

Tritone Paradox Revisited: Shepard Tone Progressions and Listener Experience

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Abstract

In this small-scale (n=32) and mixed-methods study, we revisit the Tritone Paradox (TP), along with a few factors that may challenge extant scholarship and stimulate further investigation. In particular, we explore two notions. Firstly, we analyze the role of manipulation and isolation of the Loudest Zone (LZ) in the Shepard tones (ST) involved in a TP. Secondly, we discuss the listener's individual intentionality in determining the perceptual melodic direction (ascending or descending) of TP-based melodic tritones. Our research shows the impact of these factors on perception and fosters suggestions for continued research.

Introduction

Summary and Research Objectives

This study is multifaceted in that it reaches into several subfields of music scholarship, ranging from music theory to systematic musicology and music cognition. In this research, we revisit the Tritone Paradox (TP) and the challenges it continues to pose to established models of music perception. Our study investigates whether the isolation of the Loudest Zone (LZ) of Shepard tones (STs) can impact the perception of melodic tritone direction. We also explore whether individual intentionality can impact the original perception of melodic ST tritone direction.

The term was first coined by Diana Deutsch (1986) and has appeared in her continued research agenda since. Deutsch (1986; 1992) describes the TP as a collection of divergent perceptions of a consecutive pair of pitch classes which are (1) separated by three whole tones (tritone; i.e. D-G#) and are (2) rendered as STs. STs, in turn, are simultaneous iterations of all possible (and humanly audible/discernible) octaves of a pitch class. Although STs are rather uncommon in concert music, Renaissance and Baroque composers use analogous effects in their music, a technique musicologists call "pitch circularity". Pipe organs also generate a similar effect in that it "couples" or combine several octaves of the same pitch into the same root "key".

Review of Literature

Deutsch's comprehensive and extensive research shows that the perceptual melodic direction of this consecutive pair of pitch classes as either ascending ("going up") or descending ("going down") may depend on several factors, such as language and specific accents and inflections in linguistic variety (Deutsch, 1990; 1991; 2004; 2019; 2023; 2024), geo-cultural characteristics (1994a; 1994b), and experience of the native language via the mother's voice or in early life (1996; 2004; 2007).

Deutsch (2019) discusses the proximity factor, concluding that pitch-class adjacency impacts perception. In other words, when one hears the pitch classes C and C# (red in Figure 1) subsequently and rendered in ST format, the brain is more likely to perceived them as fitting within a chromatic continuum, despite of absolute pitch height—listener, therefore, would be more likely to identify this pair of pitch classes as an ascending minor second, rather than a descending major seventh. Deutsch (1986) recognizes, however, that the tritone, such as D and G# (blue in Figure 1), poses a paradox because its participating pitch classes are diametrically opposed and equidistant in both its *recta* and *inversa* versions, thus generating the TP's ambiguity.

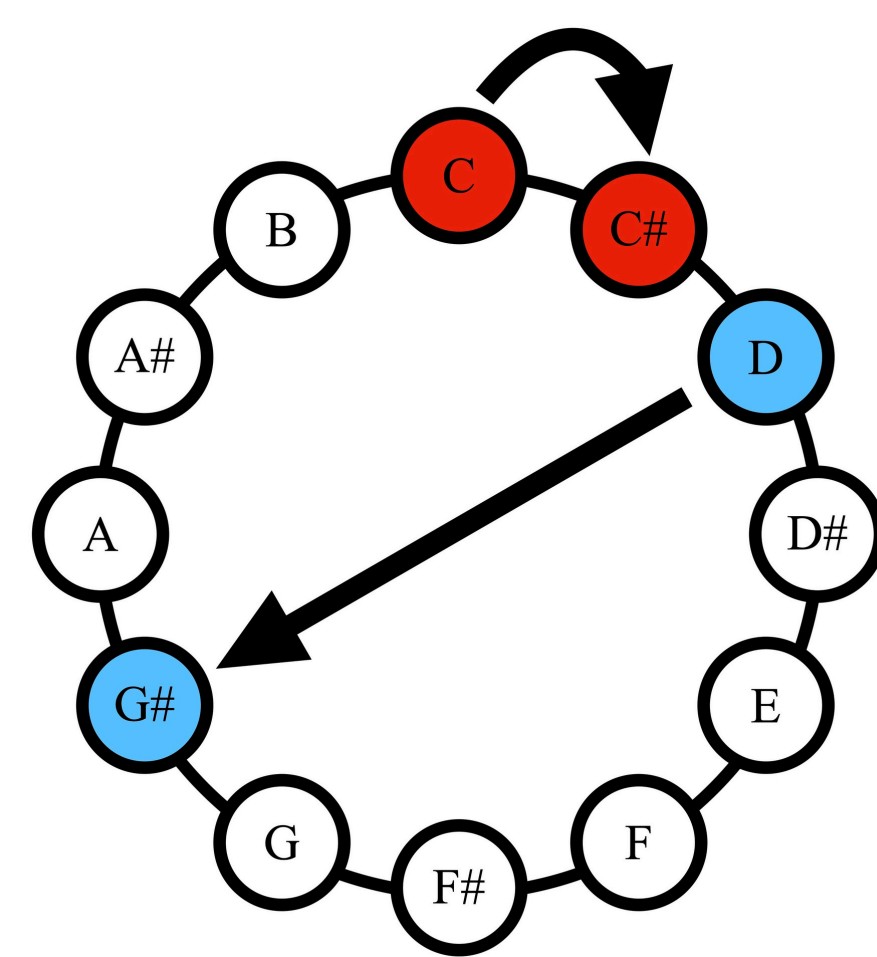


Figure 1. Graphic representation of a minor second (green) and an augmented fifth or tritone (blue).

Method

Summary

In our small-scale research, we used a mixed-methods survey to collect quantitative and qualitative data. We administered the survey through Google Forms, and our results and analysis rely on a modest dataset (n=32) collected at Burman University, in March 2026, across various demographics. We regard this survey as a small pilot study that has sparked probing thoughts for further, more detailed future research, which we aim to pursue in the form of a longer scholarly article and a conference presentation.

The Survey

In the preliminary portion of the survey, we asked participants to share non-identifying demographic details that may help establish parallels with extant scholarship on the topic—particularly language and cultural background. The core portion of the survey delved into participants' perceptions of specific auditory examples, provided alongside the form. In addition to the varied examples used by Deutsch and others in their research on the TP, we used Apple's GarageBand software to create a range of variants of this seminal sample.

Participants were asked to mark a series of tritones as ascending or descending, as presented in five audio samples. All of the samples featured the same pitch classes and the same temporal order/sequence: D-G#; A-Eb; F#-C; G-C#. Each audio file contained this series of tritones, played in succession and separated by brief silences, so participants had ample time to record their perceptual responses. Audio 1 presented a regular rendition of these tritones in order to initially measure participants' ability to recognize the most basic melodic direction. Audios 2 and 4 contained Deutsch's version of these intervals in ST format. In Audio 3A and 3B, we isolated each pitch class's Loudest Zone (LZ) and Figure 2 below graphically demonstrates these "forked" tones (hereafter represented as <, >).

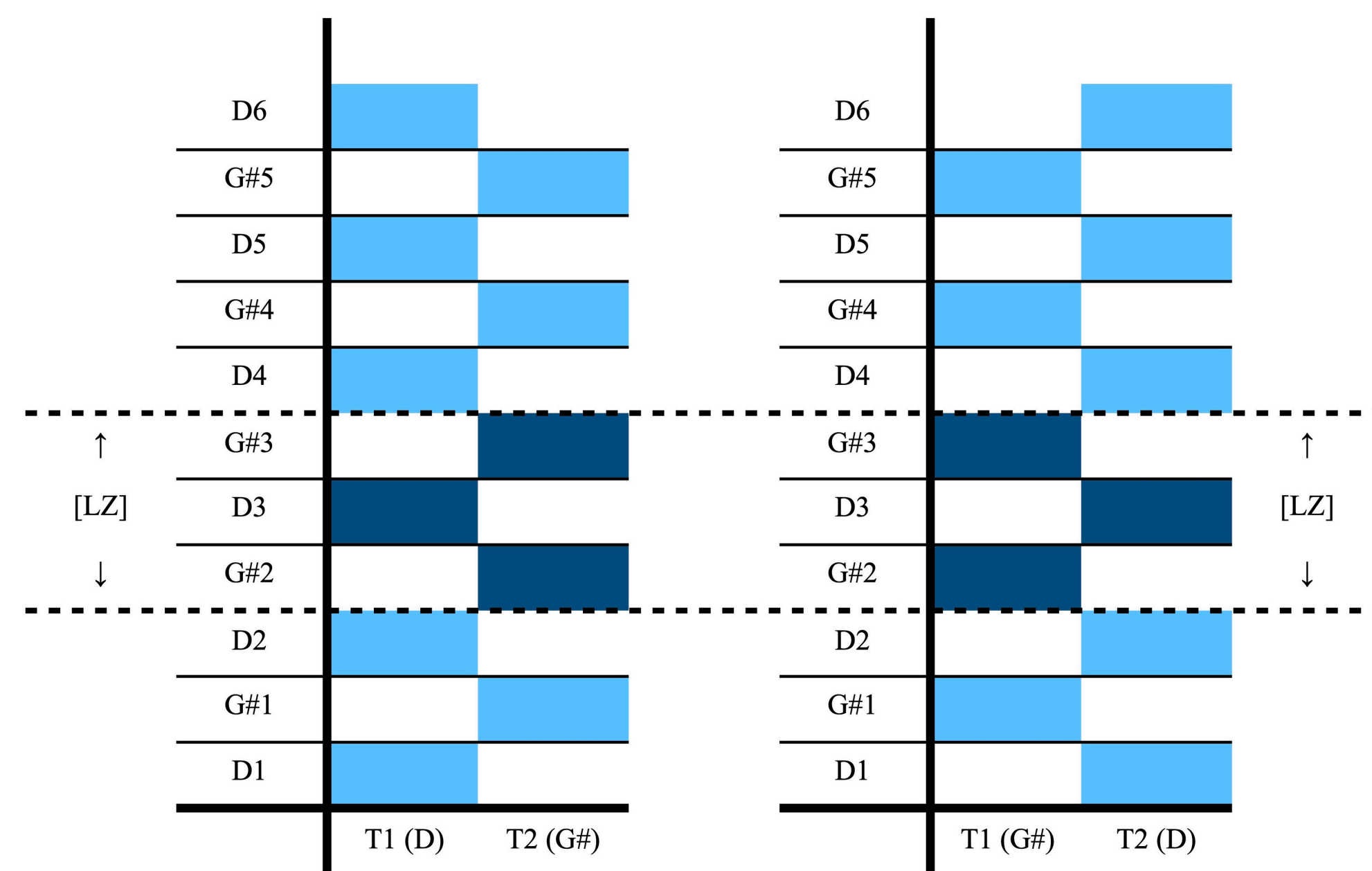


Figure 2. Graphic representation of the isolated Loudest Zone within a Shepard Tone (ST) spectrum. The "forked" tones (<, >) stand for diversion or conversion in the LZ isolation.

T1 (tone or pitch class 1) and T2 (tone or pitch class 2), played subsequently, are a tritone apart. The octaves in dark blue for each pair of pitch classes were isolated, thus eliminating the multiplicity of octaves and focusing on only two possible melodic directions as either diverging from or converging to a single pitch. The sequence of pitch classes G#-D, which is shown in the second example of Figure 2 was not used in this study, but appears here to illustrate the alternative form of pitch isolation according to the LZ that we did use in the study for other intervals.

Finally, with a reiteration of Audio 4, which contains Deutsch's original sample, we tested participants' ability to invert their perception through individual intentionality. Since Deutsch describes the TP as an auditory illusion, we imported the idea from other popular visual illusions—such as the popular "revolving woman"—which hypothesizes it is possible to invert/revert the illusion's effect upon understanding what it does and intentionally trying to change the perceptions' direction.

Results and Analysis

Description of the Demographics

The demographics of 32 participants varied widely across age, gender, ethnicity, nationality, language, level of musical training, and hearing ability. The median age of participants was 38.5 years (range, 18-79), with 56.3% (18) identifying as female and 43.8% (14) as male. 21 participants self-reported as White/European, 4 as Asian, 3 as Black/African, 1 as Hispanic/Latino, and 3 as Multiracial. Of the 32 respondents, 87.5% (28) identified as Canadian. Among the Canadian subsample, 78.6% (22) reported a singular Canadian identity (e.g., 'Canadian,' 'Canada'), while 21.4% (6) reported a partial or dual Canadian identity (e.g., 'Canadian, Zimbabwean,' 'Jamaican-Canadian,' 'Icelandic/Canadian'). The remaining 4 participants (12.5%) were non-Canadian, comprising 2 participants identifying as Indian (6.3%), 1 as Filipino (3.1%), and 1 as European (3.1%). All Canadian participants, including those with partial or dual identities, were retained in the Canadian group for analysis, assuming their upbringing in Canada had shaped their linguistic exposure during critical developmental periods.

Over half (62.5%) of participants were monolingual beyond their native language. The rest reported French (12.5%), Hindi (6.3%), and one respondent each reporting German, Spanish, English, English/Visayan, and a highly multilingual East African participant reporting fluency in six languages: Luo, Arabic (Sudan), Swahili, Somali, Luo-Ethiopia, and English (3.1%). The level of musical training was divided into three categories: minimal training (no formal training/informal/beginner-level exposure), moderate training (extended education/intermediate), and advanced training (post-secondary training/professional). 40.6% (13) reported minimal training, 37.5% (12) moderate training, and 21.9% (7) advanced training.

Finally, regarding aural abilities and perceptions, 93.8% (30) of participants reported no known or diagnosed hearing disability, while 6.3% (2) reported a known or diagnosed hearing disability. 59.4% (19) of participants did not have perfect pitch, 28.1% (9) had inconsistent perfect pitch, and 12.5% (4) were unsure.

Perception Graphs

The sequence of pitch classes and their order were the same across all of the following audio samples. Interval 1: D-G#; Interval 2: A-Eb; Interval 3: F#-C; Interval 4: G-C#. Figures 3-7 show participants' classification of these intervals as ascending (blue) or descending (red).

Perception of Audio 1

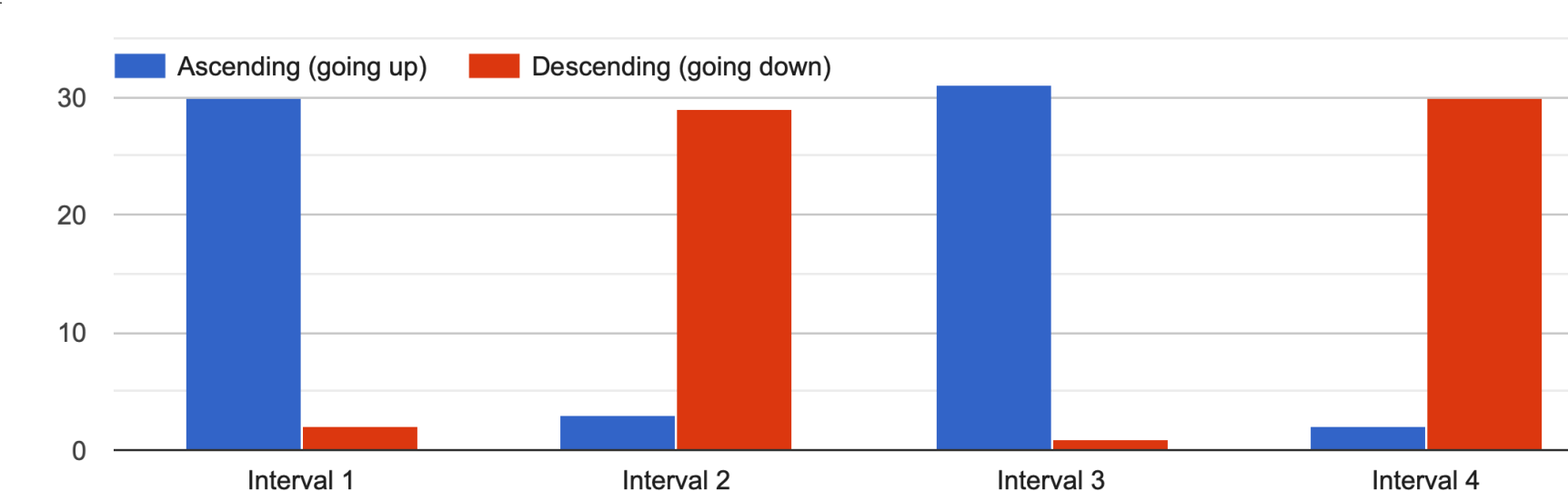


Figure 3. Audio 1 featured tritones rendered in regular/simple form---the pitches are in non-ST format.

Perception of Audio 2

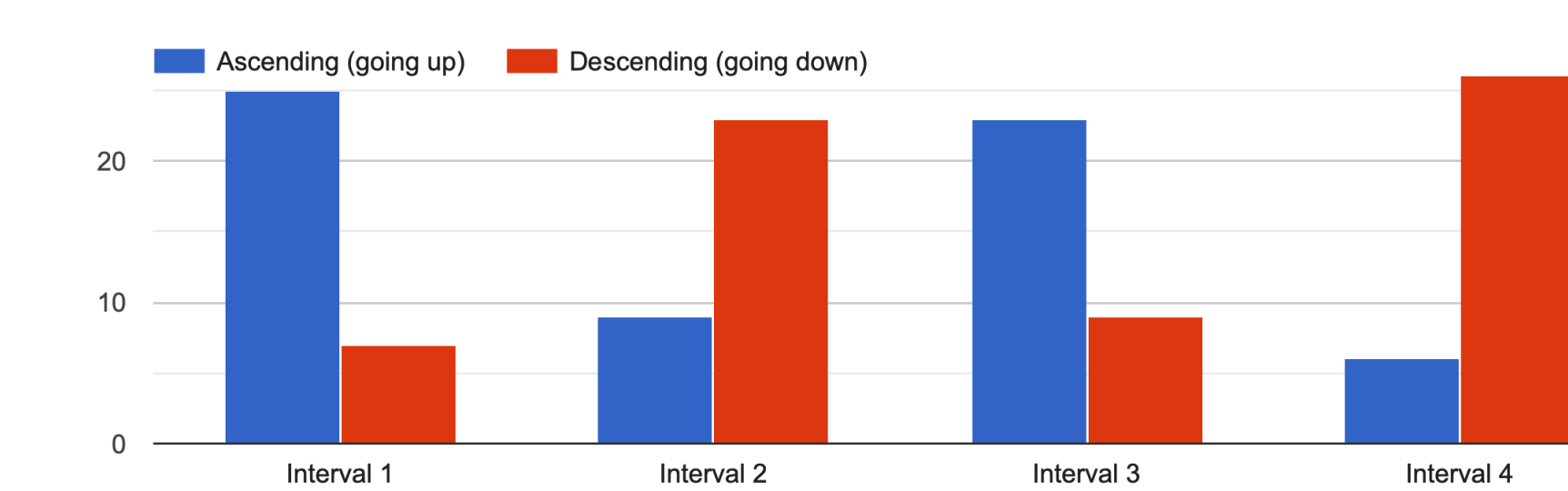


Figure 4. Audio 2 uses the audio sample available in Deutsch's (2026) website and used in her research.

Perception of Audio 3A

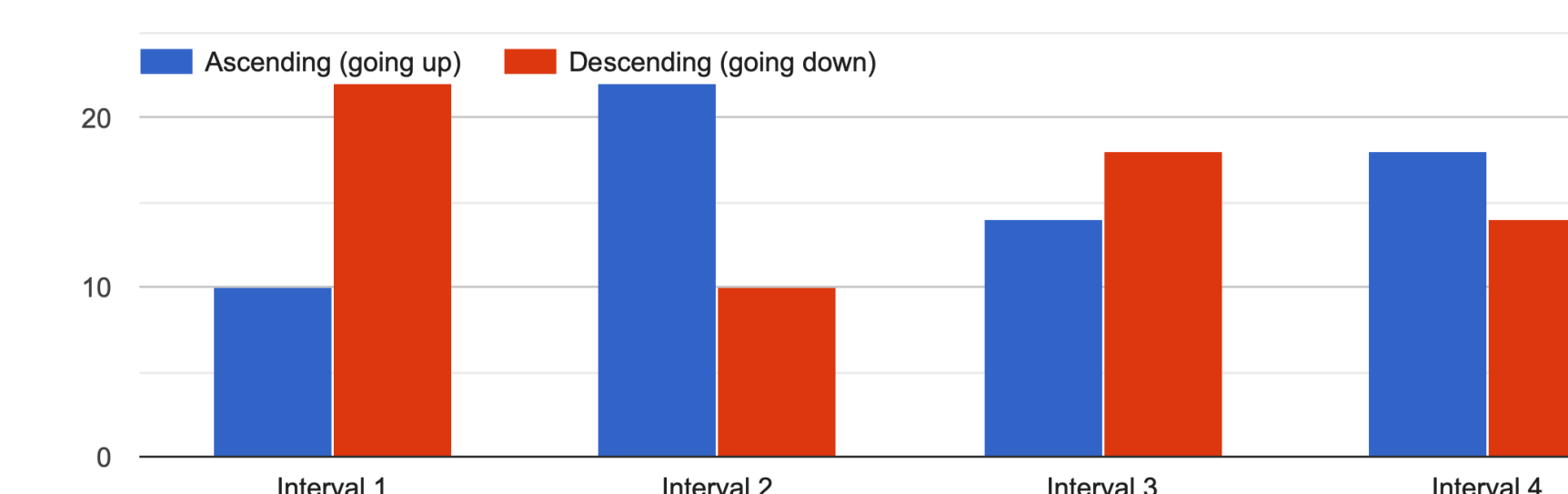


Figure 5. Audio 3A contains tritones in "forked" form according to the following pattern: Interval 1 (<); Interval 2 (<); Interval 3 (>); Interval 4 (>).

Perception of Audio 3B

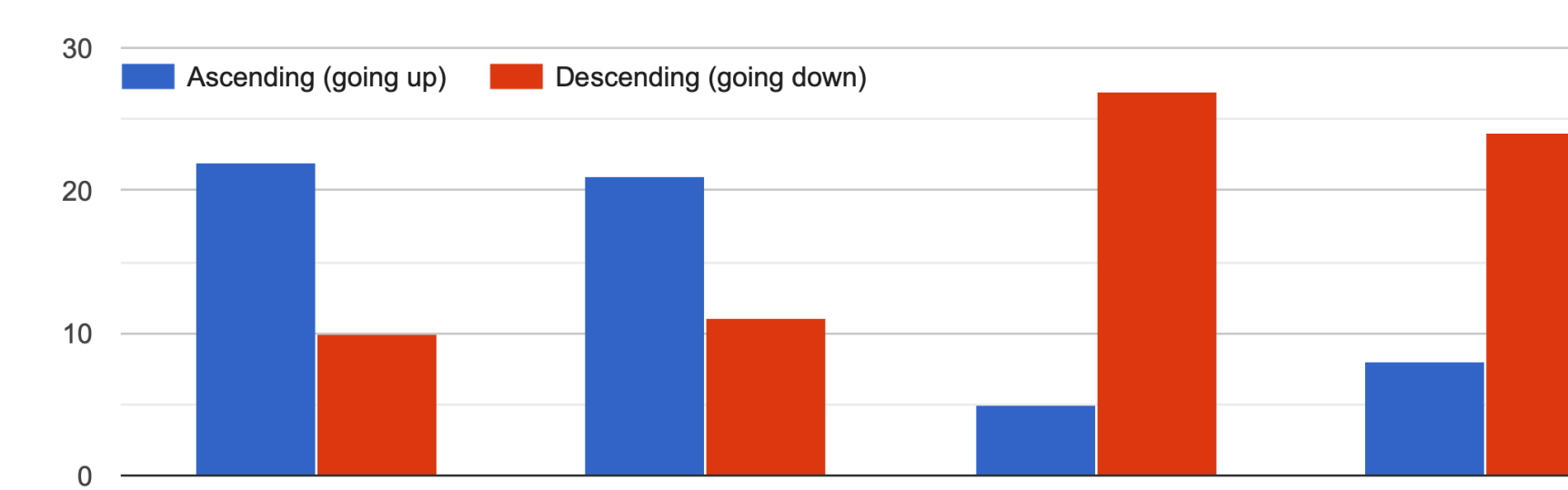


Figure 6. Audio 3B also contains tritones in "forked" form according to the following pattern, which is an inversion of the sequence in Audio 3A despite using the same pitch classes: Interval 1 (>); Interval 2 (>); Interval 3 (<); Interval 4 (<).

Perception of Audio 4

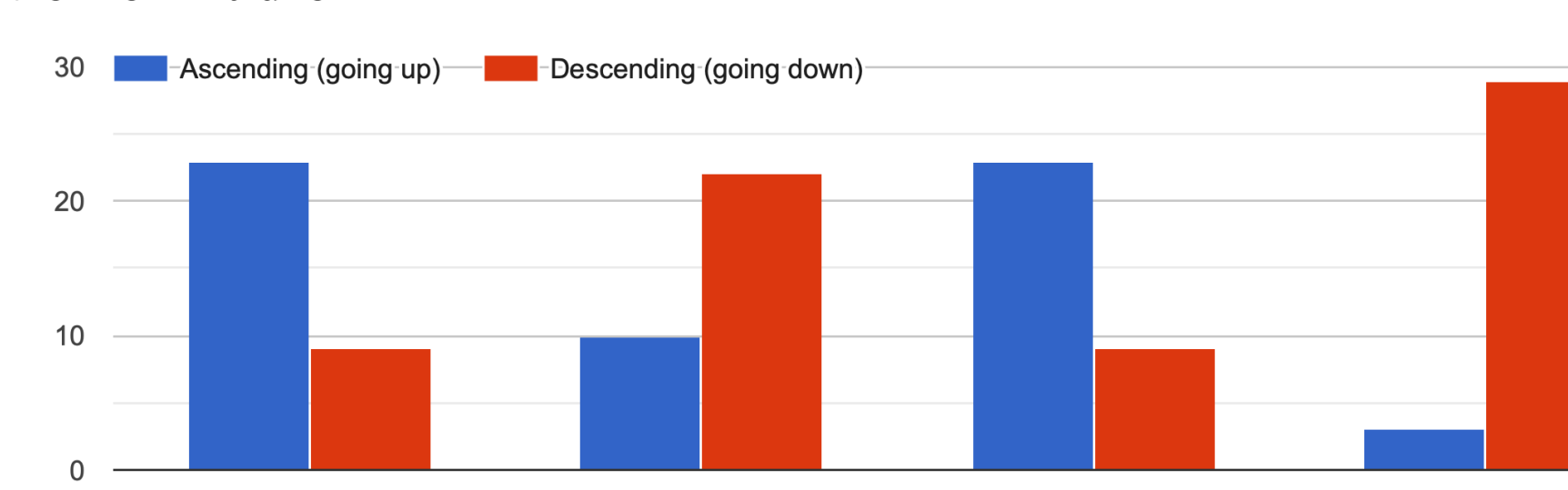


Figure 7. Audio 4 repeats Deutsch's (2026) sample, now played as an opportunity for participants to exercise their individual intentionality to alter their perception.

Discussion

Loudest Zone (LZ)

In this section, we discuss various quantitative (graphs in Figures 3-7) and qualitative (answered in narrative form) data collected through the survey. Several participants recognized the duplicated pitches in Audio 3A (Figure 5) and Audio 3B (Figure 6). According to the prompt's indication that the interval should ascend or descend, individuals classified the intervals according to this binary but were somewhat uncertain as to whether they diverged or converged. Participants also indicated that the different instrumentation between Audio 2 / Audio 4 (unknown) and Audio 3A / Audio 3B (saxophone) affected their ability to recognize interval directions or multiple octaves due to increased or decreased tone clarity.

Ability to Change Perceived Direction

Regarding individual intentionality in changing the perceived direction of the intervals between Audio 2 and Audio 4, the majority of participants reported the ability to hear the intervals differently by exercising their individual intentionality, while others reported no change. Mental focus played a central role, alongside the expectation that these pitches have the potential to ascend or descend arbitrarily. Musical ability was also instrumental in determining this change. Thus, participants' knowledge about the TP phenomenon and their musical literacy impacted the results.

Other Factors

As Figure 3 shows, some participants were unable to perceive tritones as either ascending or descending in Audio 1, which contains simple/regular, non-ST forms of the interval. This may influence larger studies and potential generalized results.

Final Thoughts & Further Research

Conclusion

Our study shows that scholarship on the TP, though spanning nearly four decades of research, is far from exhaustive. Perhaps further considerations as to the nature of the ST-based triton as an acoustic phenomenon vis-à-vis its semantic nature would be fruitful. The present study begins to suggest alternative directions.

Further Research

Among the several opportunities for further research on the TP, we have identified the following as naturally stemming from our collaboration. (A) Does re-incorporating the isolated LZ into its original ST impact the perception of interval direction? (B) Does retrograding pitch class order impact the perception of individual tritones' interval direction (D-G# becomes G#-D)? (C) Does the socio-culturally-constructed concept of "height" in relation to frequency integers play a role in the perception of tritone interval direction? (E) How does one perceive harmonic ST tritones? (F) Does the "conditioning of the ear" impact perception, whereby a tritone's LZ is placed alongside an ascending or descending sequence of n-ST melodic tritones? (G) Does the simultaneous, gradual, incremental moving from a single pitch class to its tritone in both directions impact the perception of the overall melodic direction?

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