Experiential effects of musical pleasure on dopaminergic learning

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ABSTRACT

Background

Listening to music is consistently rated as one of the most rewarding experiences in the world (Dubé & Le Bel, 2003), and neuroimaging has linked music listening with brain areas implicated in emotion and reward, such as the ventral striatum, that are regulated by endogenous dopamine transmission (Blood & Zatorre, 2001; Menon & Levitin, 2005; Salimpoor et al., 2009). Levels of striatal dopamine seem to influence reinforcement learning behavior: subjects with more dopamine tend to learn better from rewards, while those with less dopamine tend to learn better from punishments (Frank et al., 2004; Frank et al., 2007).

Aims

In this study we explored the practical implications of musical pleasure through its ability to enhance dopamine release by measuring its effect on a reward-based learning task dependent on dopamine transmission.

Method

Twenty-two musicians and twenty-three non-musicians completed at-home listening tests to select pleasurable and neutral music from an experimenter-created database of pieces taken from instrumental film scores. We then pseudo-randomly divided the participants into four groups, ensuring that each group had similar amounts of musicians and non-musicians. Group assignments specified the music (pleasurable or neutral) that subjects would hear during the Training and Test phases of a probabilistic selection (PS) learning paradigm (Frank et al., 2004); thus the groups were called 'PN' (pleasurable -- neutral), 'NP' (neutral -- pleasurable), 'PP' (pleasurable -- pleasurable), and 'NN' (neutral -- neutral). In the PS task, subjects learned to choose between three stimulus pairs of different reward probabilities through trial-by-trial feedback in a Training phase, followed by a Test phase of recombined stimulus pairs and no feedback.

Results

Throughout Training, all groups quickly and reliably learned to distinguish frequently rewarded symbols from infrequently rewarded ones, but repeated measures analyses of variances (ANOVAs) with planned comparisons revealed that non-musicians responded more accurately and quickly when listening to pleasurable music whereas musicians responded more accurately and quickly when listening to neutral music. Importantly, the groups did not differ in working memory recruitment. By the end of Training, participants across groups and musical backgrounds had learned the task to similar levels, but with contextual differences that manifested themselves in the Test phase. Musicians who learned with neutral music and were tested with pleasurable music ('NP') performed faster and more accurately than other subjects during Test, while non-musicians in the same group responded more slowly than other subjects.

Conclusions

Though there were no significant effects of reward- versus punishment-driven learning, these results suggest that pleasurable music during Training facilitated learning for non-musicians but had a negative influence on musicians, possibly indicative of a greater capacity for musicians to be distracted by musical pleasure. During the Test phase, pleasurable music benefited musicians who had not been affected by it in Training (that is, in the 'NP' group) while non-musicians were unaided by musical pleasure and less able to successfully switch musical conditions from Training to Test. Overall, musical pleasure had a greater impact on performance during Training, when it enhanced dopaminergic learning in non-musicians but distracted musicians perhaps due to non-optimal striatal dopamine transmission. These effects were complicated when participants switched musical conditions.

Keywords

Music, pleasure, dopamine, reinforcement learning, reward

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