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Summary
Common Foundations of Language and Music at a Syntactic Processing Level

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Darwin (1872) argued that language and music evolved together, whereas natural language existed long before music. In accordance with this perspective, the primary purpose of music and language is to express one's feelings by changing the tone. Over time, as music has moved away from the primary function of being generated to seduce the opposite sex, in recent times it has adopted a more aesthetic context, while language still maintains its basic communication function, with both, language and music, existing in various forms.

Music and language definitions are quite similar to one another, with there being numerous features that they have in common and which can be determined by a superficial examination. Although there are many different types of communication systems, no other species, other than humans, have both musical and language skills (Jackendoff, 2009; Fitch, 2015). Furthermore, both language and music include some form of sound production and can be transferred into symbols. Every culture has its own local form of language and music, with these local differences being quite diverse, unlike the fixed communication systems of other species. In each culture, it is possible for language and music to be combined into a song. However, both do share similar characteristics such as, pitch, rhythm, accent, tempo, structure, and rules such as, syntax and harmony. While there is also a hierarchical arrangement in the form of phoneme, morpheme, word, and phrase in the language: Western music is based upon the hierarchical arrangement of the pitch. Both language and music consist of elements that are orderly combined in perceptually discrete, complex, and larger structures. These elements are arranged according to the syntax. The brain internalizes these rules as they become exposed, in addition, these rules implicitly effect perception and performance.

In addition to the array of common features mentioned above, there are obviously some prominent differences. First of all, language is primarily used to express thoughts, while music is used to express emotions. In music, pitch is arranged in relation to a specific tone, while in language there is no such stability. Due to the structure of human vocal cords, in language, pitch continuously progresses, but in music it changes intermittently (Bidelman, Gandour & Krishnan, 2010). The melodic properties of music, such as fixed intervals and hierarchical tonal structure, are completely domain-specific and are in no way similar to the linguistic elements (Krumhansl, 1990). However, melodic contour expresses the pattern formed by the rise or fall of the pitch over time, rather than certain specific pitch intervals; in the spoken language the equivalent can be considered to be the intonation.

Considering all of the similarities and differences, the question of whether the processing of music and language is associated with common structures or resources, has been a popular research topic for several decades. Initial findings were mostly based upon neuropsychological data; the most important premise for those who argue that music and language are two independent processes, stems from the findings obtained from amusic and brain damaged individuals. Some researchers (Peretz et al., 2002) believe that congenital amusia, which is characterized by the deterioration of the pitch discrimination, is not only associated with music. This is because those who are amusic often report problems understanding the information based on the altered pitch in the spoken language, such as word stress and sentence type (question sentence/judgment sentence, etc.). On the other hand, the selective musical skill impairments that are reported in brain-damaged patients are considered to be evidence for the modular music processing system (Peretz & Coltheart, 2003). Consequently, it is still highly controversial whether or not it causes a disorder in the processing of the language.

Even though neuropsychological cases support the independence hypothesis; the resource sharing hypothesis has been supported several times with behavioral studies, electrophysiological data and imaging methods.

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In recent years, the findings of fMRI and PET techniques in studies regarding the interaction of language and music, often indicate that similar brain regions are activated during both tasks.

When taking into consideration the findings relating to the possible connections between musical skills and language skills, the positive transfer hypothesis from music to language, can be easily associated with the effect of musical education. If the perception and processing of music and language are similar, skills developed in relation to musical expertise should also effect linguistic performance. Based upon previous research, it is reported that generative music skills are related to generative language skills, syntactic language skills are related to syntactic music skills and the ability to recognize emotion in speech is related to emotion recognition in tonal sequences.

The purpose of this study is to evaluate the appropriate literature, with a critical view of opposing the findings and views, as well as the findings that support the hypothesis that language and music are related. Since syntactic processing is the most researched subject in both fields; language and music will be compared at the level of syntactic processing.

Syntactic Processing in Language and Music

The rules that arrange structural organizations in a musical pattern are defined as syntactic rules, this is because of their similarity to the syntax in the language (Bigand, Tillmann & Poulin-Charronat, 2006). EEG findings have reported that listeners have been cognitively manipulating long-distance syntactic structures that are intertwined hierarchically while listening to music, which is similar to what has occurred in language (Koelsch, Rohrmeier, Torrecuso & Jentschke, 2013).

Cognitive approaches to language and music suggest that both syntax systems are quite different from one another. The name and action categories have different functions when it comes to words in sentences, such as subject, object, predicate, and distant syntactic connections, in sentences that are specific to language. Furthermore, any pitch sequence does not have the ability to limit syntactic properties like a word. In other words, the syntactic properties of language are much more complex than music ones. Therefore, the overlap between the two areas is at a processing level, not at the level of representation.

Shared Syntactic Integration Resource Hypothesis

According to the resource sharing hypothesis, Patel (2012) has two basic claims. Firstly, language and music involve domain-specific representations. The knowledge of words and their syntactic features involves a set of representations that are distinct from the representations of chords. Secondly, when similar cognitive operations are conducted on domain-specific representations, the brain shares neural resources between the two domains. Due to the distinct representations of music and language, when it comes to brain damaged cases, selective impairment emerges. In other words, those cases which have a selective brain impairment do not provide sufficient evidence to support the hypothesis that music and language are discrete areas. Language and music systems are independent; but when the linguistic and musical stimuli access the syntactic working memory simultaneously, the resources required for processing are shared. The structural integration system integrates incoming units (word or chord) into the structure (sentence or harmonic sequence) being developed. This system works instantly, enabling the selective activation of the associated units in networks that are domain-specific for both language and music. According to the resource sharing hypothesis, the concurrent tasks involve a linguistic and musical syntactic structural integration process that will cause an interference effect.

There are behavioral methods that are frequently used in studies which are aimed to examine the relationship between language and music at a syntactic processing level.

Pitch Discrimination Task

In those studies that support the hypothesis that language and music are interactive, commonly use the pitch discrimination task. In this task, participants are presented with sentences or musical tones. The last word or tone of the sequence is either congruent or incongruent with the previous part of the sentence or chord sequence. Participants are asked to decide whether there are any abnormalities. An experimental group is compared in terms of the number of errors and the response time, with the control group. In this task, the better the performance is of musicians in determining incongruities in the language condition and distinctive occurrence of late positivity and early negativity components in musicians in the incongruity condition, should indicate the common pitch processing mechanisms in the processing of both language and music (Schön, Magne & Besson, 2004; Magne, Schön & Besson, 2006; Moreno & Besson, 2006; Marques, Moreno, Castro & Besson, 2007; Jentschke & Koelsch, 2009).

Same/Different Task

In researches that use the same/different task, tonal languages are critical when it comes to examining the lin-

guistic use of the pitch. In tonal languages, pitch changes in the word or syllable level have a lexical meaning. It is reported that participants who have a native tonal language, perform better than those who are native English speakers, when it comes to producing and discriminating musical pitches (Pfordresher & Brown, 2009; Bidelman, Gandour & Krishnan, 2011). Musicians are significantly quicker and more successful in discriminating Mandarin tones, in comparison to the control group (Lee & Hung, 2008; Marie, Delogu, Lampis, Belardinelli & Besson, 2011; Lu & Greenwald, 2016).

Detection of Syntactic Violations

During this method, linguistic and musical syntactic processing is examined using two conditions. In the language condition, the participants are presented with incorrect and correct sentences in terms of grammar; in the music condition, harmonically accurate and incorrect chord sequences are presented. In the behavioral measurements, participants are asked to indicate whether the sentence or chord sequence is correct. During the electrophysiological studies, brain responses are recorded while the participants listen to the stimuli. Studies show that individuals who have language (Broca aphasia and developmental language disorder) and learning disorders, have problems when it comes to processing musical syntax (Jentschke, Koelsch & Friederici, 2005; Jentschke, Koelsch, Sallat & Friederici, 2008; Patel, Iversen, Wassenaar & Hagoort, 2008).

Priming and Interference Paradigms

In the tasks used to test the resource sharing hypothesis, sentences and musical sequences are presented concurrently. The last chord of the melody and last word of the sentence has been manipulated to be syntactically correct and expected, or to be incorrect and unexpected. Participants are asked to pay close attention to the linguistic stimuli by ignoring the music. According to the typical findings obtained by this paradigm, music sequences that contain a syntax violation reveal early right anterior negativity (ERAN) amplitude, while sentences that are syntactically incongruent reveal left anterior negativity (LAN) amplitude. These findings reveal that the LAN amplitude is significantly reduced when sentences are presented concurrently with musical sequences containing syntax violations (Koelsch, Gunter, Wittfoth & Sammler, 2005; Carrus, Pearce ve Bhattacharya, 2013). Interferences that occur when syntactic violations and unexpected notes are simultaneously processed indicate the neural interaction between language and music. Priming effects are revealed for expected words, while it was also observed that the target word was processed that much quicker when presented with the congruent chord, rather than the incongruent chord condition (Fedorenko, Patel, Casasanto, Winawer ve Gibson, 2009; Slevc, Rosenberg ve Patel, 2009; Hoch ve Tillmann, 2010; Hoch, Poulin-Charronnat & Tillmann, 2011).

Role of Attention on Syntactic Processing

Although the shared resources hypothesis in the processing of music and language suggests that resource sharing is syntactic-specific, an alternative viewpoint suggests an attention-based explanation. According to the dynamic attending model (Jones and Boltz, 1989), harmonic accents, such as expected chords, attract attention, therefore, when the tonic chord is heard, the highest point of attention is reached. Therefore, the high level of attention facilitates the processing of the linguistic processing. This effect on music appears in the visual processing (Escoffier and Tillmann, 2008) and in the phoneme monitoring tasks (Bigand et al., 2001). In other words, there is no effect on the type of stimulus when the facilitation of linguistic processing can be explained by attention.

Conclusion

Whether music and language are interactive at the level of syntactic processing has been summarized in this study. Brain imaging studies highlight that brain regions, known to be associated with music and language skills, are similar. However, the findings in relation to the neural overlap alone, do not prove that language and music are associated with common neural systems (Peretz, Vuvan, Lagrois, and Armony, 2015). Despite overlapping brain regions, there may be a neural separation between language and music. That's why, it is important to be careful when interpreting neural data before evaluating the findings indicating neural overlap as evidence for the hypothesis that language and music have common foundations.