The Development of Melodic Representations at Early Age: Towards a Computational Model

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Introduction

⇨Pitch representation develops depending on time or age, experience and learning.

⇨Infants show developmental shifts in the focus on absolute or relative pitch information

⇨ANN have demonstrated success as being suitable for solving cognitive developmental modelling problems

⇨Collect experimental data from developmental studies concerning music perception and cognition

⇨ Reproduce developmental experiment using computational simulations

Goals

⇨ Simulation of an experimental study from developmental psychology

⇨ Understand the mechanism of the use of absolute and relative pitch cues in a tone-sequence statistical learning task

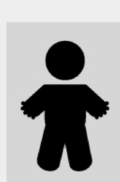
⇨ Explore Artificial Neural Networks as computational models for modeling the development of music cognition and perception

The Experiment

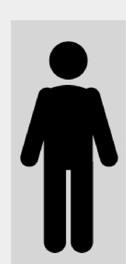
(Saffran & Griepentrog, 2001)

Are there developmental changes in the types of perceptual information detected by the mechanisms underlying auditory learning?

Subjects



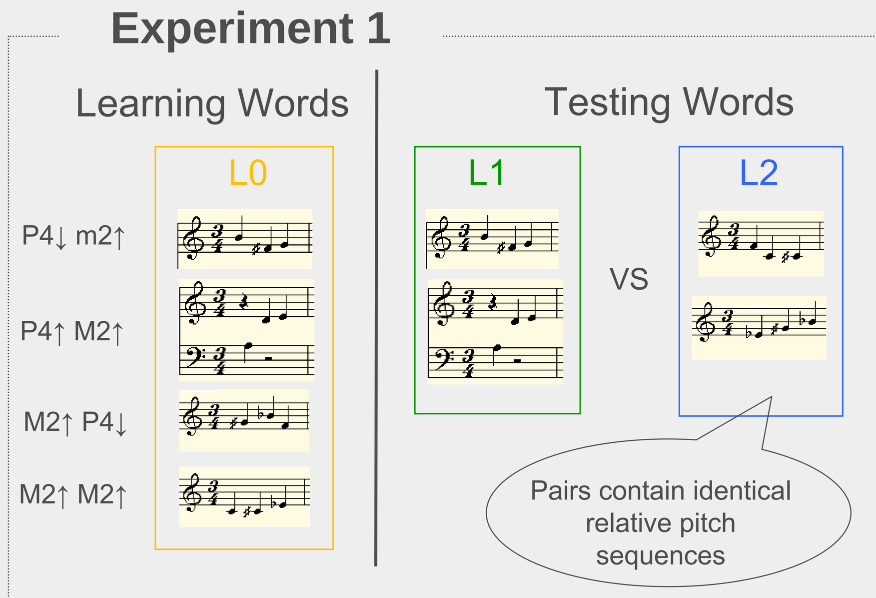
8-month-old Infants



Adults

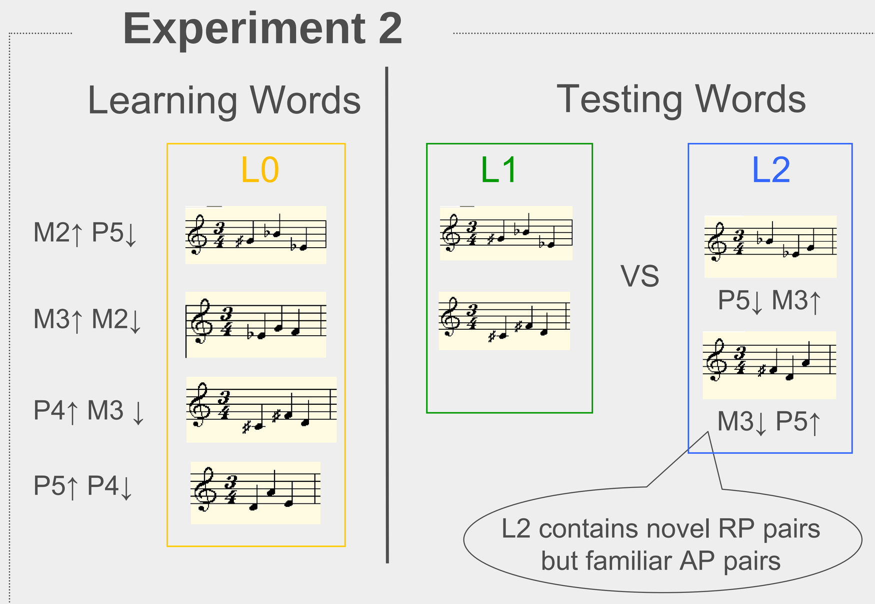
Material

Experiment 1



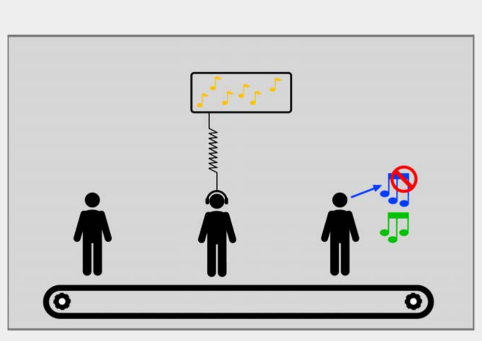
The only information available for discrimination of words (L1from L2) is absolute pitch cues!

Experiment 2



Discrimination is possible on the basis of relative familiarity of relative pitch pairs but not on the absolute pitch pairs

Task



Subjects familiarized with a 3-minute continuous sequence of tones (L0) ⟶ brief learning experience

Infants perform preferential listening methodology

Adults perform forced-choice task

Results

Infants

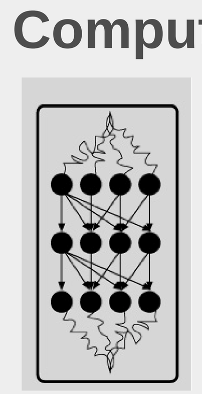
► Infants succeeded at discriminating L1 from L2 only for the contrast based on Absolute Pitch cues and failed to discriminate based on the Relative Pitch contrasts

Adults

► Adults shown opposite pattern: successful discrimination based on Relative Pitch contrasts and no discrimination based on Absolute Pitch contrasts.

The Simulation

Computational Model



FeedForward Neural Network

⇨ The "Expectator" learns to predict the continuation of an encoded tone sequence based on the observation of the current symbol (tone or interval)

⇨ Inputs (tones or intervals) are presented to the input layer and successively transformed and propagated into successive layers via connection weights until activating the output layer

⇨ Back-propagation learning rule is applied to update the connection weights

Material

$Dictionary_{L0} = \{w_1, w_2, w_3, w_4\}$ $Dictionary_{L1} = \{w_1, w_2\}$ $Dictionary_{L2} = \{w_5, w_6\}$

Training sequence = $shuffle(Dictionary_{L0}) = [w_1\ w_3\ w_1\ w_4\ w_2\ w_3\ \ldots]$

Infants:

Pitch class encoding

12 input units

Example word DED:

C ⟶ 001000000000

D ⟶ 000010000000

C ⟶ 001000000000

Adults:

Pitch class Intervals encoding

25 input units (from -12 to +12)

Example word DED:

C ⟶ 0000000000001000000000000

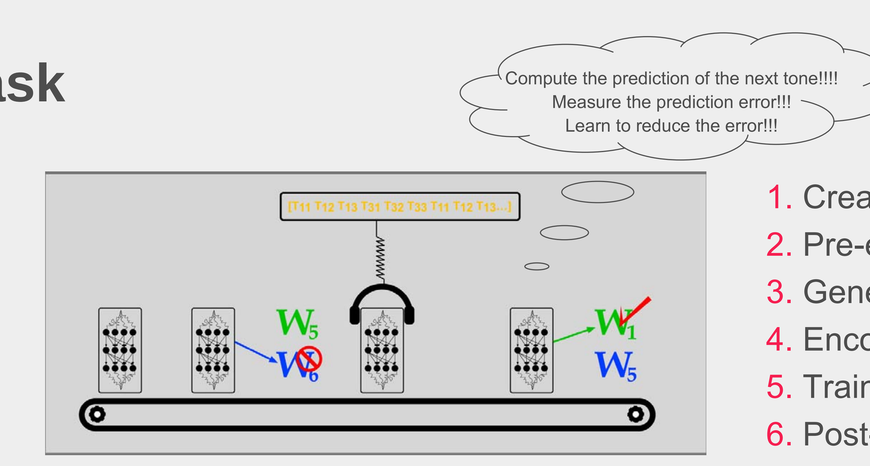
D ⟶ 0000000000000010000000000

C ⟶ 0000000000001000000000000

Training sequence encoded = $[T_{11}\ T_{12}\ T_{13}\ T_{31}\ T_{32}\ T_{33}\ T_{11}\ T_{12}\ T_{13}\ T_{41}\ T_{42}\ T_{43}\ldots]$

Training sequence encoded = $[I_{11}\ I_{12}\ I_{13}\ I_{31}\ I_{32}\ I_{33}\ I_{11}\ I_{12}\ I_{13}\ I_{41}\ I_{42}\ I_{43}\ldots]$

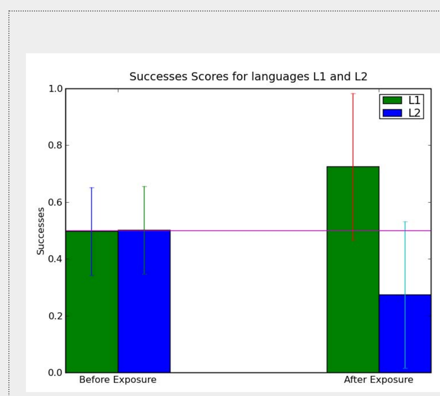
Task



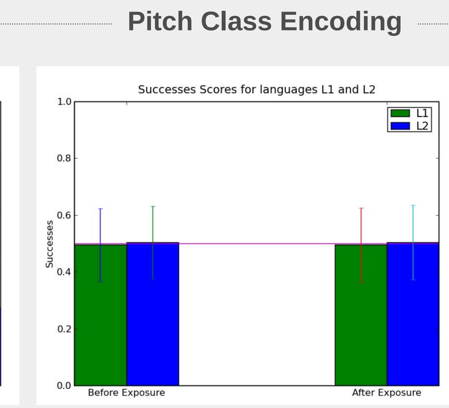
1. Create an expectator (FNN) with random initial weights
2. Pre-exposure Forced choice task
3. Generating learning sequence with L0
4. Encoding the sequence
5. Training the expectator (only one iteration)
6. Post-exposure forced choice task

Results

Pitch Class Encoding

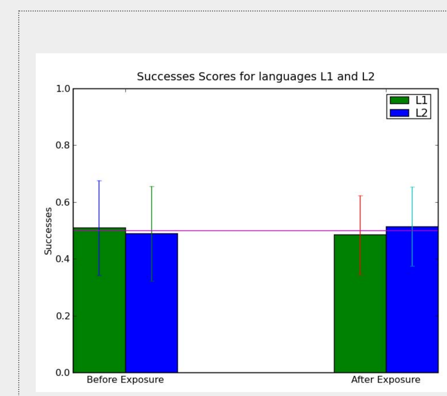


Expectator learned L1 after training (Experiment 1)

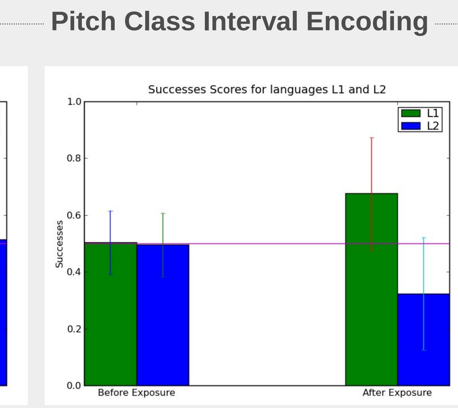


Expectator couldn't discriminate L1 from L2 after training (Experiment 2)

Pitch Class Interval Encoding



Expectator couldn't discriminate L1 from L2 after training (Experiment 1)



Expectator learned L1 after training (Experiment 2)

Main References

♪ Absolute Pitch in Infant Auditory Learning: Evidence for Developmental Reorganization. *Saffran J. R., Griepentrog G. J.,* (2001).

♪ Computational developmental Psychology. *Shultz, T. R.,* (2003).

♪ Modeling developmental cognitive neuroscience. *Westermann, G., Sirois, S., Shultz, T.R., Mareschal, D.,* (2006).

♪ Modelling the acquisition of statistical regularities in tone sequences. *Hazan A., Holonowicz P., Salselas I., Herrera P., Purwins H., Knast A., Durrant S.,* (2008).

Conclusions

✓The model was successful in learning languages for specific encodings.

✓Using Pitch Class encoding, it was possible to simulate the learning of L1 when only absolute pitch contrast were available for discrimination.

✓Using Pitch Class Interval encoding, it was possible to simulate the learning of L1 when only relative pitch contrast were available for discrimination.

Acknowledgments:

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