Melody and Prosody: Living Together in Perfect Harmony?

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Abstract

This paper offers an inspection of the similarities and differences in music and language processing. Evidence from multiple studies are utilized in an attempt to discern how entwined they are within the realm of neurological processing. While there are significant areas of overlap, points of divergence help to distinguish the order in which the brain processes the two auditory streams, and may also help in implicating which process was established first.

Music and Language

Music and language have many marked similarities that help to set them up for comparison. The fact that both are processed through our auditory system is arguably the main cause for the connection, but there are other reasons the two are viewed as similar. Both are used to communicate meanings to the observer, and both have their own sets of structural rules. Both are observed across nearly every human culture in some form, and both are considered relatively unique to humans, with the exceptions of a small subset of animals that appear to have a limited capacity for language, and songbirds that use and process music.

Though the two have many similarities, a debate has long been held concerning the extent of their interconnectedness. Most notably, an assumption has been made that music has sprung forth as an offshoot of language, though some have gone the other direction, and argued language came about as an offshoot of music (Justus & Hutsler, 2005). The debate has been ongoing in the realm of evolutionary psychology, dating so far back, Charles Darwin has a recorded opinion on the subject, stating early man “probably first used his voice in producing true musical cadences, that is in singing.” (Masataka, 2007). An opposing viewpoint would be that the two are mostly independent of each other, sharing certain neural pathways merely due to their shared input modality.

With the advancement of neuroimaging, we have been able observe the pathways that language and music processing utilize, as well as their specific levels of independence and interdependence. There is key evidence that components of language and music processing utilize different areas of the brain, which would infer that they are dissimilar processes arising independently. Other researchers state that the argument is not that the two are identical processes, but that there contains significant overlap, and as such they spring from the same evolutionary fountain.

Our key question now becomes how entwined are the two, as well as how separate do the two need to be to be considered “different”, with the hope that answering these questions might lead us to be able to answer if music is an innate, separate auditory component, or does it ride on the neuronal coattails of language.

Evidence

A good starting point in this discussion is to inspect evidence that has been gathered concerning their potential similarities and differences in the way language and music are processed by the brain. One such study sought to find if we use the same cognitive resources for structural processing of the two. Subjects were asked to listen to a sung melody that varied in complexity in two important ways. Melodically, the sentence was sung in a proper key all the way through, or had one note sung out of key. Linguistically, the sentence had a simple, subject extracted relative clause ("The boy that helped the girl got an "A" on the test") versus a more complex, object extracted relative clause ("The boy that the girl helped got an "A" on the test"). Following the stimulus, subjects were asked a simple yes or no question regarding the content to ascertain their level of understanding (Fedorenko, Patel, Casasanto, Winawer, and Gibson, 2009).

The study compared comprehension accuracy between the groups, and found that there was a larger difference between comprehension in subject versus object relative clauses when the melody was sung out of key (Fedorenko et al., 2009). The fact that the out of key melody created a larger discrepancy in comprehension shows that there is some overlap in the processing of language and music structure.

An ERP study sought to find potential correlations between language and music by mapping out the functional organization used by males and females for music and language syntactic processing. Language functions have been shown to be bilateral for females, whereas males show higher levels of language syntactic processing in the left hemisphere. This study's findings carried over the bilateral activation for females when processing music syntax, but surprisingly, showed higher processing in the right hemisphere for males (Koelsch, Maess, Grossman, and Friederici, 2003).

It would seem that this ERP study's findings provide evidence for both sides of the debate. The processes are obviously divergent in that males process music and language syntax in opposing hemispheres, yet because both processes show gender differences, and these differences between language and music are symmetrical to each other, there is supporting evidence that on some level, the brain treats the information similarly.

Another way to ascertain their level of entanglement is to inspect if a deficit in the processing of one effects the processing of the other. If the deficits correlate, then we can infer that they are intermixed at that level. Conversely, if there are specific deficits that uniquely effect language or music, then we can state that processing of language and music are divergent at that level, or earlier.

One study of interest sought to find if delayed language deficits in syntactic processing corresponded with similar musical deficits. Both language and music rely on structural rules. When these rules are violated with language, ERP activity usually shows an early right anterior negativity, as well as eliciting a late negativity, evidenced by an N5 (Jentschke, Koelsch, Sallat, & Friederici, A. D.2008). This study sought children known to have language impairments, and compared them to a control group. It was found, as expected, that syntactically irregular musical passages elicited the N5 and the early right anterior negativity in the control group, but not in the language impaired group (Jentschke et al., 2008). This study offers further evidence that, at the very least, music and language syntactic processing share some resources.

While the previous study showed that deficits in the language domain were able to predict similar deficits in music, there are more specific deficits that have been known to effect only one domain. One such example, Wernicke's aphasia, effects the ability of speech reception in those afflicted, leaving music reception intact.

A case study of a patient with Wernicke's aphasia highlights some of the components of spared musical processing. The patient, NS, lost the ability to easily process spoken language after a stroke, though could comprehend written language fine. He also showed difficulties understanding environmental sounds, such as confusing a baby crying for a cat meowing, or the sound of a jackhammer for sheep baaing. Even so, NS began listening to music after his stroke, a practice he was not particularly fond of beforehand (Mendez, 2001).

Testing showed that NS was able to correctly match melodies to relevant pictures correctly in 10 out of 10 trials, such as matching the song “Happy Birthday” with an image of a birthday cake. In a related task of matching environmental sounds to images, he was only successful 27 out of 48 trials (Mendez, 2001).

We can see through NS that the brain does not treat incoming language and music stimulus in the same fashion through all depths of processing. What was striking about this study was that, as a consequence of his stroke, environmental sounds and verbal communications were both susceptible to misperception, yet his music comprehension was spared. This finding suggests that music and language neurological pathways are divergent at some point, with music being separated out of the audio stream entirely to be processed separately.

Other deficits show us similar levels of differences in language and music processing. Patients with severe Broca's aphasia surprisingly have an easier time singing statements than relating them as words. Melodic Intonation Therapy arose to take advantage of this finding. It is theorized that it is effective due to melody production utilizing the right hemisphere, while speech production uses the left hemisphere (Schlaug, Martina, and Norton, 2008).

Obviously, the ability to relate meaningful, albeit melodic words, shows intermingling between music and language centers. The fact that damage to the left hemisphere only effects statements would seem to be strong evidence of very divergent pathways, but Schlaug et al. hypothesize that the effect of Melodic Intonation Therapy might also have to do with the slower production speed needed in the act of singing meaningful words than for speaking them, allowing the ability to draw out the temporal length of syllables (Schlaug et al., 2008).

Another interesting prospect for evidence of divergent paths stems from a different deficit, this one pertaining to music perception. Amusia, more commonly known to the general population as tone-deafness, is an inability to discern melodic pitch. In a 2009 study, Tillmann, Schulze, and Foxton studied the memory of subjects with congenital amusia, and found through memory testing that the subjects with amusia had a hard time retaining information concerning pitch and timbre in short term memory, but had the ability to retain word information at a rate statistically equal to a control group.

Evidenced by amusia, it would seem that music and language have definitively divergent processing centers. The problem with this inference is that, though amusia mainly affects music with its inability to process pitch, there are languages that rely on pitch to impart meaning as well. In English, for instance, raising pitch at the end of a sentence is used to infer what was said is a question. Before we are able to state that music and language are divergent in this aspect, it would be necessary to know if amusia effects these individuals speech perception as well.

Fortunately, a study was conducted that looked into this aspect of amusia. It was found that those with amusia fared statistically as well as the control group in discerning pitch information relating to speech (Ayotte, Peretz, and Hyde, 2002). This means that amusics are able to discern pitch information at the verbal speech level, but somewhere along the path music and language diverge and this information is lost.

Utilizing fMRI in another study, participants with amusia were compared to a control group while passively hearing tonal sequences. Interpreting the fMRI data showed that pitch distance in the melodies effected brain activity in the auditory cortices; the larger the tonal deviation, the more activity was shown in these areas. Where the two groups diverged was in the amusics deactivation of the right inferior frontal gyrus and its connection with the auditory cortex (Hyde, Zatorre, Peretz, 2011). This study shows us that, for amusics, the pitch information needed to process music is perceived and utilized for speech processes, but not passed along to corresponding musical processing centers.

Discussion

The question of interest was the level of entanglement in the brains processing of language and music, as well as how disparate they would need to be in order to be considered “different”. The evidence shows certain similarities between their respective processing. We have seen that structural processing is shared between the two domains (Fedorenko et al., 2009), and that deficits in language syntactic processing predict deficits in musical syntactic processing (Jentschke et al., 2008). We have also seen that both modalities exhibit gender differences, though the males pattern is symmetrical, not identical, between the two systems (Koelsch et al., 2003).

Nonetheless, the differences were quite striking. Wernicke's and Broca's aphasia showed that there are high levels of disconnect between the language and musical comprehension and production (Mendez, 2001; Schlaug et al., 2008). It was pointed out that some of these disparities in production ability might be due to lengthened time afforded in singing compared to speaking (Shlaug), and there is potential this is applicable to language reception problems associated Wernicke's aphasia. This is to say that NS was better able to understand words when they were spoken slowly (Mendez, 2001).

The most telling information regarding differences in music and language processing arguably comes from the literature on amusia. Perhaps most important is the idea that the pitch processing of language and music is completed separately by the brain (Hyde et al., 2009). A brief literature review did not bring up information on reverse cases, where linguistic pitch information is lost, but musical pitch information is retained. Barring the possibility of these cases, it would appear that music might have been acquired after language, as the brains initial pitch processing appears to be linguistic in nature, and passed on, either in parallel or slightly delayed, to melodic pitch areas. This idea would need much more evidence to formally posit, but is an interesting concept nonetheless.

Given the evidence, it would appear that music and language have separate but similar processing systems that share information. They appear to be done in parallel, though as previously mentioned, some aspects of music processing might come after language processing.

In regards to the question concerning how different is “different”, Justus et al. (2008) shared some fine points. Justus argues the cortex that processes specific information is the area best suited to process that type of information, and that there may always be areas of overlap. This does not constitute it being the same process. The fact that we can discriminate easily between language and music tells us that they are “different”, in that the brain discriminates between music and language easily. The two may share many of the same cognitive tools, but if an oven creates a cake and a pizza, we could not conclude that the cake and pizza are similar. That said, it is still of service to investigate the areas of their overlap, for though it might not bring us closer to understanding the “cake” (music) or “pizza” (language), it might give us a better understanding of the tool that produces such diversity; the “stove” that is our brain.

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