Assessing emotions and arousal in developmental psychophysiology studies with thermal infrared imaging

Arcangelo Merla[1,2] and Barbara Manini[3]

[1]ITAB - Institute for Advanced Biomedical Technology, and Department of Neurosciences, Imaging and Clinical Sciences – University G. d'Annunzio of Chieti-Pescara, Italy

[2]Next2U s.r.l., Pescara, Italy

[3]Petitto Brain and Language Laboratory for Neuroimaging (BL2), Gallaudet University Washington, D.C., USA

We identify the ways that Thermal infrared (IR) imaging is a unique non-invasive research tool that sheds new light on problems in early infant/child development that behavioral data alone can not answer. We show how underlying physiological responses indicative of emotional arousal and attention are measured with Thermal IR during infant social interactions that provide new knowledge about the relationship among infant emotions, social interactions, and higher cognition. We then identify how our team's basic science research has used Thermal IR to study infants' emotional/arousal states during language processing, which, in turn, has yielded predictions about when infants are most optimally "ready to learn." Building on this, we identify how this knowledge is integrated into a single system in our Robot AVatar thermal-Enhanced ("RAVE") learning tool so that it can "know" when to start and stop producing its language samples with infants, thereby approaching for the first time human-artificial agent socially-contingent conversational interactions.

Thermal IR imaging provides real-time assessment of cutaneous body temperature (Merla, 2004) and represents a suitable, non-contact and non-invasive tool for computational psychophysiology, especially suitable for developmental neuroscience (Ioannou, 2014) and human-machine interaction studies (Merla, 2014). It enables recording of emotional perspiration (Ebisch, 2012; Pavlidis, 2012), sudomotor response (Merla, 2004), cutaneous temperature variations (Hahn, 2012), cutaneous blood flow (Puri, 2005), cardiac pulse (Garbey, 2007), as well as breathing activity (Pavlidis, 2007).

Thermal IR imaging has been implemented in a variety of studies involving human emotions. It has been used to study startle response, empathy, guilt, embarrassment, arousal, stress, fear, anxiety, pain, and joy (Ioannou, 2014). Mostly studied regions are the nose tip, the periorbital, the maxillary or the perinasal area. The direction of the average temperature changes in those regions or its frequency decomposition (Cardone, 2015) are reported to be descriptive of sympathetic and parasympathetic expression of autonomic activity (Merla, 2014).

Developmental studies with children using thermal IR imaging have investigated largely maternal empathy and social interaction. Ebisch (2012) demonstrated a situation-specific parallelism between mothers and their 3 year-old children's facial temperature variations. This study was the first that provided evidence for a direct affective sharing involving autonomic responses in a purely natural context. An extension of the above study with an additional group of female participants showed that mother–child dyads in contrast to other-women–child dyads have faster empathic reactions to the child's emotional state (Manini, 2013).

Thermal IR imaging has been used to examine and characterize physiological signs that underlie self-conscious emotions in 36-40 month-old children (Ioannou, 2013). Further, behavioral and facial thermal responses were recorded in 3-4 month-old infants during the Still-Face Paradigm (Aureli, 2015) revealing that the parasympathetic system was more active than the sympathetic, which provided new insights into a former unresolved controversy in behavioral studies: infants are aroused, not distressed.

We discuss how the integration of thermal IR imaging in RAVE opens the way for achieving more socially contingent interactions and provides a foundation for the artificial agent to interpret and predict the psychophysiological state of the child (Merla, 2015).