

INTRODUCTION

- Sight-reading offers a model for studying **perception–action mechanisms**, revealing how musical structures shape perceptual expectations and motor planning during performance.
- Tonal modulations are common to Western music, yet impact on real-time performance is largely unexplored.
- Two experiments examined influence of **tonal modulations** on pianists' use of perceptual and motor representations.

HYPOTHESES

- Impact of tonal modulation on performance error rate**
H1: Key 1 < Transition > Key 2
- Impact of tonal distance on performance error rate**
H2: Far > Mid > Close > None

GENERAL METHODOLOGY

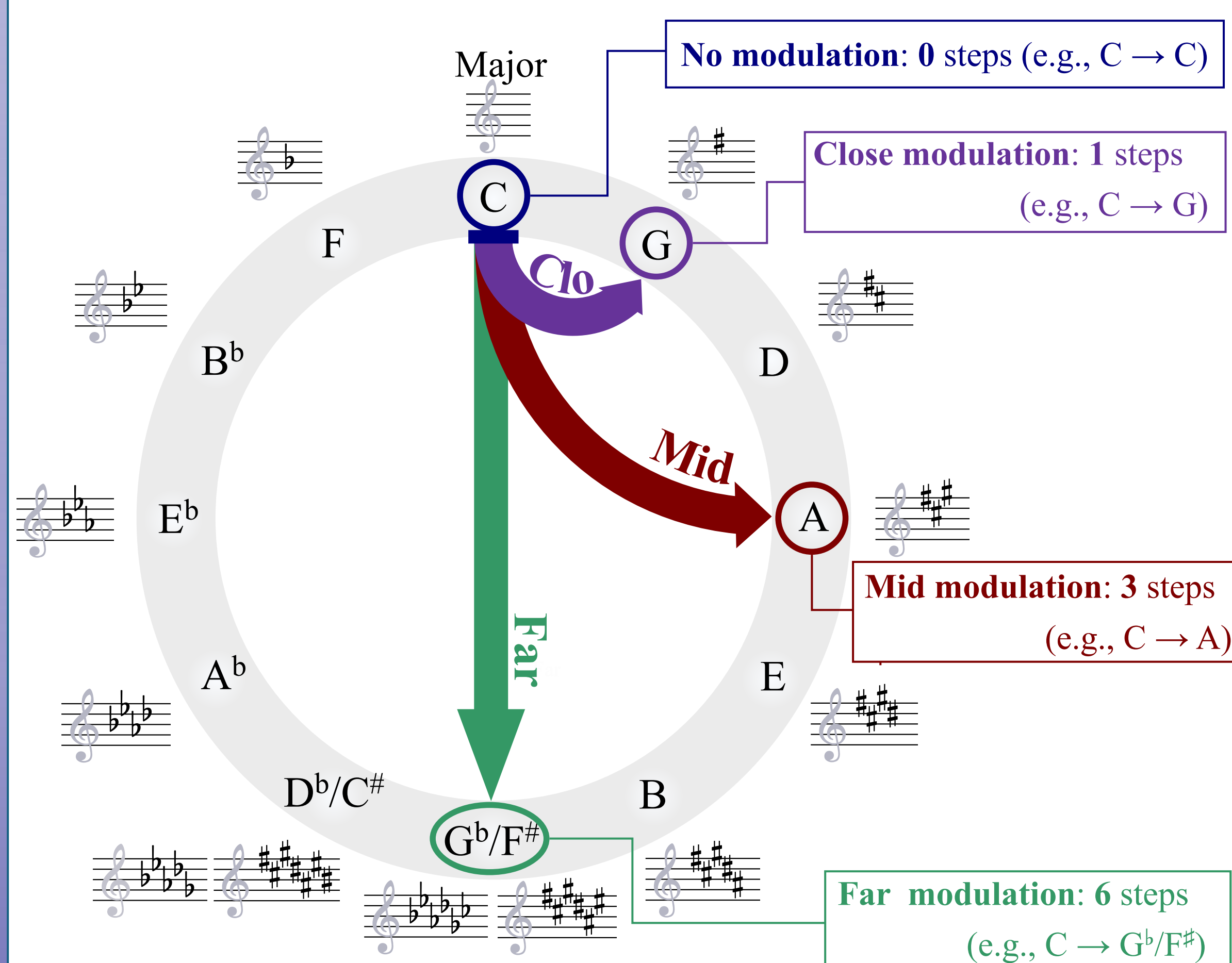
Participants:

- Experiment 1: 25 pianists (19 F; $M_{Age} = 20.6$; $Mode_{RCM\ Grade} = 10$)
- Experiment 2: 30 pianists (22 F; $M_{Age} = 20.5$; $Mode_{RCM\ Grade} = 10$)

Stimuli:

- Twelve ten-measure melodies (right-handed) created in each of the four modulation conditions; 48 melodies in total.
- All stimulus melodies contained three sections (see Figure 1a):
Key 1 (bars 1-4) → **Transition** (bar 5) → **Key 2** (bars 6-10)

Modulation Conditions: Four different modulation conditions examined, based on clockwise steps around the circle of fifths:



Procedure, Data Preprocessing & Error Coding:

- Pianists sight-read each melody and recorded using Sonar.
- Errors identified via comparison with original scores; percent errors aggregated across Key 1, Transition and Key 2 sections.

EXPERIMENT 1

Pianists performed 48 melodies (4 modulation conditions x 12 major keys; see Figure 1a for examples) in a **random order**.

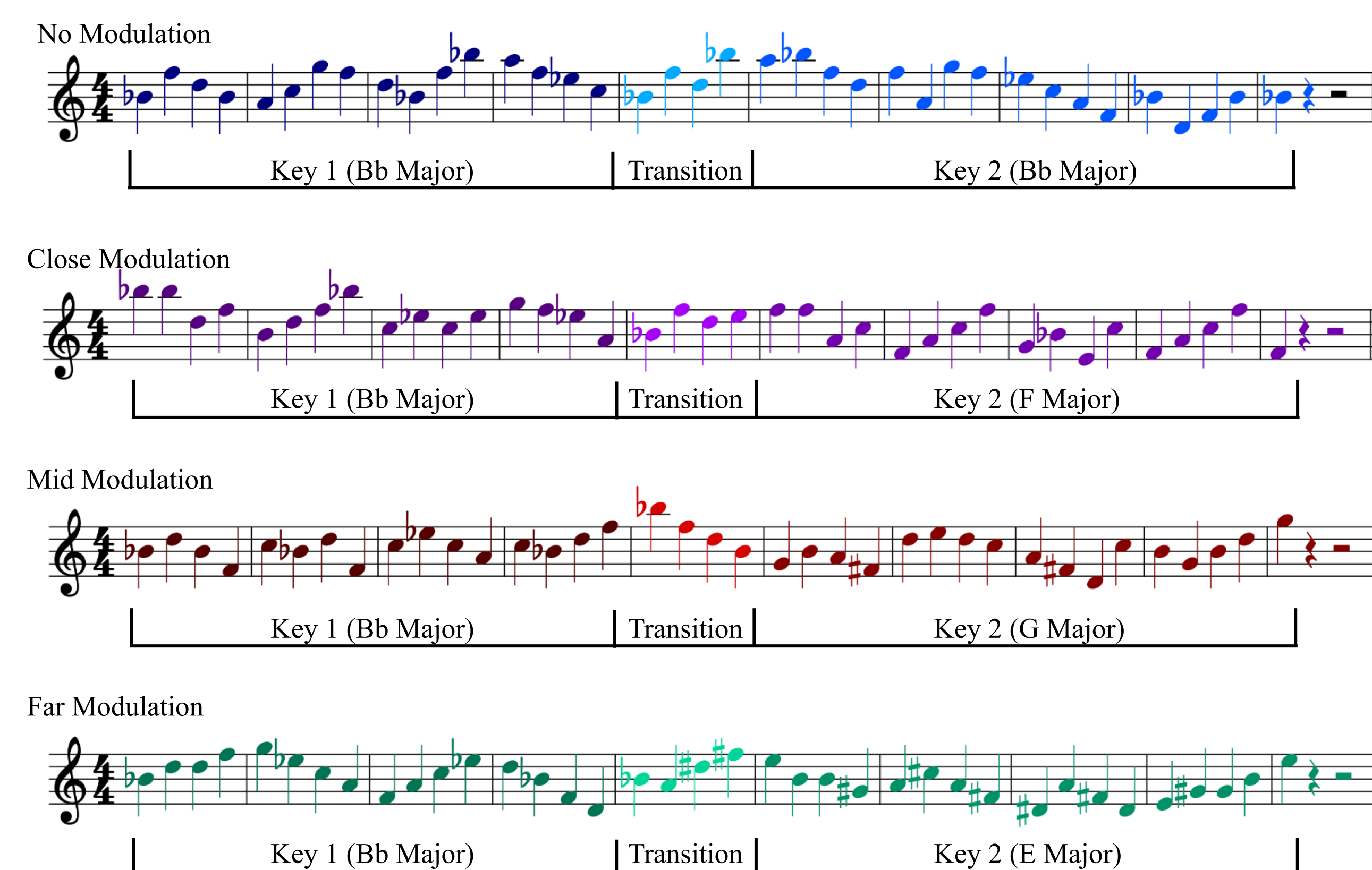


Figure 1a: Sample melodies in the no, close, mid, and far modulation conditions in Experiment 1.

Pitch errors were defined as any played note that was different from what was notated in the score (**substitution**, **addition** or **omission**).

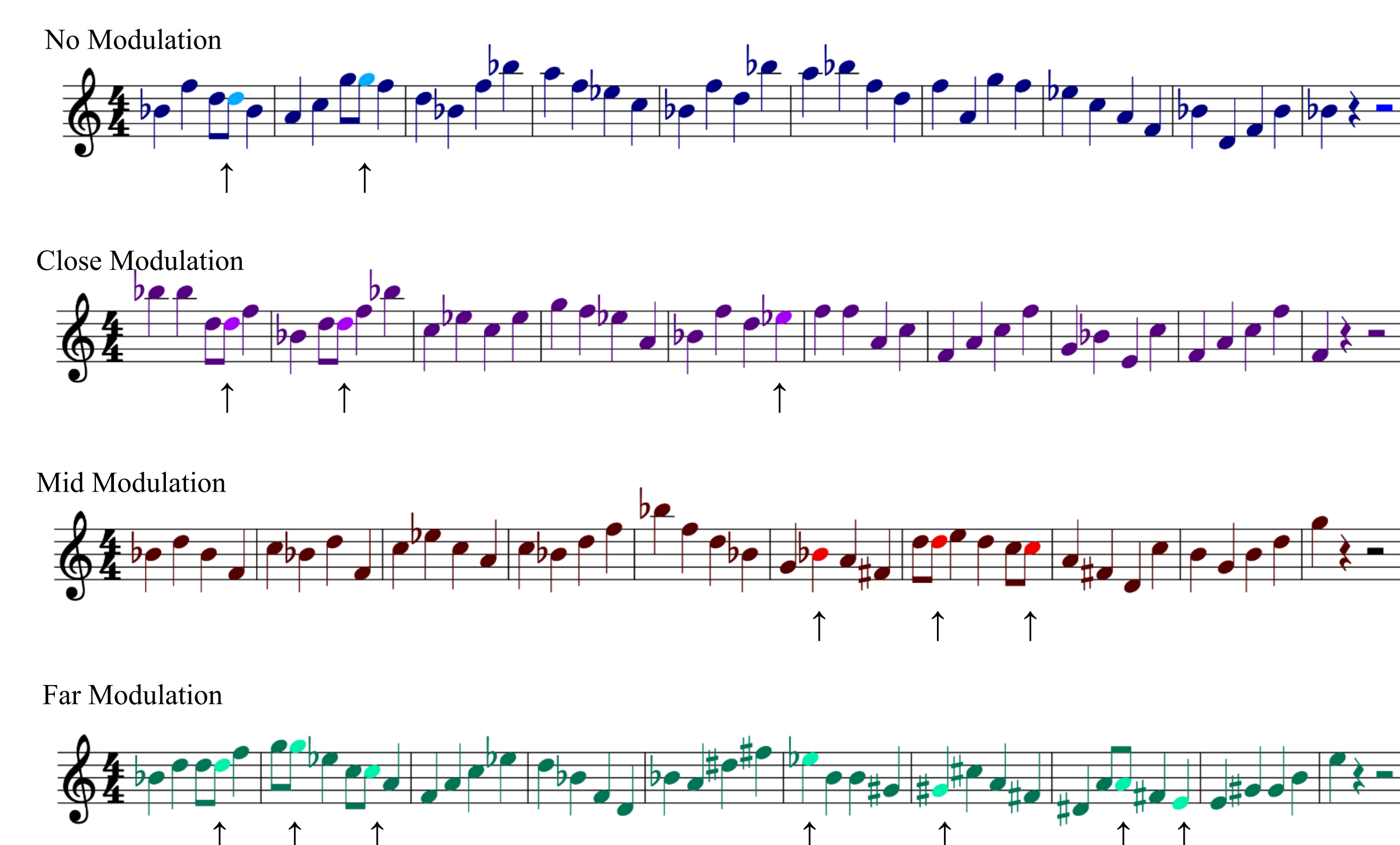


Figure 1b: Examples performances for the melodies of Figure 1a. Performance errors are indicated with ↑.

Results:

- Errors analyzed with 2-way ANOVA, factors of *Tonal Section* and *Modulation Condition* (see Figure 2).
- Main effect of *Tonal Section*, $F_{(2,48)} = 10.5$, $p < .001$; pattern of results in line with **Hypothesis 1**.

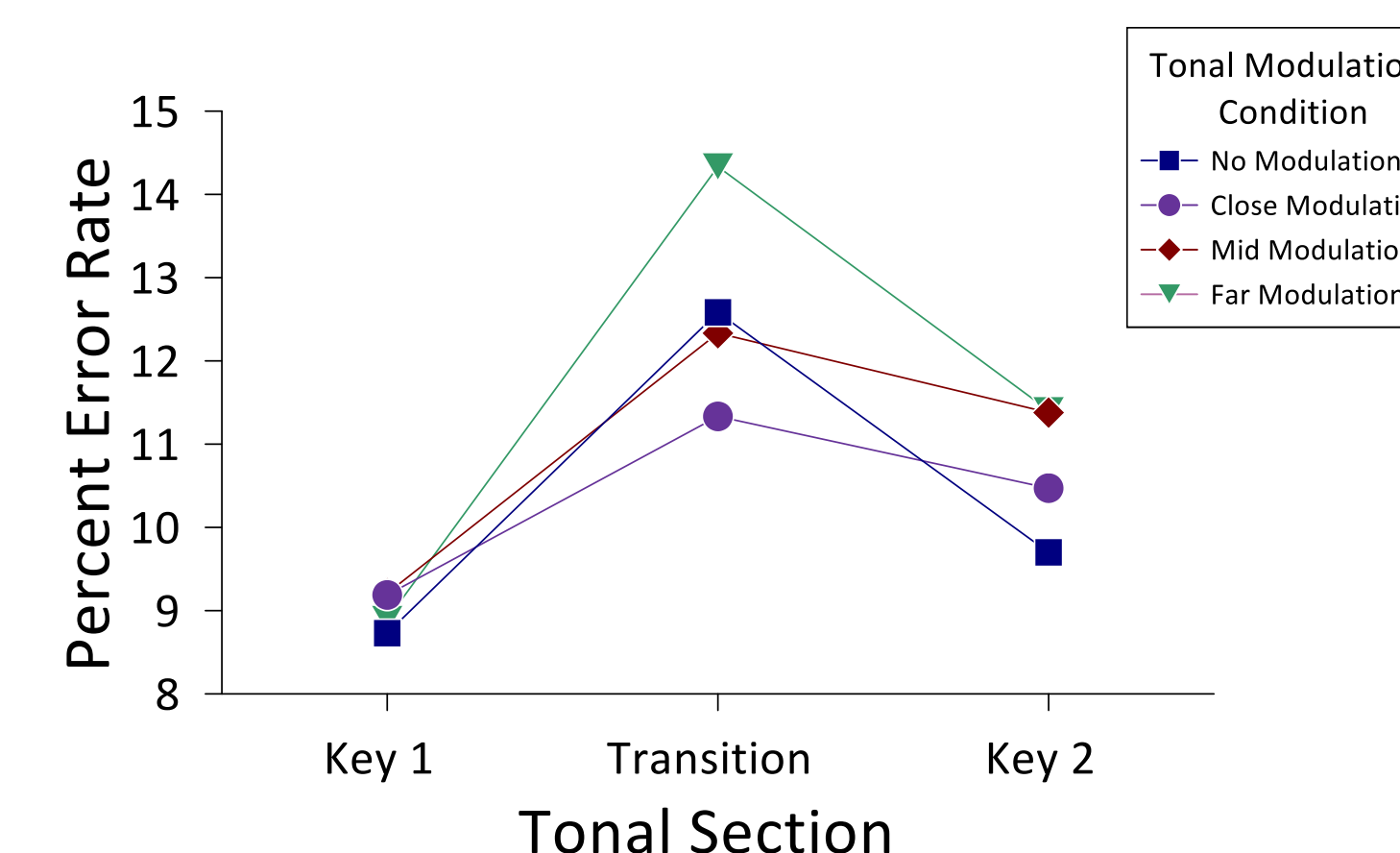


Figure 2: Error rates as a function of Tonal Section and Modulation Condition factors in Experiment 1.

Discussion:

- Tonal modulation disrupts sight-reading, particularly at transition point. Tonal distance effects demonstrated far modulations producing the most disruptions; no and close modulations the least, in line with **Hypothesis 2**.
- CONCERN #1: Error rates *also* increased at transition in the no modulation melodies, suggesting pianists expected a key change – explored in **Experiment 2**.
- CONCERN #2: Presence of mixed accidentals (sharps and flats) disrupted performance fluency – also explored in **Experiment 2**.

EXPERIMENT 2

Pianists performed the same 48 melodies using a **blocked design**, to test if they developed expectations for tonal modulation at the Transition (i.e., bar 5).

- No Modulation First Condition:** No melodies → Clo, Mid, Far melodies (randomized)
- Modulation First Condition:** Close, Mid, Far melodies (randomized) → No melodies

To test if the presence of mixed accidentals influenced performance, melodies were also rewritten using **enharmonic spelling** for all accidentals (see Figure 3).

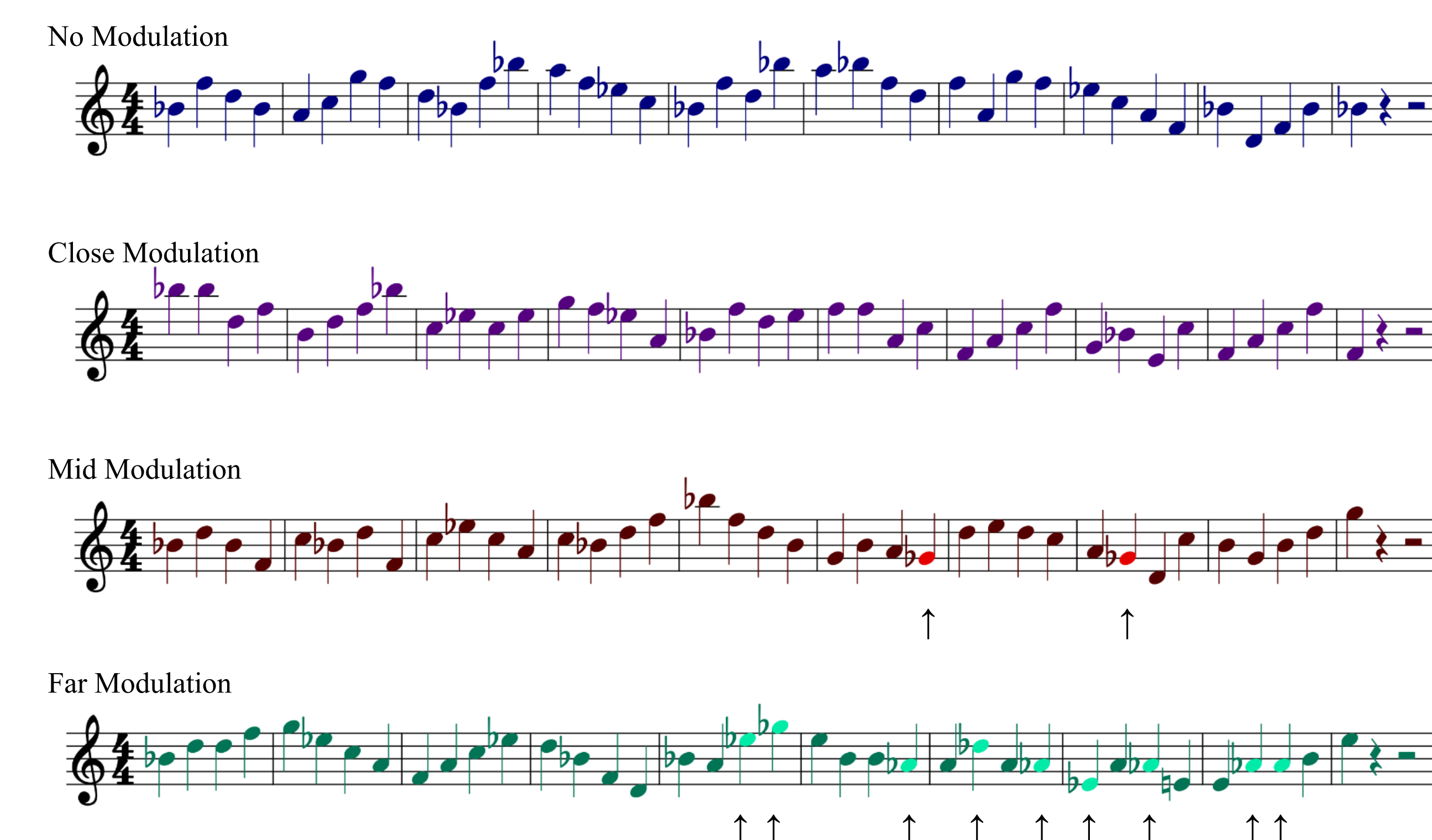


Figure 3: Sample melodies in four Modulation Conditions of Experiment 2. Enharmonically altered notes indicated with ↑.

Results & Discussion:

- Errors analyzed with 3-way ANOVA, factors of *Tonal Section*, *Modulation Condition* and *Condition Order* (Figure 4).
- Main effects of *Tonal Section*, $F_{(2,56)} = 19.2$, $p < .001$, and *Modulation Condition*, $F_{(3,84)} = 41.6$, $p < .001$. Interaction between *Tonal Section* x *Modulation Condition*, $F_{(6,168)} = 10.0$, $p < .001$.
- Blocking eliminated expectations for modulations – no increased errors at the transition in the “No” modulation melodies.

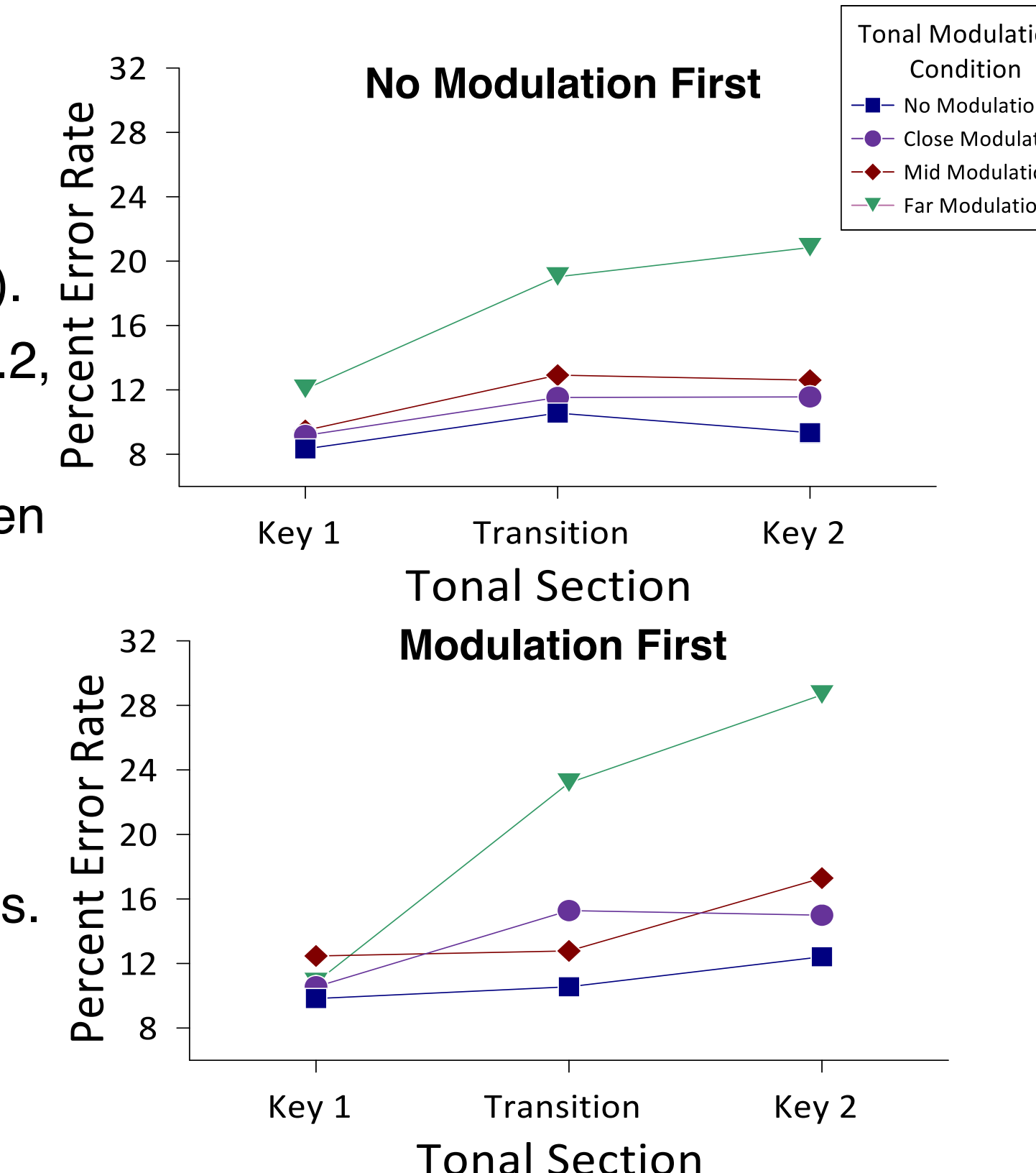


Figure 4: Error rates as a function of Tonal Section and Modulation Condition factors in Experiment 2.

Cross-Experiment Comparisons:

- Analysis of data from both experiments revealed errors increased with tonal distance. Key 2 area led to fewer errors in Experiment 1 (mixed accidentals) than Experiment 2 (enharmonic accidentals). Mixed accidentals thus provide a salient cue for key change, leading to increased performance accuracy.

GENERAL CONCLUSIONS

- Tonal modulations influence sight-reading accuracy, with transitions to new keys increasing errors in performance.
- Tonal distance of modulations affects sight-reading accuracy, with greater tonal distance leading to increased performance errors.
- Findings highlight role of perceptual and motor schemas in sight-reading.