## Title

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# Local–Global Association Between Pitch and Chord Identification Strategies

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## Abstract

Strategies for identifying pitch and chords can be understood in relation to a shared local–global processing dimension. Absolute pitch (AP) and pitch-element identification tend to reflect more local strategies, whereas relative pitch (RP) and harmonic-function identification tend to rely more strongly on global strategies. The present study examined whether individual internal dominance in pitch identification strategies is associated with corresponding dominance in chord identification strategies. Twenty-one professionally trained musicians completed pitch identification tasks (AP and RP) and chord identification tasks requiring either pitch-element or harmonic-function judgments. Individual dominance was indexed using residual-based measures to dissociate identification bias from overall ability. Dominance in local versus global pitch identification was significantly associated with corresponding dominance in chord identification across accuracy and reaction time. Analyses based on raw scores showed consistent directional trends, though most did not reach statistical significance. Overall, the findings suggest that pitch- and chord-level identification strategies interact along a shared local–global dimension, highlighting the role of individual processing dominance in musical identification.

**Keywords:** Local - Global Processing; Pitch Identification; Chord Identification; Absolute Pitch; Relative Pitch

## Introduction

Distinguishing between local and global features is a fundamental component of perceptual processing, yet it remains relatively underexplored in audition compared to vision (Navon, 1977). Although auditory local–global distinctions have been demonstrated—often revealing a bias toward global structure—these effects are better understood as reflecting flexible modes of organizing acoustic information rather than fixed stimulus properties (Justus and List, 2005; Sanders and Poeppel, 2007). Music provides a particularly suitable framework for examining this flexibility, as local perception typically relies on specific pitches, whereas global processing depends on contour (Dowling and Harwood, 2014; Peretz, 1990). While standard paradigms also elicit global precedence (Schiavetto et al., 1999), musical training modulates this hierarchy by enhancing sensitivity to local changes and attenuating global bias (Black et al., 2017; Fujioka et al., 2004; Susini et al., 2020). Together, these findings suggest that the differentiation between local and global musical information is not obligatory, but varies with listener characteristics and task context.

Although local–global processing has been studied primarily using monophonic melodic materials, converging evidence indicates that similar hierarchical principles apply to harmonic perception. Behavioral studies show that harmonic judgments depend on interactions between long-range hierarchical structure and salient local cues, such as cadential closure (Bigand and Pineau, 1997; Choi and Fujioka, 2025; Tillmann et al., 1998a,b). Neurophysiological findings further support this view: hemispheric lateralization patterns suggest that harmonic processing shifts from more global to more local strategies with musical training (Evers et al., 1999). Collectively, these results indicate that harmonic perception involves concurrent and interacting local and global processes rather than a single level of analysis.

Beyond basic perception, musical activities frequently require the identification of complex musical structures by ear itself. Such identification necessarily depends on both fine-grained acoustic detail and contextual information, implying that local and global processing must interact during musical identification. Despite extensive work on local–global processing in music perception, relatively few studies have directly examined how these processing levels operate within identification tasks. Relevant evidence comes from Ziv and Radin (2014), who showed that absolute pitch is associated with greater reliance on pitch-specific information, whereas relative pitch is associated with greater reliance on relational and contextual information in chord identification.

Pitch identification—arguably a fundamental musical skill—can be interpreted within a local–global framework corresponding to absolute pitch (AP) and relative pitch (RP). AP involves identifying pitches without external reference and aligns with local-level processing, whereas RP involves identifying pitch relations within a contextual frame and corresponds more closely to global-level processing (Levitin and Rogers, 2005; Chin, 2003). Importantly, AP and RP should not be interpreted as mutually exclusive abilities: AP has been shown to facilitate tasks typically associated with RP, such as interval naming, supporting the view that pitch identification abilities are better understood as continuous, partially independent tendencies rather than discrete categories (Dooley and Deutsch, 2011; Ziv and Radin, 2014).

This perspective raises a critical question: do pitch processing strategies linked to local and global processing at the level of pitch class also give rise to distinct strategies when identifying harmonic structures composed of multiple simultaneous pitches? Chord perception poses additional challenges, as simultaneous pitches are processed as fused entities rather than



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as independent streams (McDermott and Oxenham, 2008). To account for chord identification, previous models have proposed multi-stage mechanisms such as template switching or timbre priming constrained by lateral inhibition (Egmond and Boswijk, 2007; McLachlan, 2011). Notably, chord identification accuracy depends strongly on stimulus familiarity even in AP musicians (McLachlan et al., 2013), calling into question a rigid conceptualization of AP. Because chordal familiarity is typically established within a tonal context, this reliance implies the involvement of relational, global processing (Wilson et al., 2009), further supporting the view that AP and RP reflect flexible integrations of local and global processes rather than a strict dichotomy.

From this perspective, chord identification strategies can be framed along a local–global continuum. In musical practice, chords are defined not by isolated acoustic features but by structurally constrained configurations that specify their identities within a musical context. In their extreme forms, these constraints give rise to two contrasting modes of chord definition. A local strategy defines chords in terms of specific pitch elements; for example, an A minor triad is identified by the pitch set A–C–E, regardless of context. This pitch-element-based definition constitutes the standard approach in musical notation systems. In contrast, a global strategy defines chords in terms of harmonic function (scale degree + chord quality), whereby the same A minor triad is identified as the submediant (vi or six minor) within the context of C major (Poulin-Charronnat et al., 2005). Although harmonic function has traditionally been defined within diatonic contexts, scale degree and chord quality based definitions extend to non-diatonic and expanded settings, including figured bass, the Nashville number system, and jazz voicing theory (Cecchetti et al., 2023; De Clercq, 2019; Levine, 2011; Schulenberg, 1984). However, while local strategies map onto pitch element identification and global strategies onto harmonic function identification, the use of one does not preclude access to the other. In trained musicians, identification may begin from either strategy, with remaining information estimated through subsequent cognitive operations, potentially introducing additional sources of error or longer decision latencies (See Figure 1).

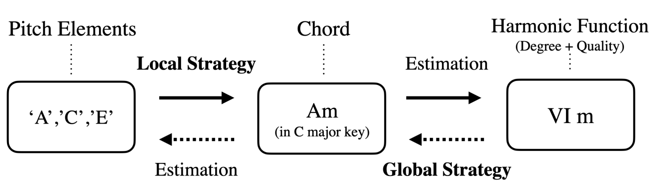


Figure 1: Conceptual schematic illustrating local and global strategies in chord identification. A chord can be identified by first attending to pitch elements (e.g., individual notes) and inferring the chord label (local strategy), or by attending to harmonic function (scale degree and quality) within a tonal context and mapping it onto a chord label (global strategy).

Taken together, strategies for identifying pitch and chords can be conceptualized along a shared local–global dimension. Absolute pitch and pitch element identification primarily reflect local strategies, whereas relative pitch and harmonic function identification rely more on global strategies. Building on evidence that the recruitment of local and global processing varies with listener characteristics and task demands, we hypothesized that individual internal dominance in pitch identification strategies would be systematically associated with corresponding dominance in chord identification strategies. Moreover, we predicted that local pitch identification ability would better predict local than global chord identification performance, whereas global pitch identification ability would better predict global than local chord identification performance.

# Methods

## Participants

Twenty-three professionally trained musicians with normal hearing participated in the study. Participants were recruited based on self-reported possession of absolute pitch (AP), relative pitch (RP), or both, as well as self-reported ability to identify musical triads by ear (years of musical training: $M$ = 13.48, $SD$ = 6.74; 9 males, 14 females). The pool of participants consisted of musicians from both classical and popular music backgrounds, with primary areas of training including piano, guitar, string instruments, composition, and vocal performance. All participants provided written informed consent prior to participation and received financial compensation. Ethics approval was obtained from the Institutional Review Board (IRB) of Seoul National University (IRB No. 2508/004-00).

## Stimuli

All stimuli were sampled piano sounds generated using a high-quality sound library (Keyscape, Spectrasonics) and tuned in equal temperament with A4 set to 440 Hz. Individual tones and chords had a duration of 1 s. In the RP test and chord identification test, a 0.5-s silent interval separated the harmonic context and the target tones.

**Pitch identification test.** The pitch identification test consisted of two subsets: an AP test and a RP test, adapted from Miyazaki et al. (2018). The AP test included 36 isolated tones spanning three octaves (C2–B5). In the RP test, each trial began with a harmonic context consisting of a dominant seventh chord followed by a tonic chord, after which two successive tones were presented. The first tone corresponded to the tonic of the key, and the second tone, serving as the target, ranged from one to eleven semitones above the tonic. Harmonic contexts were presented in three keys (C major, E major, and A♭ major).

**Chord identification test.** The chord identification test also comprised two subsets: a pitch element test and a harmonic function test. The stimulus set was identical across the two

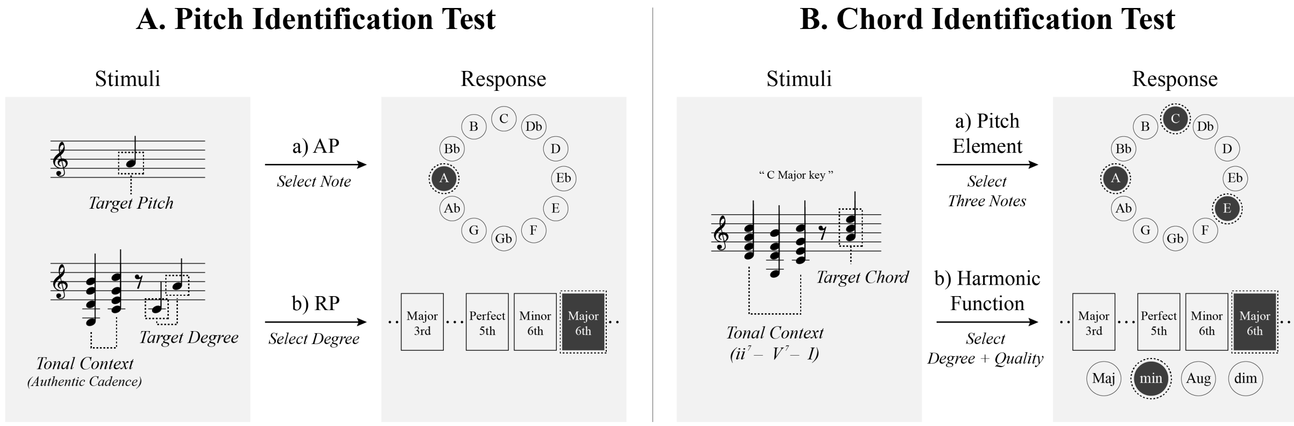


Figure 2: Schematic overview of the experimental tasks. (A) Pitch Identification Test: participants identified either the absolute pitch (AP) by selecting the target note or the relative pitch (RP) by selecting the scale degree within a tonal context. (B) Chord Identification Test: participants identified chords either by selecting pitch elements (three constituent notes) or by selecting harmonic function (scale degree and chord quality) within a tonal context.

tasks. Each trial began with an extended tonal context ($\text{ii}^7$–$\text{V}^7$–I) establishing the key, followed by a target triad to be identified. Tonal contexts were presented in C major, E major, and A♭ major, selected to include one neutral key and two keys with matched numbers of accidentals (four sharps and four flats). The keys were indicated in text. Target chords were simple, musically familiar triads belonging to one of four chord qualities (major, minor, augmented, diminished), including both diatonic and non-diatonic chords within the tonal framework. All chords were presented in root position. To maintain familiarity, the interface was designed to closely match that used in the pitch identification test.

## Procedure

Participants completed a demographic questionnaire prior to the experiment and were tested individually in a soundproof room. The experiment was implemented in PsychoPy and conducted on a 16-inch MacBook Pro. Auditory stimuli were presented via closed-back headphones (Audio-Technica ATH-M50x), and responses were collected using a wired USB mouse. Participants completed the pitch identification test followed by the chord identification test, with the entire session lasting approximately one hour. At the beginning of each trial, the on-screen cursor was reset to the center of the screen. The overall procedure is illustrated in Figure 2.

**Pitch identification test** Both the AP and RP tests consisted of 36 experimental trials, each preceded by three practice trials. In the AP test, participants identified the target pitch by selecting one of 12 pitch-class options arranged in a circular layout corresponding to the chromatic scale. This layout was used to reduce potential confusion arising from octave equivalence. In the RP test, participants identified the interval between two tones by selecting one of 11 scale-degree options (♭2–7) displayed horizontally. Responses were self-paced within an 8-s time limit, and participants were instructed to respond as accurately and quickly as possible.

**Chord identification test** Both the pitch element and harmonic function tests consisted of 63 experimental trials, each preceded by three practice trials. The key of the tonal context was explicitly displayed throughout each trial to minimize reliance on absolute pitch. In the pitch element test, participants selected the three pitch classes forming the target chord using the same circular interface as in the AP test. In the harmonic function test, participants identified the scale degree of the chord root and its chord quality using an interface adapted from the RP test. Responses were self-paced within a 20-s time limit, and participants were also instructed to respond as accurately and quickly as possible. Because the two tests shared an identical stimulus set, their order was counterbalanced across participants.

## Data analysis

**Accuracy and Reaction Time (RT) analysis** Of all recruited participants, two were excluded from the analyses because their performance fell within the chance-level range on at least one chord identification test, resulting in a final sample of 21 participants. Descriptive statistics for accuracy, RT and Spearman correlations in all tests are presented in Table 1.

Results of the Shapiro–Wilk tests showed that most scores violated the assumption of normality. Accordingly, non-parametric statistical tests were employed, including the Mann–Whitney $U$ test for group comparisons and Spearman's rank correlation for association analyses.

Consistent with previous findings, AP and RP scores (both accuracy and RT) were highly correlated, as were scores on the pitch identification and chord identification tests. All correlations were significant at $p < .001$. In addition, AP and RP accuracy differed significantly in both mean and variance, as indicated by the Wilcoxon signed-rank test and the Pitman–Morgan test ($W = 28.0$, $p = .007$ and $t = 4.94$, $p < .001$, respectively).

Given this data structure, residual analyses were conducted for each pair of scores to examine individual differences in internal dominance rather than relying on categorical ability distinctions (AP accuracy and RT regressed on RP accuracy and RT, and pitch-element accuracy and RT regressed on harmonic-function accuracy and RT). This approach isolates relative dominance by controlling for shared variance, allowing associations between dominance patterns to be examined independently of overall identification ability. Based on residual values of pitch identification accuracy, participants with residuals $\geq 0$ were classified as AP-dominant ($n = 13$), and those with residuals $< 0$ as RP-dominant ($n = 8$).

Table 1: Descriptive statistics and Spearman correlations

| Measure | Mean | SD | Spearman $\rho$ | $p$ |
|---|---|---|---|---|
| AP Acc. | 61.38 | 36.46 | 0.806 | < .001 |
| RP Acc. | 81.08 | 17.00 | | |
| AP RT | 2.04 | 1.28 | 0.790 | < .001 |
| RP RT | 2.65 | 1.04 | | |
| Pitch Acc. | 57.22 | 31.25 | 0.952 | < .001 |
| Harmonic Acc. | 52.08 | 31.28 | | |
| Pitch RT | 7.45 | 3.72 | 0.674 | < .001 |
| Harmonic RT | 7.65 | 2.75 | | |

*Note.* Acc.: Accuracy, RT: Reaction Time, AP: Absolute Pitch, RP: Relative Pitch, Pitch: Pitch Element, Harmonic: Harmonic Function

The present study used a wired USB mouse for responses. Previous work has reported mouse input latencies of approximately 10–15 ms at standard polling rates (Casiez et al., 2015). In contrast, even the smallest standard deviation of collected RTs in the present data exceeded 1s, indicating that input device latency is unlikely to have affected the results.

**Post-experimental interview processing** Following the experiment, participants briefly described their typical chord identification strategies in open-ended responses. These responses were transcribed and translated into English. To obtain an exploratory summary of commonly referenced strategies, responses were manually filtered to retain only words directly related to identification strategies (e.g., chord quality, interval relations), excluding filler words and non-strategic expressions. The resulting terms were visualized using word clouds separately for AP and RP dominant groups. This procedure was intended for illustrative purposes and was not subjected to formal qualitative coding or statistical analysis.

## Results

### Group Comparison

Group differences in chord identification test accuracy and RT were examined between the AP-dominant and RP-dominant groups. Mann–Whitney $U$ tests revealed significant group differences between the AP-dominant and RP-dominant groups in chord identification performance, including pitch-element accuracy ($U = 93.0$, $p = .003$), harmonic-function accuracy ($U = 88.0$, $p = .010$), pitch-element RT ($U = 9.0$, $p < .001$), and harmonic-function RT ($U = 21.0$, $p = .025$). These group differences were further confirmed by permutation tests, which yielded consistent significance patterns across all measures (all $p < .05$). Across all cases, the AP-dominant group showed higher accuracy and shorter RTs than the RP-dominant group.

### Bias correlation analysis

To examine whether individual biases in pitch identification ability were associated with biases in chord identification performance, residual scores were computed for each participant. Specifically, pitch identification bias was indexed by residuals obtained from regressing AP accuracy and RT on RP accuracy and RT, while chord identification bias was indexed by residuals obtained from regressing pitch-element accuracy and RT on harmonic-function accuracy and RT. For accuracy-based residuals, positive values indicate relatively greater AP dominance over RP, whereas negative values indicate relatively greater RP dominance. For RT-based residuals, negative values indicate relatively greater AP dominance, reflecting faster responses. Correlation analyses revealed that pitch residuals were significantly correlated with chord residuals for both accuracy and RT (accuracy: Spearman $\rho = .630$, $p = .002$; RT: $\rho = .648$, $p = .001$; see Figure 3). To assess whether this relationship extended beyond residual-based measures, correlations were also examined between raw score differences, defined as AP minus RP scores and pitch-element minus harmonic-function scores. Significant correlations were also observed for both accuracy ($\rho = .501$, $p = .021$) and RT ($\rho = .571$, $p = .007$).

### Raw-score based correlation comparison

Raw-score correlation analyses were conducted to examine the relative associations of AP and RP scores with chord identification performance. Spearman correlation coefficients for all pitch and chord identification score pairs are summarized in Table 2, with all correlations reaching statistical significance ($p < .01$). Overall, AP scores tended to show stronger associations with pitch element performance, whereas RP scores tended to show stronger associations with harmonic function performance. This directional pattern was observed across accuracy and RT measures, with the exception of pitch element accuracy, for which AP and RP accuracy showed comparable correlations. To assess whether these observed differences in correlation strength were statistically reliable, differences between dependent correlations were tested using Steiger's $Z$ test. A significant difference was found only for harmonic function accuracy, indicating a stronger association with RP accuracy than with AP accuracy (Steiger's $Z = -2.879$, $p = .004$). No other differences between correlations reached statistical significance.

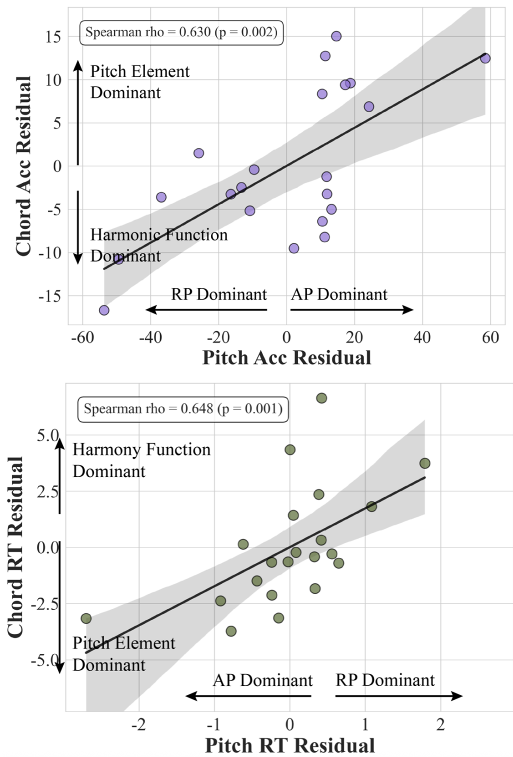


Figure 3: Results of bias correlation analysis. Relation between pitch and chord accuracy residuals (A) and RT residuals (B) are represented.

## Discussion

### Dominance of overall ability

Although individual strategies varied, results suggest that AP-related processing constitutes a more efficient approach. The AP-dominant group significantly outperformed the RP-dominant group not only on AP tasks (accuracy: $U$ = 99, $p$ < .001; RT: $U$ = 12, $p$ = .003) but also on RP tasks (accuracy: $U$ = 80.5, $p$ = .042; RT: $U$ = 24.0, $p$ = .045), with strong correlations observed across all score pairs ($p$ < .001). This asymmetry aligns with traditional classifications: over 60% of the AP-dominant group met the conventional 90% AP criterion (Miyazaki et al., 2018), whereas none in the RP-dominant group did. These findings echo previous research linking AP to broader proficiency in both local and global processing (Dooley and Deutsch, 2011; McLachlan et al., 2013; Wenhart and Altenmüller, 2019), suggesting a dominant influence of overall identification ability. However, the AP-dominant group's advantage in global chord identification may also be grounded in the task structure itself, which required the identification of both scale degree and chord quality. While chord quality necessarily relies on contextual processing, degree can be derived from the interval between two pitch components with minimal reliance on harmonic context. Accordingly, when chord quality is considered in isolation, no significant difference emerged in accuracy ($U$ = 75.5, $p$ = .095). Furthermore, the RP-dominant group exhibited a marginally significant tendency to prioritize chord quality selection ($U$ = 26.0, $p$ = .065), indicating a precedence of automatic global processing.

Table 2: Spearman correlations between raw task scores

| Domain | Variables | Spearman $\rho$ | $p$ |
|---|---|---|---|
| Accuracy | AP – Pitch | 0.889 | < .001 |
| | RP – Pitch | 0.915 | < .001 |
| | AP – Harmonic | 0.779 | < .001 |
| | RP – Harmonic | 0.942 | < .001 |
| RT | AP – Pitch | 0.852 | < .001 |
| | RP – Pitch | 0.777 | < .001 |
| | AP – Harmonic | 0.551 | < .01 |
| | RP – Harmonic | 0.656 | < .01 |

*Note.* RT: Reaction Time, AP: Absolute Pitch, RP: Relative Pitch, Pitch: Pitch Element, Harmonic: Harmonic Function

### Strategy differences in terms of individual dominance

The dominant influence of overall ability highlights the importance of individual internal distributions when differentiating between processing strategies. Not only pitch and chord identification abilities, but many abilities in music cognition are often correlated—an empirical reminder that skill often begets skill. However, when the association between pitch and chord identification biases was examined using difference-based measures, the results remained consistently significant. Residual-based analyses, which compensated for the large variance in AP ability, revealed significant correlations for both accuracy and reaction time, with a comparable pattern also observed when bias was operationalized using raw score differences.

### Local–Global Predictability from Pitch to Chord Identification

When raw scores were considered without reference to individual dominance, local and global pitch identification abilities showed generally consistent directional patterns in predicting chord identification performance. With the exception of pitch element accuracy, AP scores tended to be more strongly associated with pitch element measures, whereas RP scores tended to be more strongly associated with harmonic function measures. The weaker differentiation observed for pitch element accuracy may reflect that pitch element representations constitute the standard definition in musical practice (e.g., staff notation), making them broadly accessible regardless of AP or RP reliance. A statistically reliable difference between correlation coefficients was observed only for harmonic function accuracy ($Z = -2.879$, $p$ = .004). However, when reaction times were restricted to correct responses, an additional significant difference emerged for pitch-element RT ($Z$ = 2.946, $p$ = .003). Notably, whereas most variables were significantly correlated, AP RT (correct) and harmonic-function RT (correct) were not. This pattern may reflect reduced response time noise among participants with very low AP ability, where longer RTs may indicate incorrect, random responding rather than increased processing demands.

### Conditional Modulation of Global Precedence

While global precedence is often regarded as a generalized phenomenon, the present study observed a distinct absence of this pattern. Wilcoxon signed-rank tests revealed that local accuracy was significantly higher than global accuracy ($W = 42.50$, $p = .020$), whereas reaction times did not differ significantly ($W = 92.00$, $p = .432$). This result likely reflects the characteristics of the participants, who were highly trained musicians with an average of over ten years of training. Previous research indicates that extensive musical training can attenuate global precedence by strengthening local processing abilities (Black et al., 2017; Evers et al., 1999; Fujioka et al., 2004; Stoesz et al., 2007; Susini et al., 2020). Thus, the absence of global precedence observed here may result from the substantially enhanced local processing in this sample. At the same time, when performance within the harmonic function task was examined by comparing scale degree accuracy (which involves more computation of specific intervals) with chord-quality accuracy (which relies more purely on contextual processing), participants showed significantly higher accuracy for chord quality than for scale degree (mean accuracy: 80.4% vs. 55.9%; Wilcoxon signed-rank test, $W = 0.00$, $p = .0001$). This result aligns with the well-established finding that global judgments tend to be more robust than local judgments under conditions that favor contextual processing.

### Convergence with self-reported identification strategies

To complement the quantitative findings, we examined participants' brief post-experimental self-reports of chord identification strategies using an exploratory word cloud visualization (Figure 4). Although these reports were not subjected to formal qualitative coding or statistical analysis, they provide an intuitive overview of the terms participants spontaneously used to describe their listening strategies. Across both groups, several terms related to harmonic perception were commonly shared, including bass, top note, and references to tension, indicating that both AP and RP dominant musicians attended to core harmonic components during chord identification. However, notable differences emerged in the relative prominence and diversity of strategy-related terms across groups.

In the AP-dominant group, words associated with local, pitch-specific processing appeared more frequently (e.g., root, chord tones), along with element-level representations such as inner voices, non-chord tones, and scale degree. These patterns suggest a tendency to parse chords through constituent pitch elements and their absolute identities. In contrast, the RP-dominant group emphasized more global or relational terms (e.g., chord progression, chord quality), as well as relational pitch concepts such as scale distance, reference tone,

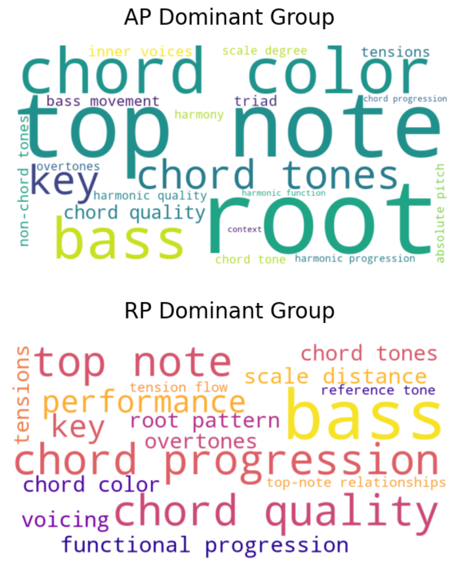


Figure 4: Exploratory word cloud visualizations of strategy-related terms extracted from brief post-experimental self-reports for the AP-dominant group group (top) and RP-dominant group (bottom).

and top-note relationships, reflecting an intervallic and functional approach. Taken together, these exploratory patterns align with the quantitative results, indicating divergence in strategy-related measures beyond overall performance differences. Although purely illustrative, the word cloud analysis highlights systematic differences in how musicians verbally characterize their identification approaches and complements the behavioral findings.

## Conclusion

The present study investigated whether local and global strategies for identifying pitch and chords interact along a shared processing dimension. Individual internal dominance in local versus global pitch identification was associated with corresponding dominance in chord identification ability. However, this work is constrained by a small sample of professionally trained musicians, limiting statistical power and stability. In addition, when raw scores were examined, most differences between corresponding correlation strengths showed only consistent directional trends without reaching statistical significance. Despite these limitations, the findings suggest that pitch- and chord-level identification strategies may be systematically related, consistent with a possible shared local–global dimension across levels of musical structure. An important direction for future research is to examine whether diverse auditory features beyond pitch and chord identification interact along the local–global processing dimension in similar ways, thereby clarifying the generality of local–global processing principles across different auditory levels.

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