Position paper: Using sensory augmentation to investigate the role of action in cognition

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This position paper focuses on the question: How can empirical experiments with sensory augmentation devices be used to further philosophical and psychological enquiry into cognition and perception?

Sensory augmentation devices may be developed for reasons from wanting to develop devices to aid sensory impairment to theoretically understanding of the role of sensory interaction in perception and cognition. The development of sensor technologies and exertion interfaces (Mueller et al., 2002) bring new possibilities for augmenting sensory information. Our work focuses on the role of sensor-based technologies and interaction in supporting cognition. This position paper introduces some pilot work undertaken to investigate the role of sensor based technologies in promoting different kinds of physical action, and the relationship between this action and participants' perception of visual displays triggered through their action. We then propose ways in which this work may be extended, and how associated empirical work might inform our understanding of the relationship between sensori-motor interaction and cognition.

Wii Remote (Wiimote) technologies use accelerometers to send information of people's physical action to generate visual and audio feedback, most commonly in gaming contexts. In the field of learning, we suggest that sensory augmentation through similar devices may support exploration and understanding of real world physical phenomena (such as forces, motion and acceleration) through embodied interaction with these concepts (Price et al., 2008). Our pilot study (Sheridan et al., 2009) used Wiimotes to recognize physical movement and to generate visualizations based on the incoming accelerometer data. Thus, action with the Wiimotes, or the sense of motion or acceleration was augmented through visualization. The aim was to explore links between action and interpretation of data, with the future aim to investigate the role that such sensory augmentation plays in supporting the conceptualization of motion and acceleration phenomena.

The study involved 21 students (aged 11-12 years), both boys and girls, who worked in groups of 3 on two different activities with the investigator for approximately 30 minutes. Two Wiimotes were connected via Bluetooth to a MacBook Pro. In the first activity, two versions of Darwiin Remote [sourceforge.net] ran simultaneously and in the second activity Osculator [osculator.net] was connected to Processing [processing.org]. In both cases, results were projected onto a large screen at the front of the room. Participants were required to grasp and grip the Wiimote in their hand, and then gesture in 3D space. Data was continuously transmitted between Wiimotes and the application in realtime so that movement in the real world is continuously updated in the digital world. Two children used one Wiimote each, while other students sat in a semi circle behind so that they could see participants' action and the digital representation.

Figure 2a. DarwiinRemote showing acceleration data from two Wiimotes (left). Figure 2b. X/Y axis of each Wiimote is mapped to a dot with a fading effect (right).

Motion in the digital world was directly linked to motion in the real world, i.e. moving the Wiimote in physical space caused the digital graphics on the screen to change. In the first activity we used a graphical representation to map acceleration from each Wiimote axis to different colour where height and direction of the wave indicated velocity (see Figure 2a). In our second activity, X/Y acceleration from each Wiimote was mapped to an abstract visualisation – a large white dot, which had a fading effect (Figure 2b). Movement in one axis caused the dot to move left or right and in the other to move up or down.

Two key themes emerged from this study that are of particular interest here:

- The important role of 'frames of reference' in shaping the relationship between action and cognition

Since we only used the acceleration data from the Wiimote, not the infrared technology, children were not required to point the Wiimote at the display. This meant they could turn their back to the screen and continue to actively engage with the system and each other. However, it also meant moving the controller in 3D space without any physical boundaries, providing no point of reference from which to orient and position themselves or the controller. Interacting through multiple degrees of freedom made interpreting the relationship between their actions and the digital representations more difficult. On the other hand when they were asked to imagine the Wiimote as a particular object or were given specific action based tasks (e.g. stirring, swimming, running) their actions were constrained, and a point of references for position and movement provided, enabling easier links to be made between action and effect. This suggests that sensory augmentation for supporting action and cognition requires clear frames of reference.

- The role of 'wittingness' (Sheridan, 2006) in experience progression, and in particular the difference in effect of doing and observing on interpretation.

From our study we suggest the importance of 'doing' and experiencing one's own action in interpretation. The study involved both observers and participants, and certain types of performative actions encouraged the transition from participant to performer (for example, when asked to choreograph movements together or to move as if they were playing a sport). We propose that this transition from passive observer to witting and active performer plays a functional role in the understanding of concepts through movement. We found that children recognized and interpreted the differences in movement data when they were actively engaged in performing actions, rather than when observing them. This suggests that action is central to meaning-making and that sensory augmentation is particularly good for providing imaginative, creative and performative activities to support learning.

The Wiimote provided a good prototyping device however, for sensing acceleration and other phenomena to a greater degree, a more sophisticated sensory device that is extendable and modular is required. Objects embedded with customizable sensor boards, such as an Arduino or tMote Invent, would allow us to make use of miniature displays, microphones, speakers and LEDs so that we could generate audio or visual feedback on the devices itself. For example, shaking the object would generate different audio/visual patterns on the object's surface. With the addition of wireless technology, we could wirelessly network to other devices so that multiple users could generate improvised ensemble performances distributed across multiple objects. These types of technologies also open up the possibility for distributed and collaborative learning experiences.

This research direction aims to improve our understanding of the relationship between action and conception (action and cognition), and the role of action (or doing) in understanding mappings and relationships between action and concept. For example, if we showed that being involved in first person action was central to the concepts formed (or even if there was a difference in conceptualization between observer and actor) then this would inform us about the links between physical action (proprioceptive sensory experience) and cognition.

We are currently developing technologies to further explore the use of sensory augmentation to investigate links between action and cognition and information about our progress is available on our website (http://www.lkl.ac.uk/research/tangibles/).

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