

# What can an eye-tracker tell us about the linguistic representations of heritage speakers?

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Workshop: Heritage Language Acquisition

LAVA: Language Acquisition, Variation & Attrition

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# GOAL

- Psycholinguistic methodologies can provide information about the linguistic systems of heritage speakers and their processes of acquisition.
- Production and comprehension may undertake different cognitive processes.

# OUTLINE

- **INTRODUCTION**
  - L2 Immersion & Heritage Speakers
  - Comprehension vs. Production
  - Online Methodologies
  - Predictive Processing
  - Spanish Mood (Indicative/Subjunctive)
- **RESEARCH QUESTIONS**
- **STUDIES**
- **DISCUSSION**

# IMMERSION

- Immersion in the L2 environment results in changes in the **production** of both languages:

|                     | Native Language  | Second Language  |
|---------------------|--|--|
| <b>Phonology</b>    | Sounds from the second language are incorporated in the native language.             | Non-existing sounds in the native language are acquired. |
| <b>Lexicon</b>      | It gets harder to retrieve lexical items in the native language.                     | More words are incorporated in the lexicon.              |
| <b>Morphosyntax</b> | Second Language syntactic structures are produced during native language production. | Second language morphosyntactic system improves.         |

(e.g., Baus, Costa, & Carreiras, 2013; Bousquette et al, 2016; Bullock, 2009; Bullock & Gerfen, 2004; Link, Kroll, & Sunderman, 2009; Schmid, 2004, 2013; Schmid & Jarvis, 2014)

# IMMERSION

- Most of the research has focused on **production**.
- Other studies have shown that immersion can affect comprehension (e.g., Chamorro, Sorace, & Sturt, 2016; Dussias & Sagarra, 2007)

## Dussias & Sagarra (2007)

- **MATERIALS:**

El policía arrestó a la **hermana** de la **criada** que estaba enferma.

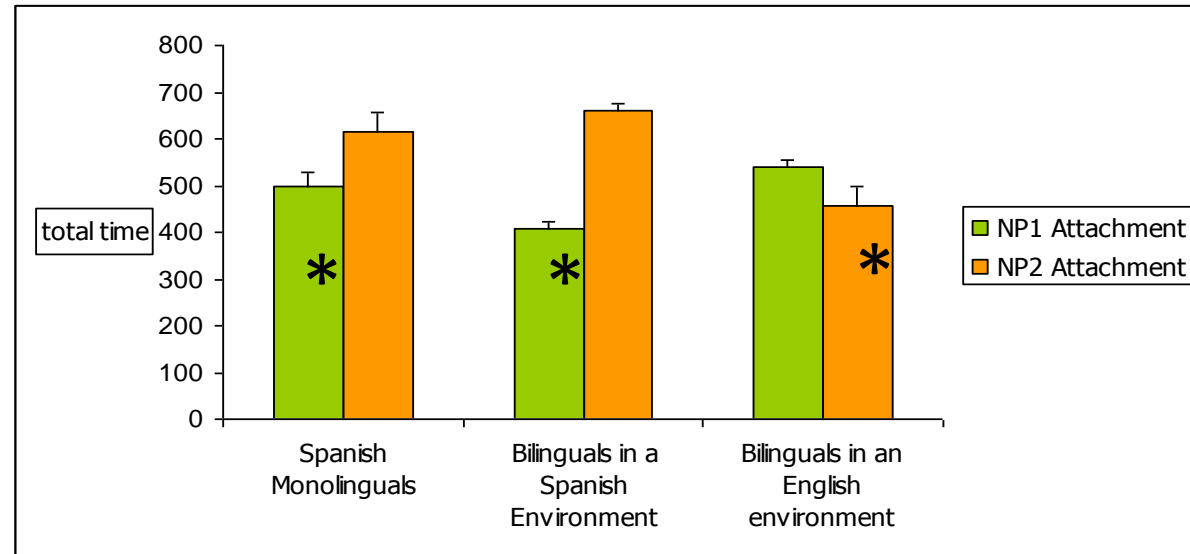
*The policeman arrested the **sister** of the **servant** who was sick.*

**English:** la criada estaba enferma (the servant was sick)

**Spanish:** la hermana estaba enferma (the sister was sick)

# IMMERSION

- Results:



Dussias & Sagarra (2007), *Bilingualism, Language & Cognition*, 10, 101-116

- They suggested that native speakers of Spanish immersed in an L2 English environment processed these sentences like English speakers.

- **Why is immersion relevant to the study of heritage speakers?**
- Heritage speakers can be considered bilinguals with extreme L2 immersion.
- We should expect that the L1 in heritage speakers shows a linguistic system different to those bilingual speakers living in an L1 environment.



# PRODUCTION vs. COMPREHENSION

- How is their linguistic system different?
- Most importantly: Why?
- What do we know about the production and comprehension of heritage speakers?



- Online and offline data have suggested that the grammars of heritage speakers are different than the grammars of **native speakers**.  
(e.g., Montrul, 2009; Montrul & Perpiñán, 2011, Pinto & Raschio, 2007; Polinski and Kagan, 2007)
- Yet, they seem to be better than **L2 learners**.  
(Mikulski & Elola, 2013)
- Heritage speakers may suffer from **attrition or incomplete acquisition**.  
(Albirini et al., 2011; Benmamoun et al, 2014; Montrul, 2002; Montrul & Bowles, 2009; Polinski, 2011).
- More recently, researchers have argued that linguistic representations in heritage speakers may be a result of **experience**.  
(e.g., Hopp & Putnam, 2015; Polinski, 2008; Putnam & Salmons, 2013)
- Possibly, that experience can result in similarities with native speakers.  
(e.g., Lee-Ellis, 2011; O'Grady et al, 2011; Pegoraro, 2016)

- Most studies in comprehension have been conducted **offline**, which have led to the conclusion that heritage speakers are different than native speakers (e.g., Gürel, 2015, Mikulski, 2010, Montrul & Ionin, 2010; Rinke & Flores, 2014) although may be dependent on **dialect** (Pires & Rothman, 2009).
- **Online** comprehension studies have studied the cognitive abilities of heritage speakers (Montrul et al, 2009), **lexical access** (Montrul & Foote, 2014), the online processing of linguistic **features** (Chamorro, Sorace, & Sturt, 2016; Jegerski, Keating, VanPatten, 2016; Keating, Jegerski, & VanPatten, 2016).
- In general, **results** from these online task have revealed no differences between heritage and native speakers in online comprehension, arguing that heritage speakers may end up being more native if they get enough linguistic experience.
- In fact, Chamorro, Sorace, & Sturt (2016) argue that online and offline comprehension data can lead to different results and how important it is to study both to understand the whole picture.

- There is a need for more studies that can measure the online comprehension of heritage speakers as it unfolds overtime and compare the results to offline performance.
- The issue relies on what is considered online.

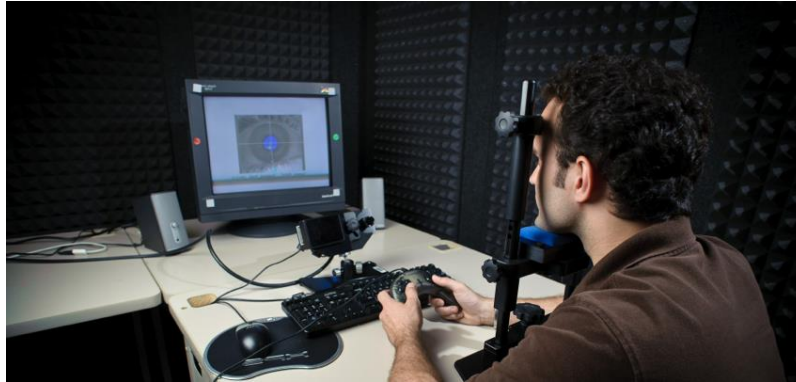
- What are these online methodologies?
  - Moving window
  - Eye-tracker
  - Electroencephalogram (EEG)
  - Functional Imaging (fMRI)

- **SELF-PACED READING TASK**

EL PERRO COME UN HUESO

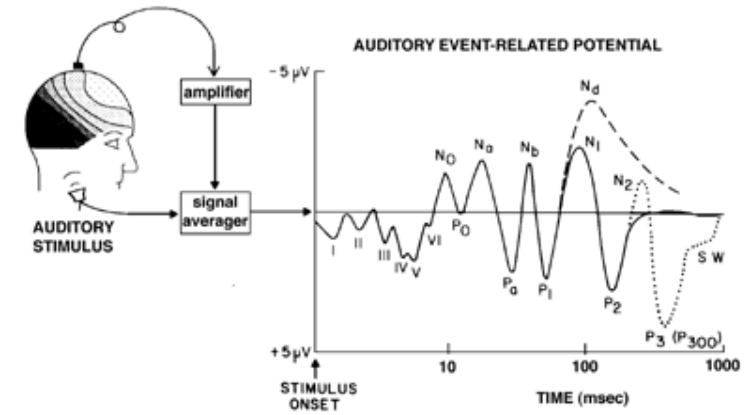
- It records the time between the presentation of the word to the moment they press the key to show the next word.
- Rational: words that are cognitively more costly will produce longer reading times in ms.
- Cons: Measures are not overtime but per word.

- **EYE TRACKER**



- It records fixations (where and how long).
- Rational: words that are cognitively more costly will produce longer fixations in ms.
- It can identify measures of early and late measures of comprehension.

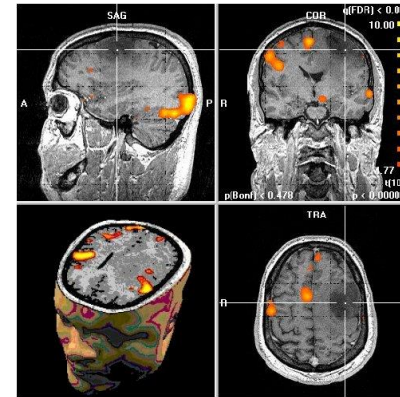
## • ELECTROENCEPHALOGRAPH (EEG)



- It records brain activation at a moment in time.
- It connects this activation to linguistic components (P100, N400, P600...)
- It measures comprehension overtime in ms.
- Cons: Expensive; not natural procedure.



- **FUNCTIONAL MAGNETIC RESONANCE IMAGING (fMRI)**



- It records brain activation at a moment in time.
- It creates physiological images of brain activation.
- Cons: limited access; costly; brain related.

# EYE-TRACKER

- **What can an eye-tracker tell us about comprehension?**
- It can provide us with data about how speakers use lexical information online to anticipate information as it unfolds (**predictive processing**).
- This is something that monolinguals seem to be able to do (e.g., *jinx game*)

# PREDICTIVE PROCESSING

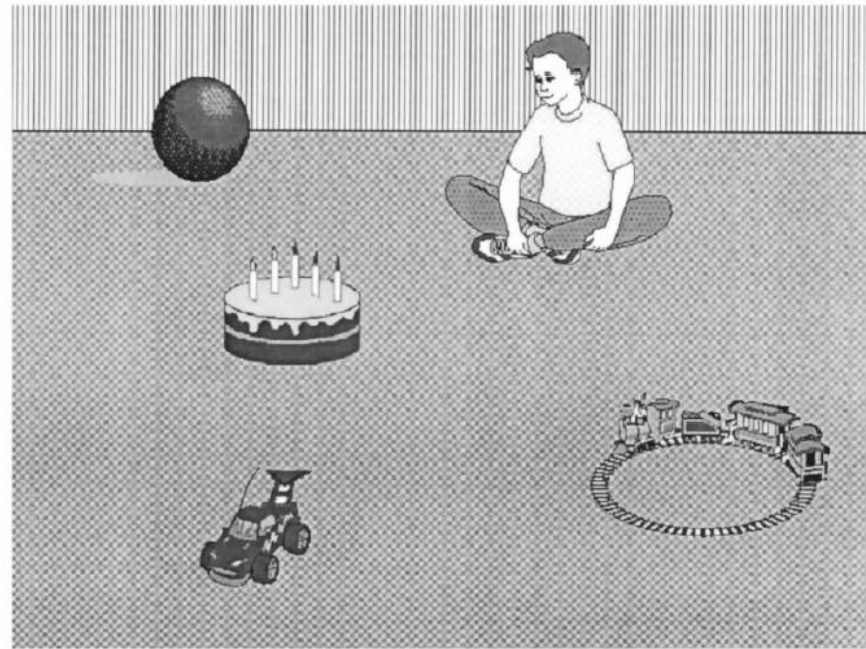


Fig. 1. Example scene used in Experiments 1 and 2 (Sections 2 and 3). Participants heard ‘*The boy will move the cake*’ or ‘*The boy will eat the cake*’ whilst viewing this scene.

- When native speakers heard the sentence “*The boy will eat the...*”, they looked at the picture of the *cake* before the word was produced.

- Need of a trigger and a target:

(1) *The boy will eat the cake*

- trigger: “eat”
- target: “cake”

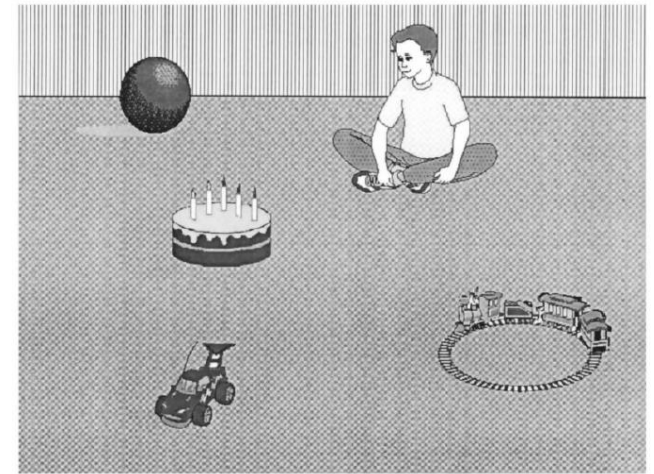


Fig. 1. Example scene used in Experiments 1 and 2 (Sections 2 and 3). Participants heard ‘*The boy will move the cake*’ or ‘*The boy will eat the cake*’ whilst viewing this scene.

- How can prediction be researched in reading?

- The **Subjunctive Mood** in Spanish:

Some **verbs** in Spanish require a **verb** in the subjunctive mood:

(2) El profesor les **aconsejó** a los alumnos que **estudiaran** mucho para el examen.

*The professor **advised** the students  
**to study** hard for the exam.*

- The Subjunctive Mood in Spanish is different from the Subjunctive Mood in English:

(3) The employees **demand** that the managers **resign**.

*Los empleados **demandan** que los encargados **renuncien**.*

This is important because if something is expected to change, it will be a feature that is different between Spanish and English.

## What do we know about the subjunctive in heritage speakers of Spanish?

- Use the indicative morphology in production and comprehension. (e.g., Mikulski & Elola, 2013 Montrul and Perpiñán, 2011)
- They are less productive than native speakers but more productive than L2 learners. (Mikulski & Elola, 2013)
- Their linguistic representations seem to be affected experience.
- They suffer incomplete acquisition/attrition.
- However, there are not enough online comprehension studies to bring up definite conclusions.

# SUMMARY

- Immersion affects the L1 linguistic representations in production and comprehension.
- We need more online comprehension studies.
- The eye-tracker methodology is suitable to capture early and late measures of comprehension in heritage speakers.
- Previous studies have suggested that heritage speakers experience incomplete acquisition/attrition of the subjunctive mood.



# QUESTIONS

1. Do non-immersed native speakers of Spanish use the lexically-encoded information of Spanish verbs to produce/process the subjunctive morphology of a subordinate verb?
2. Does immersion in the L2 affect the ability of native speaker of Spanish to produce/process the subjunctive morphology of a subordinate verb?

Corpus Study. Complete Subcategorization Bias by Verb

| VERB         | Subcategorization Bias |              |            |               |            |               |            |               |           |              |           |              | TOTAL      |              |
|--------------|------------------------|--------------|------------|---------------|------------|---------------|------------|---------------|-----------|--------------|-----------|--------------|------------|--------------|
|              | RC                     | %            | SC         | %             | NP         | %             | Inf        | %             | Imp       | %            | Pre-Posed | %            | N          | %            |
| Aconsejó     | 1                      | (6.2)        | 7          | (43.8)        | 3          | (18.8)        | 5          | (31.2)        | 0         | (0)          | 0         | (0)          | 16         | (1.90)       |
| Deseó        | 0                      | (0)          | 2          | (11.8)        | 15         | (88.2)        | 0          | (0)           | 0         | (0)          | 0         | (0)          | 17         | (2.05)       |
| Encargó      | 0                      | (0)          | 2          | (13.3)        | 7          | (46.7)        | 6          | (40.0)        | 0         | (0)          | 0         | (0)          | 15         | (1.80)       |
| Impidió      | 0                      | (0)          | 0          | (0)           | 11         | (15.9)        | 58         | (84.1)        | 0         | (0)          | 0         | (0)          | 69         | (8.30)       |
| Ordenó       | 0                      | (0)          | 35         | (39.3)        | 1          | (1.1)         | 36         | (40.4)        | 8         | (9)          | 9         | (10.1)       | 89         | (10.70)      |
| Permitió     | 0                      | (0)          | 1          | (0.4)         | 18         | (6.4)         | 259        | (91.5)        | 0         | (0)          | 5         | (1.8)        | 283        | (34.00)      |
| Pidió        | 3                      | (1.4)        | 109        | (49.3)        | 64         | (29.0)        | 36         | (16.3)        | 6         | (2.7)        | 3         | (1.4)        | 221        | (26.50)      |
| Prohibió     | 0                      | (0)          | 1          | (2.4)         | 12         | (28.6)        | 29         | (69.0)        | 0         | (0)          | 0         | (0)          | 42         | (5.05)       |
| Propuso      | 2                      | (4.0)        | 8          | (16.0)        | 14         | (28.0)        | 22         | (44.0)        | 3         | (6)          | 1         | (2.0)        | 50         | (6.00)       |
| Rogó         | 0                      | (0)          | 12         | (80.0)        | 0          | (0)           | 0          | (0)           | 2         | (13.3)       | 1         | (6.7)        | 15         | (1.80)       |
| Sugirió      | 1                      | (6.2)        | 8          | (50.0)        | 3          | (18.8)        | 4          | (25.0)        | 0         | (0)          | 0         | (0)          | 16         | (1.90)       |
| <b>TOTAL</b> | <b>7</b>               | <b>(0.8)</b> | <b>185</b> | <b>(22.2)</b> | <b>148</b> | <b>(17.8)</b> | <b>455</b> | <b>(54.6)</b> | <b>19</b> | <b>(2.3)</b> | <b>19</b> | <b>(2.3)</b> | <b>833</b> | <b>(100)</b> |

**INFINITIVE > SENTENCE COMPLEMENT > RELATIVE CLAUSE** 26

## **OFFLINE SENTENCE COMPLETION STUDY**

- Three groups of participants:

Table 1. Individual Measures by Group from LHQ.

|                         | GROUP        |            |          | ANOVA    |
|-------------------------|--------------|------------|----------|----------|
|                         | Non-immersed | Immersed   | Heritage |          |
| N                       | 38           | 28         | 24       |          |
| Age                     | 23           | 29.21      | 19.13    | p < .001 |
| Proficiency in Spanish: |              |            |          |          |
| Speaking                | 9.45         | 9.32       | 6.92     | p < .001 |
| Reading                 | 9.47         | 9.25       | 6.50     | p < .001 |
| Understanding           | 9.66         | 9.46       | 8.17     | p < .001 |
| L2 Immersion            | --           | 7.18 years | 18 years | p < .001 |

Table 2. Individual Differences per Group from Experimental Tasks

|           | GROUP        |          |          | ANOVA      |
|-----------|--------------|----------|----------|------------|
|           | Non-immersed | Immersed | Heritage |            |
| DELE      | 43.61        | 40.75    | 26.26    | $p < .001$ |
| MELICET   | --           | 37.88    | 40.57    | $p = .115$ |
| LDT SCORE | 79.16        | 76.96    | 65.91    | $p < .001$ |
| BNT SCORE | 47.79        | 43.04    | 22.65    | $p < .001$ |

- Offline Sentence Completion Task:

16 experimental sentences + 48 fillers.

## **SENTENCES:**

Jacobo les **aconsejó** a sus vecinos que...

*Jacobo advised his neighbors to...*

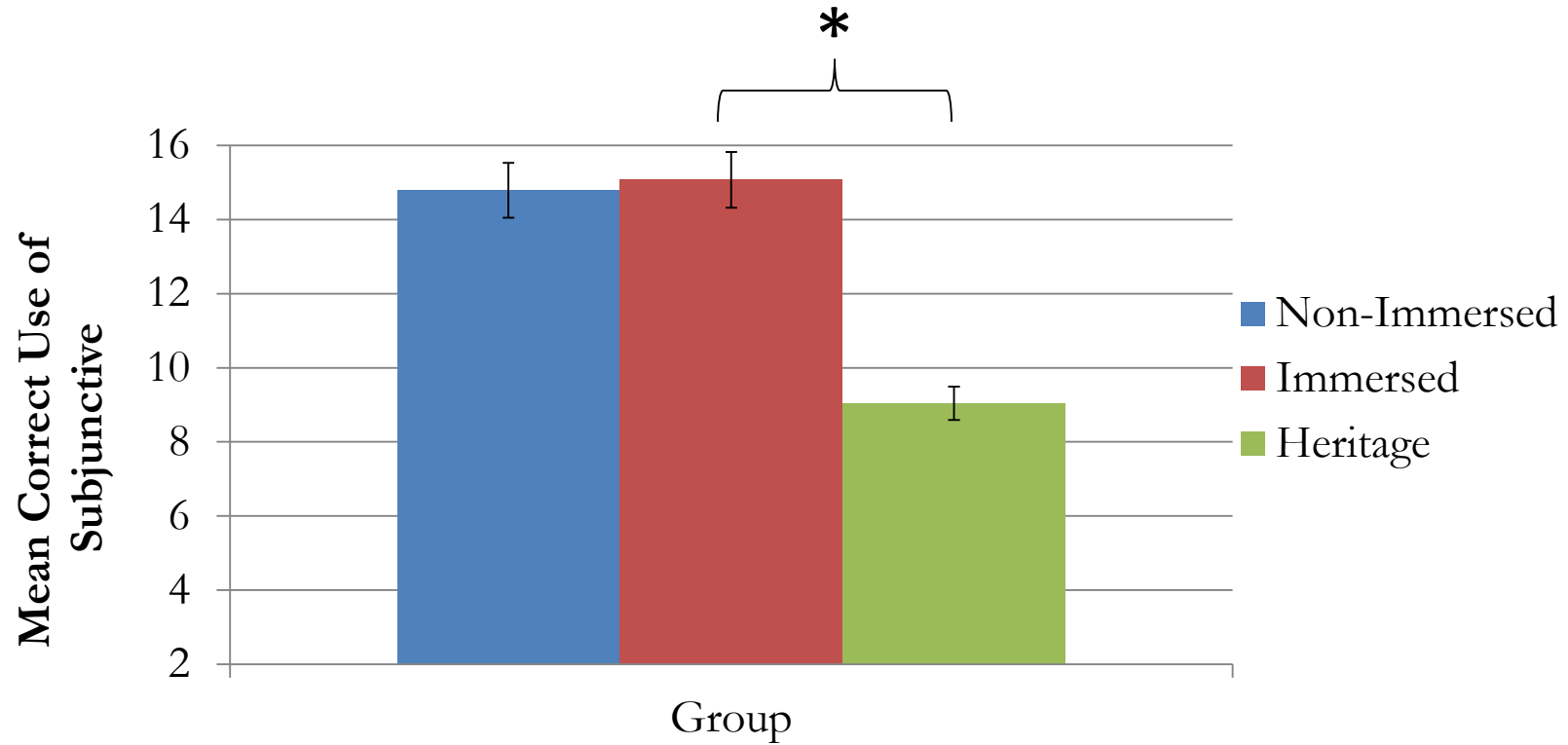
# HYPOTHESIS

If immersed and heritage speakers lose sensitivity to the mood morphology in Spanish, they will complete the experimental sentences with verbs marked in the indicative mood instead of the subjunctive mood.

If immersion does not play a role in production, no significant differences in production will be expected among the three groups.

- ANOVA with *score* as dependent variable and *group* (non-immersed, immersed, heritage) as between-subjects factor.
- **RESULTS:**
  - Significant difference in the amount of correct use of subjunctive across groups,  $F(2,86) = 34.14, p < .001$ .





- The Heritage group completed fewer sentences correctly in the subjunctive mood than the Immersed and Non-Immersed groups.

# CONCLUSION

- Heritage speakers produced more continuations using the incorrect mood morphology (indicative mood).
- These results replicate previous studies that show that heritage speakers are significantly different to monolingual speakers in the offline production of mood morphology.
- Possible explanations: attrition caused by immersion or incomplete acquisition.

# STUDY 2

## **ONLINE EYE-TRACKING STUDY**

- Same three groups of participants:

Table 1. Individual Measures by Group from LHQ.

|                         | GROUP        |            |          | ANOVA    |
|-------------------------|--------------|------------|----------|----------|
|                         | Non-immersed | Immersed   | Heritage |          |
| N                       | 38           | 28         | 24       |          |
| Age                     | 23           | 29.21      | 19.13    | p < .001 |
| Proficiency in Spanish: |              |            |          |          |
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| LDT SCORE | 79.16        | 76.96    | 65.91    | $p < .001$ |
| BNT SCORE | 47.79        | 43.04    | 22.65    | $p < .001$ |
| O-SPAN    | 34.84        | 40.32    | 35.55    | $p = .078$ |

## Indicative Condition

- MC** La fundación les permitió a los científicos  
**RC** que organizaron el simposio de física  
**SC** que publicaran una obra en memoria del fallecido.

*The foundation permitted the scientists  
who organized the Physics Symposium  
to publish a work in memory of the deceased.*

## Subjunctive Condition

- MC** La fundación les permitió a los científicos  
**SC** que organizaran el simposio de física **y**  
**SC** que publicaran una obra en memoria del fallecido.

*The foundation permitted the scientists  
to organize the Physics Symposium and  
to publish a work in memory of the deceased.*

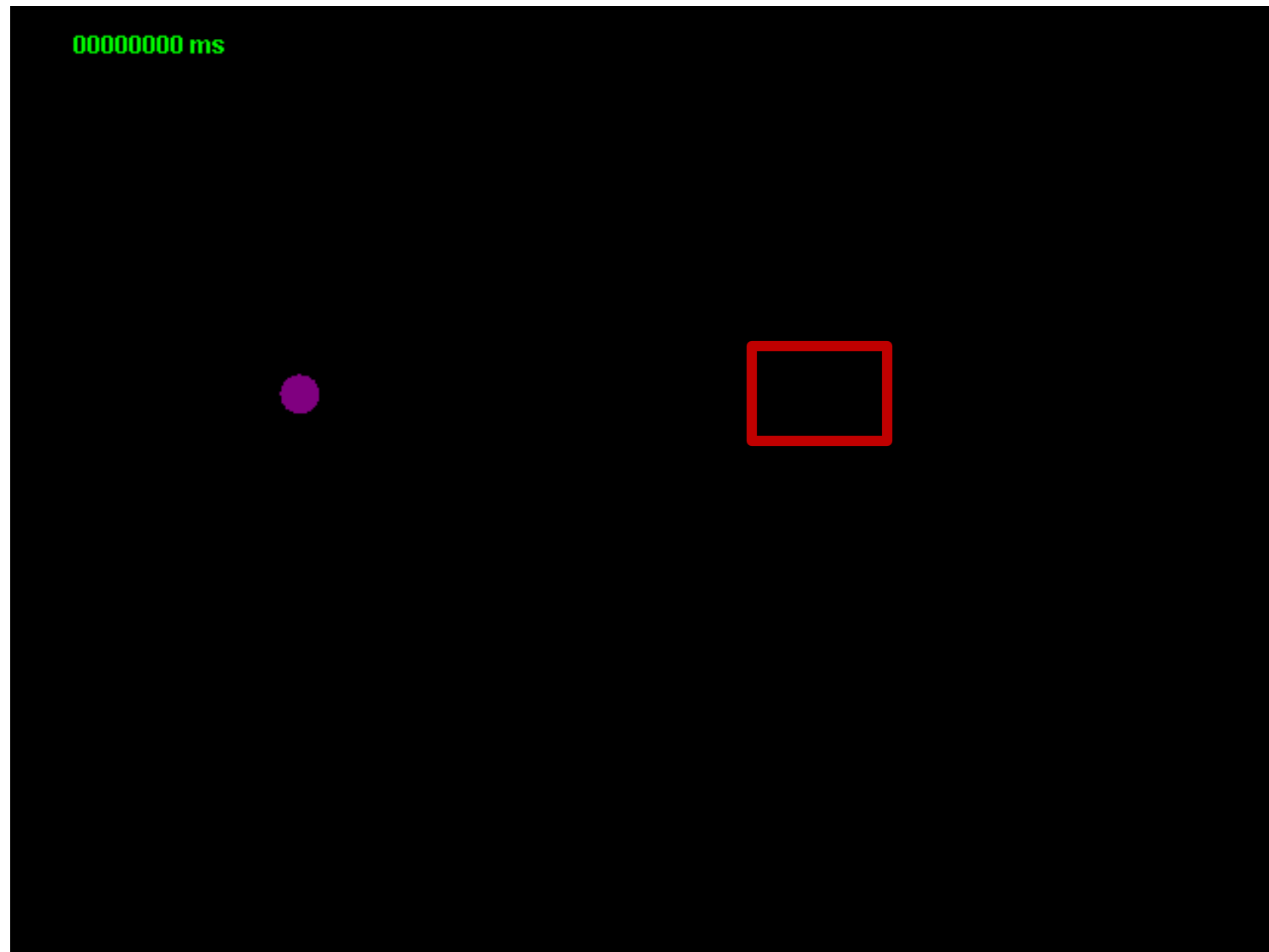
# HYPOTHESIS

Predicted information will be read faster than unexpected information.

La fundación les permitted a los científicos que organized/ran el simposio de física (y) que publicaran una obra en memoria del fallecido.

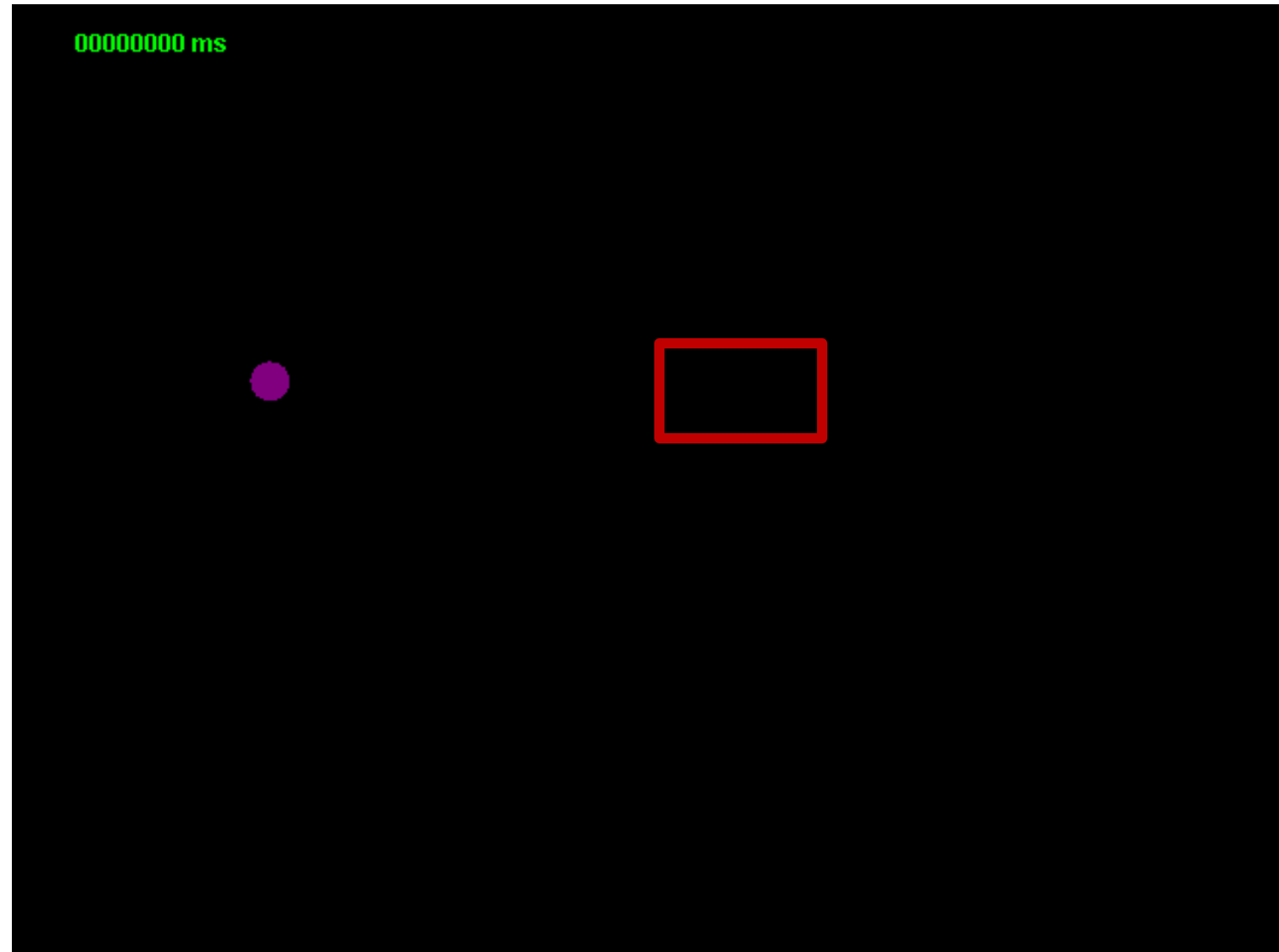
Reading Times: **Indicative** > **Subjunctive**

# HYPOTHESIS





# HYPOTHESIS



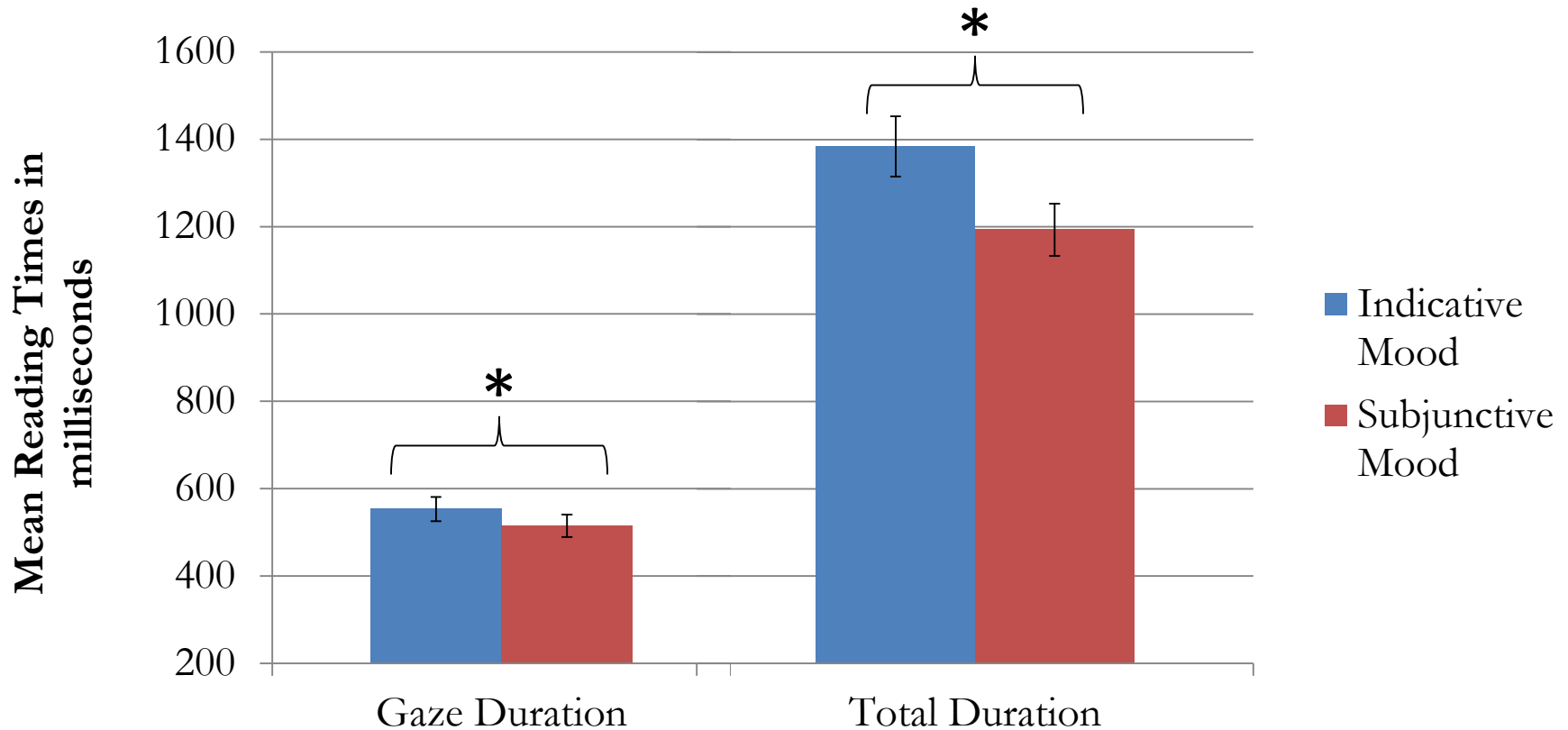
- Data collected with EyeLink 1000 eye-tracker.
- Two measures were extracted:

**Gaze Duration:** The total duration (in milliseconds) of all fixations in a word before the next word is read. Considered an **early measure** of processing.

**Total Duration:** The total duration of all fixations in a target region. Considered a **late measure** of processing.

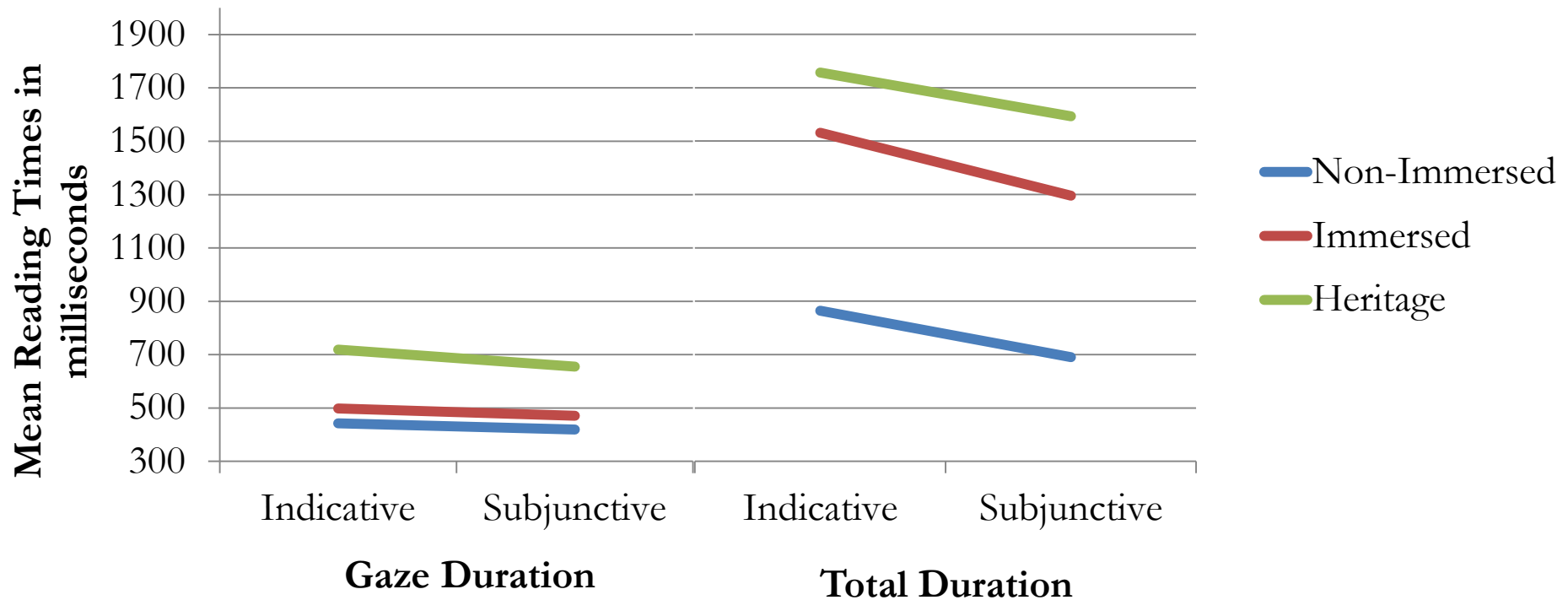
- Repeated Measures ANOVA with *clause type* (RC/SC) as within-subjects factor and *group* (non-immersion, immersion, heritage) as between-subjects factor in gaze and total duration.
- **RESULTS:**
  - Significant effect of clause type:
    - Gaze Duration:  $F(1,87) = 4.43, p = .038$
    - Total Duration:  $F(1,87) = 23.65, p < .001$
  - No interaction between clause type and group:
    - Gaze Duration:  $F(1,87) = .468, p = .628$
    - Total Duration:  $F(1,87) = .318, p = .729$

# RESULTS



- Participants took significantly longer to read the verb in the indicative mood than the subjunctive mood.

# RESULTS



- The lack of interaction shows that all three groups behaved similarly in the reading task.

# CONCLUSION

- Participants in all three groups behaved similarly.
- Heritage speakers were slower in processing the sentences.
- They used the lexical information of the main verb to predict the correct morphology at the first subordinate clause.
- The results suggest that immersion did not have an effect on comprehension of materials in this study.

1. Do non-immersed native speakers of Spanish use the lexically-encoded information of Spanish verbs to produce/process the subjunctive morphology of a subordinate verb?

Yes. Results show that the non-immersed group used the lexically-encoded information of the main verb to produce and to predict the subjunctive morphology of the subordinate verb.

2. Does immersion in the L2 affect the ability of native speaker of Spanish to produce/process the subjunctive morphology of a subordinate verb?

Yes and no. It affected the production in heritage (chance).

However, there were no differences between participants in the online comprehension task. All three groups took longer to read the verb in the indicative mood than the subjunctive mood.



- **Why did immersion not affect processing?**
- Dussias and Sagarra (2007) revealed changes of L1 attachment preferences in immersed L1 Spanish – L2 English speakers.

## Structurally different or Frequency of structure

(Putnam & Sánchez, 2013)

- Attachment preference:

El policía arrestó a la hermana de la criada que estaba enferma.

*The policeman arrested the sister of the servant who was sick.*

- RC/SC ambiguity:

La fundación les permitió a los científicos que organizaron/an el simposio de física que publicaran una obra en memoria del fallecido.

*The foundation permitted the scientists who organized the*

*Physics Symposium to publish a work in memory of the deceased.*

## Entrenchment and Resonance

(Unified Competition Model, MacWhinney, 2012)

- **Entrenchment:** The features in the heritage grammar may be entrenched. This can result in harder acquisition in the L2 but also, less variation in the L1.
- **Resonance:** It is possible to acquire those features with enough exposure to the L2 and that the features of the L1 change with extensive experience with the languages.

- **The subjunctive in Heritage speakers**
- Results suggest that:
  - features of the L1 could be entrenched in heritage speakers.
  - the heritage speakers read the verbs in subjunctive faster than the verbs in the indicative.
  - they had the distinction between the indicative and the subjunctive in their grammatical system.
  - they do not have incomplete grammars neither they have attrited representations of Spanish mood.

- **Incomplete acquisition?**
- Full incomplete acquisition would have resulted in no use of the subjunctive forms in production task and longer reading times for the subjunctive in comprehension.
- Partial incomplete acquisition could explain the production results, but not the results in the comprehension task.
- Results give no evidence of incomplete acquisition.

- **Attrition?**
- The presence of attrited features of the Spanish mood could explain the results in the production task but not the results in the comprehension task.
- Results give no evidence of attrition.

- Thus, these results bring a new perspective on the study of heritage speakers.
- It is possible that we are not getting the whole picture on linguistic representations by not looking into the online comprehension of heritage speakers.
- Yet, online and offline measures seem to provide different results. So... how can we explain these differences?
- It is possible that the differences reside in the cognitive processes used by the production and the comprehension systems.

- **Missing Surface Inflection Hypothesis:**

“According to the missing surface inflection hypothesis, L2 learners have intact functional projections, but errors stem from problems during production only (a mapping or processing deficit)” (Montrul, 2011)

“If bilinguals show deficits in production but not in the interpretation of these aspectual forms, then these results will indicate that production problems may just consist of an inability to map semantic features onto morpho-phonological material” (Montrul, 2002)

- **Model for heritage grammars:**

“Critically, what fluctuates in this process is neither the input nor the perfect acquisition of language on behalf of (sequential early bilingual) children; rather, what fluctuates is not the grammar per se but the levels of activation of the lexicon and the strength of the associations between functional, semantic and PF features” (Putnam & Sánchez, 2013)

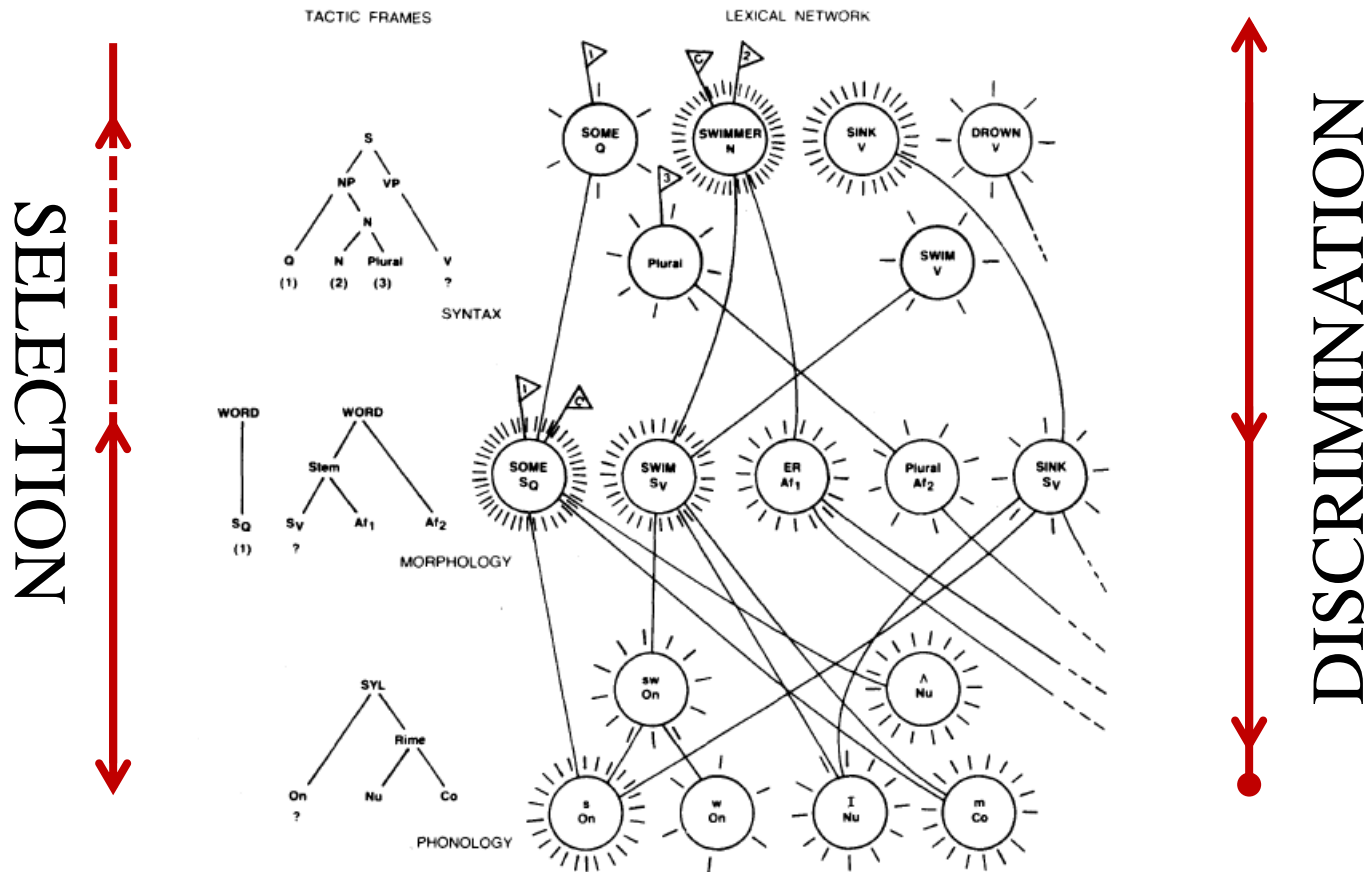


## Production/Comprehension Mapping Hypothesis:

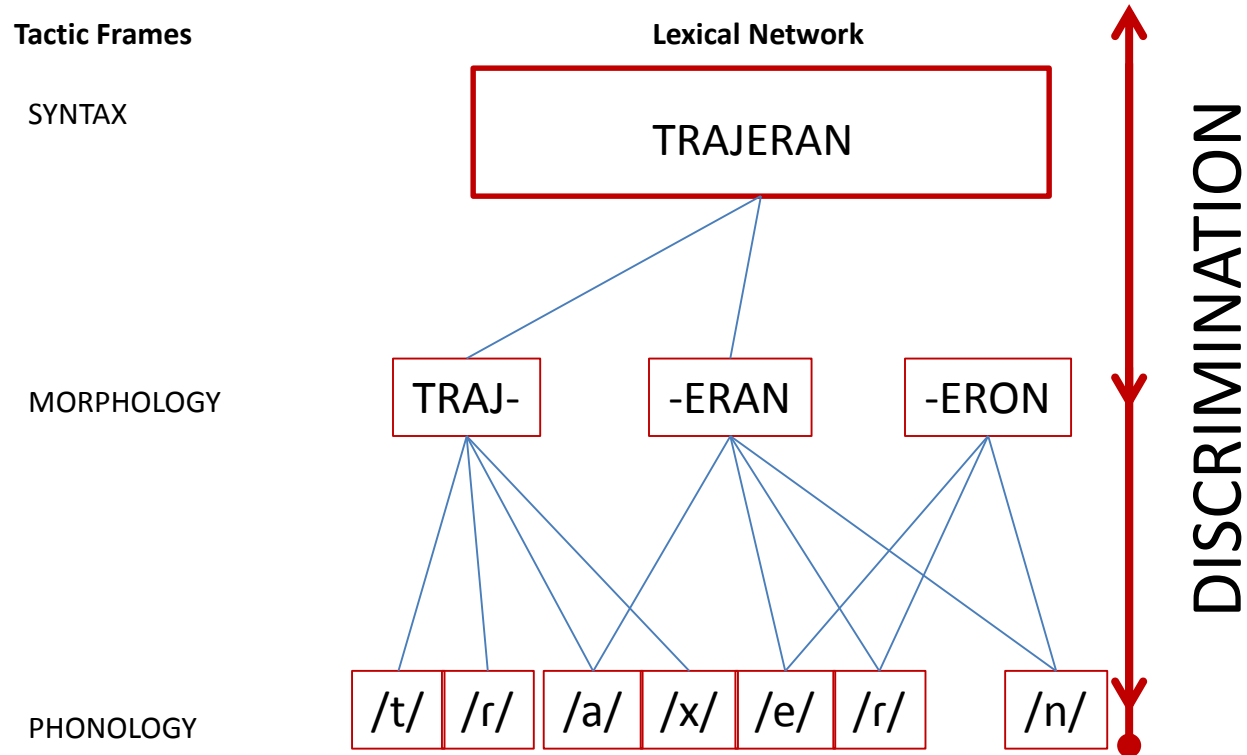
- Production and comprehension follow different cognitive processes.
- A **selection** process controls production whereas a **discrimination** process controls comprehension.
- Selecting a linguistic feature among all the linguistic features one has makes the mapping process more costly than rejecting the few possibilities that are given to us.
- This cost may lead to errors.
- Linguistic experience may activate the specific features of the language and, consequently, make the selection process easier.

# DISCUSSION

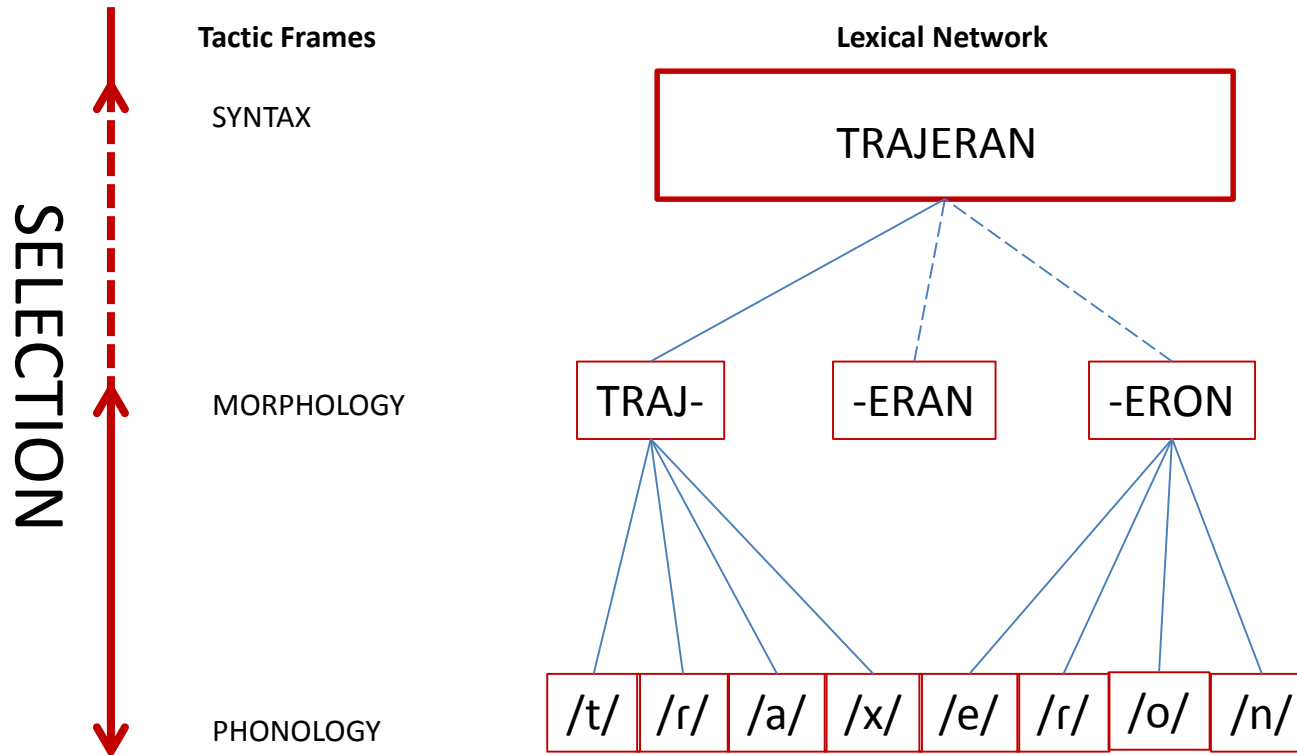
## Production/Comprehension Mapping Hypothesis



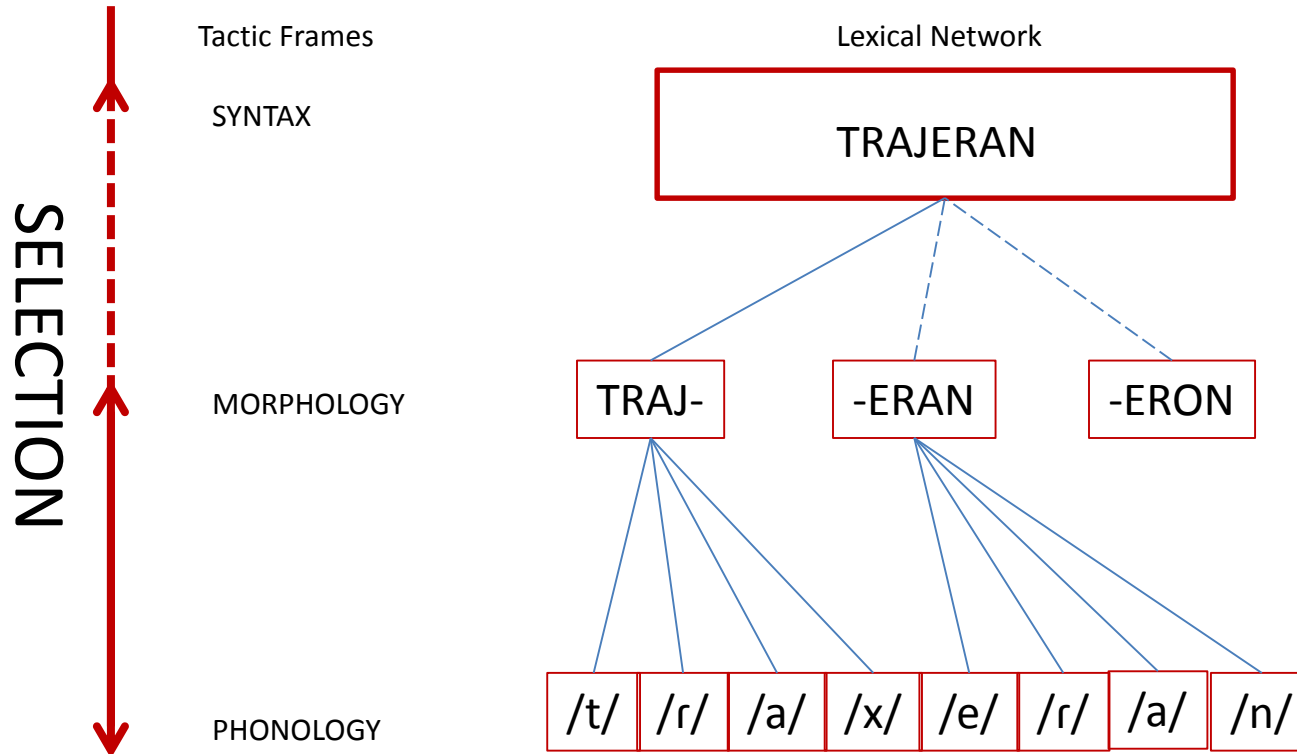
## Production/Comprehension Mapping Hypothesis



## Production/Comprehension Mapping Hypothesis



## Production/Comprehension Mapping Hypothesis



- Living in the L2 environment does not necessarily affect the L1 linguistic representations of bilingual speakers.
- Mood features can be entrenched in heritage speakers, even when they do not surface in production.
- **Production/Comprehension Mapping Hypothesis:** Production and comprehension follow different cognitive processes that can be affected by the linguistic experience of a speaker.

**Thank you!**

**¡Gracias!**

# What can an eye-tracker tell us about the linguistic knowledge of heritage speakers?

Álvaro Villegas

Workshop: Heritage Language Acquisition

LAVA: Language Acquisition, Variation & Attrition

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