Response: A commentary on: “Neural overlap in processing music and speech”

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In comparison to a more classical approach investigating the modularity of music and language processing, recent research focuses on the investigation how and to what extent music and speech processing share neural correlates. This research has implications for the use of music for education and rehabilitation, and provides us with further insights regarding origins and evolution of music. As reviewed by Peretz et al. (2015), neuroimaging studies have been strongly contributing to this debate, suggesting both neural overlap and separability. In their commentary, Kunert and Slevc (2015) point out that behavioral and electrophysiological studies can also contribute to this investigation, and they provide an overview of research using a music-language interference paradigm.

In this paradigm, musical sequences and linguistic sentences were presented simultaneously. Each material (or both at the same time) can introduce a structural violation (or a more complex structure), and behavioral and electrophysiological measures are recorded to investigate whether the violation of the structure in one material (e.g., music) influences the processing of the structure in the other material (e.g., language). For example, participants read syntactic garden-path sentences, presented segment-by-segment and time-locked to the chords of a musical sequence (Slevc et al., 2009). These chords were either musically correct and expected (respecting musical syntactic-like structures), or incorrect and unexpected (i.e., an out-of-key chord). Results reveal interference of the musical material with the processing of linguistic syntax. Some studies have compared this interference effect with the effect of musical structures on semantic structure processing. The different result patterns have been interpreted in terms of interference being syntax-specific, pointing to more general structural integration or reflecting shared attention and cognitive control.

Comparing music and language processing, whether using neuroimaging, behavioral or electrophysiological methods, requires careful control and matching of the experimental material. First, when investigating the processing of cognitive structures and expectancy violations, care must be taken that the introduced structure violations (or manipulations) do not create additional violations, which might provide alternative explanations. Second, the manipulations in the material of the two domains need to be comparable in terms of their complexity (also when comparing syntactic and semantic processing).

The first point is particularly crucial for musical structure manipulations: the material must be constructed to exclude explanations based on low-level processing, which might provide a
more parsimonious interpretation of the data than higher-level cognitive structure processing (e.g., Bigand et al., 2014; Collins et al., 2014). In Western tonal music, sensory and cognitive structures are indeed entwined, leading psychoacoustic and cognitive approaches to provide highly correlated accounts of musical structures (e.g., Bigand et al., 1996; Leman, 2000). Psychoacoustic approaches have challenged cognitive approaches that claimed for musical syntax processing: a short-term sensory memory model, operating on echoic images of periodicity pitch, can account for the musical functions of tones in tonal contexts (Leman, 2000).

This long-standing debate in music cognition research does not only concern the investigation of musical structure processing, but also the investigation of interference between musical and linguistic (syntactic, semantic) processing. This research domain should thus also question the relevance of the interference between music and language processing (with and without the concurrent manipulation of the other dimension), as done similarly in studies using Garner’s interference paradigm (Garner, 1974). Even though initially developed to investigate perceptual processes, Garner’s paradigm has been used to study sensory and linguistic processes (e.g., Melara and Marks, 1990) or text and melody in song (see Lidji, 2007). It also calls the domain to further study the directionality of the interference between music and language processing (with most studies having investigated the effect of music on language processing, see however Steinbeis and Koelsch, 2008).

**References**

Bigand, E., Delbé, C., Poulin-Charronnat, B., Leman, M., and Tillmann, B. (2014). Empirical evidence for musical syntax processing? Computer simulations reveal the contribution of auditory short-term memory. *Front. Syst. Neurosci.* 8:94. doi: 10.3389/fnsys.2014.00094

Bigand, E., Parncutt, R., and Lerdahl, F. (1996). Perception of musical tension in short chord sequences: the influence of harmonic function, sensory dissonance, horizontal motion, and musical training. *Percept. Psychophys.* 58, 124–141. doi: 10.3758/BF03204842

Collins, T., Tillmann, B., Delbé, C., Barrett, F. S., and Janata, P. (2014). From the audio signal to sensory and cognitive representations in the perception of tonal music: modeling sensory and cognitive influences on tonal expectations. *Psychol. Rev.* 121, 33–65. doi: 10.1037/a0034695

Fedorenko, E., Patel, A., Casasanto, D., Winawer, J., and Gibson, E. (2009). Structural integration in language and music: evidence for a shared system. *Mem. Cognit.* 37, 1–9. doi: 10.3758/MC.37.1.1

Fiveash, A., and Pammer, K. (2014). Music and language: do they draw on similar syntactic working memory resources? *Psychol. Music* 42, 190–209. doi: 10.1177/0305735612463949

Garner, W. R. (1974). *The Processing of Information and Structure.* New York, NY: Erlbaum, Potomac, Wiley.

Gibson, E., and Fedorenko, E. (2013). The need for quantitative methods in syntax and semantics research. *Lang. Cogn. Processes* 28, 88–124. doi: 10.1080/01690965.2010.515080

Hoch, L., Poulin-Charronnat, B., and Tillmann, B. (2011). The tonal function of a task-irrelevant chord influences language processing: syntactic versus semantic structures. *Front. Psychol.* 2:112. doi: 10.3389/fpsyg.2011.00112

Hoch, L., and Tillmann, B. (2012). Shared structural and temporal integration resources for music and arithmetic processing. *Acta Psychol.* 140, 230–235. doi: 10.1016/j.actpsy.2012.03.008

Kunert, R., and Slevc, L. R. (2015). A Commentary on: “Neural overlap in processing music and speech.” *Front. Hum. Neurosci.* 9:330. doi: 10.3389/fnhum.2015.00330

Leman, M. (2000). An auditory model of the role of short-term memory in probe-tone ratings. *Music Percept.* 17, 481–509. doi: 10.2307/40285830
Lidji, P. (2007). Intégralité et séparabilité: revue et application aux interactions entre paroles et melodie dans le chant. *L’année Psychol.* 107, 659–694. doi: 10.4074/S000350330700406X

Melara, R. D., and Marks, L. E. (1990). Dimensional interactions in language processing: investigating directions and levels of crosstalk. *J. Exp. Psychol. Learn. Mem. Cogn.* 16, 539–554. doi: 10.1037/0278-7393.16.4.539

Peretz, I., Vuvan, D., Lagrois, M. É., and Armony, J. L. (2015). Neural overlap in processing music and speech. *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* 1370:20140090. doi: 10.1098/rstb.2014.0090

Perruchet, P., and Poulin-Charronnat, B. (2013). Challenging prior evidence for a shared syntactic processor for language and music. *Psychon. Bull. Rev.* 20, 310–317. doi: 10.3758/s13423-012-0344-5

Slevc, L. R., Rosenberg, J. C., and Patel, A. D. (2009). Making psycholinguistics musical: self-paced reading time evidence for shared processing of linguistic and musical syntax. *Psychon. Bull. Rev.* 16, 374–381. doi: 10.3758/16.2.374

Steinbeis, N., and Koelsch, S. (2008). Shared neural resources between music and language indicate semantic processing of musical tension-resolution patterns. *Cereb. Cortex* 18, 1169–1178. doi: 10.1093/cercor/bhm149

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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