EVENT ABSTRACT

# Professional instrumentalists excel at musical anomaly detection: Possible evidence for embodied cognition from single-trial EEG discrimination

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We are extremely good at detecting anomalies in our sensory input. For example, while listening to a piece of Western-style music, we can often detect a forced key change or an out-of-key pitch, even if we are not musicians. Here, we investigate differences between musical experts and non-experts in terms of the underlying neural signatures of musical anomaly detection. Experts had 32.6±10.0 years of cello performance experience among a range of ages covering 41.6±10.6 years, while non-experts at 0 years of cello performance experience among a comparable range of ages, though some non-experts had played musical instruments in the past. Specifically we analyzed the electroencephelograms (EEG) of five expert cello players and five non-cello players while they listened to excerpts of J.S. Bach's Prelude from Cello Suite No.1. All subjects were familiar with the piece, with experts having extensive experience playing the piece. Subjects were told that anomalous musical events could occur at random within the excerpts of the piece and to count the number of such events, reporting the number after each excerpt. Subjects were instructed not to move while listening to the excerpts and this was verified via visual monitoring. Experts had significantly better behavioral performance (i.e. correct counts) than non-experts, though both groups had mean accuracies of >= 85% (experts' accuracy fraction = 0.94±0.03, novices' mean accuracy fraction = 0.85±0.12). To analyze the EEG data, we trained a logistic regression classifier and assessed its single-trial performance with a leave-one-out (LOO) analysis, using the area under the receiver-operator characteristic (ROC) curve as a metric of accuracy (i.e., the value of Az). In analyzing the EEG this way, we found significant neural correlates only post-stimulus (Bonferroni corrected, $p < 0.01$), indicating the subjects' neural response to the anomaly. In particular, we summarized each subject's neural discrimintation with the maximum value of Az. We found that each subject had the same relative detection accuracy and significance across groups as seen in the reported behavioral counts, though overall the accuracy from neural correlate based detection (experts' Az = 0.86±0.04, novices' Az = 0.75±0.06) was approximately 10% less than behavioral accuracy.
Using the subject specific timing we found for the maximum discriminating neural correlates, we performed source reconstruction and compared significant differences between cello players and non-players. We found significant differences ($p < 0.01$) that included a right lateralized source distribution in experts consistent with the cortical representation of the left hand– i.e. the hand a cellist would use to generate the anomalous key-changes while playing. Together these results suggest that when detecting anomalies in a musical stream, experts with experience performing the piece generate activity in sensory-motor centers that would be involved in executing the action needed to generate the anomaly. Conversely significant activation in non-experts was seen in the left superior temporal gyrus, which has been implicated in general perceptual decision-making tasks. Together, these results suggest that sensory anomalies detected by experts may in fact be partially a result of an embodied cognition, with a model of

the action for generating the anomaly playing a role in its detection, while novices' anomaly detection is not embodiment-dependent.

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## Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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