Work note: Palindromes in music and in music perception

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(1) Main questions:

a. Q. Are repetitions preferred over palindromes in actual musical compositions?

A. Yes, so much so that nobody bothers to mention the fact (Kempf, 1996). There are two theories as to why:

(i) Palindrome detection requires a stack (attributed to Shepard by Dowling 1972), so listeners wouldn't notice if a composer used a palindrome, so why bother?

(ii) Global reversal creates local ungrammaticality (Kempf, 1996), so it is hard to make a palindrome that still sounds musical.

Both of these points are relevant to phonology: Segment-level reversals could be hard because you need a stack to make or detect one, or they could be hard because they cause local phonotactic violations (e.g., reversing English *hoe*, *ring*, or *ant*). We can separate the two possibilities in our experiments.

b. Q. Are repetitions easier to detect than palindromes in music-perception experiments?

A. I haven't found a direct comparison between the two, except for (Krumhansl et al., 1987), which was about telling which of two Schoenberg pieces a stimulus was based on (it's easier if the stimulus repeats part of the original piece than if the stimulus reverses part of it).

c. Q. Are palindromes easier to detect by eye than by ear? That could include

(i) Auditory temporal-only sequence (melody) vs. visual temporal-only sequence (movie)

(ii) Auditory spatial-only sequence (left-to-right arrangement of musicians playing simultaneously) vs. visual spatial-only sequence (static picture)

(iii) Auditory temporal-only sequence (melody) vs. visual spatial-only sequence (static picture)

A. No direct comparison found in any of these cases.

1 Palindromes in music

(2) We're talking here about palindromes at the melodic level, i.e., the same sequence of notes (same pitch, same duration) in the opposite order. Other levels of structure like *Kyrie eleison, Christe eleison, Kyrie eleison* (Kempf, 1996) don't count.

(3) Melodic palindromes definitely exist. However, they seem to be rare and noteworthy. Kempf (1996) instances

a. In tonal music: Guillaume de Machaut, *Ma fin est mon commencement*; J. S. Bach's crab canon from the *Musical Offering* (Canon cancrizans, BWV 1079.3a), *Menuetto al Rovescio* from Haydn's piano sonata in A-major (Hob.: Group 16, No. 26); Igor Stravinsky, *Ricercar II* of his (apparently only) Cantata.

b. In atonal music: "many examples", specifically in Webern and Schoenberg.

Dowling (1972, 417) says that the retrograde transformation (playing a sequence of notes, then time-reversing it) is rare but attested throughout history of Western music.

(4) Kempf (1996, 159) asks: "What is it that makes an application of this compositional procedure [mirror reversal] so extremely difficult and complicated in the realm of traditional, tonal music?", and answers that Western musical grammar creates

a. *Non-reversible pitch sequences*: He or she cites T D/SD SD D/D D T as a "typical" progression whose retrograde version is "not only unusual but impossible because it does not follow certain fundamental laws of classical harmony". Doesn't say what those laws are.

b. *Non-reversible prosody*: "[W]hat about the basic compositional and aesthetical principle of treatment of dissonance on the accented beat, if the first beat of a bar becomes the last and unaccented one?!"

"A simple conclusion would be that the thoretical and practical possibilities of application of mirror symmetry around a vertical axis are very limited in tonal music. It is not surprising that the realizations of such a mirror symmetry appear only sproadically in the history of tonal music, and exclusively in a formal microstructure or short pieces or movements."

(5) Kempf (1996) seems to be saying that the rarity of palindromes is due to their violation of sequential conventions that can be evaluated locally, rather than to an inherent inability of human listeners to detect reversals in time.

2 Palindromes in music perception

(6) Dowling (1972): Used isomorphic visual and auditory tasks.

a. *Auditory task*: Indep. vars. were: Instructions (exact recognition, contour recognition) * rate (fast vs. slow) * Transform (Inversion, Retrograde, Retrograde Inversion) * stim type (exact-interval size preserving, contour preserving – turned out to make no difference, so collapsed across it).

b. Dependent measure was area under "memory operating characteristic" (MOC) curve.

c. 45 trials (15 exact transform, 15 contour transform, 15 different). 355 generic UCLA students [i.e., not specifically musicians]. Smallest cell had 9 Ss.

d. Instructions for Exact Ss explained to each S their target transform and the importance of distinguishing exact from contour-preserving. Instructions for Contour Ss were likewise, but told them to treat contour and exact alike.

e. Warning tone 2s before trial. Two stims on each trial. Standard started on Middle C and wandered randomly up and down for four more notes. ISI 2 sec. Comparison started on a random different note, not Middle C but within 7 semitones. Rates were 5 tones/sec or 2 tones/sec.

f. Ss in the Exact conditions had to respond whether the comparison sequence was a [insert the transform for your participant group here] of the standard, and rate confidence on 4-step scale. Ss in the Contour condition did the same, but were supposed to treat exact transforms and contour transforms alike. No feedback.

g. *Visual task*: Exact, Fast, (Inv, Ret, RI). 10 trials. LH side of page is standard, five equally-spaced dots; then vertical rule, then RH side is four comparison stims (each also five equally-spaced dots). Pick the one that is your assigned transformation. Got feedback after all 10 problems, then did the main (auditory) part of the exp.

h. *Results* from the auditory test (collapsing across Exact vs. Contour conditions, so that "same" resps to both Exact and Contour stims are counted correct): Slow always better (bigger area under MOC) than Fast. Inversion usually better than Retrograde; Retrograde Inversion always worst. Contour stimuli were easy in the Ret (esp Ret Slow) condition. Visual pre-training didn't help significantly. Retrogrades significantly above chance in all conditions except Exact Fast.

The results of the visual pre-training are not reported (i.e., results from the "VEF" condition are the results obtained by visually pre-trained participants on the auditory test, not their results on the visual pre-training itself).

i. These were harder stims than actual music, since they were atonal, used small intervals, had no rhythm, and used comparison stims that were very similar (while an actual composer would have made different melodic lines in a piece very different).

j. Implicit/explicit: "Ss often described their method of doing the transformations in terms of reversing an image of the notes, or of turning it upside down .... Thus, Ss' introspections agreed with those of most musicians."

k. "Shepard (p.c. 1972) has suggested that the inversions might be easier because among the three they allow for the element-by-element comparison of the comparison stimulus with memory of the standard in the same temporal order. ... This kind of procedure will not work for retrogrades and retrograde inversions. In those cases, the order of one of the stimuli must be reversed .... Reversal can occur only after storage of the whole stimulus has occurred." [That's about inversions compared to reversals and inverted reversals, but it would apply equally well to outright repetitions, which are even more faithful than inversions.]

(7) Balch (1981): Exp. 1: Random eight-note melody (played by a human on a recorder) followed by a second eight-note melody that was either an Inversion, Retrograde, or Retrograde Inversion of the first, or else a Different random eight-note melody. Ss rated the second melody for "goodness" as continuation of the first, "whatever that judgement meant for them". 24 trials, 8 sec or so to rate each one. Highest ratings for R, then I, then RI, then D, for both low- and high-musical-experience groups. Author suggests on p. 53 that the high ratings for R could be due to the fact that the last note of the first melody was always the first note of the second melody.

Did not compare reflection with repetition.

(8) Krumhansl et al. (1987): This one was about learning two standards, then deciding which one a new melody is a transformation of. Directly compared reversals with repetitions, to the great advantage of the latter.

a. Exp. 2: Ss first learned to distinguish between two Schoenberg tone rows (used in two different compositions). The melodies were presented as "circular", i.e., each note was simultaneously sounded in five octaves, so that octave membership (and hence direction of change from note to note) was arbitrary.

b. No rhythmic differences between notes in this experiment.

c. Then they were given new melodies and asked which of the two Schoenbergs they sounded more like. They were told that the new melodies would be inversions, retrogrades, or retrograde inversions. They were asked to decide whether the fragment came from Sch 1 or Sch 2. 20 trials of each of eight sequences.

d. Repetition was significantly better than the other three, which were significantly better than chance, all of this by ANOVA on PrCorr. Big inter-S differences, though almost all Ss [looks like there were 23?] were individually significantly above chance. Significant positive correlation with academic music training; significant negative training with hours per week listening to popular music.

(9) Dienes and Longuet-Higgins (2004): Very relevant theoretically; they write in their abstract:

> The dominant theory of what people can learn implicitly is that they learn chunks of adjacent elements in sequences. A type of musical grammar that goes beyond specifying allowable chunks is provided by serialist or 12-tone music. The rules constitute operations over variables and could not be appreciated as such by a system that can only chunk elements together.

a. They are specifically interested in the grammar of 12-tone music. You arrange the 12 pitch classes (12 notes, and any octave multiples thereof) to make a "prime tone row". From that you can make 12 transpositions by choosing an integer from 0 to 11 and adding it to every pitch class, and then 12 retrogrades by playing the 12 transposition backwards. So when they say "retrograde", they don't mean "exact mirror reversal", they mean "reversed transpose". "Its comprehensibility as a serialist piece entails firstly that a tone row should be recognized as the same auditory object under the four transforms (transpose, retrograde, inverse, retrograde inverse). Listening to such a composition would involve beholding this auditory object as it was successively reflected, translated, and restated through the composition." (p. 534)

b. Detecting implicit vs. explicit: "Implicit knowledge" == "state of knowing some content ... when the person does not know they are in that mental state" (p. 536). ⇒ Collect confidence ratings for judgements. Purely implicit knowledge shows up as above-chance performance when they think they're guessing, and no improvement when they're confident. These criteria would classify as "explicit knowledge" inexplicable intuitions that could feel stronger or weaker, so these authors may not mean the same thing we mean by implicit/explicit knowledge.

c. Experimental stimuli: Tone rows where the second hexachord (second six pitch classes) was a transformation of the first. (Complicated algorithm for doing this.) One consequence is that the second hexachord was *never* an exact time-reversal of the first; it was always transposed. 100 such rows were randomly generated, 50 each for training and test. A random 25 of the test rows had the order of the second hexachord randomly jumbled. Each note lasted 0.5s.

d. Exp. 1: Training was just listening to a tone row and rating it from 1 (very unpleasant) to 10 (very pleasant). At test, they were told that the training stims obeyed some rules, and that half the test stims obeyed and half violated; which was which? And how confident are you? 10 college students in each transform condition. Mean overall classification was at chance for each condition.

e. Someone they knew named Philip Fine, who knew a lot about atonal music, did individually well above chance in all four transform conditions. He said afterwards that "he hummed the first three notes of each hexachord and compared them across hexachords" (p. 540).

   When the tones were "octified", i.e., individually transposed up or down an octave, the transpose was suddenly at chance, and the retrograde was the best at 80%.[1]

f. Unnamed experiment at the start of Exp. 2a: Like 1, but the tones in the first hexachord were ordered clockwise or counterclockwise so that they didn't jump around as much, making the hexachord (the experimenters thought) perhaps more memorable. It didn't help; Ss in the transform conditions did no better than control Ss who just got a test phase and were asked "to sort tunes that seemed more rule governed from those that did not" (p. 541). For details, they refer you to the supplementary materials.

(10) Mongoven and Carbon (2017): Ss heard tone sequences (of length 8 to 128 notes, and with the notes varying in duration) that were either palindromes, sort-of palindromes, or non-palindromes, and had to classify them as one of those three. The analysis is kind of murky (doesn't distinguish response bias from sensitivity) but it looks like people are better than chance at saying that palindromes are palindromes (52%, chance = 33%) and that non-palindromes aren't palindromes and aren't sort-of palindromes (74%, chance = 66%).

No comparison with translational symmetry.

They note that unlike in visual domain, where more dots makes reflection easier to detect, here more notes make it harder. Fast and short also made for hard.

(11) Petrović et al. (2017): Even conservatory students have a hard time detecting musical palindromes, both when they hear the music and when they hear and transcribe it so that it's in front of them visually. Did not compare with translational symmetry.

[1] That rules out the following strategy: If the first three notes of the second hexachord are a transpose, then he could detect that easily enough. If they aren't, then he'd know that it had to be retrograde or retrograde inversion, so he'd check the last two notes of the second hexachord to see if the direction of change matched or mismatched that of the first two notes of the first hexachord. But with the octified stimuli, he does great on retrograde even while doing terribly on transpose.

Lots of interesting-looking citations but they aren't in the bibliography.

References

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