Phoneme Learning in a Musical Context

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Introduction

- A sensitivity to distributional properties of phonetic tokens has been hypothesized to lead learners to induce the appropriate underlying phonemic categories ([1],[2]).
  - In babies and adults, exposure to a continuum from [da] to [ta] with highest frequencies at the ends of the distribution (i.e., a bimodal distribution) leads to discrimination of [da] and [ta] tokens compared to exposure to a unimodal distribution with a peak at the center of the continuum.
- Separately, musical experience has been shown to influence linguistic abilities (the OPERA model, [3]).
  - A lot of literature has been shown the effects of musical training on language learning ([4],[5],[6]).

Current Study

- The current study examines if distributional learning of phonemes can be enhanced by musical presentation of stimuli.
  - English speakers were exposed to an eight-step continuum, with a *unimodal* or *bimodal* distribution.
  - Additionally, half the participants were trained with a monotonous presentation of the tokens (*Control*), while the other half were exposed to the tokens in a melody (*Music*).

Auditory stimuli

- Audio stimuli: Hindi voiced and unvoiced labials /**ba**/ and /**pa**/
  - /b/ has negative VOT while /p/ has near-0ms VOT
  - Recorded by a Hindi native female
  - Made an auditory continuum using 8 phones with 7ms-interval
- Additionally, used /ma/ as a filler sound

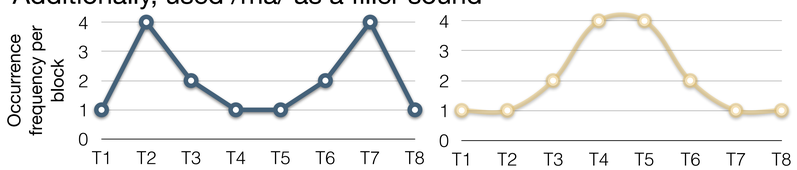


Fig 1. A continuum from [ba] to [pa] (from T1 to T8) in a bimodal (left) and unimodal (right) distribution. Pre-voicing duration of T1 is -49ms and that of T8 is 0ms.

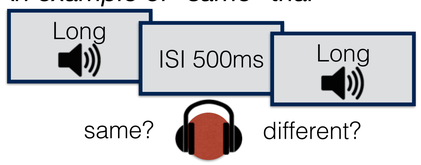
References

(1) Maye, J., Werker, J. F., & Gerken, L. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition, 82*(3), B101-B111.
(2) Maye, J., & Gerken, L. (2000). Learning phonemes without minimal pairs. In *Proceedings of the 24th annual Boston university conference on language development*, Vol. 2, 522-533.
(3) Patel, A. D. (2011). Why would musical training benefit the neural encoding of speech? The OPERA hypothesis. *Frontiers in Psychology, 2*, 142.
(4) Moreno, S., Marques, C., Santos, A., Santos, M., Castro, S. L., & Besson, M. (2008). Musical training influences linguistic abilities in 8-year-old children: more evidence for brain plasticity. *Cerebral Cortex, 19*(3), 712-723.
(5) Alexander, J. A., Wong, P. C., & Bradlow, A. R. (2005). Lexical tone perception in musicians and non-musicians. In *Ninth European Conference on Speech Communication and Technology*.
(6) François, C., Chobert, J., Besson, M., & Schön, D. (2012). Music training for the development of speech segmentation. *Cerebral Cortex, 23*(9), 2038-2043.

Methods

Practice, 10 trials

- **Stimuli:** 10 pairs of English words
  - Half: 'same' trials
  - The other half: 'different' trials
  - Order of trials pseudo-randomized
- **Task:** Participants were asked to make a judgment whether the sound pair that they just heard was the same or different by pressing appropriate keys
- *An example of "same" trial*



- *An example of "different" trial*

Acquisition Phase - Control

- **Participants:** Native speakers of English (no bilinguals)
  - 8 in bimodal, 8 in unimodal
- *Stimulus presentation:*
  - An eight-step continuum was presented in psuedo-randomorder in either bimodal or unimodal distribution (*Fig* 1).
    - Total 16 tokens per block, 12 blocks
  - One filler sound 'ma' was presented per block

Acquisition Phase - Music

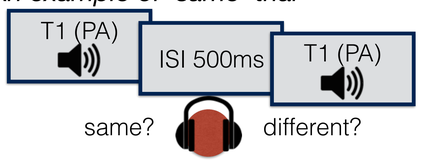
- **Participants: 4** in bimodal, 5 in unimodal
- *Stimulus presentation:*
  - Same token sequence as control except the pitch of the tokens was manipulated to approximate a melody (Vivaldi's *Winter*)

★**Task for *all groups*:** Participants were asked to press [space bar] when they heard a 'ma' sound

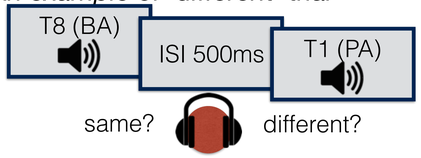
Test, 40 trials

- **Stimuli**: Only token 1 (T1) and token 8 (T8) were used
  - Half: '*same*' trials
    - A pair of T1 or T8
  - The other half: '*different*' trials
    - A pair of T1 & T8 or T8 & T1
  - Four 'same' trials and 4 'different' trials per block, 5 blocks
- **Task**: Same as practice.

- *An example of 'same' trial*



- *An example of 'different' trial*



Results

Proportion of correct trials (Control)

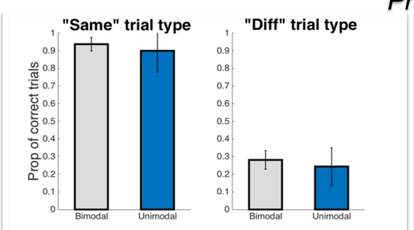


Fig 2. No signifiant differences between bimodal and unimodal groups on 'same' and 'different (diff)' trial types.

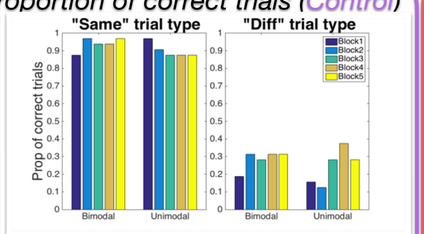


Fig 3. No signifiant differences between bimodal and unimodal for any block. For each group, no signifiant differences across blocks.

Proportion of correct trials (Music)

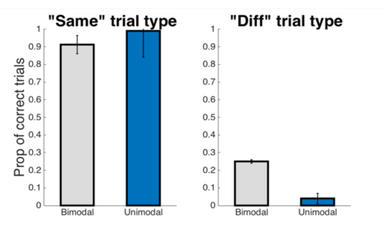


Fig 4. No signifiant differences between bimodal and unimodal groups on 'same' and 'diff' trial types

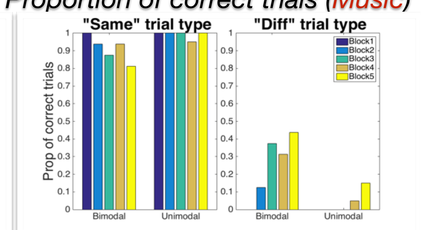


Fig 5. No significant differences between bimodal and unimodal for any block. For each group, no signifiant differences across blocks.

Conclusion and Discussion

- *No statistical differences between control and music groups on 'different' trial type (not only overall but also block performance). Large bias to respond 'same'*
- *However, we found numerically large differences between **music**'s bimodal and unimodal group on 'different trials' but not in **control**.*
- *Current data does not show any effect of musical stimuli on phoneme learning although the **music** group shows a pattern more compatible with phoneme learning than the **control** group.*

Hit and False Alarm rate in Control and Music