THE SOURCE DILEMMA: PERCEPTUAL COHERENCE AND THE CONTINUUM OF CONSONANCE-DISSONANCE

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1. Introduction

1.1. Overview

Here we present counterintuitive datasets of music listeners' perception of consonance-dissonance in a variety of tonal and atonal musical contexts. Specifically, we present evidence that listeners consonance-dissonance ratings are influenced by psychoacoustic factors beyond the tonal structures of music. For example, participants rated atonal music as more consonant under particular spatial orientations or timbrel distributions of the sounds sources. In addition, we provide evidence that consonant and dissonant musics entail differential cognitive loads. These datasets resulted from various investigations of the *source dilemma hypothesis,* a psychophysical model of consonance-dissonance perception developed by the first author that describes dissonance as an emergent property of a *source dilemma,* where musical sounds produce incoherent auditory percepts, and consonance as an emergent property of *source transparency,* when musical sounds produce coherent auditory percepts.

1.2. Aims

The present report addresses two primary research interests. First, we sought to replicate previous findings (see Bonin, 2014) that timbrel and spatial coherence influence the consonance and dissonance of musical sounds. In doing so we hoped to extend the generality of this observation by using both a novel stimulus set and an alternative participant response method. Second, we investigated a corollary prediction of the source dilemma hypothesis: If dissonance accompanies incoherent auditory perception, then one might expect dissonant music to require greater cognitive processing than consonant, perceptually coherent music.

We tested these predictions with three experiments that measured participants' affective and cognitive responses to musical stimuli differing in their perceptual coherence. In each experiment, we selectively manipulated one of the music's harmonic, timbrel, or spatial characteristics to create coherent and incoherent musical counterparts. We expected that the incoherent musical stimuli would be perceived as more dissonant and interfere to a greater extent with performance on a concurrent cognitively demanding task than its coherent musical counterpart.

2. Method

Each of the three experiments consisted of three blocks. In each block, participants completed a cognitively demanding task (the visual 2-back task; 2500ms SOA, 20% target rate) presented on a 24" Phillips 244E monitor (1920x1080, 80pt Helvetica font) while listening concurrently over stereo headphones (Sony MDR-MA100) to no music, coherent music, or incoherent music. The no music condition served as a practice block and was always presented first, while the order of the music blocks were counterbalanced between participants.

The musical stimuli were derived as "coherent" and "incoherent" counterparts that differed only in the psychoacoustic parameter of interest for that experiment. In Experiment 1, participants (n=48) listened to no music, tonal (harmonic), or atonal (inharmonic) music. In Experiment 2, participants (n=75) listened to no music, atonal music exhibiting timbrel coherence (two segregated timbres), or atonal music exhibiting timbrel incoherence (one fused timbre). Finally, in Experiment 3, participants (n=75) listened to no music, atonal music exhibiting spatial coherence (two segregated spatial locations), or atonal music exhibiting spatial incoherence (one fused spatial location). Participants' performance on the concurrent 2-back task was analyzed both in terms of accuracy and response times. After each block in which music was presented, we asked participants to rate the music they had just heard in terms of "pleasantness," "unpleasantness," "consonance," and "dissonance" on a 7-point Likert scale.

3. Results

As expected, perceptual coherence predicted the listeners' consonance-dissonance ratings of the musical stimuli in all three experiments. Regarding our second hypothesis, the cognitive interference data revealed an unexpected effect of our psychoacoustic manipulations and provided only partial support for our predictions. Consistent with our predictions, we found in Experiment 1 that incoherent atonal music interfered to a greater extent with cognitive performance on the 2-back task than coherent tonal music. Surprisingly, however, we found in Experiments 2 and 3 that the timbrelly and spatially coherent atonal musics imposed greater cognitive loads on the listener than their incoherent counterparts despite the fact that they were rated as less dissonant and unpleasant.

In Experiment 1, participants rated the atonal music as more dissonant, more unpleasant, less consonant and less pleasant than the tonal music (all $t(1,47) > 2.5$, all $p < 0.01$). Furthermore, consistent with our second hypothesis, atonal music also led to slower response times ($t(1,47) = 5.7$, $p < 0.001$) and less accurate responses ($t(1,47) = 2.8$, $p < 0.01$) on the concurrent cognitively demanding task compared to tonal music. These results are consistent with the findings of Masataka and Perlovsky (2013) that dissonant music leads to slower and less accurate performance on incongruent Stroop trials compared to consonant music, but are at odds with the Bodner, Gilboa and Amir (2007) findings that dissonant music enhances performance on cognitively demanding tasks relative to consonant music.

In Experiment 2, participants rated the atonal music exhibiting timbrel coherence as less dissonant and less unpleasant than the atonal music exhibiting timbrel incoherence (all $t(1,74) > 2.2$, all $p < 0.05$). Surprisingly, however, the atonal music exhibiting timbrel coherence interfered to a greater extent with performance on the concurrent 2-back task than did the atonal music exhibiting timbrel incoherence, eliciting slower ($F(1,74) = 16.203$, $p < 0.0001$) and less accurate ($t(1,74) = 5.435$, $p < 0.0001$) responses.

Mirroring the effects observed in Experiment 2, participants in Experiment 3 rated the atonal music exhibiting spatial coherence as less dissonant and less unpleasant than the atonal music exhibiting spatial incoherence (all $t(1,74) > 2.05$, all $p < 0.02$). However, again in contrast with our predictions, the spatially coherent atonal music led to slower ($F(1,74) = 17.01$, $p < 0.0001$) and less accurate ($t(1,74) = 5.45$, $p < 0.0001$) response times on the cognitively demanding 2-back task than did the spatially incoherent atonal music.

The unexpected cognitive interference effects we observed between the timbrelly and spatially coherent stimuli and their incoherent counterparts produce several interesting implications. First, they are in contrast to the broad prediction of the source dilemma hypothesis that more dissonant music should generally require greater cognitive processing than less dissonant music. Such results indicate that participants found the perceptually coherent musics more consonant and enjoyable despite the fact that the brain was working harder to process them, and indicate the need for more specific predictions about the relationship between cognitive processes and dissonance phenomenology (it is worth reiterating here that we *did* find the predicted interference effect using a harmonic coherence manipulation). Thus, in conjunction with those from Experiment 1, these results demonstrate that the affect induced by musical stimuli is not sufficiently predicted by the cognitive processing that the stimuli require (i.e., it is not simply the case that atonal musics induce negative affect because they are difficult to process, or vice versa).

With these conclusions in mind, the source of this additional cognitive load in the timbrelly and spatially coherent atonal musics in Experiments 2 and 3 remains to be determined. One possibility is that, in order to maintain the reduced dissonance and unpleasantness in the segregated timbrel and spatial conditions, listeners must actively maintain the segregation of the independent musical streams, producing a divided attention requirement that increases the cognitive demand of these stimuli. This divided attention requirement could ostensibly overshadow the more nuanced differences in cognitive demand produced as a function of perceptual coherence, and would explain why we observed our expected results as a function of harmonicity in Experiment 1, where the coherent (fused) harmonic condition did not require active maintenance of stream segregation, eliminating this potential source of cognitive interference.

Consistent with this possibility is a recent publication from Demany, Erviti and Semal (2015), demonstrating that attention can be divided between segregated musical tone streams, and that response sensitivity declines as divided attention requirements increase. Future empirical studies could address this issue by investigating the interactive influence between perceptual coherence and divided attention on cognitive processing demands.

4. Conclusion

We conclude that perceptual coherence readily predicts the perception of dissonance across a variety of psychoacoustic manipulations. Based on our results, however, the relationship between consonance-dissonance and cognitive processing demands remains unclear and requires further empirical investigation. Our results provide what we hope are compelling insights regarding the consideration of multidimensional psychoacoustics in dissonance research.

References

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