A Comparision of Pitch Identification in Auditory Imagery and Perception Tasks

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Introduction

Individuals possessing absolute pitch (AP) are not only capable of identifying tones without a reference sound, but can also internally generate or imagine tones of a specific pitch. Research suggesting that auditory perception and mental imagery involve common neural resources [1] raises the question whether perception and imagery abilities are correlated in AP musicians.

If AP perception and imagery are correlated, how close is the correspondence? Preferential effects for certain pitch registers (central rather than extreme) and key categories (white rather than black piano keys) have been observed in perception [3, 4, 5]. Does such selectivity also characterize imagery?

Methods

Participants

8 pianists (24.3 ± 3 years of age; 2 female) possessing AP.

Perceptual Identification Task

Participants were presented with tones that they were required to identify by pitch name [5]. The tone range spanned C2-B5 (with semitone resolution) and each tone was presented three times in random order, with the constraint that consecutive tones were separated by at least one octave. Responses were made via key press on a mute keyboard. The experiment comprised a block of sine tones and a block of piano tones.

Imagery Task

The imagery task involved generating tones mentally in the absence of external reference sounds. Participants were cued visually to imagine tones spanning the range C2-B5 in semitone steps. They were required to rate the vividness of each imagined tone, and imagery acuity was tested via a probe tone task (see Fig. 1).

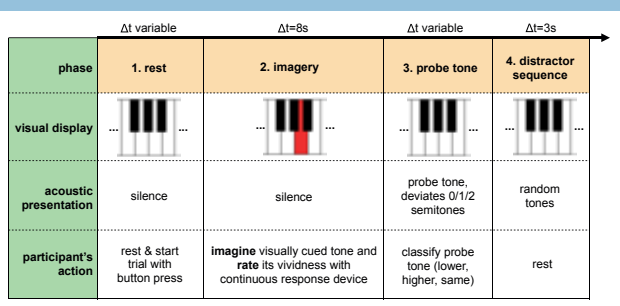

Fig. 1

1. **Rest:** Participants initiated each imagery task trial by pressing a button on a computer keyboard.
2. **Imagery:** An illuminated key on a keyboard specified the tone to be imagined. While imaging this tone, participants rated the vividness of the imagined tone using a continuous response device (Fig. 2)
3. **Probe tone:** A probe tone was presented (a sine tone for four participants and a piano tone for the other four). Participants were instructed to indicate, as quickly as possible, whether this tone was lower, higher or of the same pitch as the visually cued imagined tone. Responses were made via three buttons on a computer keyboard.
4. **Distractor sequence:** A sequence of random tones (of the same timbre) with random onsets and duration was presented at the end of the trial.

Each visually cued tone was repeated three times within the test session. Presentation order was randomized, with the constraint that consecutive cued tones were separated by at least one octave.

The continuous response device was sampled with a frequency of 20 Hz. Onset and peak times were extracted algorithmically from the response time series (Fig. 3). The rise time was defined as the peak time minus the onset time.

Fig. 2

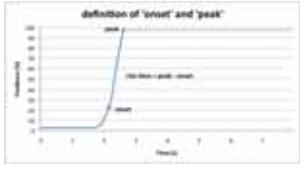

Fig. 3

Results

Perception

- Hit rates for perceptual identification ranged from .65 to .99 across participants.
- The effects of pitch register and key category on labeling time failed to reach statistical significance (*ps*>.067; Fig. 4)

Imagery

- The onsets and peaks of vividness ratings were characterized by broad distributions across tones and across subjects, ranging from 1s-7s (Fig. 5)
- Images were generated faster for tones from the fourth octave (middle C4-B4) than for tones from other octaves (*ps*<.019 for onsets times and peak times; Fig. 6)
- Images were generated faster for white key than black key tones (*ps*<.001 for onset and peak times; Fig. 6)
- Rise times did not vary as a function of pitch register or key category.
- Hit rates for probe tone classification ranged from .75 to .98 across participants.

Relations between perception and imagery

- The hit rate for probe tone classification correlated positively with perceptual identification accuracy for the same timbre (*r*=.873, *p*=.010; Fig. 7)
- No significant correlations were found between onsets and peaks in the imagery task and the time required for labeling in the perceptual identification task (*ps*>.082)

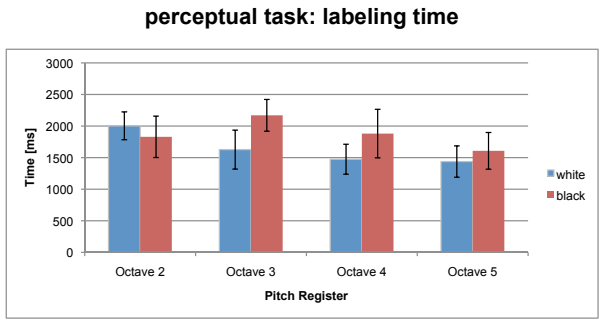

Fig. 4

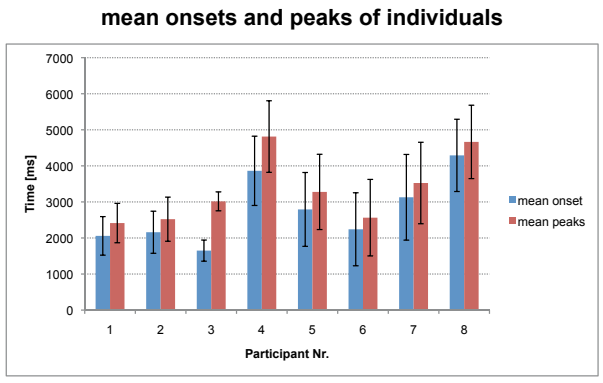

Fig. 5

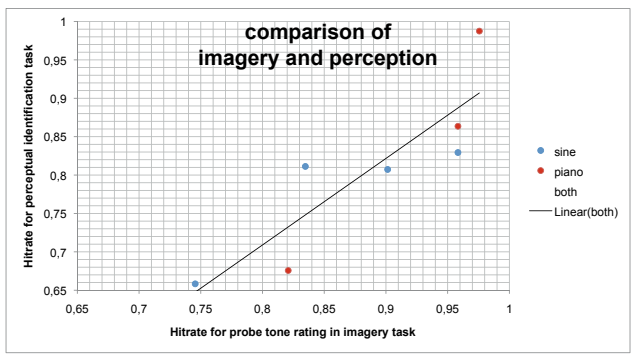

Fig. 7

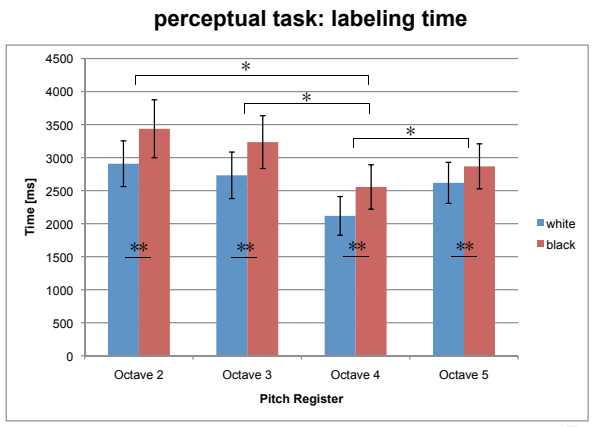

Fig. 6

Discussion

Perceptual and imagery abilities were found to be correlated in AP musicians, though the correspondence between the effects of pitch register and key category was not perfect.

Although the advantage for white keys and tones from the fourth octave in our imagery task is consistent with previous results for perceptual identification [3, 4, 5], the corresponding effects did not reach statistically significant levels in our perceptual identification task (perhaps due to the relatively small number of participants).

The finding that the effects of pitch register and key category were more robust for imagery than perception may be a consequence of imagery, requiring greater cognitive resources than the automatic process of labeling a perceived pitch.

Absolute pitch has been shown to be established mainly in early years of life [2]. Therefore, the observed effect may be related to relatively large amounts of experience playing on the white keys in the centre-right of the keyboard (as when playing music in C major with the right hand in near-body space) during piano training in childhood. Such specific exposure may selectively enhance auditory-motor associations that drive imagery for the corresponding tones.

The correlation between accuracy in the perceptual identification and image generation tasks highlights a general relationship between perception and imagery in AP individuals. The precise spatiotemporal nature of overlap in underlying neural processing is currently being investigated in a high-field fMRI (7T) study employing multivariate pattern classification techniques.

References:

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