Quantifying the role of rhythm in infants' language discrimination abilities: A meta-analysis

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Language discrimination

- Infants must make sense of acoustic input
- Knowledge acquired about language as early as at birth
- Acoustic information they are sensitive to
- Changes over time

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Language discrimination

Mehler et al. (1988).

	4-day-old French
French/ Russian	YES

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Language discrimination

Mehler et al. (1988).

	4-day-old French
French/ Russian	YES
English/ Italian	NO

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Language discrimination

Mehler et al. (1988).

	4-day-old French	2-month-old American
French/ Russian	YES	NO
English/ Italian	NO	YES

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Language discrimination

Mehler et al. (1988). - **Discrimination**

	4-day-old French	2-month-old American
French/ Russian	YES	NO
English/ Italian	NO	YES

Moon et al. (1993). - **Preference**

	2-day-old Spanish	2-day-old American
Spanish/ English	Prefer Spanish	Prefer English

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Language discrimination

Nazzi et al. (1998). - **Discrimination**

	2-day-old French
English/Japanese	YES
English/Dutch	NO

Rhythm-class hypothesis

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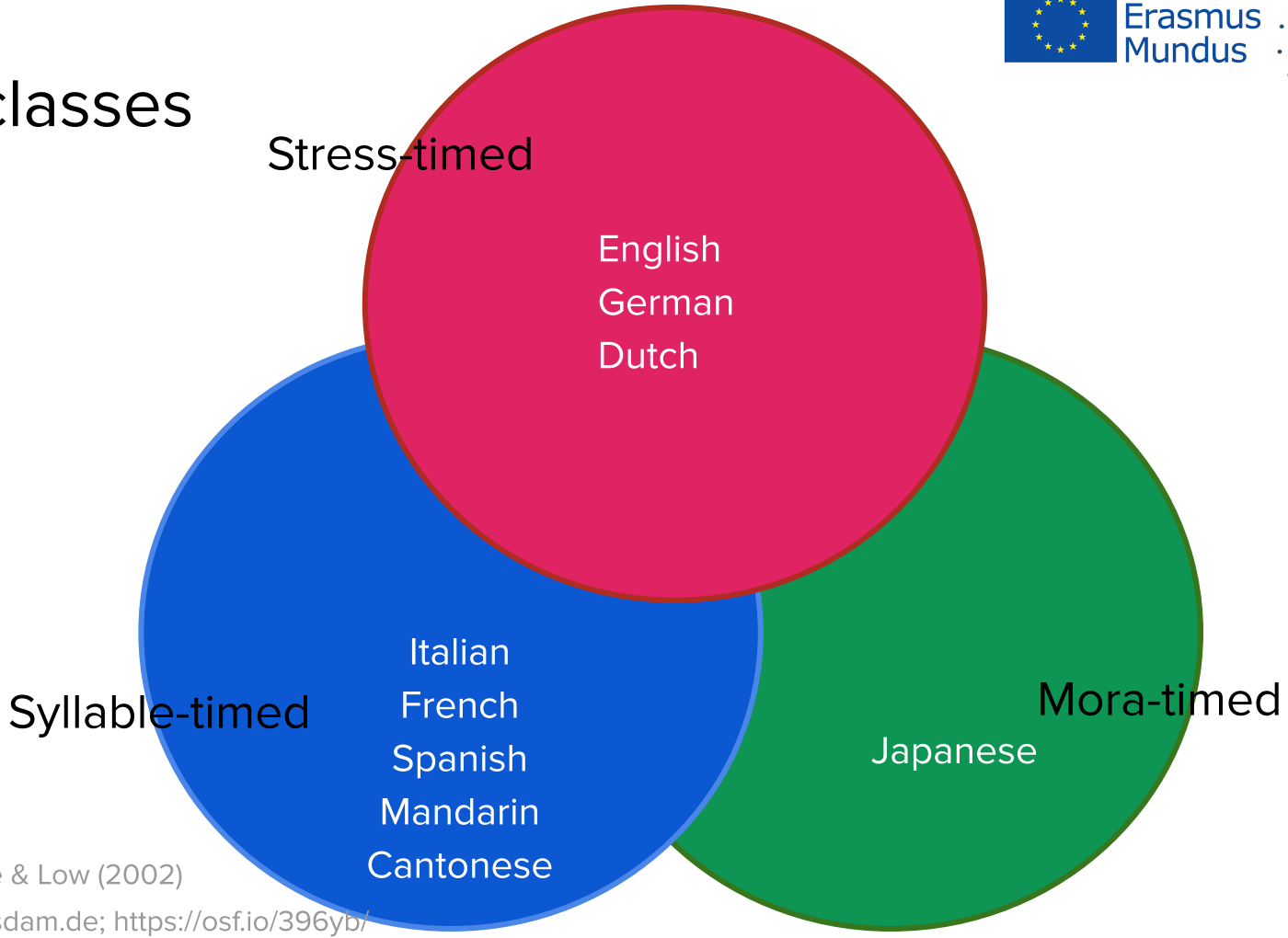
Rhythm classes



Abercrombie (1967);
Ramus et al. (1999); Grabe & Low (2002)

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Rhythm and language discrimination

- Successful discrimination of languages in **different** rhythm classes [1-4]
- Unsuccessful discrimination of languages in **same** rhythm class [1, 3, 5]

1. Nazzi et al. (1998); 2. Christophe & Morton (1998); 3. Nácar Garcia et al. (2018); 4. Nazzi et al. (2000); 5. Vicenik et al. (2011);

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Rhythm and language discrimination

- Successful discrimination of languages in **different** rhythm classes [1-4]
- Unsuccessful discrimination of languages in **same** rhythm class [1, 3, 5]

- Successful discrimination of languages with **segmental** cues obscured, **prosodic** cues retained [6-11]

1. Nazzi et al. (1998); 2. Christophe & Morton (1998); 3. Nácar Garcia et al. (2018); 4. Nazzi et al. (2000); 5. Vicenik et al. (2011); 6. Byers-Heinlein et al. (2010); 7. Ramus (2000); 8. Mehler et al. (1988); 9. Molnar et al. (2013); 10. Bosch & Sebastián-Gallés (1997); 11. Chong et al. (2018)
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Rhythm and language discrimination

- Successful discrimination of languages in **different** rhythm classes [1-4]
- Unsuccessful discrimination of languages in **same** rhythm class [1, 3, 5]

- Successful discrimination of languages with **segmental** cues obscured, **prosodic** cues retained [6-11]

- Contrasting results [4, 5]
- Consider: strength of evidence and methodological differences

1. Nazzi et al. (1998); 2. Christophe & Morton (1998); 3. Nácar Garcia et al. (2018); 4. Nazzi et al. (2000); 5. Vicenik et al. (2011); 6. Byers-Heinlein et al. (2010); 7. Ramus (2000); 8. Mehler et al. (1988); 9. Molnar et al. (2013); 10. Bosch & Sebastián-Gallés (1997); 11. Chong et al. (2018)
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The current meta-analysis

- Systematic literature search
- Quantitative synthesis

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The current meta-analysis

Research Question

How do typically-developing babies' language and accent discrimination skills change from birth up to 12 months of age?

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The current meta-analysis

Research Question

How do typically-developing babies' language and accent discrimination skills change from birth up to 12 months of age?

Prediction

Effect sizes will be larger in **younger** babies if languages belonged to **different** rhythm classes, compared to the **same** rhythm class

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Methods: Eligibility criteria

Discrimination or preference

Distinct languages, or accents/dialects

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Methods: Eligibility criteria

Discrimination or preference

Distinct languages, or accents/dialects

Birth to 12 months

Healthy

Monolingual or multilingual

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Methods: Eligibility criteria

Discrimination or preference

Distinct languages, or accents/dialects

Birth to 12 months

Healthy

Monolingual or multilingual

Natural continuous speech

Auditory or audiovisual
Manipulations allowed

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Methods: Search protocol

26	Known studies
3	Two Google Scholar searches
3	Mailing lists
8	Reference lists
2	Author recommendations

37
eligible studies
194
effect sizes
from
1630 unique titles

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Methods: Data extraction and analysis

= **Hedges *g* effect size**

- Sample size
- Means and SDs
- *t*-values
- *F*-values

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Methods: Data extraction and analysis

= **Hedges *g* effect size**

- Sample size
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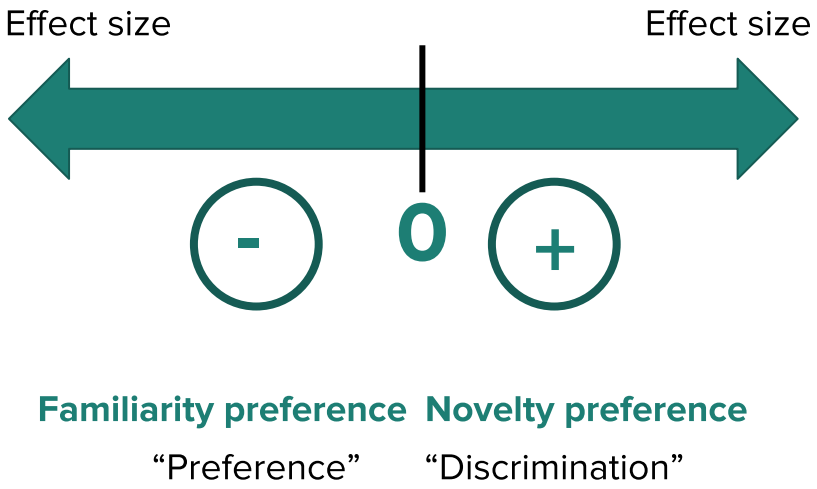

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Methods: Data extraction and analysis

- Paradigm — Discrimination, Preference
- Rhythm class
- Mean age
- Speech manipulation
- Method

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Methods: Data extraction and analysis

Paradigm	Discrimination, Preference
Rhythm class	Same, Different
Mean age	
Speech manipulation	
Method	

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Methods: Data extraction and analysis

Paradigm	Discrimination, Preference
Rhythm class	Same, Different
Mean age	0 to 366 days
Speech manipulation	
Method	

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Methods: Data extraction and analysis

Paradigm	Discrimination, Preference
Rhythm class	Same, Different
Mean age	0 to 366 days
Speech manipulation	None, Segmental, Intonation, Segmental and intonation
Method	

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Methods: Data extraction and analysis

Paradigm	Discrimination, Preference
Rhythm class	Same, Different
Mean age	0 to 366 days
Speech manipulation	None, Segmental, Intonation, Segmental and intonation
Method	Central fixation (CF), Head-turn Preference Procedure (HPP), High-Amplitude Sucking (HAS), Forced Choice (FC), EEG/NIRS

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Methods: Data extraction and analysis

Model in RStudio:[1]

Paradigm /

Rhythm class * Mean age * Speech manipulation

+ Method

Random = Study / Infant / Experiment

1. *metafor* package in RStudio (R Core Team, 2020; RStudio Team, 2020; Viechtbauer, 2010)

Results

Discrimination

Hedge's *g* = **0.272**

95% CI [0.152 0.392]

z=4.454, p<0.0001

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Results

Discrimination	Preference
Hedge's *g* = **0.272**	Hedge's *g* = **-0.333**
95% CI [0.152 0.392]	95% CI [-0.549, -0.117]
z=4.454, p<0.0001	z=-3.021, p=0.003

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Results

Paradigm/Method only significant predictors in pre-registered analysis

Discrimination

CF > HAS = HPP > EEG/NIRS

Preference

CF > HAS = HPP = EEG/NIRS

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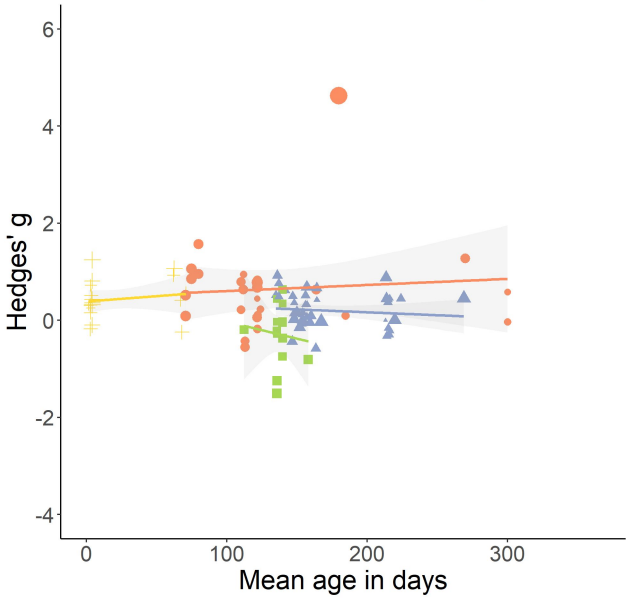
Results

Paradigm/Method only significant predictors in pre-registered analysis

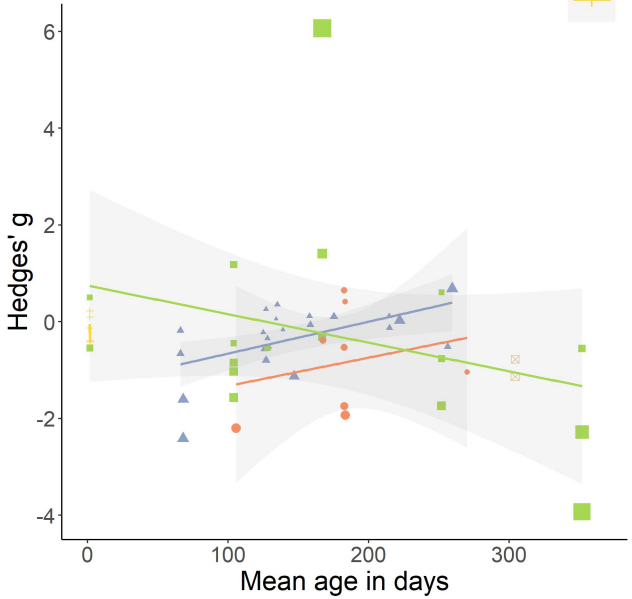
Discrimination

CF > HAS = HPP > EEG/NIRS



Preference

CF > HAS = HPP = EEG/NIRS

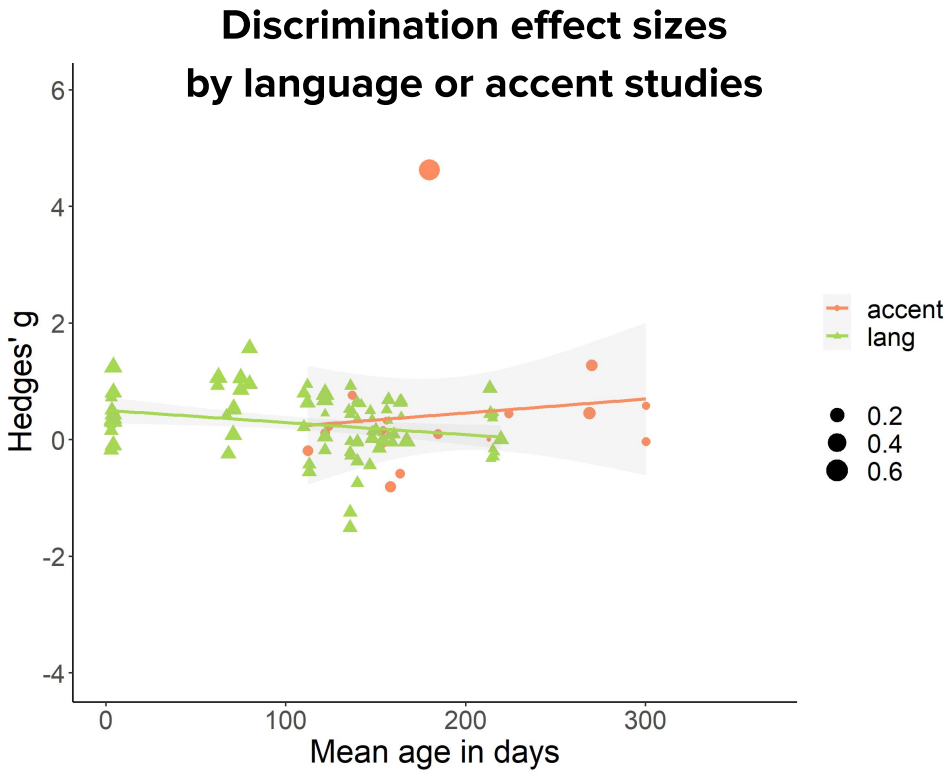


CF
HPP
EEG/NIRS
HAS

1

1. *ggplot2* package in RStudio (Wickham, 2016)

Exploratory analysis



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Exploratory analysis

Same language	Accent, Language
Native language	Yes/Yes, Yes/No, No/No

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Exploratory analysis

Model in RStudio:

➔ No significant effect of same language

Paradigm /

Same language /

Rhythm class * Mean age * Native language

+ Method

Random = Study / Infant / Experiment

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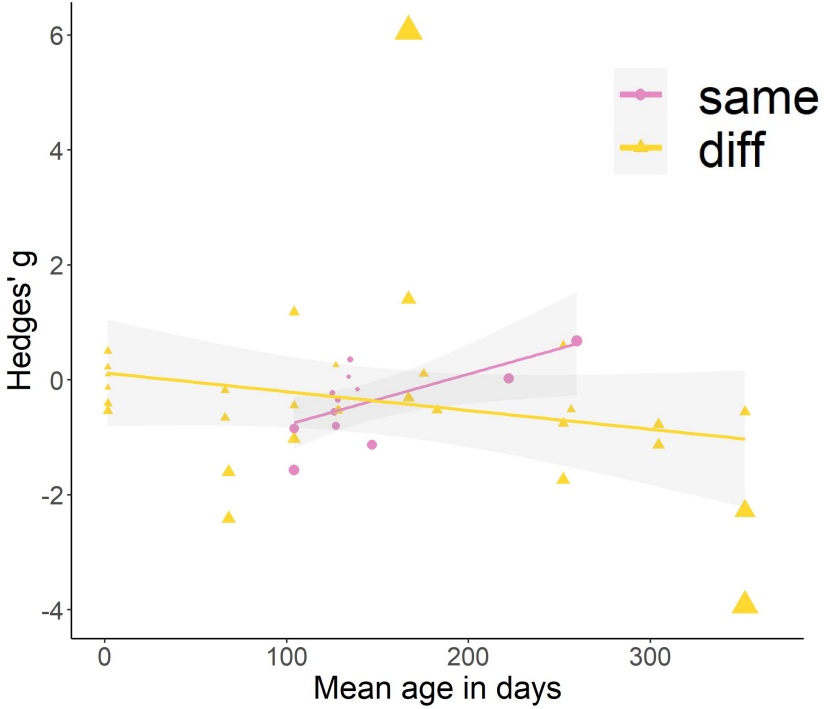
Results

Preference effect sizes by rhythm class (excluding accent studies)



- Preference paradigms
- Different languages tested
    - *Age * Rhythm class*
    - LRT = 6.802, p=0.033

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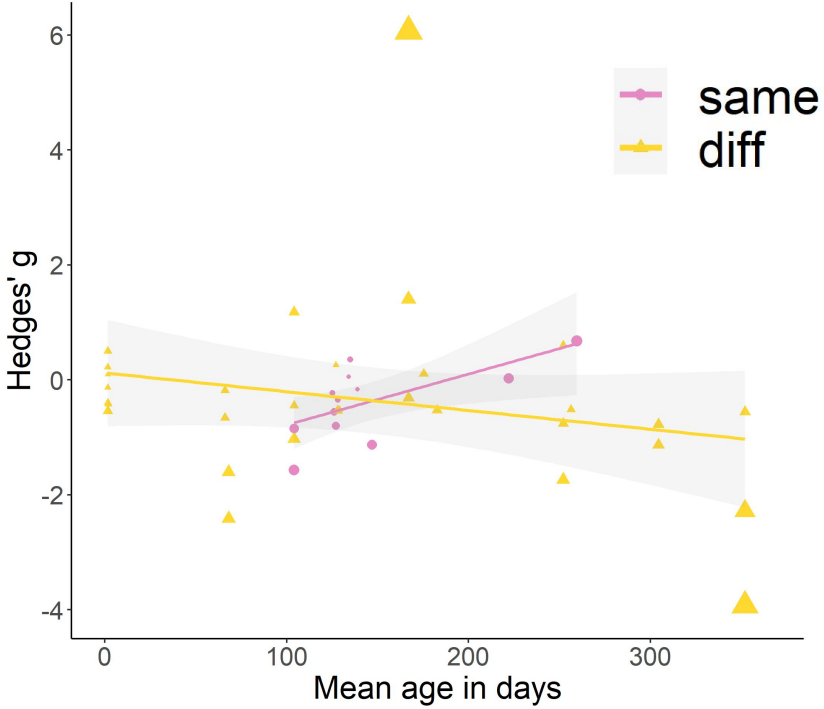
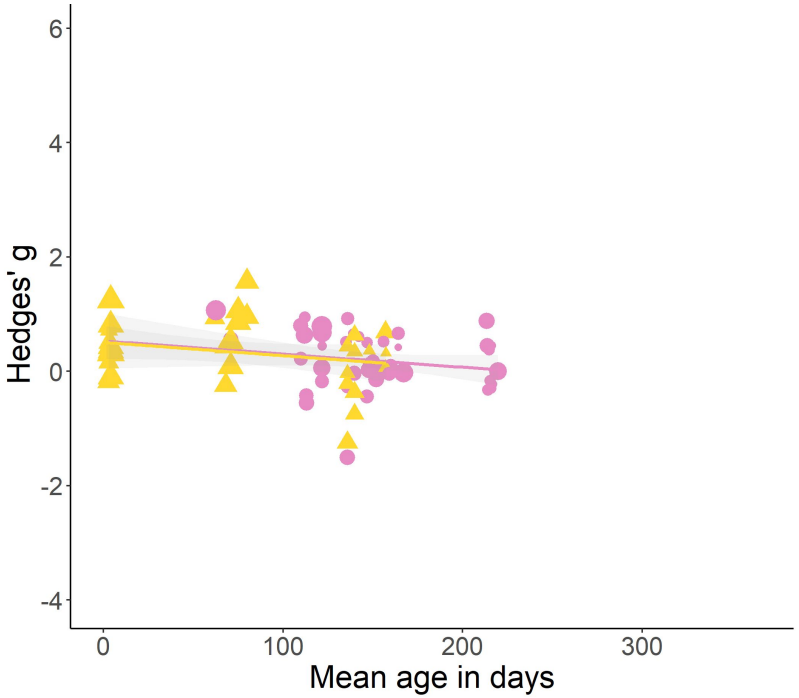
Results

Preference effect sizes by rhythm class (excluding accent studies)



Discrimination effect sizes by rhythm class (excluding accent studies)



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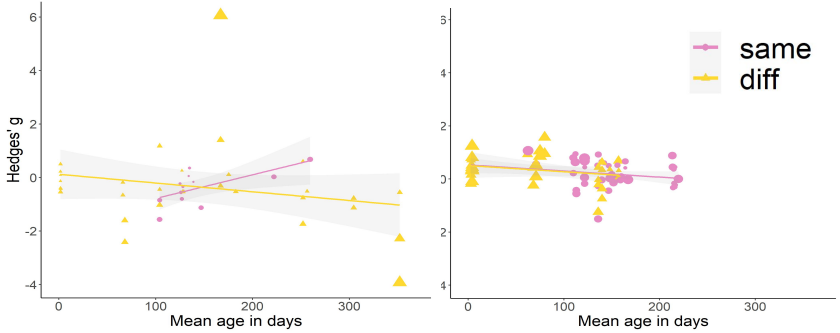
Results



Research Question

How do typically-developing babies' language and accent discrimination skills change from birth up to 12 months of age?

Finding

Interaction of age and rhythm class in preference paradigms testing two distinct languages

Different rhythm classes: > *familiarity preference*, > *age*

Same rhythm classes: > *novelty preference*, > *age*

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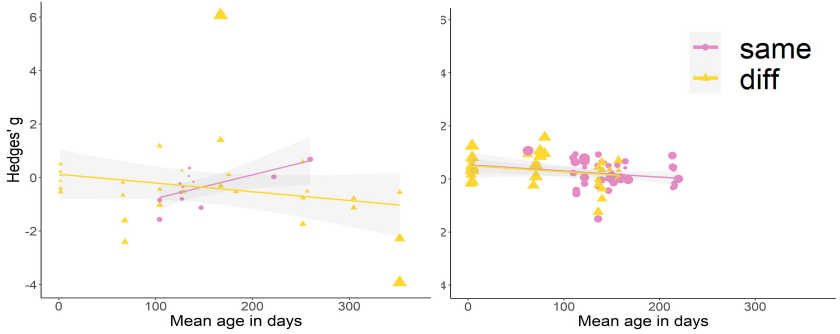
Results



Research Question

How do typically-developing babies' language and accent discrimination skills change from birth up to 12 months of age?

Finding

Interaction of age and rhythm class in preference paradigms testing two distinct languages

Different rhythm classes: > *familiarity preference*, > *age*

Same rhythm classes: > *novelty preference*, > *age*

Discussion

- Babies can discriminate regardless of rhythm class
- Contradicts rhythm-class hypothesis
- But, prefer native rhythm?

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Next steps

Research Question 2

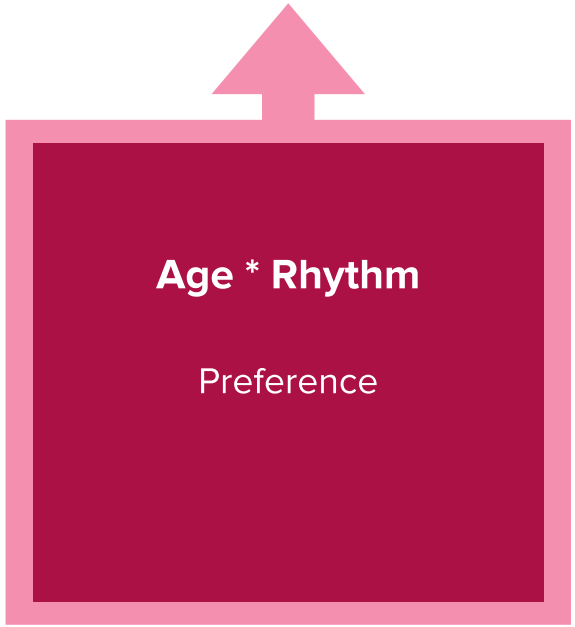
Which durational cue(s) best predict babies' language and accent discrimination skills from newborns up to 12 months of age?

Approach

Replace factor “rhythm class” with durational metrics:
Proportion and variability of consonant and vowel interval; [1, 2]
word-final lengthening,[3] speech rate[4]

1. Grabe & Low (2002); 2. Ramus et al. (1999); 3. White et al. (2014), 4. White et al. (2012)

Future research



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Future research

Age * Rhythm

Preference

Method

Central fixation

EEG/NIRS

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Limitations

	Limitations
Large amount of unexplained variance	×
Broad eligibility criteria - heterogeneous sample	×

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Limitations and strengths

Limitations		Strengths	
Large amount of unexplained variance	✗	✓	All available evidence collated and quantified
Broad eligibility criteria - heterogeneous sample	✗	✓	Database updatable

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Conclusions

Discrimination ➜ non-rhythmic cues

Preference ➜ familiar language rhythms (?)

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Conclusions

Discrimination → non-rhythmic cues

Preference → familiar language rhythms (?)

Next steps: Durational cues

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Thank you!

Questions?

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**included in qualitative synthesis only

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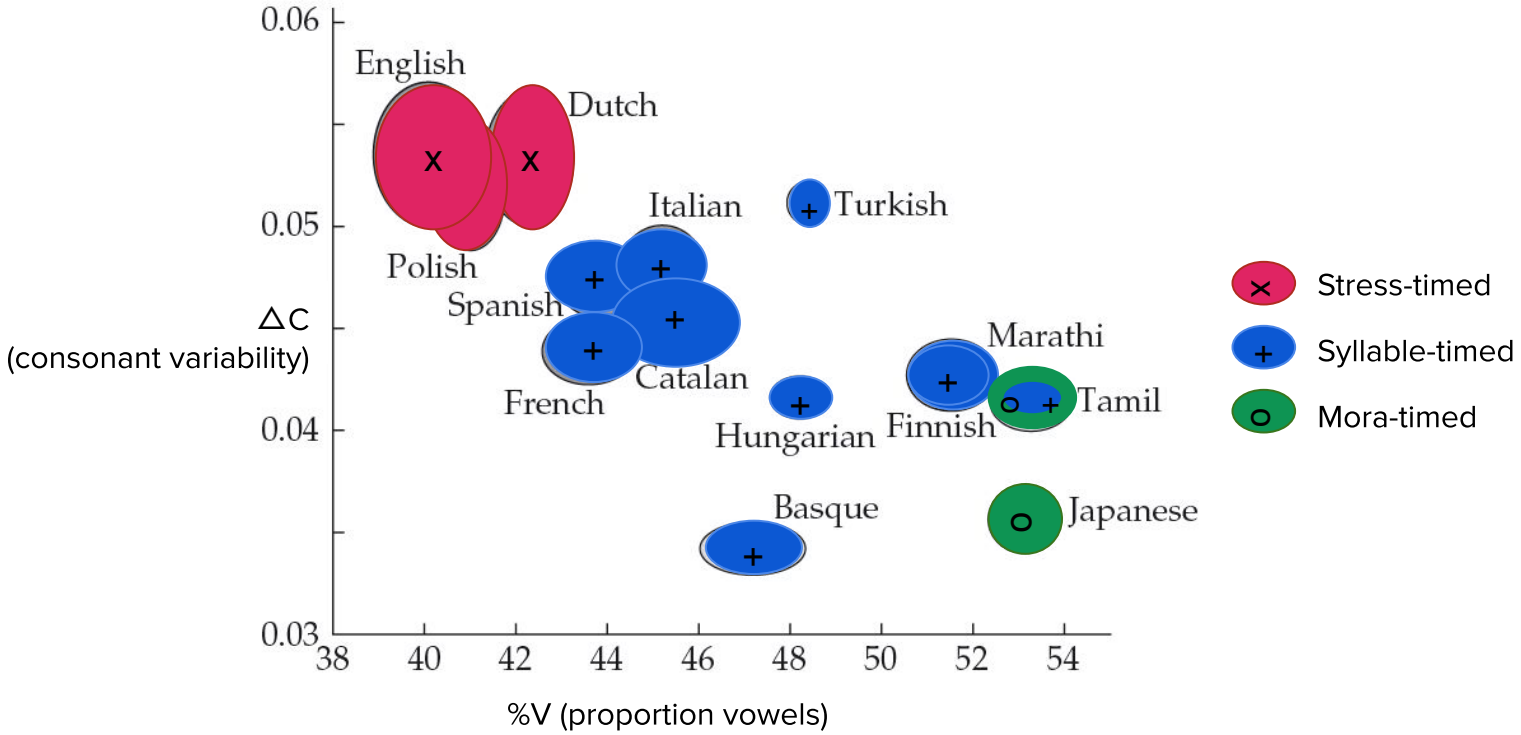
Appendix

Rhythm classes



Abercrombie (1967); Grabe & Low (2002); Nespor et al. (2011); Ramus et al. (1999)

loretta.gasparini@uni-potsdam.de; https://osf.io/396yb/

Rhythm and language discrimination

Age	Discrimination	No discrimination
2 days	English Japanese [1]	English Dutch [1]
2 months	English Japanese [2]	French Japanese [2]
4 months	Spanish German Catalan German Italian German [3]	Spanish Italian* Catalan Italian* [3]
5 months	English Japanese English Dutch [4]	English Dutch English Japanese [5]

1. Nazzi et al. (1998); 2. Christophe & Morton (1998); 3. Nácar Garcia et al. (2018); 4. Nazzi et al. (2000); 5. Vicenik et al. (2011)

Rhythm and language discrimination

Successful discrimination with segmental cues obscured

Age	Languages	
2 days	English Tagalog	1
3 days	Dutch Japanese	2
4 days 2 months	French Russian English Italian	3
3.5 months	Basque Spanish	4
4.5 months	Catalan Spanish	5
7 months	German English	6

1. Byers-Heinlein et al. (2010)
2. Ramus (2000)
3. Mehler et al. (1988)
4. Molnar et al. (2013)
5. Bosch & Sebastián-Gallés (1997)
6. Chong et al. (2018)

The current meta-analysis

Research Question

How do typically-developing babies' language and accent discrimination skills change from birth up to 12 months of age?

Predictions

Effect sizes will be larger in young babies for any between-rhythm-class contrasts compared to within-rhythm-class contrasts

As age increases, effect sizes should be larger for studies where the native language was tested

Methods

MetaLab

http://metalab.stanford.edu/

PRISMA

TRANSPARENT REPORTING OF SYSTEMATIC REVIEWS AND META-ANALYSES

http://prisma-statement.org/

OSF HOME

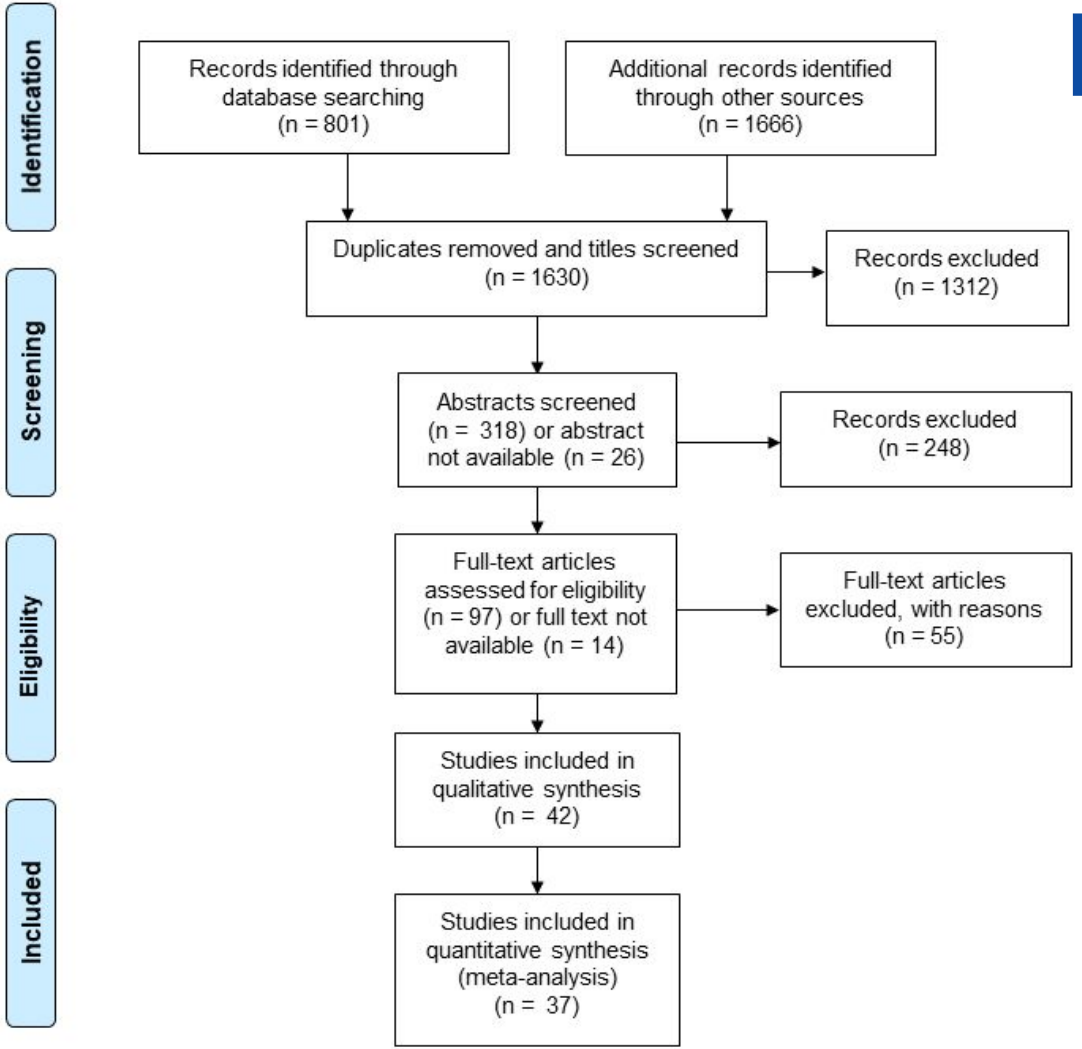
Quantifying the role of rhythm in infant...

https://osf.io/396yb/

Methods: Search protocol

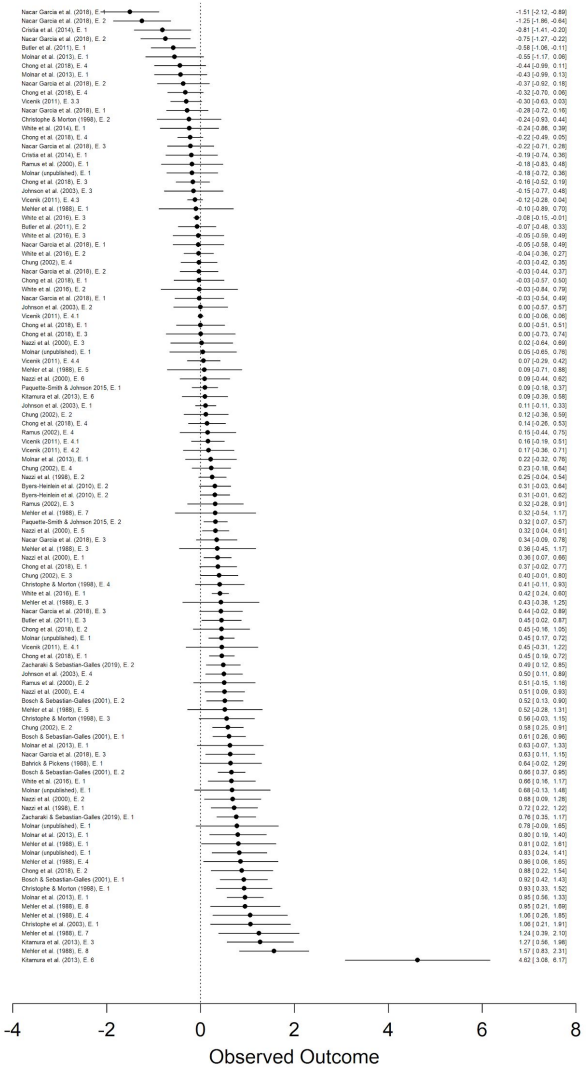
26	Known studies	Known to authors
3	Google Scholar Search 1	{"infant" OR "infancy" OR "baby"} & {"language discrimination" OR "dialect discrimination" OR "accent discrimination" OR "rhythm class discrimination"}
0	Google Scholar Search 2	{"infant" OR "infancy" OR "baby"} & {"deltaC"} & {"rhythm"}
3	Mailing lists	• ICIS • CogDevSoc • CHILDES
8	Reference lists	All included studies
2	Author recommendations	First or corresponding authors

loretta.gasparini@uni-potsdam.de; https://osf.io/396yb/; All screening decisions available *here* and all included studies *here*


Identification
Screening
Eligibility
Included
Records identified through database searching (n = 801)
Additional records identified through other sources (n = 1666)
Duplicates removed and titles screened (n = 1630)
Records excluded (n = 1312)
Abstracts screened (n = 318) or abstract not available (n = 26)
Records excluded (n = 248)
Full-text articles assessed for eligibility (n = 97) or full text not available (n = 14)
Full-text articles excluded, with reasons (n = 55)
Studies included in qualitative synthesis (n = 42)
Studies included in quantitative synthesis (meta-analysis) (n = 37)

Results

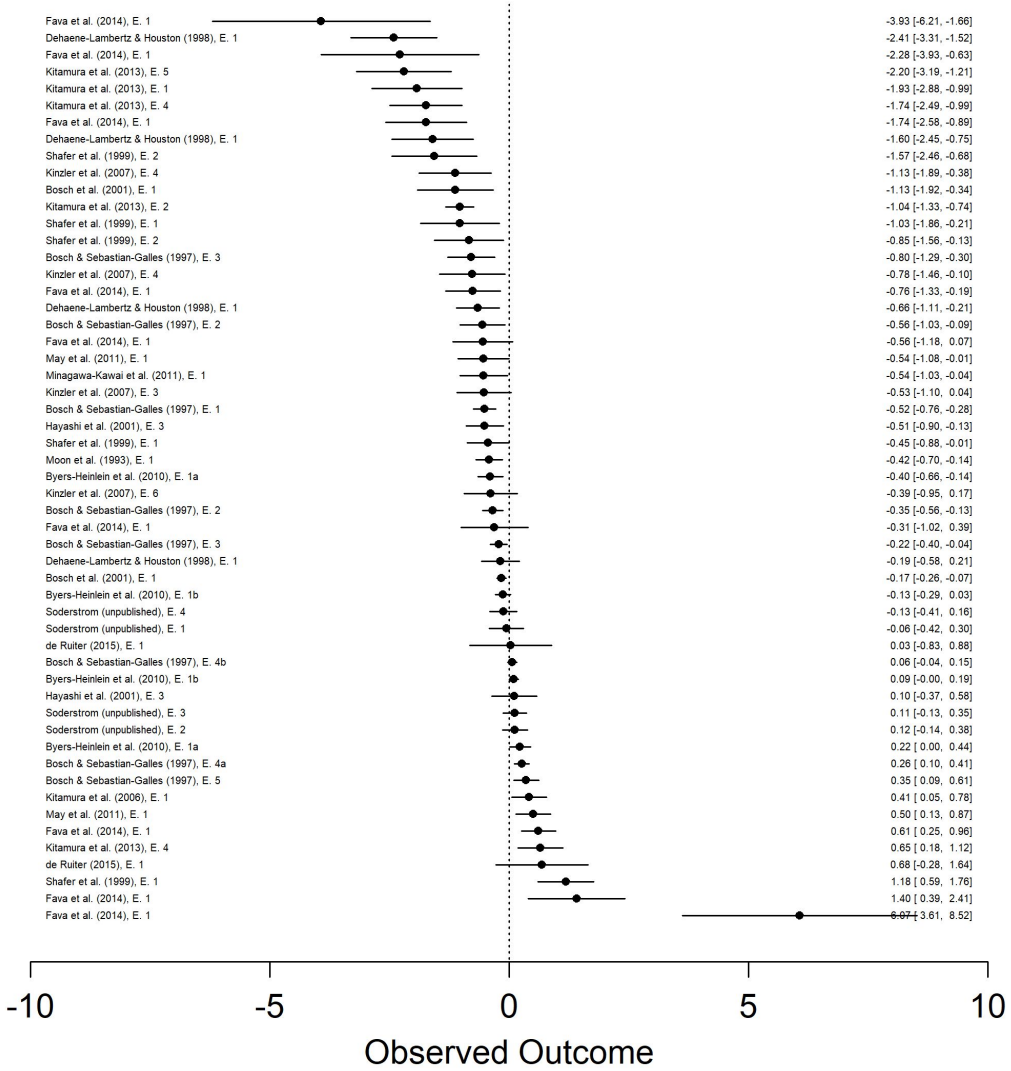
Discrimination



All reproducible code available *here*

Results

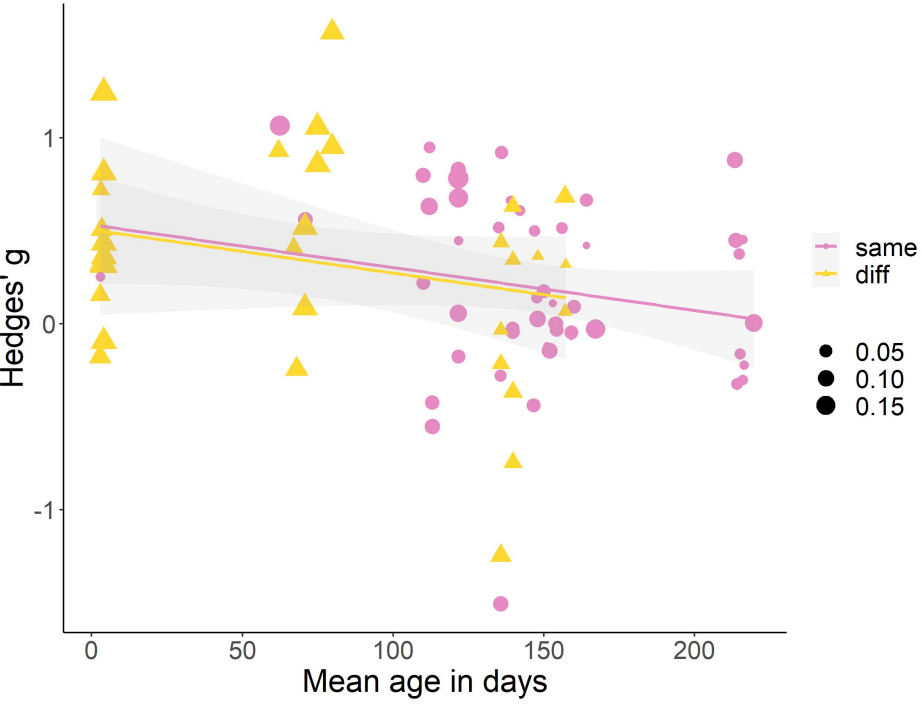
Preference



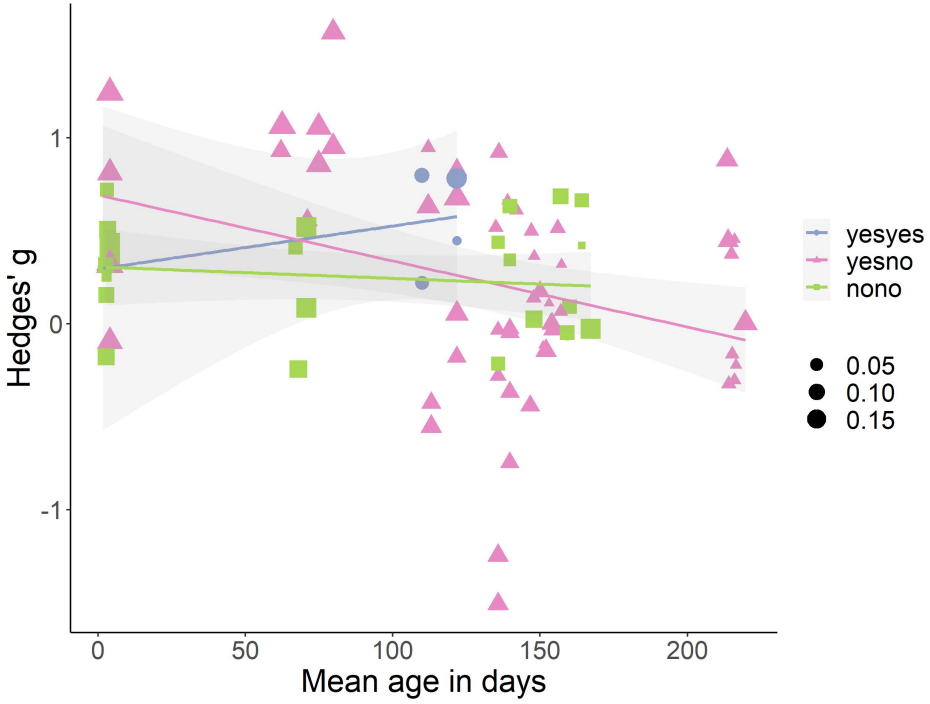
All reproducible code available *here*

Results

Discrimination effect sizes by rhythm class

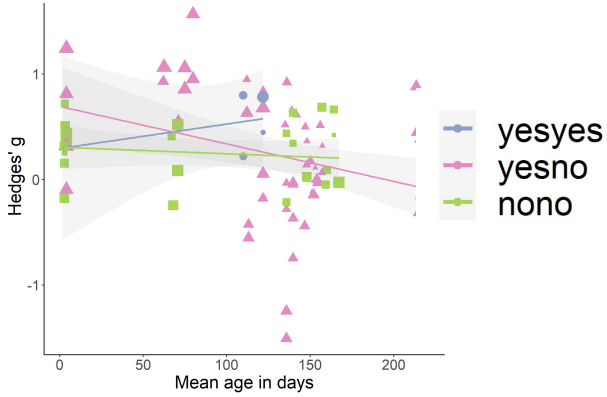


Discrimination effect sizes by language nativeness



All reproducible code available *here*

Discussion



No clear effect of language nativeness

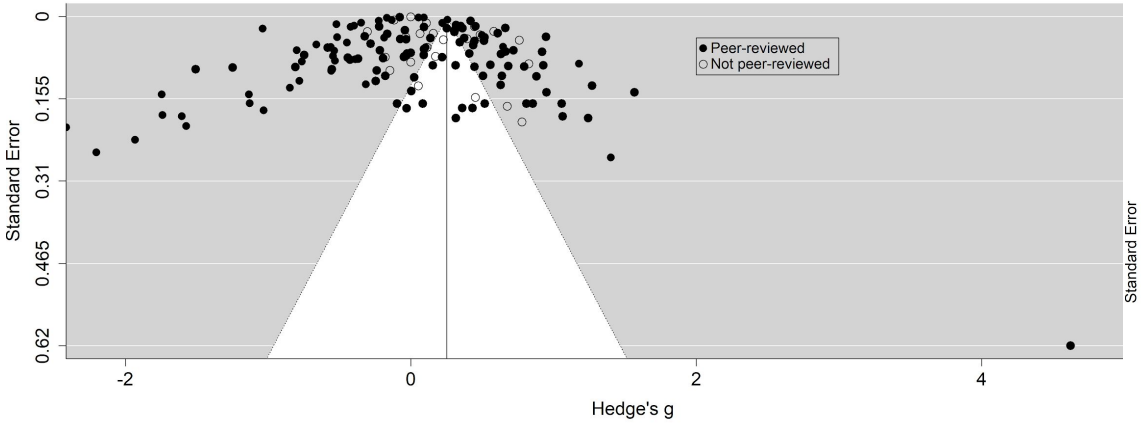
Trend in opposite direction to predictions:

Nativeness has more of an effect in younger ages

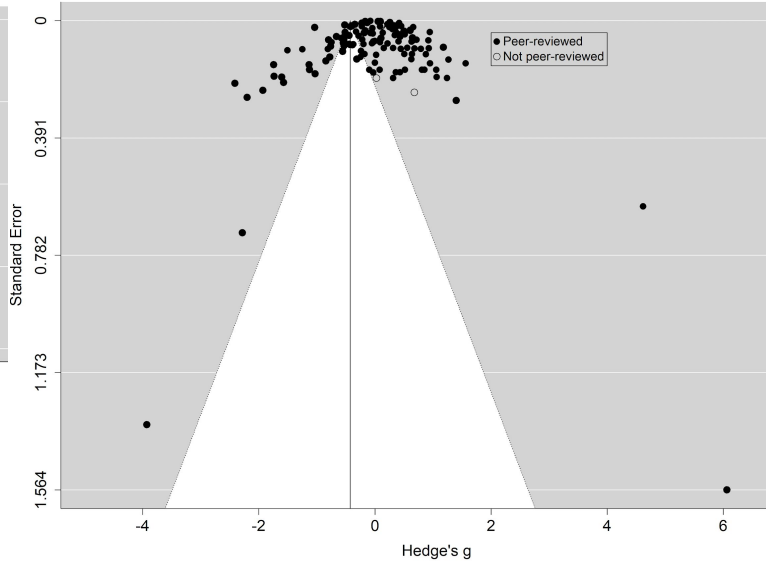
At later ages both familiarity and novelty preferences in discrimination paradigms when native language is one of the tested languages (yesno), which brings overall effect size closer to 0

Results: Risk of bias

Discrimination studies



Preference studies

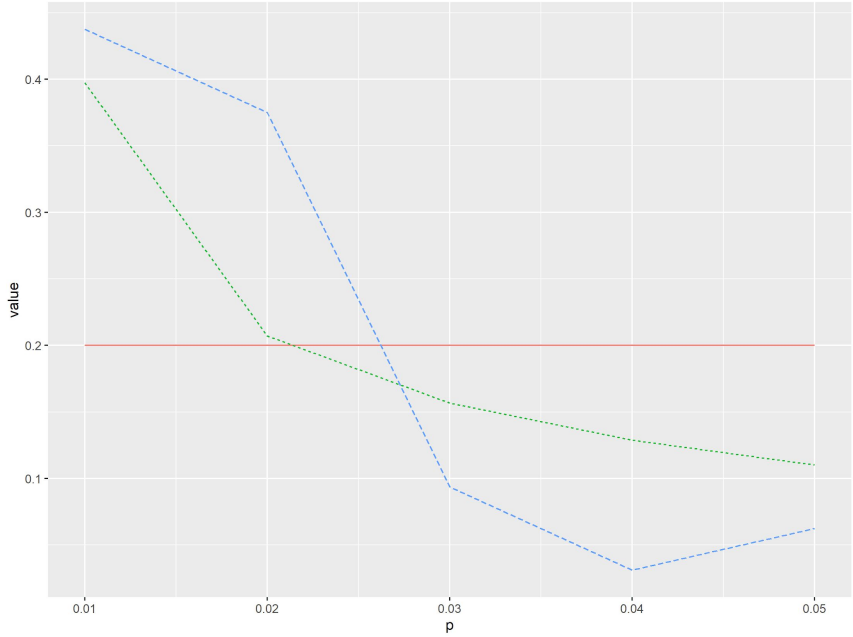


Significant asymmetry in discrimination studies

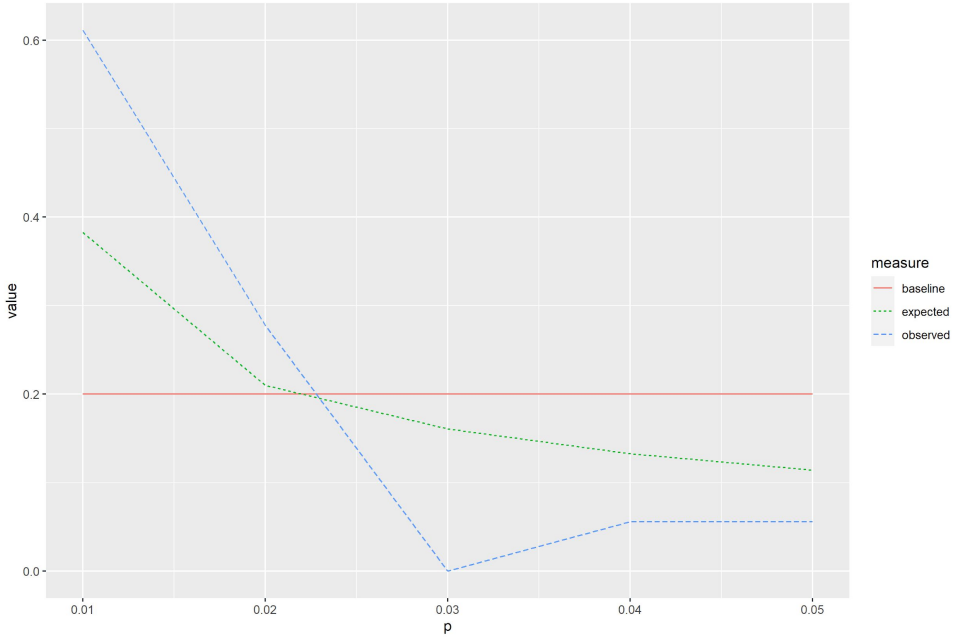
All reproducible code available *here*

Results: Risk of bias

Discrimination studies



Preference studies



No evidence of p-hacking or publication bias

All reproducible code available *here*

Future research

- Discrimination
  - Rhythmically similar — 0 to 3 months
  - Rhythmically distinct — 5 months +
- Preference
  - Distinct languages — 5 months +

EEG/NIRS — Central fixation

Durational metrics — Non-durational cues[1]

1. e.g. Vicenik & Sundara (2013)