USING FEEDBACK TO MANIPULATE THE TONAL HIERARCHY

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1 Introduction

Tonality is the complex hierarchical structure that governs the organization of pitch in Western music and is learned implicitly [1–4]. This implicit knowledge allows non-musicians to rate the belongingness of probe tones within a tonal context in a manner consistent with music theoretical descriptions of tonality [5]. Recent work has shown that the tonal hierarchy can be manipulated using random performance feedback when participants listened for tonal incongruities in melodies [6]. Random feedback reduced accuracy and confidence in identifying "out-of-key" notes in melodies and suppressed the late positive electrical brain responses usually elicited by the conscious detection of such a note [7]. This leads to the possibility of using reversed performance feedback to alter the perception of a single note.

2 Méthode/Method

2.1 Participants

Twelve volunteers took part in this study. They provided written informed consent in accordance with the Interdisciplinary Committee on Ethics in Human Research at Memorial University of Newfoundland. All participants were healthy, free of any cognitive deficit, hearing or visual impairments and had less than five years of formal musical training with no music theory training. Participants received a small cash honorarium for their participation.

2.2 Stimuli and Procedure

Tonal judgement task

A set of 160 melodies of between 7 and 15 successive tones were composed by two trained musicians for this study. Stimulus files are available at https://osf.io/pyrt7/. Melodies were synthesized in two versions, one "good" (in-key) and one "bad" (out-of-key), resulting in 320 melodies in total. The changed pitch always affected the same tone, which was 500 ms in duration and fell on the first downbeat in the third bar. For in-key melodies, target tones were either the II or IV scale degrees, and for out-of-key melodies, the target tones were bII or #IV (tritone).

For each trial, the participant heard two versions of the same melody and was asked which melody contained a bad note, and if they were sure or unsure of their choice. The type of performance feedback was manipulated across 3 Blocks (40 trials each): No feedback (*Baseline*), bad feedback (*Feedback*) and correct feedback (*Recovery*). During the *Feedback* block, bad feedback was only given for melodies containing the II and bII scale degrees. That is, when the participant reported that the bII was 'bad', they were told they were wrong, and when they reported that the II was 'good', they were told they were wrong, and vice versa. During the *Recovery* block the feedback provided was correct

Probe tone paradigm

To determine how each participants' ratings for each of the chromatic notes changed as a function of reversed feedback, a standard probe-tone paradigm was used. Each trial consisted of a 100 ms burst of white noise, followed by the *context*, an arpeggio of 7 tones, and finished with a *probe tone*, which was one of the twelve notes of the chromatic scale. The arpeggio in the key of C was: C (I) E (III), G (V), C (+1 octave), G, E, C. Each tone was 500ms long, with a 200 ms silent period between each tone. The probe tone was 1200ms after the final tone of the context. All stimuli can be found on the project's OSF page (https://osf.io/pyrt7/). For each trial, participants rated how well the probe tone "fit" into the context on a scale of 1-7. Each tonal hierarchy block covered 4 keys and consisted of 48 trials. This was repeated 4 times throughout the study (*PT1, PT2, PT3, PT4*)

Overall Procedure

The study took place over two days and involved deception. Participants were told as part of the informed consent process that the feedback provided was designed to improve their performance. On day 1, participants completed the *PT1*, the *Baseline* block, two *Feedback* blocks and the *PT2*. On the second day, participants completed the *PT3*, two *Feedback* blocks, the *PT4*, a debriefing and the *Recovery* block (optional). Before being debriefed, participants were asked if they had noticed anything strange about the feedback. No participant identified the reversed feedback pattern. Seven of the twelve participants completed the recovery block.

3 Résultats/Results

We use frequentist statistics, alpha = .05. All analysis ran in R 3.6.2 with RStudio using the tidyverse package [8].

3.1 Tonal judgement task

In all blocks, correctly identifying the 'bad' note (i.e., bII or #IV) as 'bad' was considered correct, regardless of the feedback provided. Confidence was scored as *sure* or *not sure*, regardless of accuracy. Figure 1 plots mean accuracy and confidence in each Block for each Scale Degree. In a linear model predicting Accuracy with Block, Scale Degree and their interaction as predictors (Figure 1A), the main effect of

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scale degree was significant. While coefficients decreased for each successive block, it was not a significant predictor. Accuracy for scale degree 2 was always better than scale degree 4, and sometimes that difference was significant in follow-up t-tests with Bonferroni correction.

In a linear model predicting confidence with block, scale degree and their interaction as predictors (Figure 1B), all predictors were significant. Confidence was lower during *Feedback* blocks compared to *Baseline* and *Recovery* blocks, and was lower for the IV/#IV judgment compared to the II/bII judgement.

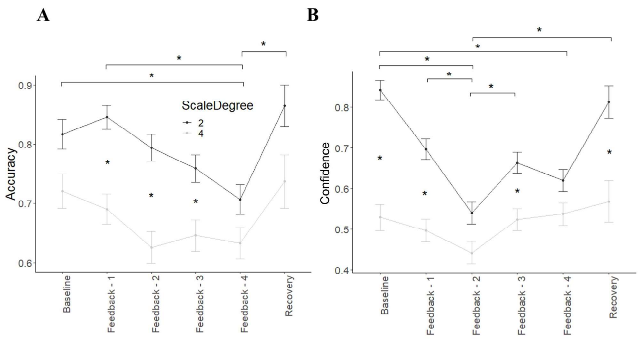

Figure 1: Mean accuracy (A) and confidence (B) in each block for each scale degree. Error bars show standard error of the mean. Significant differences are marked by brackets and asterisks, $p < .0005$.

3.2 Probe tone paradigm

Figure 2 shows mean ratings (A) mean ratings for each manipulated scale degree bII, II, IV and #IV for *PT1, PT2, PT3 and PT4*. We expected ratings for the bII to increase from *PT1-4*, and for ratings of the II to decrease from *PT1-4* due to the *Feedback* blocks.

In a linear model predicting rating with scale degree, block and their interaction, scale degree was a significant predictor. A linear model predicting standard deviations (proxy for confidence) with scale degree, block and their interaction, scale degree was a significant predictor.

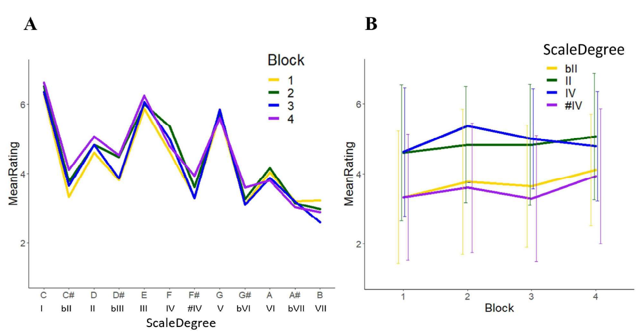

Figure 2: Mean ratings for all scale degree and blocks (A) and for manipulated scale degrees for each block (B).

4 Discussion

Participants were not convinced that a "bad" note was "good", nor did manipulation systematically alter their overall tonal hierarchy schema. Though accuracy decreased over time, assuming a continued linear trend, it would take longer exposure to bad feedback to cause the intended switch. Accuracy decreased slowly even as certainty decreased quickly.

It is noteworthy that accuracy and certainty were higher for II than for IV. Typically perceived as an especially dissonant note, the tritone (#IV) should be the easiest to identify as "bad". However, most notes can be manipulated to be perceived as well-fitting with context alone. It is possible that the #IV was consistently approached and resolved in a way that promoted more "fit" than the bII.

5 Conclusion

Within the feedback blocks, our work replicates previous studies that found decreases in confidence and accuracy when inaccurate feedback is provided, although our accuracy results failed to reach significance [6]. More importantly, by using a probe tone paradigm our results suggest that perception of a single note in the tonal hierarchy is resistant to targeted manipulation using bad feedback, suggesting that representation of the tonal hierarchy is stable.

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