A Neurofeedback protocol using a sophisticated interactive video game to improve social responsiveness in children with ASD

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INTRODUCTION

Individuals with autism spectrum disorder (ASD) show deficits in social and communicative skills such as imitation, empathy, and shared attention, as well as restricted interests and repetitive patterns of behaviors. While no single explanation can account for the spectrum of autism, converging evidence implicates that a dysfunction in the human mirror neuron system (MNS) could be one underlying cause. ASD individuals exhibit normal EEG mu rhythm suppression, a presymptomatic index of MNS activity, for self-generated movement, but fail to suppress during observation of movement. Neurofeedback training (NFT) to increase mu rhythm power (i.e. 8-12 Hz over sensorimotor cortex) was shown to reduce the behavioral symptoms in children with ASD as well as to increase mu suppression to movement observation [1].

In the present study we address (1) the counter-intuitive observation that NFT that enhances mu power actually results in more mu suppression and (2) the interplay between neurophysiological and behavioral components in children with ASD by the use of an interactive video game providing feedback that corresponds directly to the underlying significance of the trained signals (i.e. imitation behavior) as well as to the behavior that is reinforced such as successful social interactions.

NEUROFEEDBACK PARADIGM

Participants and sessions
- 14 participants divided into 2 groups (7 still in training)
- Confirmed diagnosis of ASD
- 6-17 years old
- No prior NFT experience
- 16 one-hour NFT sessions 2-3 a week plus Pre- and Posttest

Recordings
- Electroencephalography (EEG): C4
- Electromyography (EMG): left arm
- Electrocardiography (ECG): left wrist and right neck
- Skin conductance (SC): left index and ring finger
- Respiration: belt around the abdomen

Study design and game
The new game consists of game episodes (e.g. apple picking, balloon ride, dragon fight) as well as interaction sequences before each game episode. During the game episodes children can control the game by enhancing mu activity (8-12 Hz) and simultaneously decreasing power in the theta (3-8 Hz) and high beta range (18-30 Hz) over C4 [1].

Unique to this game are the interaction sequences in which the child’s avatar must first approach the game character. Then, while facing the game character, children have to increase (group 1) or decrease (group 2) mu power. The rewarding feedback involves the child’s avatar imitating the facial emotions of the game character.

CONCLUSIONS

(1) Both groups improved in the “Reading the Mind in the Eyes” - Test and in adaptive behavior indicated by the parents. Group 1 additionally improved in social responsiveness and the treatment was rated more effective.

(2) The two different NFTs achieved specific effects:
- Group 1 trained only mu increase and showed more mu power as well as more mu suppression during two out of four movement observations at C3 and C4 in the Post- compared to the Prettest.
- Group 2 trained mu increase during game episodes and mu decrease during interaction sequences. Group 2 showed the same level of mu power and more mu suppression during all movement observations at least at C3 in the Post- compared to the Prettest.

(3) The sample size is still too small to draw final conclusions about which NFT protocol is more beneficial to children with ASD.

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