Brain regions sensitive to structure in language vs. music are largely non-overlapping in the human brain

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Neuro imaging and behavioral investigations have argued for overlap in the cognitive and neural mechanisms that support structural processes in language and music (Patel et al.,1998; Maess et al., 2001; Koelsch et al., 2002; Koelsch et al.,2005; Levitin&Menon,2003; Tillman et al.,2003; Fedorenko et al.,2009; Slevcet al.,2009), with only one recent study suggesting otherwise (Rogalsky et al.,2011). However, neuropsychology studies have revealed dissociations between linguistic and musical deficits (Luriaetal.,1965; Peretz,1993; Peretz & Coltheart, 2003).To address this discrepancy, we examined the neural locus of structural processing in language and music using fMRI in individual subjects. Each participant (n=12) was run on (1) a language “localizer” experiment that included visually presented sentences and strings of pronounceable nonwords and that has been previously shown to identify key frontal and temporal regions implicated in linguistic processing (Fedorenko et al.,2010), and (2) a music experiment with four conditions featuring different degrees and aspects of music structure (intact music, music with scrambled note pitches, music with scrambled note onsets and durations, and music with both pitch and rhythm scrambled).

Results: brain regions sensitive to linguistic structure. In each subject we defined language-sensitive regions (see Fedorenkoetal.,2010, for method details) and examined the response of these regions to the music conditions. None of the regions showed a significant Intact Music>Scrambled Music effect, although some regions showed a trend in this direction. Moreover, the response to the Intact Music condition in these regions was on average below the level of the Nonwords condition.

Results: brain regions sensitive to musical structure. First, we performed a group-constrained subject-specific analysis (Fedorenkoetal.,2010) to search for spatially consistent music-structure-sensitive regions across subjects, using individual activation maps for the Intact Music>Scrambled Music contrast (thresholded at p<.001). This analysis discovered bilateral anterior superior temporal regions, bilateral regions in mid/posterior STG/MTG, and bilateral regions in the premotor cortex and the SMA. Each of these regions was activated in at least 8/12 subjects individually (the right temporal regions were present in at least 10/12 subjects).We then examined the response of these regions to the structural manipulations of music and language. All regions showed a highly robust Intact Music>Scrambled Music effect as measured from data not used to localize the regions. The response to the Pitch Scrambled and Rhythm Scrambled conditions fell between the Intact and Scrambled conditions in all of the regions, suggesting that these regions are sensitive to both pitch and rhythm structure. However, although most of the music-sensitive regions showed a response to the language conditions, none of the regions showed a significantly greater response to Sentences than Nonwords. Moreover, the right anterior temporal region (previously implicated in musical processing;e.g.,Peretzetal.,1994) and the right posterior temporal region did not respond to the language conditions more than to the Scrambled Music condition.

These data show a robust dissociation between cortical regions that are sensitive to the presence of structure in linguistic vs. musical stimuli. These results are consistent with the patient literature, but inconsistent with previous neuroimaging, ERP and behavioral studies that have argued for overlap between these two domains. We argue that the previously observed overlap effects originate not within language- or music-sensitive regions discussed above, but rather in the domain-general regions of the fronto-parietal network that have been argued to respond to a wide range of cognitive demands (e.g.,Duncan,2001).