

A Cognitive Model of Bilingual-Lead Differentiation and Convergence

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The Wellsprings of
Linguistic Diversity



Australian
National
University

Collaboration

- 
- joint work with Luisa Miceli
 - Forthcoming paper: *From Lexical Clash to Rapid Differentiation: bilingual cognitive processing in contact-induced change*

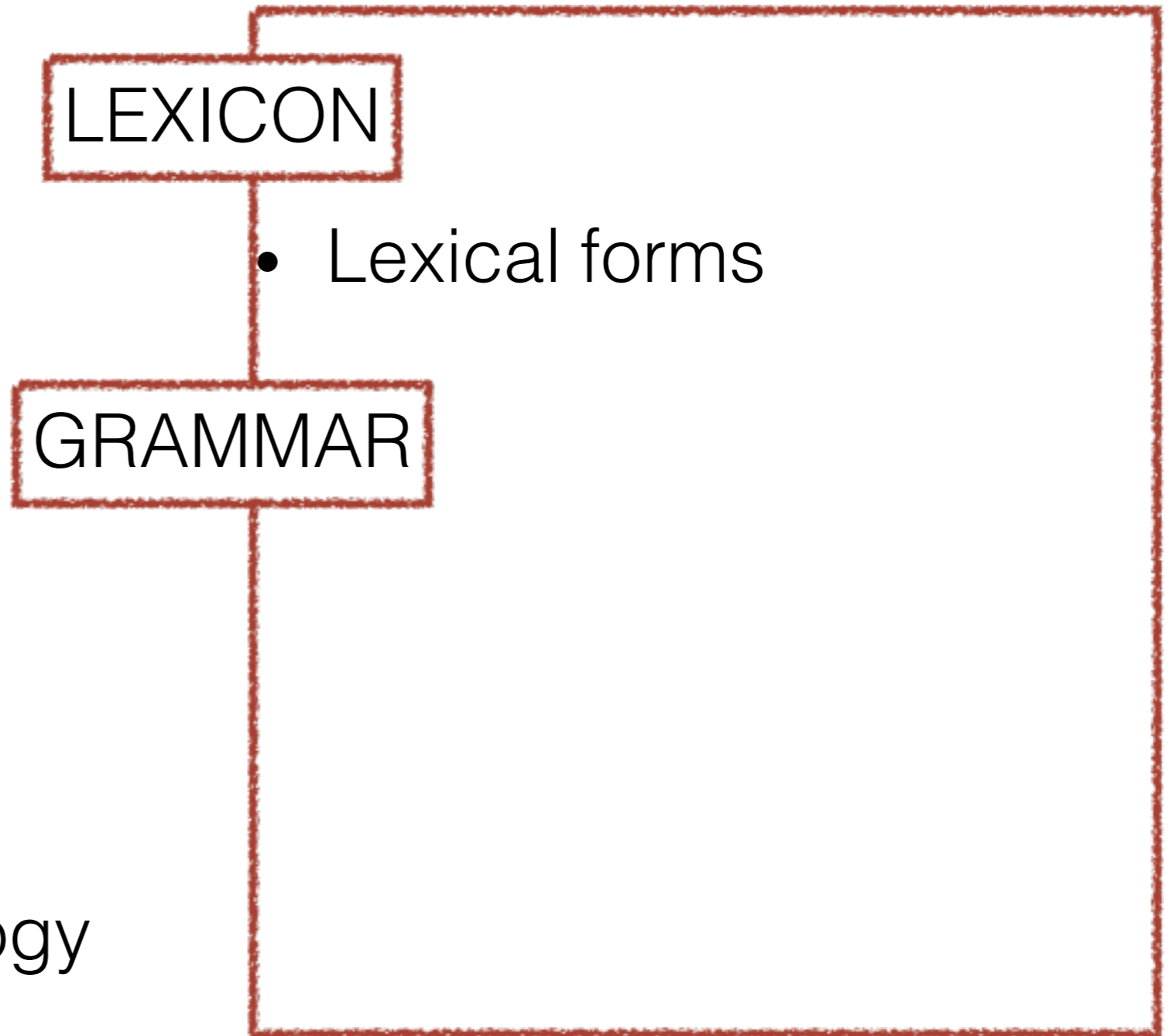
Outline

- Stable bilingualism vs normal transmission
- Experimental evidence for differentiation
- Cognitive model of bilingual production
- Agent-based modelling of macro-linguistic dynamics
- Diagnostic: similar structure / different vocabulary
- Implications for comparative method and phylogenetics

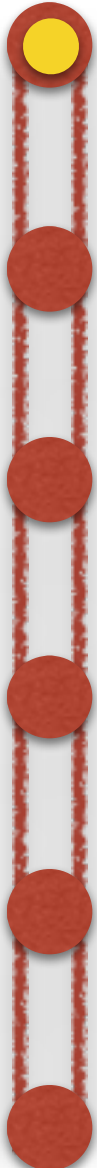
Structure vs Form



- Lexical semantics
- Morphosyntax
- Other semantics
- Phonetics / Phonology

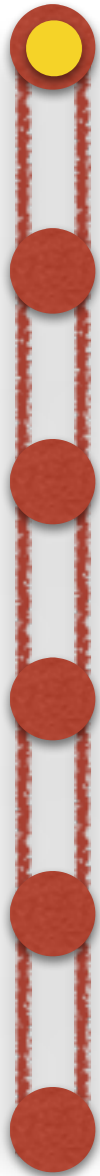


Doppels

- 
- similar *form* / similar *semantics* across languages
 - psycholinguistics uses *cognate*
 - clashes with use of *cognate* by historical linguists
 - propose new term ***doppel***

Doppels

	Doppel	Non-Doppel
Cognate	Kom hier en breng me een glass water (NL)	dziesięć (PL)
Non-Cognate	foto (NL) dies (LA)	



DISTINGUISHING LINGUISTIC FROM COGNITIVE



Language-internal

Change due to causes
within the language
system itself

Speaker-internal

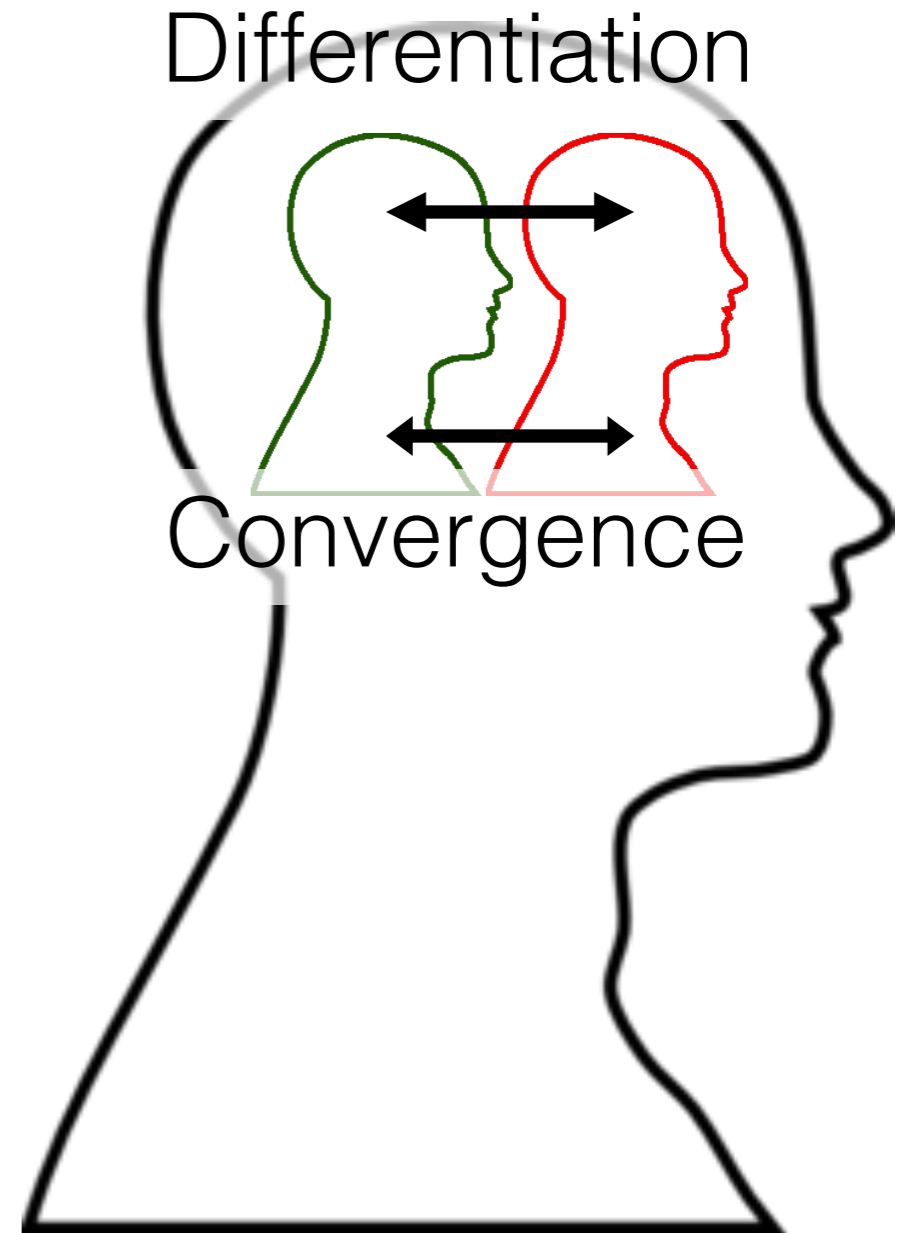
Change due to language
implementation in
individuals

Outcomes

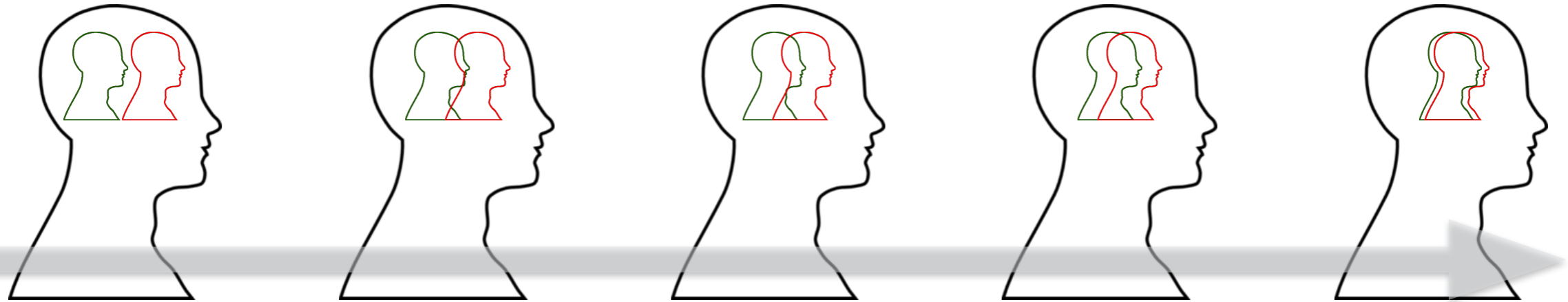
Indistinguishable biases
in speaker behaviour

Bilingualism

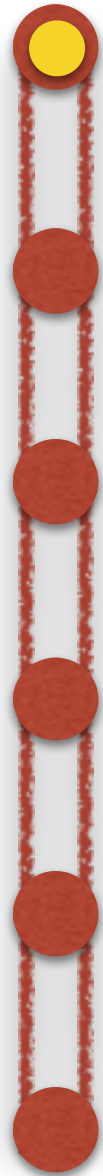
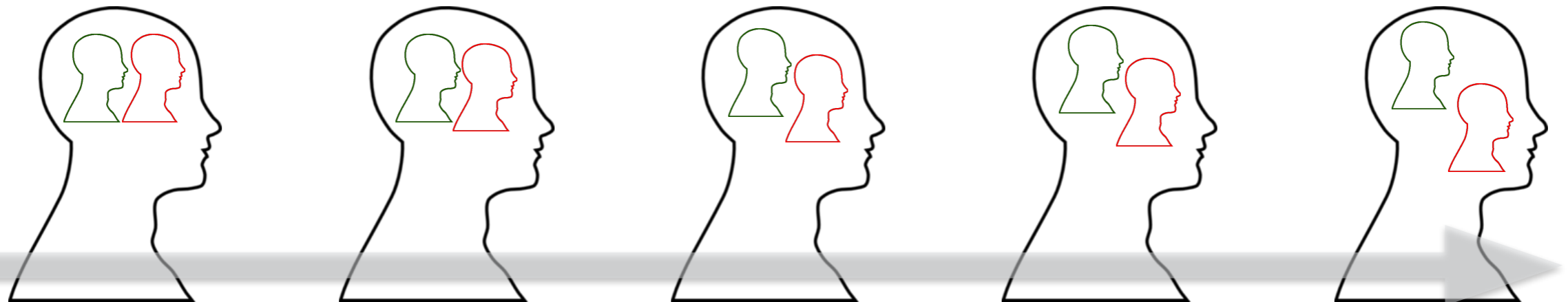
- in bilinguals, speaker-internal change can be different to language-internal
- the languages can suffer convergent and differentiating biases



Stable Bilingualism

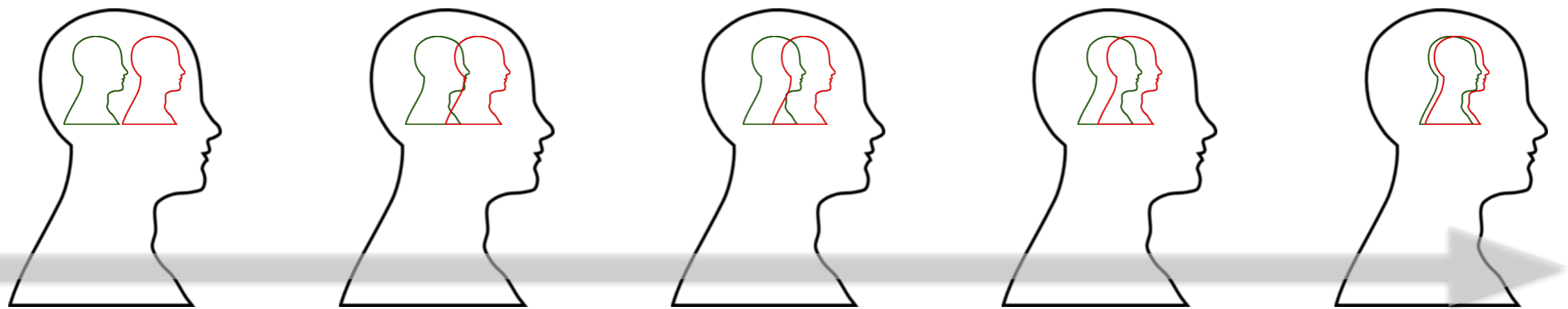


- With stable bilingualism, the effects of these biases ratchet up over time: both convergence and differentiation



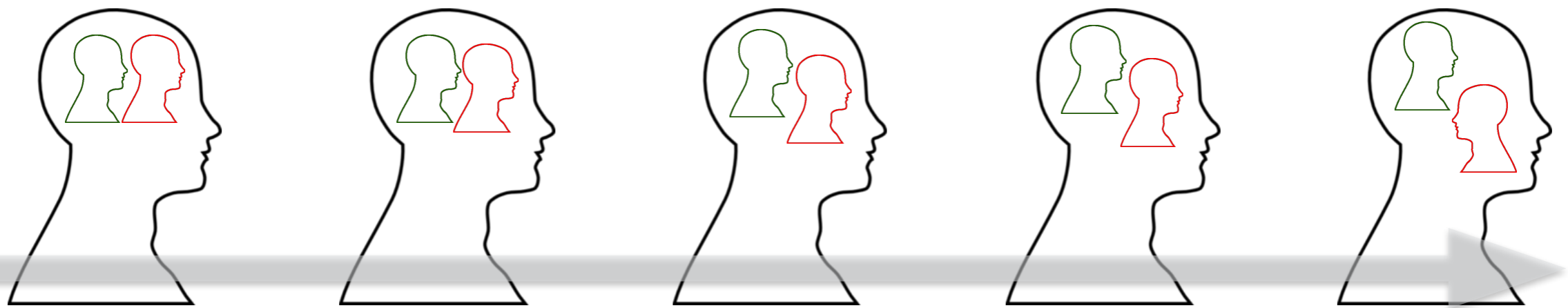
Structure Converges

- Structure converges with prolonged contact
 - Sprachbund areas



Forms Differentiate

- Forms differentiate or maintain differences
 - particularly if structures are similar or converging



Metatypy

- structure converges Ross 2007
- forms may converge only slowly, or not at all
- or even differentiate François 2011

Lemerig	tər	ɪ	χɔlɔl	ʔøɾmaʔ	ʔæ.kiʔis	n	tɛktɛk	mɔχɔt
Koro	nɪr	tɪ	rɔŋ	taβul	wɔs.mɛlɛ	ɔ	βalβalaw	namɪχɪn
	3pl	not.yet1	know	properly	not.yet2	art	speech	poss:1incl.pl
They don't know our language very well yet								

Experimental Evidence for Differentiation

- ... at the micro-linguistic level
- Dutch/English bilinguals living and working in AU
- push them into Bilingual Mode Grosjean 1988, 1997
- 41 survey items: each could be answered with a doppel or a non-doppel
- HYPOTHESIS: *Bilinguals in bilingual mode will use doppels less frequently than monolinguals*

The Questions

Dutch/English Bilingual

Gisterenmiddag ben ik naar het strand geweest.
Yesterday afternoon I went to the beach.

I wanted to take a ____ of the sunset.

POSSIBLE RESPONSES: *photo*, picture

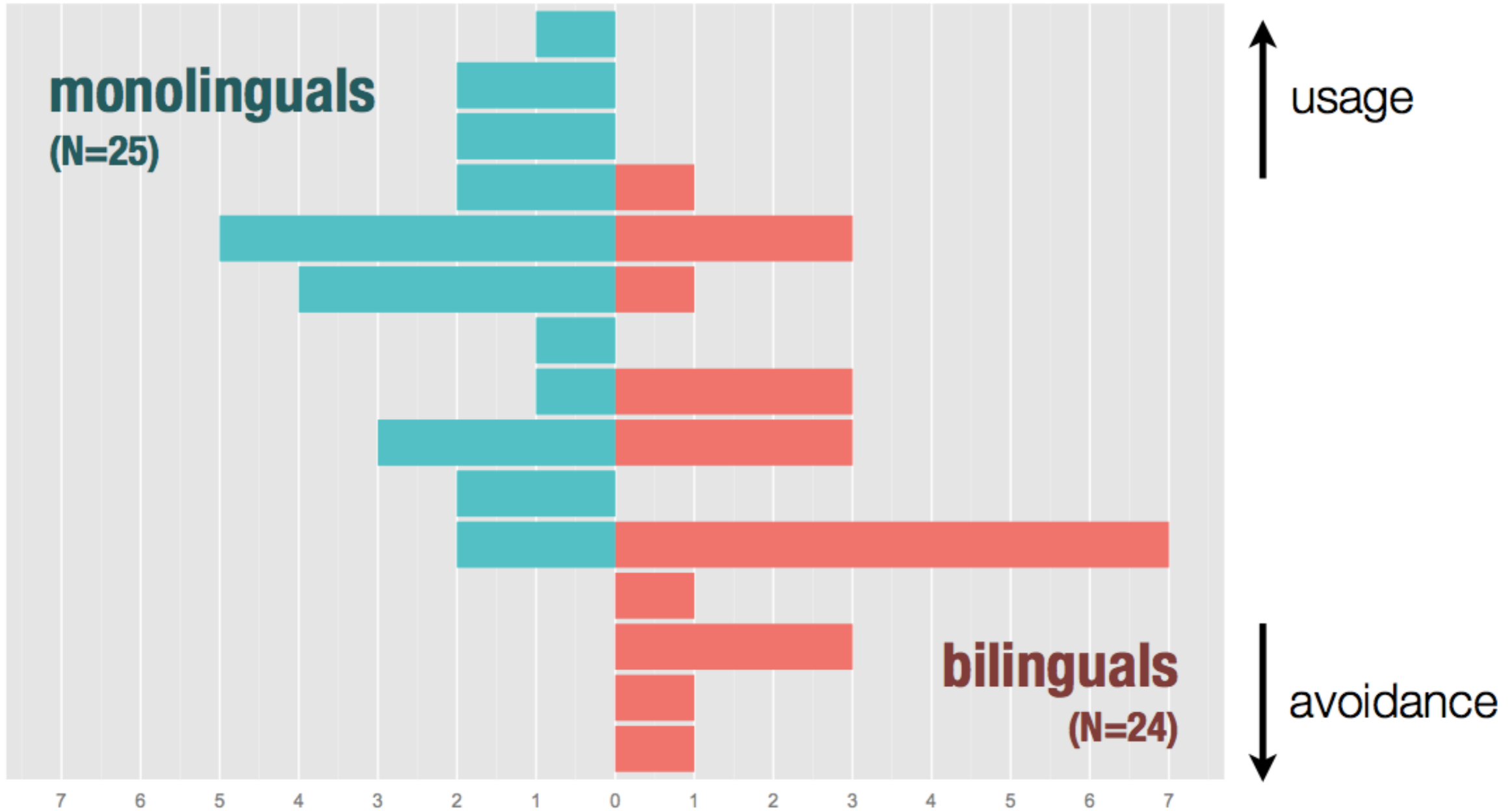
The Questions

English Monolingual

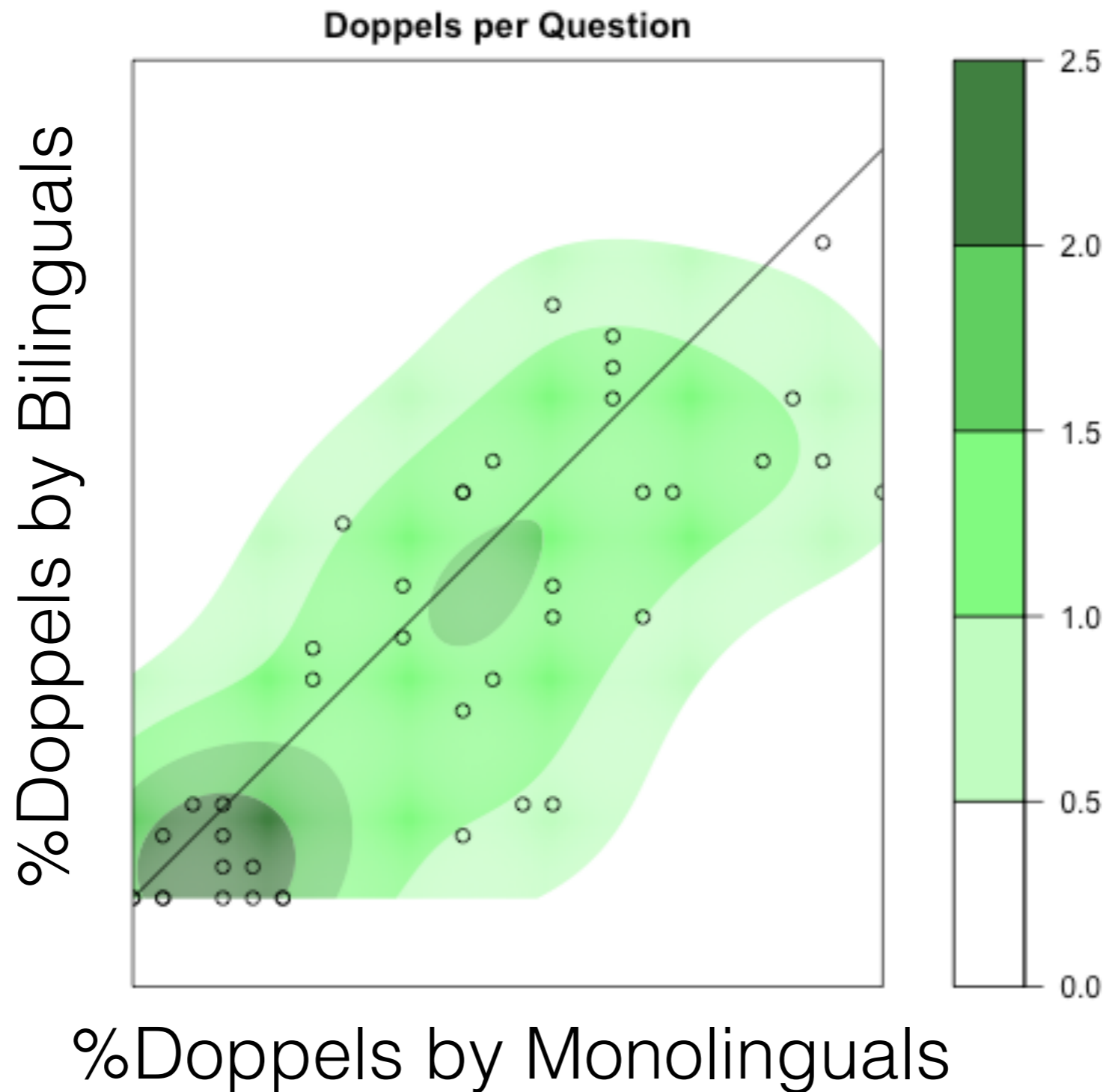
Yesterday afternoon I went to the beach.

I wanted to take a ____ of the sunset.

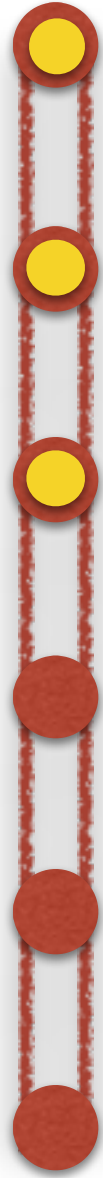
The Results



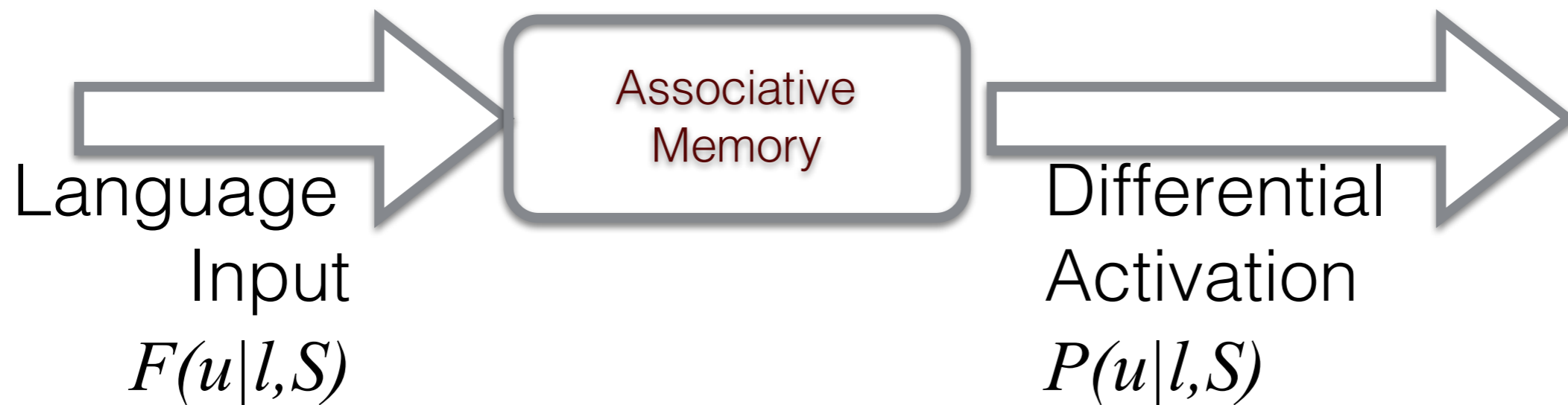
The Results



Cognitive Model of Bilingual Production

- 
- A model of bilingual production which:
 - is psycholinguistically plausible
 - allows for variation in bilingual mode
 - relates monolingual word frequencies to bilingual frequencies
 - *explains our experimental results*

Associative Memory and Differential Activation

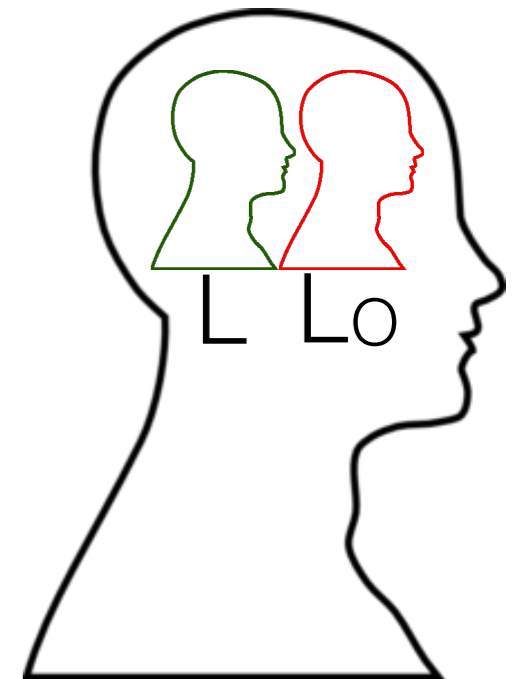


$$P(u|l, S) = kF(u|l, S)$$

*u = utterance, l = language, L = target language, S = semantics
B = bilingual mode, M = monitoring effort*

Bilingual Mode

- Bilingual mode = readiness to use either language
- $B=1$ equally ready to use L or L_0
- $B=0$ only ready to use L



Probability
of generating
language candidates
given bilingual mode

$$P(L|B) = (2 - B)/2$$

$$P(L_0|B) = B/2$$

u = utterance, l = language, L = target language, S = semantics
 B = bilingual mode, M = monitoring effort

Bilingual Mode

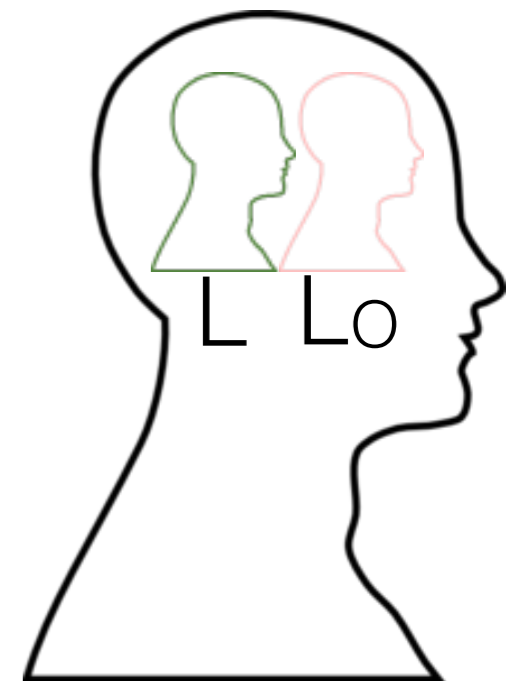
- $B=0.5$ (half bilingual mode)

- $P(L|B)=0.75, P(L_0|B)=0.25$

- language mixed state

- weights likelihood of candidate forms

Probability of utterance given semantics, language

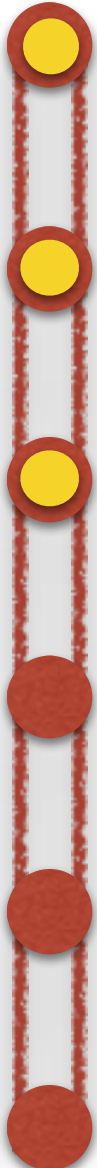


$$P(u|S, B) = \sum_l P(u|l, S)P(l|B)$$

Probability of utterance given semantics, bilingual mode

$u = \text{utterance}, l = \text{language}, L = \text{target language}, S = \text{semantics}$
 $B = \text{bilingual mode}, M = \text{monitoring effort}$

Convergence

- 
- The mixed language of bilingual mode on its own, leads to:
 - convergence of distributions, and
 - free code-switching

Monitoring for Language

- If bilinguals generate candidates in L₀, why are intrusions infrequent?
- monitoring for language appropriateness
- blocks production of any non-L words



Probability
of language l
given utterance,
semantics & mode

$$P(l|u, S, B) = \frac{P(u|l, S)}{P(u|S, B)} P(l|B)$$

u = utterance, l = language, L = target language, S = semantics
 B = bilingual mode, M = monitoring effort

Monitoring Effort

- monitoring is resource dependent
 - degrades with haste, cognitive load
- parameter *Monitoring Effort M*



$$P(l|u, S, B, M) = P(l|u, S, B)^M$$

Probability
of language l
moderated by
monitoring effort

u = utterance, l = language, L = target language, S = semantics
 B = bilingual mode, M = monitoring effort

Bayesian Model of Production Frequency

- Bayes' Theorem: how known data d impacts on the distribution of an unknown h

$$P(h|d) = \frac{P(d|h)P(h)}{P(d)}$$

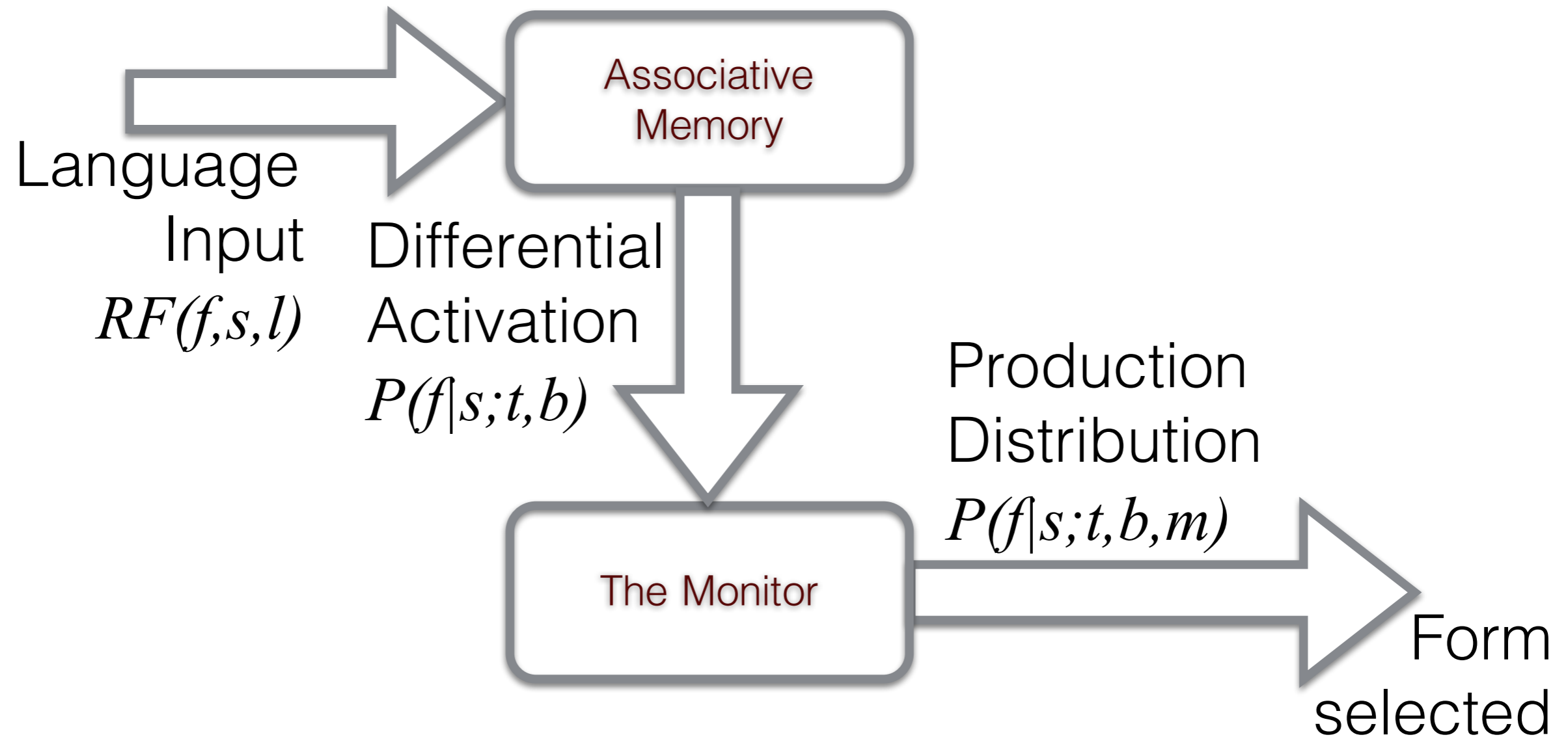
- probability of an utterance, given it has passed the language filter

$$P(u|L, S, B, M) = \frac{P(L|u, B, M)}{P(L|B, M)}P(u|S, M)$$

*u = utterance, l = language, L = target language, S = semantics
B = bilingual mode, M = monitoring effort*

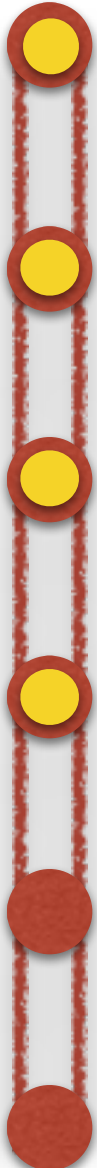


An Bilingual Agent Model



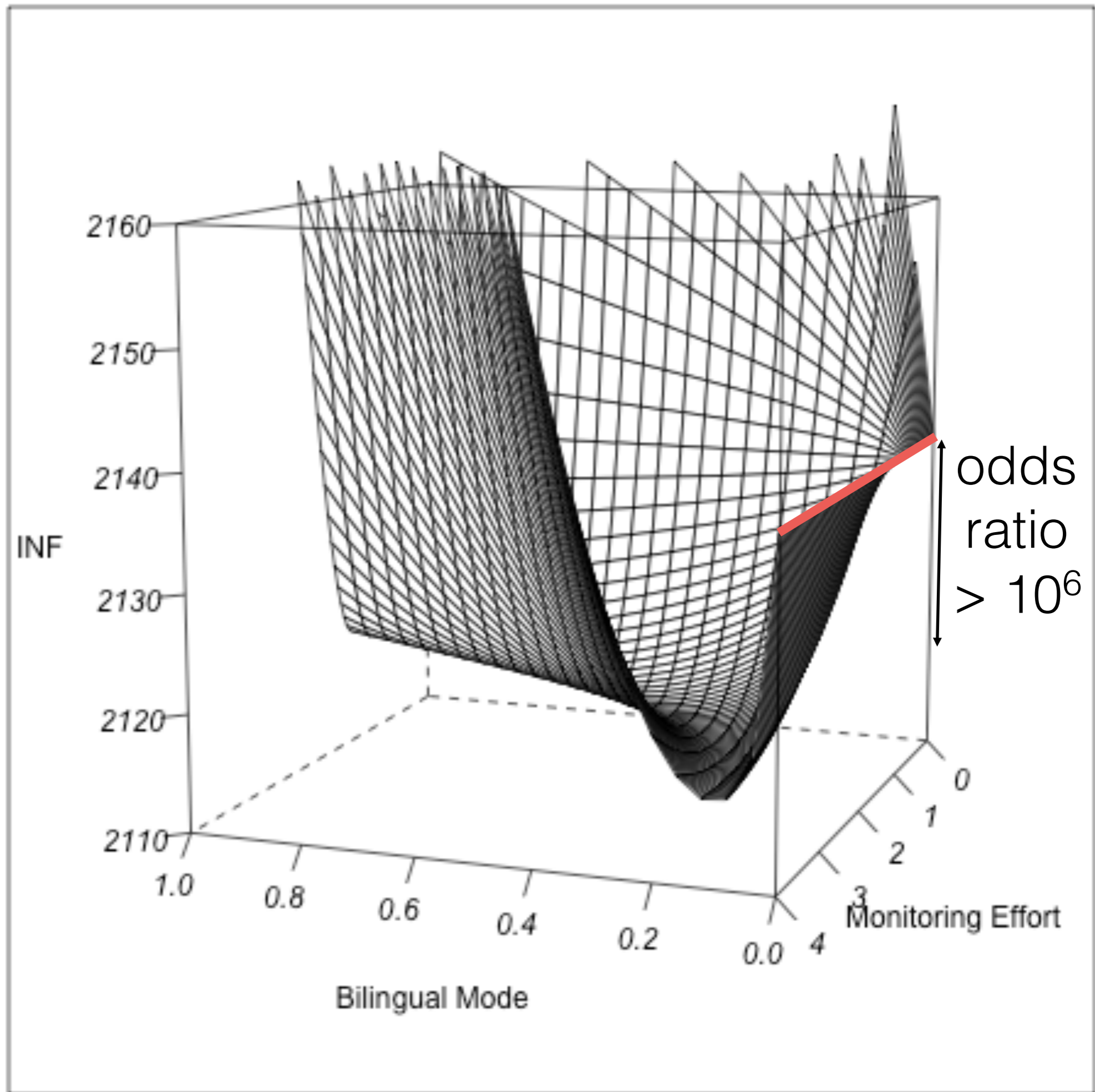
$f = \text{form}, l = \text{language}, t = \text{target language}, s = \text{meaning}$
 $b = \text{language mode}, m = \text{monitoring effort}$

Verification of Agent Model

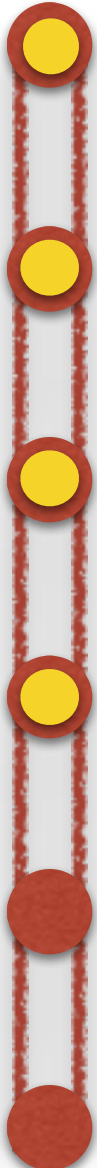
- 
- Used the experimental data to test the model
 - English frequencies from control condition
 - **Caveat** Dutch (simulated) 0.5 doppel, 0.5 non-doppel alternative for each meaning
 - want to find level of bilingual mode and monitoring

$-\log_2$ of
the probability
(INF) of the
experimental
results given
various settings of
bilingual mode
and monitoring
effort

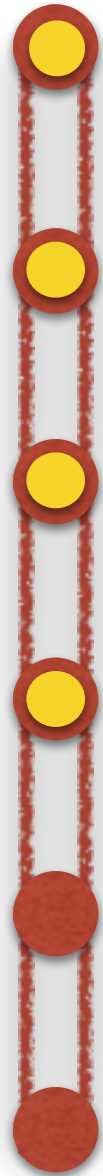
lower is better




Discussion of Results

- 
- the model accords with our experimental evidence
 - speakers don't need to *intend* to differentiate
 - or be pushed to do so for social pressures
 - monitoring to ensure correct language is used leads to differentiation

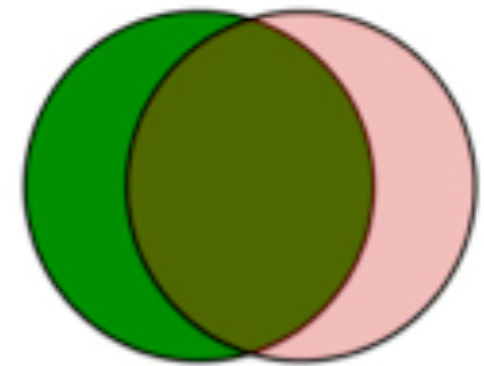
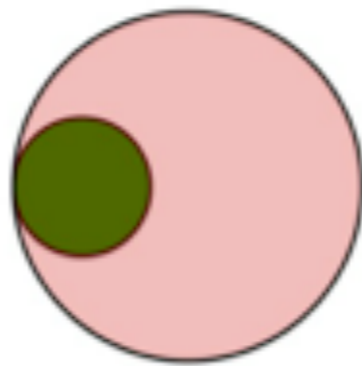
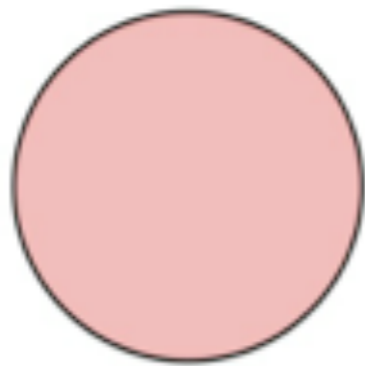
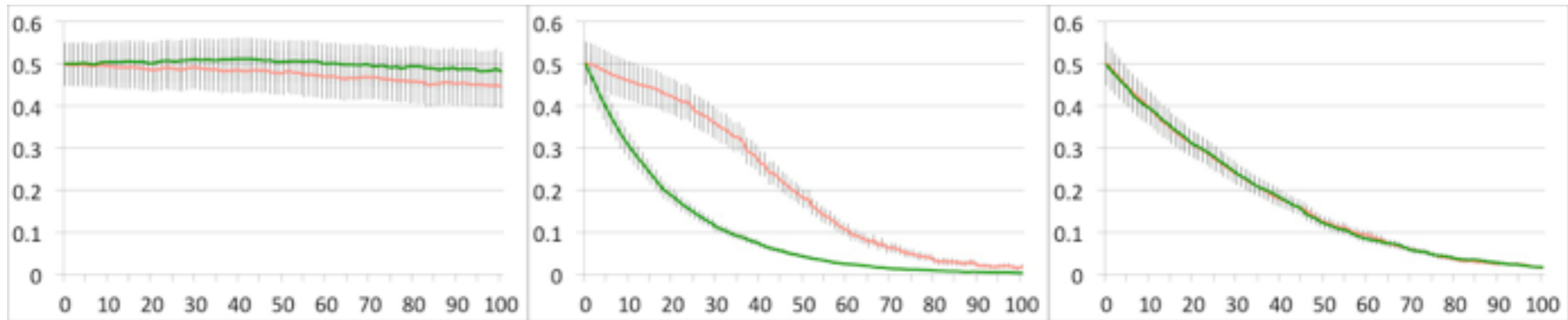
Agent-Based Modelling of Language Macro-Dynamics



Agent-Based Modelling of Language Macro-Dynamics

- 
- A vertical decorative line on the left side of the slide, consisting of a red textured line with six circular markers. The top three markers are yellow, and the bottom three are red.
- Agents are born > listen / learn / speak > die
 - Get distribution of languages at birth
 - Produce according to posterior distros in all their languages
 - Their output added to compendium of inputs


Simulated Outcomes



Levels of Retained Cognate Vocabulary

- r_l = retention rate in language l
- $P(r_1 \& r_2) = P(r_1) P(r_2)$ - binomial distribution
- $P(r_1 \& r_2) \ll P(r_1) P(r_2)$ - potential differentiation
 - stable bilingualism?
- $P(r_1 \& r_2) \gg P(r_1) P(r_2)$ - shared retentions
 - subgroup?
- need to factor out other causes of non-independence of retentions / replacements

Diagnostic: Differential Replacement

- 
- GRAPH OF $-\text{LOG BAYES FACTOR OF COMMON RETENTION TO CHANCE; GIVEN BEST DIFFN MODEL TO CHANCE MODEL} * \text{NUMBER OF SHARED ITEMS}$

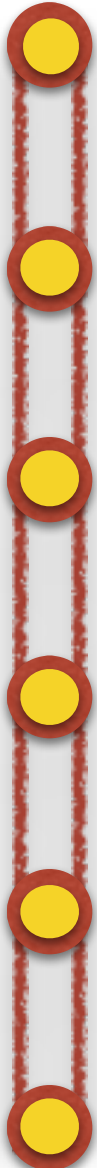
Diagnostic: Similar Structure but Different Vocabulary

- Metatypy example: forms distinct, structure converged
 - monitor attends mostly to forms, not structure
 - doppel-avoidance in form while structure converges

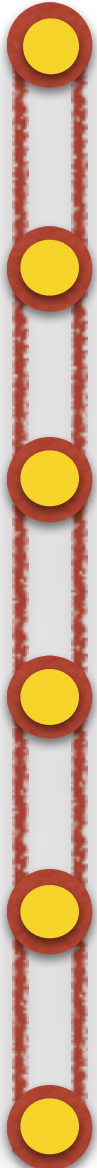
Lemerig	tər	ɪ	χɔləɫ	ʔøɾmaʔ	ʔæ.kiʔis	n	tɛktɛk	mɔχɔt
Koro	nɪr	tɪ	rɔŋ	taβul	wɔs.mɛɛ	ɔ	βalβalaw	namɪχɪn
	3pl	not.yet1	know	properly	not.yet2	art	speech	poss:1incl.pl

- In process in Catalan Arnal 2011

Implications of Anti-Doppel Bias: The Comparative Method

- 
- cognate numbers reduced for same time depth
 - harder to establish regular correspondences
 - more changes seem irregular and idiosyncratic
 - applicability of method unaffected otherwise

Implications of an Anti-Doppel Bias: Phylogenetics

- 
- tests the models ability to cope with variable replacement rates
 - replacements not independent across languages
 - agrees with finding of rapid initial divergence
 - more doppels
 - communities more likely to be collocated, so more bilinguals

Summary

- speaker- and language-internal forces; doppels; bilingual mode
- experimental evidence of differentiation of forms
- probabilistic model of bilingual form selection
 - fits data with odds ratio $> 10^6$
- no need for special social pressures to differentiate
- simulation shows progressive loss of shared vocal
- reduces data for comparative method; complicates assumptions for Bayesian phylogenetic modelling