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THE EFFECTS OF TONALITY ON LISTENER RESPONSE TO METRIC MODULATION

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Introduction

One of the inherent characteristics of music as an art form is the temporality of a given work. Music scholars and musicians alike agree that rhythmic events and the grouping of these events into meter has an immediate and significant effect on the listener.[1] Dowling, Lung, and Herrbod found that metrical placement had a strong effect on listeners' ability to recognize familiar melodies interwoven with "distractor" notes.[2] A 2009 human response study confirmed this, demonstrating that listeners were more likely to perceive that stable pitches were on metrically strong beats, even for metrically ambiguous stimuli. These studies have illuminated how meter (time structure) might affect the perception of other musical elements. However, Jones submits that "…to understand meter perception, we must discover factors in sound patterns and in listeners that bias people to hear a pattern's time structure in a particular way"[3] rather than the other way around. One of the most notable features in Western music is the pitch hierarchy system known as tonality. This essential element of Western music seems like a strong candidate to influence meter perception, particularly as the aforementioned studies have suggested that meter and melody are linked in some way.

The possible connection between meter and tonality has been a subject of interest among music theorists. Some theorists insist on a connection between tonal stability and metrical strength[4] while others doubt an inherent relationship between functional harmonic progressions and metrical structure.[5] Empirical studies have shed more light on this topic. In his book *Hearing in Time*, Justin London used a combination of music theory and empirical studies to suggest that tonal interpretation of events could result in the perception of a metrical accent.[6] Nichola Dibben's 1994 study showed that listeners were less able to hierarchize atonal melodies as opposed to tonal ones, and tonal hierarchy is a key element of how a tonal melody is heard (according to the theories of Lerdahl and Jackendoff.)[7] The study concluded that in some contexts, pitch may provide the best reference point for listeners, influencing other factors like temporality and texture.[8] A recent study by Christopher White used a series of experiments to test whether listeners associated tonal stability with metrically strong placement in a measure. The results of the study indicate that the metrical placement of pitches affected whether listeners heard them as tonally stable (though the tonal stability of harmonies did not affect listener's metrical interpretation).[9] According to David Temperley, "all the evidence — theoretical wisdom, corpus data, and White's experiments — suggests that there is a connection between meter and "tonal stability" broadly defined."[10]

The aforementioned studies have aimed to shed light on how humans perceive meter, and in the case of White, specifically how harmony and meter might interact. However, none of these studies have compared metrical perceptions in a tonal context to those in a landscape where tonality is nowhere to be found. If tonality and meter are indeed connected, the absence of tonality should affect a listener's sense of meter. In keeping with the work of London and Jones, in this study meter can be defined as "a stable recurring pattern of temporal expectations."[11] In notated music, this is usually conveyed with the use of time signatures, with a change in time signature (also known

[1] Parncutt, 409.
[2] Cited in London 2004, 12.
[3] Jones, online access.
[4] Carl Dalhaus and Carl Schacter, cited in Caplin, 1.
[5] Wallace Berry, cited in Ibid.
[6] London 2004, 23.
[7] Dibella, 21-22.
[8] Prince, Thompson & Schmuckler, 1614.
[9] White, 32.
[10] Temperley, 40.
[11] London, 2002, 531.

as a metrical modulation) often signalling a change in the underlying pulse felt by listeners. In this study, we investigate whether the presence (or absence) of tonality affects listeners' ability to detect a change in underlying pulse.

Method

Six listeners were presented with twenty-four melodies in a randomized order. For each melody, the listener was instructed to use a computer space bar to tap the underlying pulse for a series of melodies. Listeners were also given the instruction: "Listen carefully as the pulse may change." This instruction was given to ensure listeners continued actively listening throughout each example. Though this instruction gave listeners a clue – to expect a possible change in pulse – the listeners still had no information about the nature of a potential metrical change, or when it might occur in each stimulus. Each melody was preceded by a "count-in" – that is, a metronomic beating of a one full measure. The "count-in" provided more support for the meter, a necessary clue given that listeners only had between 7 and 9 measures to entrain to the first meter before a metrical modulation took place. Listeners' response data was then compared to a "ground truth" that is, a tapping pattern generated from the MIDI files themselves which was mathematically even and tapped the notated meter throughout.

Stimuli

There were twenty-four stimuli, twelve tonal melodies and twelve atonal melodies. The main challenge in constructing stimuli was limiting the number of variables to make sure results were not influenced by factors other than tonality. For this reason, all melodies were equal in length (16 measures), and tonal melodies remained in the same key throughout. The aforementioned studies found that tonal stability was correlated with metrical strength, so in the tonal melodies, strong beats were most often correlated with implied chord tones (see figure below). Each tonal melody had an atonal "equivalent" which shared a similar register, range, and contour, removing these three musical elements as experimental variables. Because listeners experienced the stimuli in a randomized order, the relationship between the two melodies in a pair would not necessarily be evident, allowing the listener to potentially experience every melody as a unique stimulus.

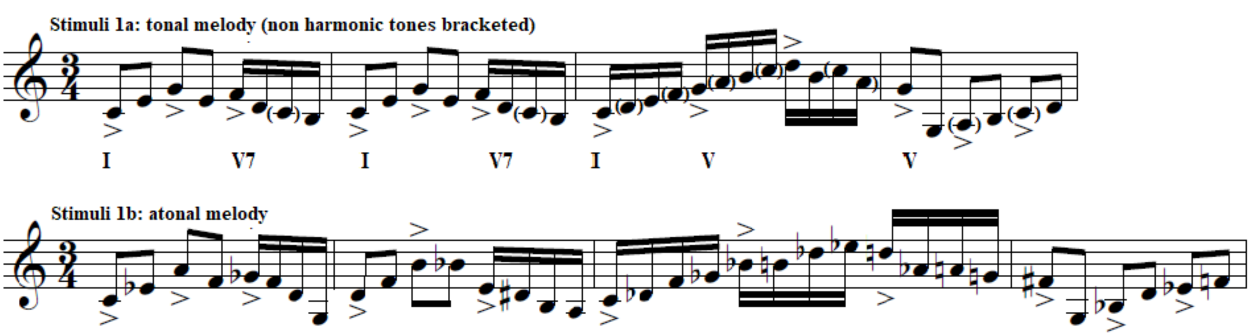

Figure 1: Stimuli

All melodies began in a 3/4 time signature with the tempo of 108 beats per minute for the quarter note (with the eighth note therefore equaling 216 bpm). The change in meter did not change the duration of the eighth note, but instead grouped eighth notes differently creating a change in the underlying pulse, but with both the new and old meter connected by a common subdivision (see Figure 2 below). For the purposes of this experiment, the terms "pulse" and "meter" are used somewhat interchangeably, as the metrical modulations in play maintain the eighth note value but change the grouping, resulting in a different pulse after each metrical modulation.

Original time signature	Original pulse	New time signature	New pulse
3/4	♩ = 108 (♩ =.556 seconds) ♪ = 216 (♪=.278 seconds)	5/8 (2+3)	♩ = 108 (♩ =.556 seconds) ♩. = 72 (♩. =.833 seconds)
3/4	♩ = 108 (♩ =.556 seconds) ♪ = 216 (♪=.278 seconds)	6/8	♩. = 72 (♩. =.833 seconds)
3/4	♩ = 108 (♩ =.556 seconds) ♪ = 216 (♪=.278 seconds)	7/8 (2+2+3)	♩ = 108 (♩ =.556 seconds) ♩. = 72 (♩. =.833 seconds)

Figure 2: Metrical modulation equivalencies

Throughout each example, the meter was emphasized with agogic accents. This facilitated the listener identification of meter in such short excerpts. The type of metric modulation and the temporal location of each metric modulation was distributed evenly amongst the pairs (see Figure 1 below). This grouping made it possible to parse the results for specific variables.

Location of modulation	Melodic pairs
Early (m. 7)	3, 4, 5, 6
Halfway (m. 9)	7, 8, 9, 10
Late (m. 11)	1, 2, 11, 12

Type of modulation	Melodic pairs
3/4 to 5/8	5, 6, 7, 8
3/4 to 6/8	1, 2, 3, 4
3/4 to 7/8	9, 10, 11, 12

Figure 3: The distribution of temporal location and type of metric modulation across stimuli.

In cases where the meter modulated to a non-isochronous time signature, the beat divisions were arranged in 2+3 for 5/8 time and 2+2+3 for 7/8 time. According to Justin London, these divisions are based on music theoretical well-formedness rules and known perceptual limits.[12]

Results

Participants seemed to have little trouble establishing the initial pulse, with participants unable to tap a consistent or clear pulse only 3% of the time. Because these erratic tapping responses comprised only 3% of the data, this 3% was disregarded. The results were then analyzed to determine if listeners tapped differently after the metric modulation took place, or if they maintained the original pulse despite the change in beat cycle.

Preliminary analysis indicates that neither the location of the modulation (either at m.7, m. 9, or m. 11) nor the type of modulation (modulating from 3/4 to either 5/8, 6/8, or 7/8) resulted in different responses from participants. Participants also did not consistently improve over the course of the experiment. However, overall results were different depending on whether listeners were responding to a tonal or atonal melody. When responding to atonal melodies, 76% of the time, participants did not change their tapping pattern, compared with 69% of the time when responding to tonal melodies. Participants successfully navigated the metric modulation in tonal melodies 6% of the time, consistently tapping the original meter, and adopting the new meter by the end of the example. This result

[12] London, 107.

only occured 1% of the time for atonal melodies. This finding supports our original speculation that tonality would influence how listeners adapted to a change in pulse.

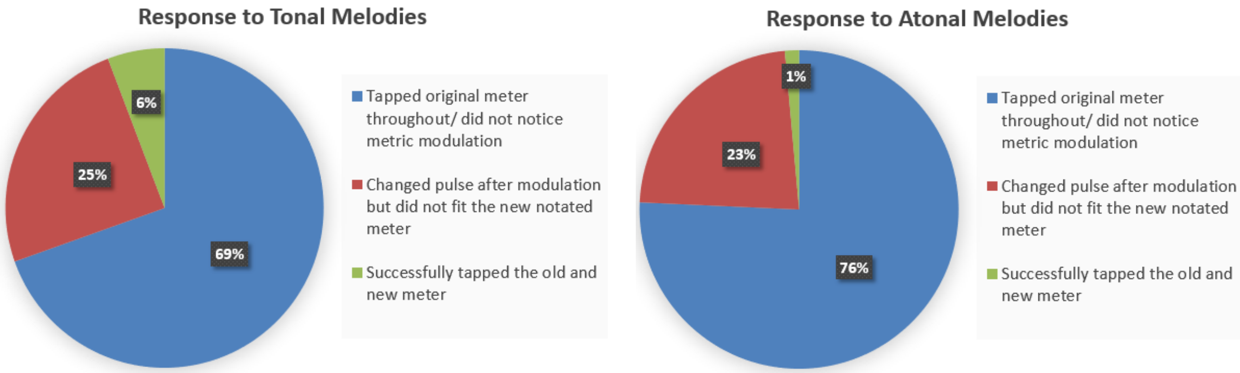

Figure 4: Response to tonal and atonal melodies

According to Peter Marten's study, "individual listeners engage with musical meter in different ways" and therefore "ambiguity of tactus should be an expected feature of any audience's response to metrical music."[13] The results of this experiment support Marten's statement. Most listeners tapped a quarter note pulse (approximately .556 of a second) for the original time signature of ¾. However, one listener occasionally tapped a dotted half note pulse, which remained relevant during the switch to 6/8 time. Another listener, when confronted with a metrical shift, started tapping a pulse approximately .9 of a second long. This does not easily fit into any subdivision of the notated meter.

Discussion

The results demonstrate that tonality (or the absence of tonality) did affect whether listeners detected a metrical shift in the music. This supports a connection between tonality and meter. Tonality is so prevalent in Western musical contexts that Western listeners are familiar with conventions of tonal and metrical interaction. Thus, tonality (in conjunction with other elements not examined in this study) may provide important clues to the listener about the beat structure. Because tonality is intrinsically linked with harmony, a future study could include a harmonic parameter, rather than relying on the harmony implied by a single melodic line. It is possible that this modification could result in a more significant difference in response to atonal and tonal melodies.

The stimuli were created synthetically, resulting in mathematically even values. Justin London's research suggests that listeners base their temporal expectations and judgements on expressive deviation present in music. Therefore the lack of any deviation in our stimuli may be less musically real and could be the reason for listeners not adopting a new metrical framework after modulation. If so, this could provide support research which claims expressive microtimings have a significant influence on perception. This would be an important consideration for composers creating synthesized or mathematically even music. Unless the initial metrical structure intends to be maintained, composers may wish to elucidate any metrical shifts through orchestration. Conversely, when composing music intended for live performance, composers could anticipate that some metrical ambiguity would be mitigated through performance by live musicians.

[13] Martens, 433.

Participants continued tapping in the original meter the majority of the time for both tonal and atonal melodies. This result was somewhat surprising, as the stimuli's use of the agogic accents and idiomatic rhythms used were intended to make the new meter as clear as possible. This may indicate that features not included in this study (such as harmony, ensemble playing) are more salient than tonality in the role of metrical modulation. It is possible that the short length of the stimuli (16 measures each) did not give listeners enough time to relinquish the original meter in favour of the new. Additionally, this trend may reflect a tendency to maintain metrical entrainment with a particular cycle unless a new pulse is maintained for a long period of time. If so, this tendency is particularly strong considering participants continued tapping in 3/4 time even when the new beat cycle differed in length, such as the modulations to 5/8 or 7/8 time. Performers may find this highly relevant, as they may wish to over-emphasize a metrical modulation in order to more quickly acclimate listeners to the new meter.

Listeners' response to metrical modulation was also somewhat unexpected. For tonal melodies, 25% of the time, listeners changed their tapping pattern after the modulation (compared with 23% of the time for atonal melodies) but did not begin tapping the new meter. Instead, listeners tapped erratically or without a consistent pulse, or tapped a rapid subdivision not clearly related to the new notated meter. This suggests that the metrical shift was evident to listeners, but that the new meter was perhaps not entirely clear. Though all stimuli outlined the beat structure with agogic accents, it's possible that stimuli could have clarified the metrical structure with other types of accents (such as durational or registral) on metrically strong beats. Overall, though the scope of this study was very limited, the results provide further evidence for a connection between tonality and meter. Though it is still not clear exactly how these factors interact, listeners were better able to successfully adopt a new metrical structure when hearing a tonal melody as opposed to an atonal one.

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