Sir, Lai et al. (2012) explored the preserved musical abilities in those with autism in association with language disabilities. They reported no differences in structural neural pathways between those with and without autism, and that functional systems that process speech and song were more effectively engaged for song than speech in autism.

There is one study that could dampen their hopes of finding specific structural differences that could account for preserving musical abilities while hindering speech. Schwartz et al. (2003) showed that the frequency ratios used as the building blocks of music (i.e. the chromatic scale) are embedded into all human languages. Statistical analysis of thousands of snippets of languages from around the world demonstrated a concentration of frequency ratios that are identical to those in the chromatic scale. Subsets of the chromatic scale form the basis for virtually all of human musical scales found across geography and time. Thus, music and speech are intimately entwined in a way that is typically unrecognized.

Why are the frequencies of the chromatic scale so heavily favoured in the sounds that we use to create our speech? More specifically, how does the neurotypical mind exploit these frequency ratios in a way that facilitates decoding speech, but perhaps hinders music abilities? On the flip side, what is it about autism that many have enhanced musical perception of these same ratios at the expense of comprehending speech? The answer is not dependent upon connectivity or genetics; rather it is entirely contained in ideas about signal processing and, more specifically, the savant hypothesis (Fabricius, 2012).

Straight forward analysis of the physics of a vibrating string shows that the frequency ratios comprising the chromatic scale are precisely the ratios that are most easily compressible. Hence, humans have loaded their phonemes with frequency ratios that are most easily compressible, presumably to facilitate rapid decoding of speech. Many find it paradoxical that typical individuals can decode 20–30 speech sounds per second, but non-speech sounds blend into unidentifiable noise at only 15 sounds per second (Liberman et al., 1967).

Arguments utilizing signal compression clarify this paradox and explain why speech sounds are filled with easily compressible frequency ratios. Simply stated, compression allows for more rapid cognitive processing. As suggested by the savant hypothesis, neurotypical minds learn to work with compressed approximations of sensory signals while those with autism work with more complete and precise representations. Neurotypical minds seem to surrender detail retention in favour of increased processing speed and cognitive fluidity.

For example, all infants seem to be born with absolute pitch, but only 1 in 10,000 adults retain this ability (Saffran and Griepentrog, 2001). Unsurprisingly, absolute pitch is much more common in autism with a prevalence of 1 in 20 (Sacks, 1995). Lossy compression schemes surrender precision for efficient representation, resulting in some error of the approximate representation. Thus, a full and detailed neural representation corresponds to a better sense of pitch, while a variably compressed representation results in a varying degree of error of pitch perception. As Lai et al. (2012) noted, tonal changes in music happen at a much slower time scale. Thus, the extra detail retention of autistic perception results in enhanced musical abilities where the time scales of pitch change are much longer and do not require rapid processing. Speech, however, favours approximate pitch representation in order to process the rapid succession of pitches embedded into the phonemes of our language.

In a recent article published in Brain, Eyler et al. (2012) explored a failure of lateralization of language processing in...
those with autism. Normal lateralization of cognitive functions other than language is also disrupted in autism (Pierce et al., 2001). As noted by Eyler et al. (2012), all infants can easily discriminate all non-native speech phonemes, but typically developing infants lose this ability by 10 months of age. Concurrent with this time frame of developmental perceptual narrowing is the increased left hemispheric activity in processing vowel sounds (Sato et al., 2003). This identical time frame of perceptual narrowing with increased left hemispheric processing bias is not coincidental. The details take a little too much space to explain in this brief letter, but straightforward signal processing arguments suggest that developing normal lateralization patterns depend upon being able to first form compressed representations of sensory signals before the brain can begin to utilize the traditional regions for specialized processing activities. A more detailed explanation can be found in Fabricius (2012). In summary, most of the nuances of strengths and weakness in autistic cognition and development are more easily explained from a signal processing approach rather than structural or functional connectivity arguments.

References


