Human Cognition Lab
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TRACKING THE EMERGENCE OF CONSONANT/VOWEL ASYMMETRIES IN VISUAL-WORD RECOGNITION:

EVIDENCE WITH DEVELOPING READERS

8º ENCONTRO NACIONAL
DA ASSOCIAÇÃO PORTUGUESA
DE PSICOLOGIA EXPERIMENTAL

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Cs/Vs asymmetries in adults

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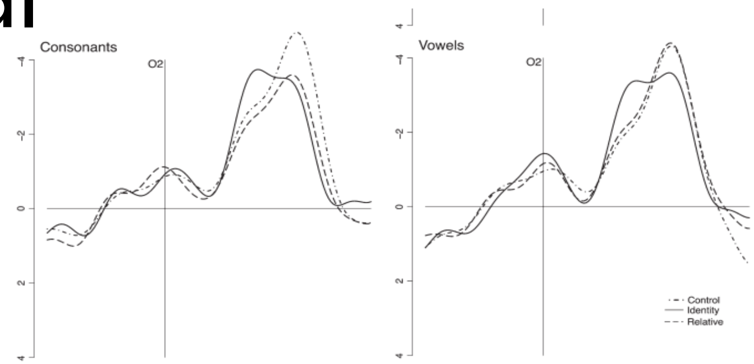
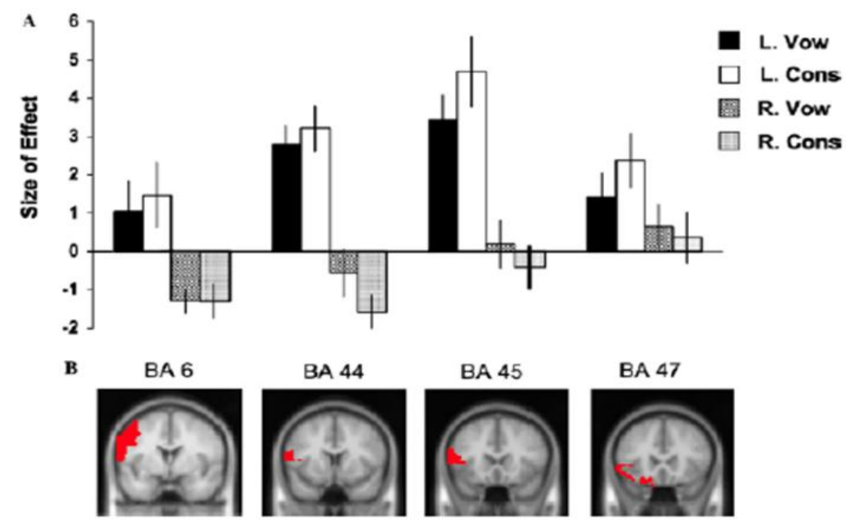
- Evidence: Behavioral
  - **lexical decision** (e.g., Berent & Perfetti, 1995; Carreiras et al., 2007; Duñabeitia & Carreiras, 2011; New et al., 2008; Vergara-Martínez et al., 2011).
  - **delayed-letter paradigm** (e.g., Lee et al., 2001, 2002).
  - **stroop** (e.g., Berent & Marom, 2005).
  - **visual-letter search** (e.g., Acha & Perea, 2010).
  - **boundary technique** (e.g., Winskel & Perea, in press).
  - **semantic categorization** (e.g., Carreiras et al., 2009).
  - **word reconstruction experiments** (e.g., Cutler et al. 2000; van Ooijen 1996).

Cs/Vs asymmetries in adults

- Evidence: neurophysiological
  - **ERPs** (e.g., Carreiras et al., 2008, 2009).
  - **PET** (e.g., Sharp et al., 2005)
    - more activation for Cs than for Vs transformations in the left inferior frontal gyrus (an area involved in visual-word recognition).
  - ***fMRI*** (e.g., Carreiras & Price, 2008)
    - more activation in the right middle frontal cortex for Cs transformations and in the right middle temporal cortex for Vs transformations.



**unsane --> insane/unsafe*



Cs/Vs asymmetries in adults

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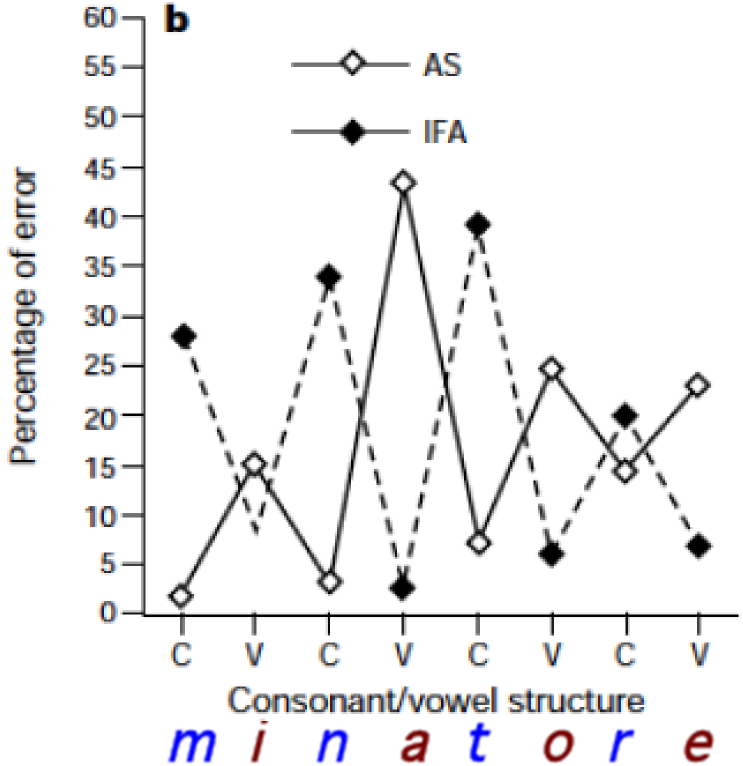
- Evidence: clinical
  - Aphasic patients with selective impairments in Cs and/or Vs production (e.g., Caramazza et al., 2000; Miceli et al., 2004).
  - Double dissociation (Caramazza et al. 2000, *Nature*)
    - AS: more errors on Vs than Cs
      - (27% vs. 9%).
    - IFA: more errors on Cs than Vs
      - (5% vs. 28%).



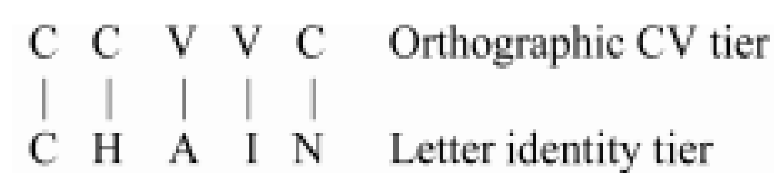
Cs/Vs asymmetries in adults

- None of the current computational models of visual-word recognition (e.g., **overlap model:** Gomez, Ratcliff, & Perea, 2008; **spatial coding model:** Davis, 2010; **Bayesian reader model:** Norris, 2006; **SERIOL model:** Whitney, 2001; **overlap open-bigram model**, Grainger et al., 2006) can accommodate the consonant/vowel asymmetries.
  - Should they include a CV skeleton tier in the orthographic representation?
    - CV **skeleton:**

provavelmente

xxxxxxxxxxxxx

provavelmente



Cs/Vs asymmetries in adults

- Theoretical account (Nespor, Peña, & Mehler, 2003)
  - Cs and Vs are categorically distinct objects that play a fundamental distinct role in language:
    - Cs more important for lexical-related processes.
    - Vs more important in marking the prosodic and the (morpho)syntactic regularities in a language.
  - Studies in artificial grammars (e.g., Bonatti et al., 2005; Peña et al., 2002; Toro et al., 2008, 2009):
    - adults rely more on Cs to segment words in the continuous stream;
    - adults rely more more on Vs when they have to extract the structural regularities of the signal.

Aims

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- Study the relative contribution of Cs and Vs in the visual-word recognition of developing readers: **Is there a consonant bias at early stages of reading acquisition?**
- First study with developing readers in visual-word recognition, although several studies were conducted with children in speech:
  - Acquisition of new nonwords (e.g., Havy & Nazzi, 2009; Kovács & Mehler, 2009; Nazzi, 2005; Nazzi & Bertoncini, 2009; Nazzi & New, 2007).
  - Auditory recognition of known words (e.g., Mani and Plunkett, 2007, 2010; Nazzi, Floccia, Moquet, & Butler, 2009).

Hypothesis

- H_1
  - If there is a developmental continuity between what is observed early in speech processing and in the visual-word recognition domain, we expect to observe an advantage of Cs over Vs at early stages of reading acquisition.
- H_2
  - Moreover, we expect that this advantage (magnitude of the effect) may increase as function of age and stage of reading acquisition.

Method

- 3 experiments:
  - Experiment 1: skilled adult readers (university students).
  - Experiment 2: beginning readers (2nd Grade).
  - Experiment 3: intermediate readers (4th Grade).

- Masked priming paradigm + lexical decision task
  - The Masked Priming Paradigm provides a method to examine priming effects without conscious perception in early visual word form processing (e.g., Forster & Davis 1984, Rastle et al. 2000, 2003).

New et al. (2008)

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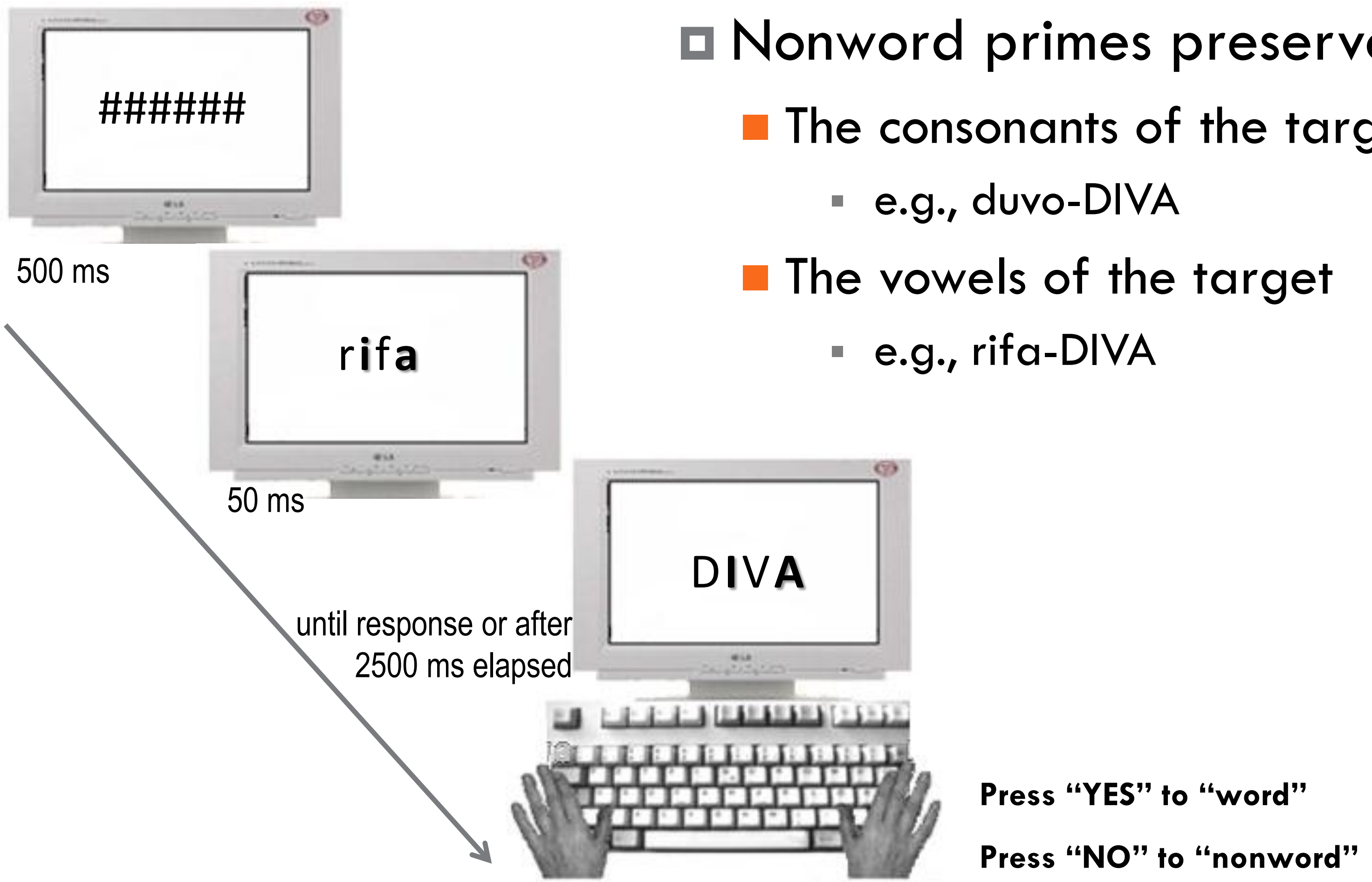
- Is this a word?



- Nonword primes preserved either:
  - The consonants of the target
    - e.g., duvo-DIVA
  - The vowels of the target
    - e.g., rifa-DIVA

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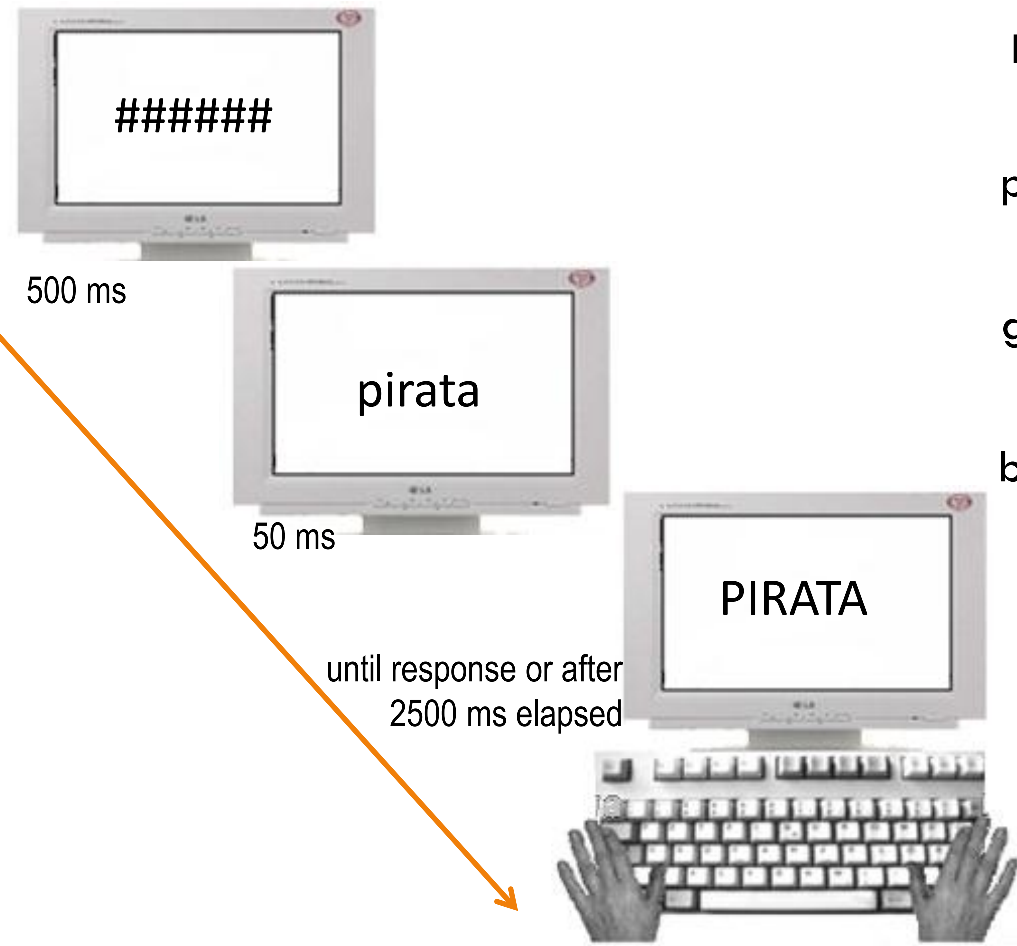
Our study

- Is this a word?



- pirata-PIRATA — Identity
- pureto-PIRATA — Consonant-related
- gicala-PIRATA — Vowel-related
- beculo-PIRATA — Unrelated

Press "SIM[sim] to "word"

Refrain response to "noword"

Stimuli: words

- 64 Portuguese words from the ESCOLEX database (Soares et al., in press).
  - matched on **length** (letters and syllables: CV: 5.0, 2.5; VC: 5.0, 2.5, respectively); **frequency** (CV: 150.04; VC: 147.52); **contextual diversity** (CV: 0.29; VC: 0.33); and **orthographic neighbors** (CV: 1.28; VC: 1.16).

32 CV structure

- 16 disyllabic: e.g., VASO[VASE]
- 16 trisyllabic: e.g., PIRATA [PIRATE]

32 VC structure

- 16 disyllabic: e.g., AZUL[BLUE]
- 16 trisyllabic: e.g., ANIMAL [ANIMAL]

Stimuli: nonwords

- 64 Portuguese nonwords created by the substitution of 1 or 2 letter letters in others 64 ESCOLEX words.
  - matched with the experimental ones in **length** (number of letters and syllables) and **frequency.**
  - 4 lists of materials were created to counterbalance items.
  - Participants were randomly assigned to each list.

32 CV structure

- 16 disyllabic: e.g., nepo
- 16 trisyllabic: e.g., tiroda

32 VC structure

- 16 disyllabic: e.g., ulim
- 16 trisyllabic: e.g., ovidel

Study 1 (adult skilled readers)

- Participants:
  - 24 undergraduate students from University of Minho (M_{age}: 20.6 years; 21 female). All participants had normal (or corrected-to-normal) vision and were native speakers of European Portuguese. None of them had any sensory, neurological, or learning disabilities.
- Materials and Procedure:
  - The experiment was run individually in a sound-proof room. Presentation of the stimuli and the recording of data were controlled by DMDX software (Forster & Forster, 2003).
  - CV and VC target words did not differ statistically in the P-PAL Portuguese adult lexical database (Soares et al., 2010).

Study 1: Results

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- ANOVA based on a 4 (**type of prime**: identity, consonant, vowel, unrelated) x 2 (**word structure**: CV, VC) x 4 (**list**: List 1, List 2, List 3, List 4) design.

Table 1: *Mean Lexical-Decision Reaction Times (RTs; in Milliseconds) and Percentage of Errors (% E) for Consonant-Initial and Vowel-Initial Words.*

	Type of target					
	Consonant-initial structure		*Vowel-initial structure*		*All targets*	
Priming condition	RT	% E	RT	% E	RT	% E
Identity (e.g., *pirate-PIRATA*)	548	0.0	541	1.2	544	0.6
Consonant-related (e.g., *pureto-PIRATA*)	592	0.5	579	2.4	586	1.4
Vowel-related (e.g., *gicala-PIRATA*)	610	0.0	600	0.5	605	0.3
Unrelated (e.g., *beculo-PIRATA*)	605	0.0	596	2.1	601	1.1

- main effect of **type of prime**, $F_1(3,60)=35.03$, $\eta^2=.64$, $p<.001$; $F_2(3,168)=28.22$, $\eta^2=.34$, $p<.001$.
- main effect of **word structure**, $F_1(1,20)=5.52$, $\eta^2=.22$, $p<.05$.

Study 1: Results

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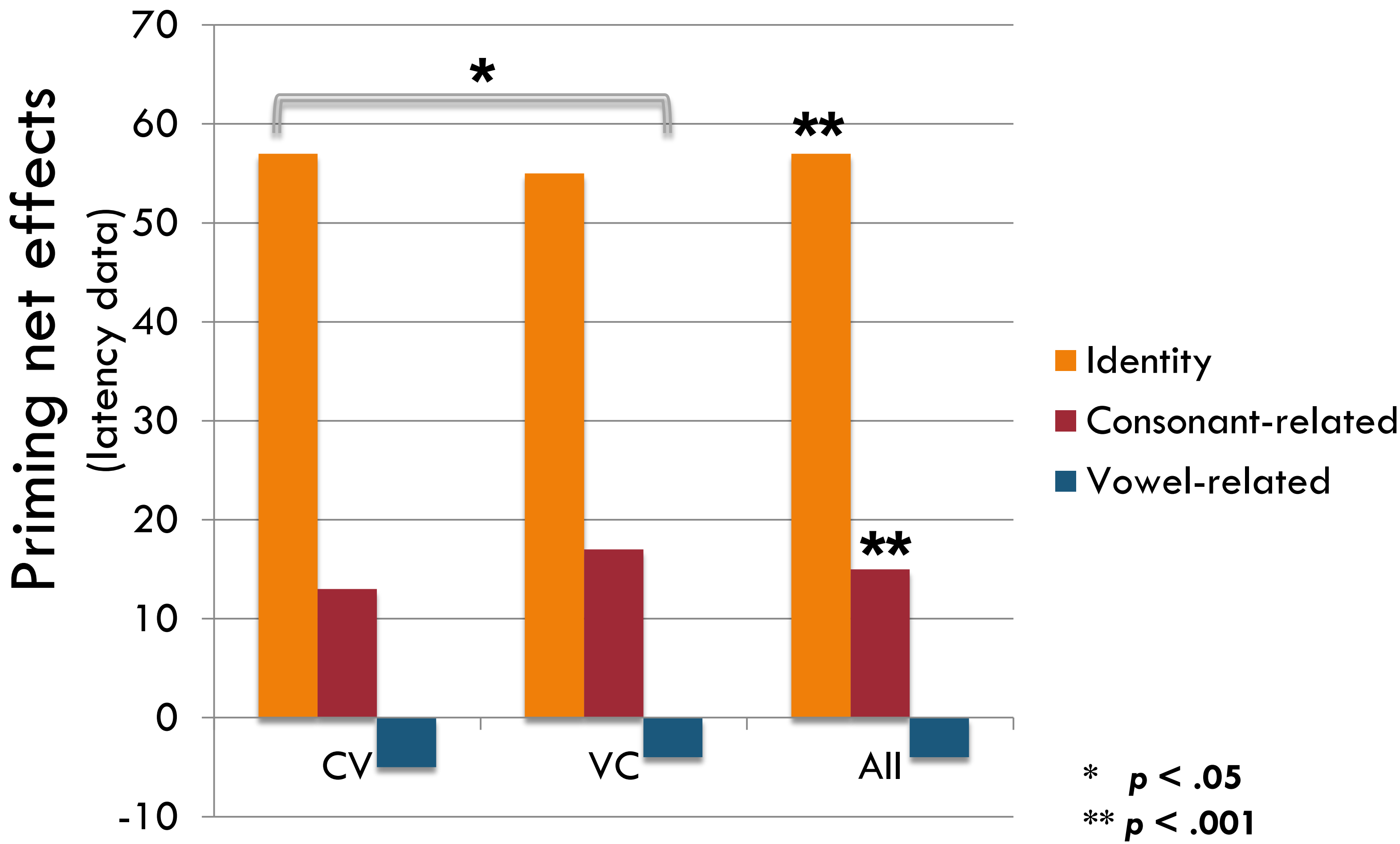

Study 2 (2nd graders)

- Participants:
  - 24 2nd Grade children (M_{age}: 7.5 years; 12 female), participated voluntarily in the experiment. All participants had normal (or corrected-to-normal) vision and were native speakers of European Portuguese. None of them had any sensory, neurological, or learning disabilities. The experiment took place at the end of the academic year.
- Materials and Procedure:
  - the same as Experiment 1. The experiment took place in groups of four children in a quiet room. DMDX software (Forster & Forster, 2003) was used to present stimuli and to collect data.

Study 2: Results

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- ANOVA based on the same design as Experiment 1.

Table 2: *Mean Lexical-Decision Reaction Times (RTs; in Milliseconds) and Percentage of Errors (% E) for Consonant-Initial and Vowel-Initial Words.*

	Type of target					
	Consonant-initial structure		*Vowel-initial structure*		*All targets*	
Priming condition	RT	% E	RT	% E	RT	% E
Identity (e.g., *pirate-PIRATA*)	985	7.2	1,005	12.6	995	9.9
Consonant-related (e.g., *pureto-PIRATA*)	1,061	5.4	1,025	13.3	1,043	9.3
Vowel-related (e.g., *gicala-PIRATA*)	1,070	5.6	1,052	12.2	1,061	8.9
Unrelated (e.g., *beculo-PIRATA*)	1,056	5.2	1,041	11.0	1,048	8.1

- **Latency data:** main effect of **type of prime,** $F_1(3,60)=3.87$, $\eta^2=.13$, $p<.05$; $F_2(3,159)=6.08$, $\eta^2=.10$, $p<.001$.
- **Error data:** main effect of **word structure,** $F_1(1,20)=17.29$, $\eta^2=.46$, $p<.001$.

Study 2: Results

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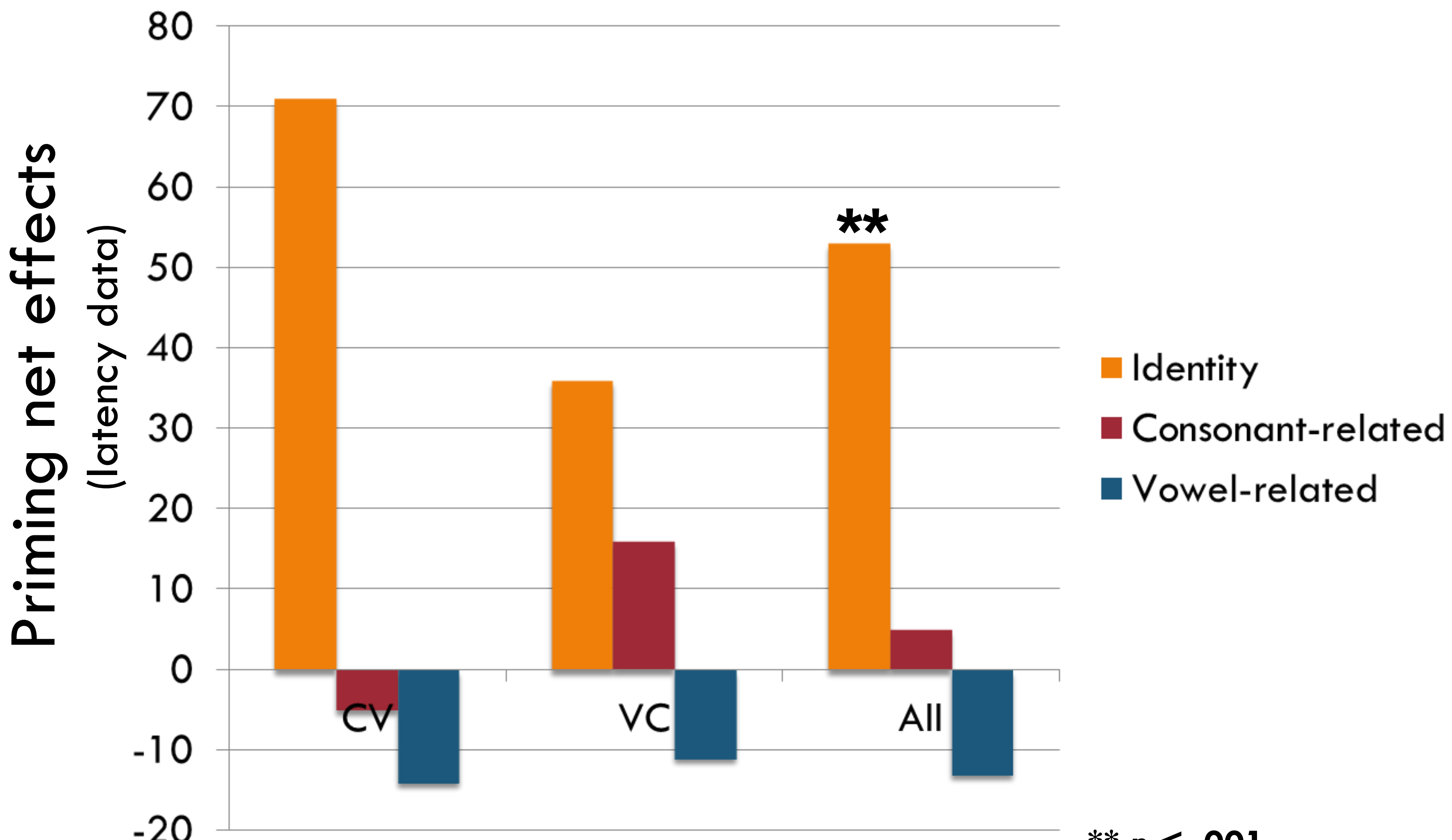

** $p < .001$

Study 3 (4th graders)

- Participants:
  - 24 4th Grade children (M_{age}: 9.9 years; 13 female), participated voluntarily in the experiment. All participants had normal (or corrected-to-normal) vision and were native speakers of European Portuguese. None of them had any sensory, neurological, or learning disabilities. The experiment took place at the end of the academic year.
- Materials and Procedure:
  - the same as Experiment 1 and 2. The experiment took place as in Experiment 2 in groups of four children in a quiet room. DMDX software (Forster & Forster, 2003) was used to present stimuli and to collect data.

Study 3: Results

- ANOVA based on the same design as Experiment 1 and 2.

Table 3: *Mean Lexical-Decision Reaction Times (RTs; in Milliseconds) and Percentage of Errors (% E) for Consonant-Initial and Vowel-Initial Words.*

	Type of target					
	Consonant-initial structure		*Vowel-initial structure*		*All targets*	
Priming condition	RT	% E	RT	% E	RT	% E
Identity (e.g., *pirate-PIRATA*)	792	1.0	804	12.1	798	6.6
Consonant-related (e.g., *pureto-PIRATA*)	814	2.3	852	9.5	833	5.9
Vowel-related (e.g., *gicala-PIRATA*)	901	2.0	847	10.1	874	6.0
Unrelated (e.g., *beculo-PIRATA*)	847	3.7	844	8.6	846	6.1

- **Latency data:** main effect of **type of prime,** $F_1(3,60)=7.18$, $\eta^2=.26$, $p<.001$; $F_2(3,165)=8.26$, $\eta^2=.13$, $p<.001$; **type of prime*word type** $F_1(3,60)=2.92$, $\eta^2=.13$, $p<.05$; $F_2(3,165)=4.23$, $\eta^2=.07$, $p<.01$.
- **Error data:** main effect of **word structure,** $F_1(1,20)=70.97$, $\eta^2=.78$, $p<.001$; $F_2(1,56)=4.53$, $\eta^2=.07$, $p<.05$.

Study 3: Results

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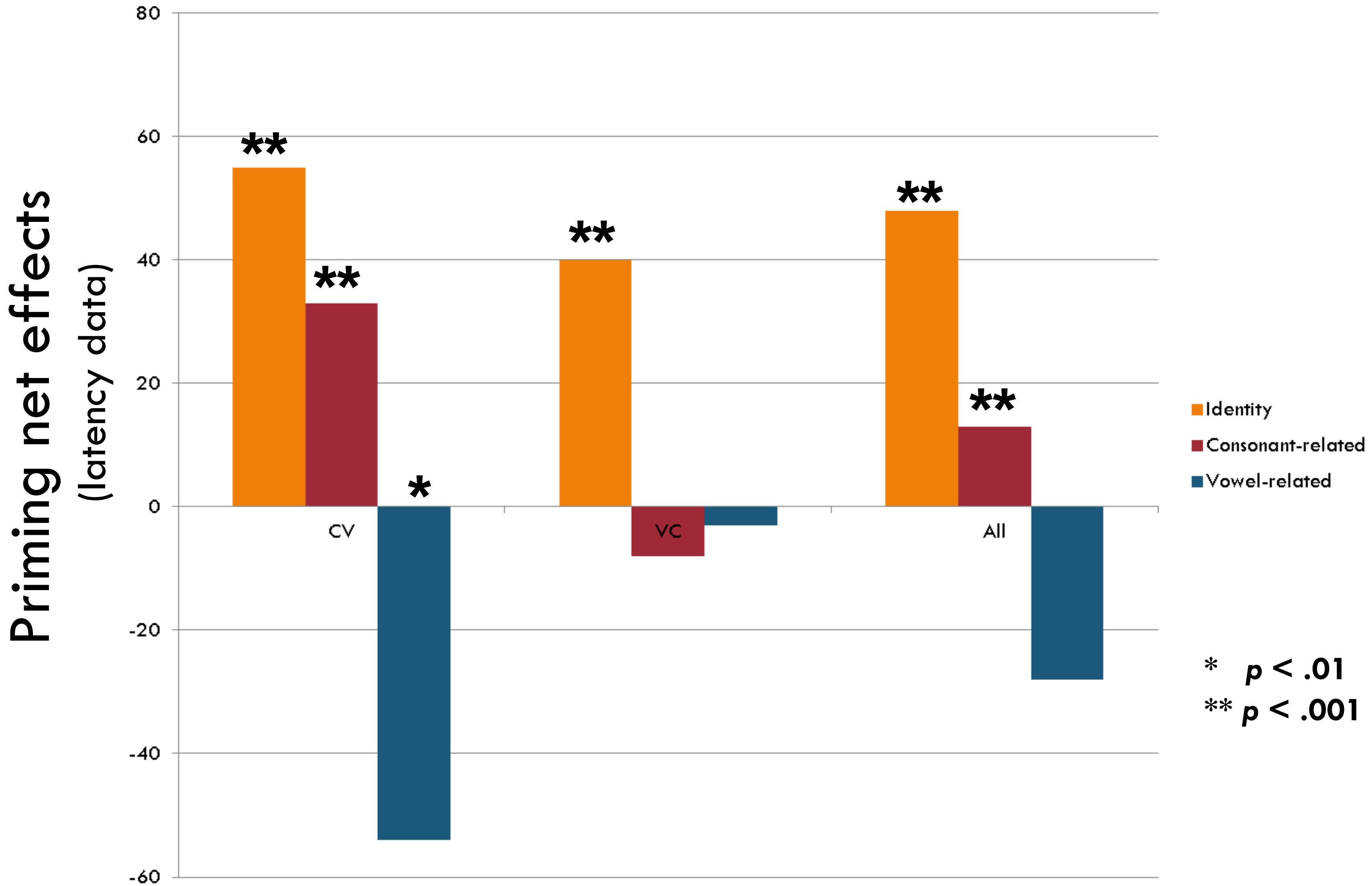

Main findings

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- Advantage of Cs over Vs in Portuguese adult-skilled readers.
  - extending previous findings in other alphabetic languages (e.g., English, French, Spanish) to Portuguese.
- Advantage of Cs over Vs in 4th graders but not in 2nd graders.
  - showing that the consonant bias emerges only at a later stage (intermediate stage) of reading acquisition.
- Advantage of Cs over Vs for both CV and VC words in adult-skilled readers, though restricted to CV words in 4th graders. In CV words there is additionally an inhibitory effect from Vs.
  - showing not only that the consonant bias emerges gradually in reading acquisition, but also that Vs can produce inhibition.

Discussion

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- Absence of any significant priming effects (besides identity priming) at early stages of reading acquisition:
  - immaturity of the visual-word recognition system.
  - task requirements.

- Emergence of the consonant bias in 4th graders restricted to CV words (i.e., for words like PIRATA not for ANIMAL).
  - 4th graders more proficient in reading
  - familiarity with CV words
    - CV is the most familiar word structure in Portuguese (Vigário et al., 2006).
    - ESCOLEX: CV words occur in 82.5% of 4 and 6 six-letter words; VC words occur in 11.6%. CV words were also more frequent (CV: 69,945.97 and VC: 8,280.66 per million words).

Discussion

- Inhibition of Vs in 4th graders in CV words (i.e., 54ms slower in gicala-PIRATA than in bocelo-PIRATA)
  - lexical activation from "*the number of consonant or vowel skeleton neighbors shared between the target and its consonant and vowel primes respectively*" (New & Nazzi, 2013).
    - VASO has a higher number of vocalic skeleton neighbors (*A*O: e.g., *taco*, *nado*, *dado*, *ralo*, *lavo*, *raro*, *favo*, *falo*, *raso* etc.), than consonantal skeleton neighbors (V*S*: visa)

      CV words: vowel skeleton neighbors= 30.0 and consonant skeleton neighbors=1.6

      VC words: vowel skeleton neighbors= 6.6; and consonant skeleton neighbors=1.5
  - Vowel-preserving primes (e.g., balo-VASO or gicala-PIRATA) would activate a large number of lexical candidates which hampers visual-word recognition in non-proficient readers (due to inhibitory connections at the lexical level).

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THANK YOU!

VNIVERSITAT DE VALÈNCIA

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