Objectives:
Autism spectrum disorders are characterized in part by socio-communicative impairments that are resistant to many forms of treatment. These impairments may be due in part to aberrant connections within the human action-observation or mirror neuron system (MNS). A putative marker of MNS activation is the 8-13 Hz sensorimotor EEG signal known as the mu rhythm. Mu modulation during observation of biological actions has been found to be reduced in ASD. One proposed intervention to normalize MNS activity is neurofeedback training (NFT), an operant conditioning technique in which trainees learn to volitionally control power levels in EEG frequency bands based on real-time feedback from a computer. We used functional MRI to compare effects of mu-rhythm based NFT in a group of children and adolescents with high-functioning ASD and a matched group of typically developing (TD) children.

Methods:
All participants completed between 20-30 hours of NFT, during which they attempted to modulate mu EEG power (8-13 Hz) at electrode site C4 to control aspects of a video game or movie. The goal was to maintain mu power above a pre-determined threshold while keeping theta and beta power below pre-determined thresholds.

All participants received fMRI scans before and after training during performance of an action imitation task and during rest, as well as anatomical and diffusion tensor imaging scans. Along with parent questionnaires and assessments related to ASD symptom severity and socio-communicative abilities, data from these pre- and post-NFT scans were used to test for effects of mu NFT.

Results:
Brain activation (percent BOLD signal change) was measured during an action observation and imitation task. These data were entered into a whole brain ANOVA including group (ASD, TD) as a between-subject factor and training (pre-NFT, post-NFT) as a within-subject factor. Statistically significant group x training effects were found in brain areas comprising the MNS. In the ASD group, these changes in BOLD activation following the training were accompanied by positive changes in pen-and-paper assessments of socio-communicative abilities.

Conclusions:
Mu NFT beneficially affects socio-communicative impairments in ASD, and these behavioral benefits are accompanied by increased activations in brain areas involved in action observation and imitation. Mu NFT appears to have different effects on a matched group of typically developing individuals, who showed minimal changes in behavioral measurements and a decrease in imitation-related brain activations following NFT. Our findings suggest that mu NFT may be effective in the treatment of ASD in children and adolescents.