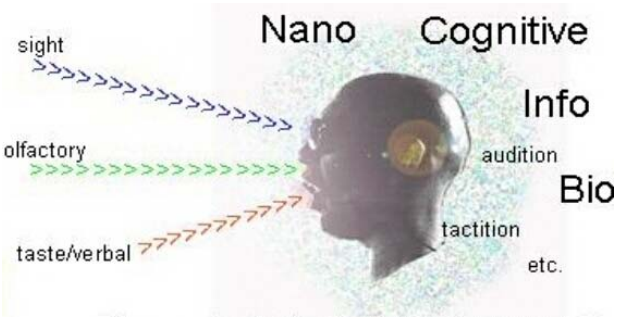


Figure 5 Future Convergent Technology Interface

In closing we predict a future convergent technology interface to optimize exploration of alternative realities that would not require head mounted displays, worn trackers, or the like. Existing at a molecular level and inhabiting the Kinesphere (Laban, 1963) it is conceptualized as utilising the bi-directional communication attributes of nano technology, as closure stimuli of the human afferent efferent neural loop, also known as the stimulus – response chain (Scherer, 2000); shown in figure 5 and previously stated by Brooks (2000; 2004a).

Acknowledgements

Participants, families and staff from the four institutes involved in the research during the two years in Aarhus.

References

Abrilian, S., Devilers, L., Buisine, S., and Martin, J.-C. (2005). EmoTV1: Annotation of Real-life Emotions for the Specification of Multimodal Affective Interfaces *Proceedings of HCI International 2005*, (in press). Las Vegas, USA. Lawrence Erlbaum Associates.

Aderklou, C., Fritzdorf, L., & Petersson, E. (2001). Pl@yground; Pedagogical Innovation and Play Products Created to Expand Self-development through Child Collaboration through Computer-Mediated-Communication (CMC). *Socrates, Leonardo & Youth, Project No.: 91893-CP-1-2001-1-SE-MINERVA-M*. Halmstad University.

Bigün, J., Petersson, E., & Dahiya, R. (2003). Multimodal interfaces designing digital artifacts together with children. *Proceedings of 7th International Conference on Learning and Educational Media*. Bratislava, Slovakia.

Brooks, A. (1999). Virtual Interactive Space (V.I.S.) as a Movement Capture Interface Tool Giving Multimedia Feedback for Treatment and Analysis [Abstract]. *Proceedings of the 13th International Congress of The World Confederation for Physical Therapy*, (p. 66). Yokohama, Japan.

Brooks, A. (2000). Mr.Beam. Journal of the European Network for Intelligent Information Interfaces http://www.i3net.org/ser_pub/services/magazine/march2001/i3mag10.pdf pp. 2-6.

Brooks, A. (2004a). HUMANICS 1: A study to create a home based telehealth product to supplement acquired brain injury therapy. In P. Sharkey, R. McCrindle & D. Brown (Eds.) *Proceedings of the 5th Int. Conf. on Disability, Virtual Reality, and Associated Technologies* (pp. 43-50). Oxford University, UK: University of Reading Press.

Brooks, A. (2004b). Robotic synchronized to human gesture as a virtual coach in (re)habilitation therapy, *Proc.Int. Workshop for Virtual Rehabilitation*, Lausanne, Switzerland, pp.17-26.

Brooks, A. (2004c). Soundscapes. In *Inhabited Information Spaces – Living with Your Data*, D N Snowdon, E F Churchill and E Frécon (Eds.), Springer-Verlag London, pp. 89-100.

Brooks, A. (2005). Enhanced Gesture Capture in Virtual Interactive Space. *Digital Creativity*, **16**, 1:43-53.

Brooks, A., & Petersson, E. (2005a). Humanics 2: Human Computer Interaction in Acquired Brain Injury Rehabilitation. *Proceedings of HCI International 2005*. Las Vegas, USA. Lawrence Erlbaum Associates. CD-ROM.

Brooks, A., & Petersson, E. (2005b). Recursive Reflection and Learning in Raw Data Video Analysis of Interactive 'Play' Environments for Special Needs Health Care. In *Proceedings of Healthcom2005. 7th International Workshop on Enterprise Networking and Computing in Healthcare Industry* (pp. 83-87). Busan, Korea.

Brooks, A., Hasselblad, S., Camurri, A., & Canagarajah, N. (2002). Interaction with shapes and sounds as a therapy for special needs and rehabilitation. In P. Sharkey, C. Sik Lányi, P. Standen (Eds.), *Proceedings of the 4th Int. Conference On Disability, Virtual Reality, and Associated Technologies* (pp. 205-212). Veszprém, Hungary.

Burke, K. (1969). *A grammar of motives*. Berkeley: University of California Press.

Clegg, J.A., Standen, P.J., & Cromby, J.J. (1991). Interactions between adults with profound intellectual disability and staff. Australia and New Zealand. *Journal of Developmental Disabilities*, 17:4, 377-389.

Csikszentmihalyi, M. (1992). *Flow: The psychology of optimal experience*. Stockholm: Natur och Kultur.

Csikszentmihalyi, M. (1991). *Flow. The Psychology of Optimal Experience*. New York: Harper Perennial.

Davies, R. (2005). Commentary on Standen, P. J., & Brown, D. J., Virtual Reality in the Rehabilitation of People with Intellectual Disabilities: Review. *CyberPsychology & Behavior* 8. 3., 285.

Effron, D. (1972). *Gesture, Race and Culture*. The Hague, Moulton

Ekman, P. & Oster, H. (1982). Review of Research. In P. Ekman (Ed.) *Emotion in the Human Face*. Cambridge (pp. 147-174)

Emerson, E., & Hatton, C. (2000). *Violence against social care workers supporting people with learning difficulties: a review*. Institute for Health Research, Lancaster University (NISW): Retrieved July 8, 2005 . http://www.dangerousbehaviour.com/Disturbing_News/violence%20and%20learning%20diffs.pdf.

Gusfield, J. R. (Ed.). (1989). *Kenneth Burke on symbols and society*. Chicago: University of Chicago Press.

Hunt, J. (1965). Intrinsic motivation and its role in psychological development. In D. Levine (Ed.) Nebraska Symposium of Motivation 13: Lincoln, University of Nebraska Press.

Knapp. M.L. and Hall, J.A. (1992). *Nonverbal Communication In Human Interaction* (3rd ed.) New York: Harcourt.

Laban, R. (1963). *Modern Educational Dance* (2nd ed.). London: Macdonald & Evans Ltd.

Patton, M.Q. (1990). *Qualitative Evaluation and Research Methods*, Newbury Park, CA: Sage.

Petersson, E. (2000). Innovative play products – development of toys for children's play and rehabilitation. [Abstract]. *Proceedings of SNAFA Conference*. Halmstad, Sweden.

Petersson, E. (Ed.) (2004). Using and developing new learning technologies by integrating physical and virtual toy systems. *Socrates, Leonardo & Youth*. Halmstad University, Sweden.

Rogoff, B. (1990). *Apprenticeship in Thinking. Cognitive Development in Social Context*. New York: Oxford University.

Rokeby, D. (1998). The Construction of Experience: Interface as Content. Retrieved 3.7.2005 from http://homepage.mac.com/davidrokeby/home.html

Rommetveit, R. (1979). On the architecture of intersubjectivity. In R. Rommetveit & R. M. Blakar (Eds.), *Studies of language, thought and verbal communication* (pp. 93-108). London: Academic.

Scherer, K.R. (2000). Emotion. In M. Hewstone, & W. Stroebe (Eds.). *Introduction to Social Psychology: A European perspective* (3rd ed., pp. 151-191). Oxford: Blackwell.

Taylor, D. (1960). Toward an information processing theory of motivation. In D. Jones (Ed.), Nebraska Symposium on Motivation, 1960: Lincoln, University of Nebraska Press.

Trevarthen, C. (1979). Communication and cooperation in early infancy: A description of primary intersubjectivity. In M. Bullowa (Ed.), *Before speech* (pp. 321-347). Cambridge University Press.

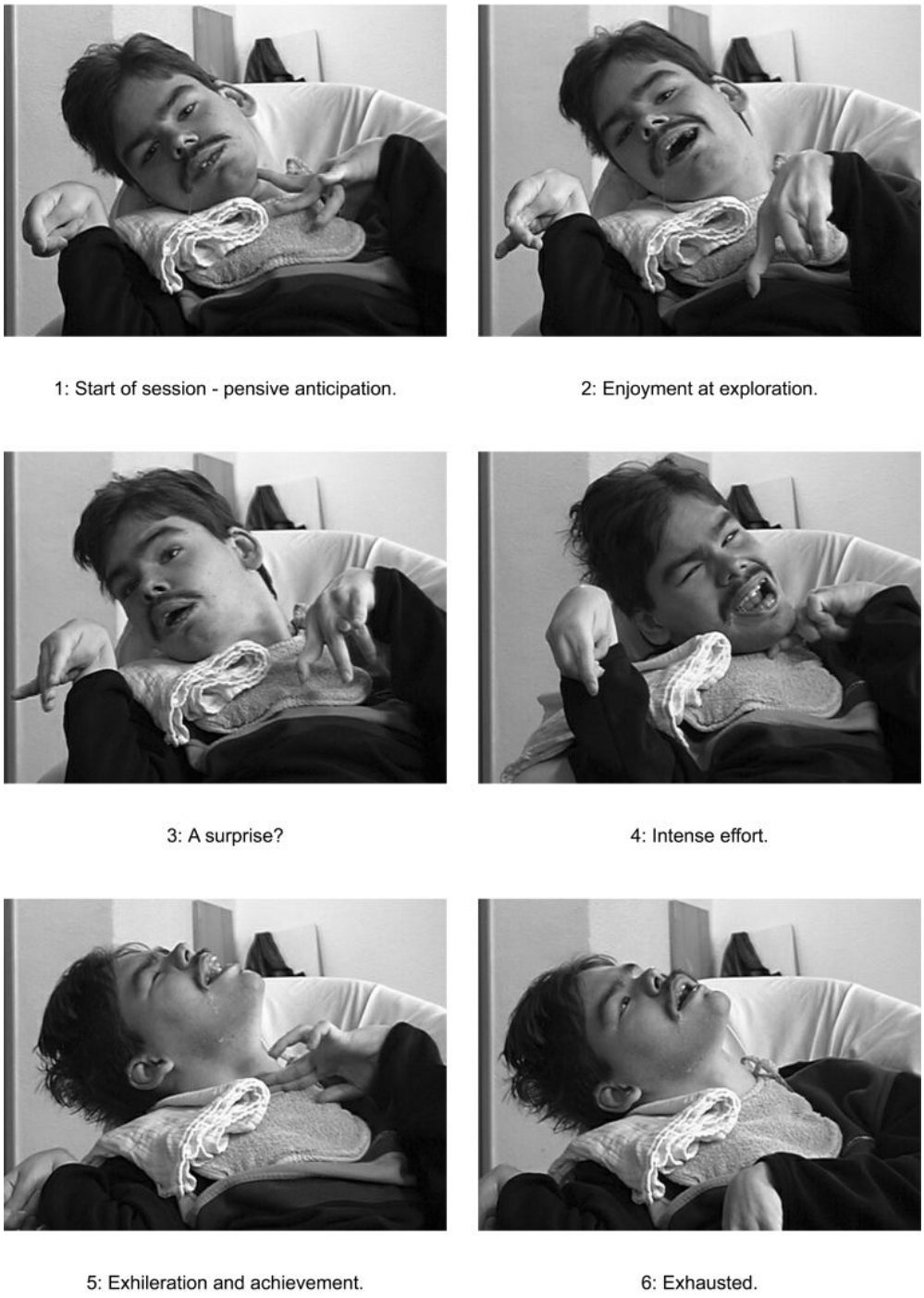
Vygotsky, L.S. (1981). The genesis of higher mental functions. In J. V. Wertsch (Ed.), *The concept of activity in Soviet Psychology* (pp. 144-188). New York: Sharpe.

Vygotsky, L.S. (1978). *Mind in Society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wertsch, J.V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Cambridge, MA: Harvard University Press.

Wertsch, J.V. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University.

Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem-solving, Journal *of Psychology*, vol. 66, 181-191.



Appendix 1. Image sequence from a single session action cycle with interpretations of the phrase.

Background on John: Although born 1975 without a disability at age 2.5 years a vitamin pill became lodged in his throat causing his state. Following this incident he did not move or respond to any stimulation for 2 years. The SoundScapes sessions with him began in 1998. He deceased in March 2000. The extracts are from just one of the video taped sessions carried out during this time. In 2005 this video tape was presented to the parents. The involved music consultant for adult handicapped was also present. Together the three parties were interviewed by an independent researcher with the help of a translator and they were video recorded as they watched the session video. The emotional viewing session followed a semi-structured interview created for the study. Subsequently they supplied John's personal diary which was completed by the day-care personnel during the period of sessions. Both diary and interview/viewing stated to the positive effects of the sessions. *N. B. Most people upon viewing the figures focus on the facial expression, thereby mainly ignoring the hands. The six segmented images in appendix 2 illustrate how segments of the whole combine to indicate a 'gestalt' individuality of expression which is conveyed through body semantics that the facilitator should try to recognize. This constitutes the analysis segmentation theory as outlined in the text.*

Appendix 2: The images above (and appendix 1) are selected from an extended investigation with John (name changed) a SoundScapes participant with profound disability hosted at a day centre in Denmark. In the sessions the participant's gestures (head and hands) manipulated various 'short staccato' sound patches on a digital synthesizer; this through non-intrusive 3D infrared volumetric sensor technology. The <start> image above is his mode without interaction. Following the registration of the sounds he joyfully explores; gets a surprise; and intensely focuses on the feedback – his facial/hand suggest a *concentrated effort*. His final phrase in the action cycle is defined head realignment that corresponded to a vocal utterance that was recognized by his parents in a viewing segment of a video interview (see Brooks and Petersson, 2005) as being related to the pitch change of the sound patch he was manipulating (so mimicking/mirroring the sounds he played). This achievement – concluded with a *relaxation* of the hands and was followed by a state of rest <End> where the hands can be seen as resembling the state in the <start> image. Intervention strategies were also incorporated with John whereby a volumetric sensor was positioned immediately in front of his face so as to source his cheek muscle which the helpers informed was his only perceived controllable body part in an effort to play drums. For more on this intervention/facilitator role and guided participation, see Brooks and Petersson (2005).