16th MCI Symposium, Special Topic Workshop and Forum

The effects of bilingualism on verbal and nonverbal memory measures on Mild Cognitive Impairment (MCI)

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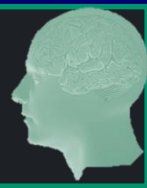
Alzheimer's Disease Research Center



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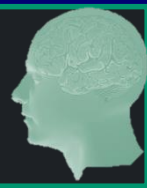

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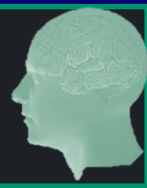
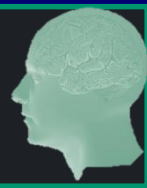
Background



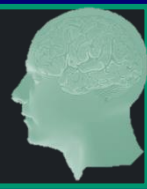
Keeping two languages active increases cognitive reserve among bilinguals and may delay the emergence of dementia (Fischer & Schweizer, 2014; Perani & Abutalebi, 2015).

Background



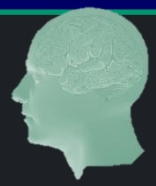
Executive control is the most prominent cognitive domain affording an advantage to bilinguals over monolinguals (Bialystok & Poarch, 2014; Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Ruocco, 2006; Bialystok, Craik, & Ryan, 2006; Bialystok, Craik, Green, & Gollan, 2009).

Background – Executive function



Typically, bilinguals show less interference than monolinguals in tasks with salient conflict, such as **the Simon task** (Bialystok et al., 2004; Salvatierra & Rosselli, 2010), **the Stroop task** (Bialystok, Craik, & Luk, 2008), and **the Flanker task** (Costa, Hernández, & Sebastián-Gallés, 2008).

Background – Executive function



The **cognitive advantage of bilingualism** has been mainly reported **in tasks of inhibitory control** (Bialystok, 2011), a basic process reflected in **the executive function construct** (Miyake et al., 2000; Jurado & Rosselli, 2007).

Background: possible explanation

- Active bilinguals have greater inhibitory control (IC), likely from the active monitoring two languages, involving: 1) **selecting** the correct language from two competing options, 2) **keeping one language** "on" and the other "off", and 3) continuously **switching** between both languages (Kroll, Bobb, & Hoshino, 2014).
- IC is acquired because bilinguals cannot simply "shut off" one language and function like monolinguals (Abutalebi & Green, 2007; Kroll, Dussias, Bogulski, & Valdés Kroff, 2012).

Background

- Keeping two languages active increases cognitive **reserve** among bilinguals and **may delay** the emergence of dementia (Fischer & Schweizer, 2014; Perani & Abutalebi, 2015).
- In bilinguals, dementia onset occurred an average **of 4.1 years later** compared to dementia onset in monolinguals (Bialystok, Craik & Freedman, 2007; Alladi et al., 2013; Woumans et al., 2015)
- Delays in cognitive decline have been associated to the **number of spoken languages** (Chertkow et al., 2010; Kavé, et al, 2008)

Background

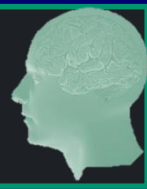
- Shared mechanisms for the delay in dementia onset among bilinguals and those with **higher education** (Chertkow et al., 2010; Gollan et al., 2011)
- The protective effect of bilingualism relates to **immigrant status:**
  - immigrant bilinguals had a 5-year delay in dementia onset, however, this advantage was not found in non-immigrant bilinguals (Chertkow et al., 2010).
  - Influence of bilingualism is not moderated by immigrant status. (Lawton, et al., 2015)

Background: Controversial bilingual effects

The bilingual advantage in cognitive processing and slower rates of **progression to dementia** are **controversial**

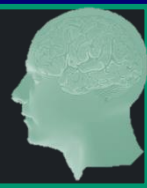
(Hilchey & Klein, 2011; Duñabeitia, Hernández, Antón, Macizo, Estévez, Fuentes, & Carreiras, 2014; Paap & Greenberg, 2013; for reviews see Calvo, García, Manoiloff, & Ibáñez, 2016; Paap, Johnson, & Sawi, 2015).

Background: Controversial bilingual effects



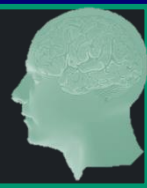
- Among 1067 Spanish–English-speaking elderly individuals tested over 23 years, memory and executive function were better in bilinguals at baseline, although rates of progression to dementia were equivalent in bilinguals and monolinguals (Zahodne et al., 2014).

Background: memory



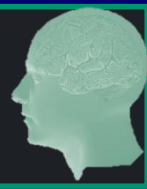
The potential bilingual advantage in abnormal aging is not well studied in other cognitive functions such as memory.

Background: memory



- Evidence confers bilingualism an advantage on **spatial working memory** (Luo, Craik, Moreno, & Bialystok, 2013; Kerrigan, Thomas, M. S. C., Bright & Filippi, 2017).
- **Verbal memory**: equivalent performance in bilinguals and monolinguals (Ransdell & Fischler, 1987) , although bilinguals were slower than monolinguals.

Background: memory



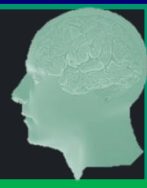
- Elderly bilinguals who acquired their second language in adulthood, performed significantly better in their eighth decade than was predicted from their baseline cognitive abilities at 11 years old, with the strongest effects observed on general intelligence, verbal fluency, and reading. **In memory**, the benefit of **early bilingualism** was noted only in the group **with high childhood intelligence** (Bak et al., 2014) .

The Current Study

Compare the performance of Spanish–English bilinguals to cognitively similar English and Spanish monolinguals on verbal and nonverbal memory tasks.

We focused on a cohort diagnosed with **aMCI** to investigate the effect of bilingualism on different cognitive domains among individuals with **presumed early-stage neurodegenerative disease.**

The Current Study: Aims



1. Evaluated the **impact of a quantitative index of bilingualism** on a **verbal memory** test which **promotes verbal interference and requires different levels of executive function**, in the form of inhibitory control, during the cued recall of semantically related information.
2. Explored the association of performance on memory scores from an inhibitory tasks (Stroop CW, on verbal memory.

LASSI-L 15 List A Target Words (three semantic categories)

Clothing, Fruits, Musical instruments

Free recall of List A Targets

Cued Recall of List A Targets (Cued A1)

After presentation, Second Cued Recall of List A Targets (Cued A2- maximum storage in STM)

Present List B targets

Free recall list B (proactive interference)

First Cued recall of List B (proactive interference)

Present list B targets again

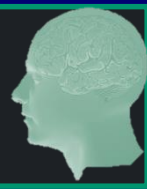
Second Cued recall of List B (B2Cued recovery from proactive interference)

Free recall List A (Free A3-retroactive interference)

Cued recall list A (Cued A3-retroactive interference)

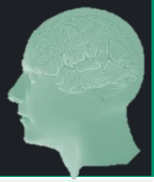
Delayed recall both lists

The Current Study: Aims



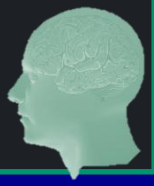
To examine the relationships between MRI measures of regional brain volumes and cognitive performance.

Method:
aMCI participants (N=67; 70% female)



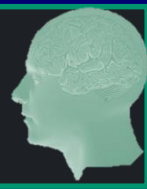
	Bilingual Mean (SD) N=42	Monolingual Mean (SD) N=25	F	p	$p\eta^2$
Age	72.02 (7.81)	73.60 (8.92)	.579	.449	.009
Years of education	14.76 (3.32)	14.58 (2.29)	.062	.804	.001
MMSE	26.41 (3.43)	26.36 (2.97)	.005	.944	.000
MoCA	20.19 (3.95)	20.48 (4.06)	.082	.775	.001
Block Design (raw)	28.76 (11.69)	27.36 (10.28)	.246	.622	.004
MINT total	24.82 (4.86)	26.82 (5.50)	2.24	.139	.035
Trails A Time (sec.)	82.14 (47.38)	63.12 (32.72)	.402	.528	.006
Stroop CW (raw)	27.86 (6.36)	25.57 (5.13)	3.02	.096	.050

Method: Language proficiency



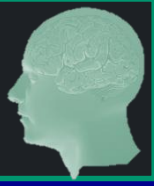
Level of Proficiency	Bilingual Mean (SD) N=42	English Monolingual Mean (SD) N=21	F	*p*	$p\eta^2$
Speaking English	7.31 (2.45)	8.65(2.38)	2.19	.144	.04
Understanding English	7.75 (2.16)	9.00(1.94)	4.37	.042	.08
Reading English	7.80 (2.19)	8.27(2.55)	0.50	.480	.01
Total English Proficiency	7.62 (2.22)	8.64 (2.22)	2.26	.138	.04
		Spanish Monolingual Mean (SD) N=4			
Speaking Spanish	8.84 (1.53)	8.25 (0.70)			
Understanding Spanish	9.47 (1.30)	9.00 (0.81)			
Reading Spanish	8.59 (1.86)	8.75 (1.25)			
Total Spanish Proficiency	8.86 (1.27)	8.66 (0.90)			

Method: Materials



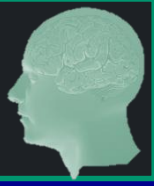
- **<u>Bilingual assessment</u>**: Language Experience and Proficiency Questionnaire (LEAP-Q) assesses self-rated measures of proficiency (Marian, Blumenfeld, & Kaushanskaya, 2007).
- **<u>Degree of bilingualism</u>**: dividing each participant's lower average LEAP-Q score (in either English or Spanish) by the higher average LEAP-Q score (in the other language) yielding a score between 0 (monolingual) to 1 (perfectly bilingual), (Gollan, Salmon, Montoya, & Galasko, 2011).

Method: Materials



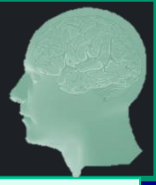
- **<u>Verbal Memory</u>:** Loewenstein-Acevedo Scales for Semantic Interference and Learning (LASSI-L).
- **<u>Nonverbal Memory</u>:** the Benson Figure Test, a simplified form of the Rey-Osterrieth Complex Figure measuring visuo-constructional and visual memory functions (Possin et al., 2011). It involves copying a figure and a 10-15-minute delayed recall, constructing the figure from memory.

Method: Materials



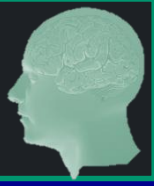
- **MRI measurements:** Forty-four aMCI subjects (18/25 monolinguals and 26/42 bilinguals).
- To assess volumes in AD's signature regions, **the hippocampus and the entorhinal cortex were examined.**

Results



Variable	Bilingual Mean (SD) N=42	Monolingual Mean (SD) N=25	F	*p*	$p\eta^2$
Verbal Memory					
LASSI-L					
Cued A2 (15)	**12.07 (2.4)**	**10.52 (3.1)**	**5.10**	**.02**	**.075**
Cued B1 (15)	6.27 (2.0)	5.96 (2.6)	.298	.58	.005
Cued B2 (15)	**9.30 (2.6)**	**7.96 (3.6)**	**4.57**	**.03**	**.065**
Delayed recall A & B (30)	14.45 (7.3)	12.56 (7.8)	.962	.33	.015
Nonverbal Memory					
Benson Figure Delayed recall (17)	7.25 (4.68)	6.33 (4.06)	.633	.42	.010

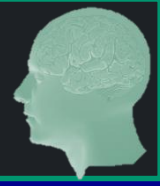
Summary of multiple regression analyses for bilingual and monolingual differences on memory tests



	LASSI-L Cued A2			LASSI-L Cued B2		
Predictors	B	SE B	β	B	SE B	β
Age	-.034	054	-.11	-.043	.051	-.132
Education	.175	.131	.24	.086	.124	.114
MoCA	.167	.139	.213	.386	.132	.470**
Degree of bilingualism	.322	1.94	.038	3.50	1.85	.308*
R^2	.177			.372		
F	1.77			3.84		
p	.157			.010		

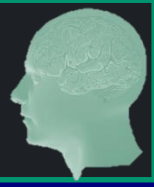
Note. *p < .05. **p < .01 (2-tailed)

Correlations between memory measures, Stroop-CW and MRI volumes in the monolingual group



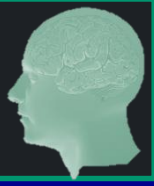
	A2 Cued	B1 Cued	B2 Cued	FDR A&B	FDR BF	CWS	LHV	RHV	LEV	REV
A2 Cued	**1.00**	**.830****	**.783****	**.864****	**.588****	**.558***	**.413**	**.433**	**.223**	**.482**
B1 Cued		1.00	.864**	.758**	.416*	.438*	.548*	.437	.198	.347
B2 Cued			**1.00**	**.705****	**.492***	**.396**	**.701****	**.502***	**.122**	**.360**
FDR A&B				1.00	.759**	.512*	.505*	.531*	.250	.519*
FDR BF					1.00	.422*	.563*	.467	.461	.485
CW Stroop						1.00	.262	.132	.056	.077
LHV							1.00	.684**	.257	.341
RHV								1.00	.284	.765**
LEV									1.00	.370
REV										1.00

Correlations between memory measures, Stroop-CW and MRI volumes in the bilingual group



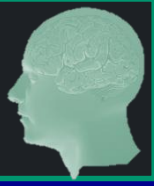
	A2 Cued	B1 Cued	B2 Cued	FDR A&B	FDR BF	CWS	LHV	RHV	LEV	REV
A2 Cued	**1.00**	**.438****	**.586****	**.816****	**.656****	**.264**	**.464***	**.190**	**.395**	**.317**
B1 Cued		1.00	.617**	.413**	.359*	.278	.064	.059	.319	.370
B2 Cued			**1.00**	**.705****	**.482****	**.435****	**.517****	**.473***	**.641****	**.625****
FDR A&B				1.00	.688**	.364*	.464*	.444*	.421*	.242
FDR BF					1.00	.076	.552**	.518*	.349	.442*
CWS						1.00	.203	.215	.316	.167
LHV							1.00	.841*	.438*	.344
RHV								1.00	.382	.307
LEV									1.00	.670**
REV										1.00

Conclusions



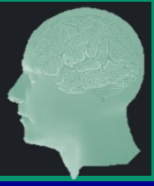
- **Superior performance** of aMCI bilinguals over aMCI monolinguals on **verbal memory**.
- Bilinguals outperformed monolinguals on two indices of the LASSI-L: **Cued A2** and **Cued B2**.
- In both groups, **significant correlations** emerged between maximum learning capacity (Cued A2) and left hippocampal volume, while the index that assessed recovery from proactive semantic interference (Cued B2) correlated with both right and left hippocampi in the bilingual group.

Conclusions



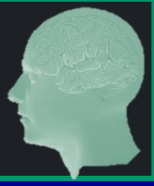
- Strong association between Cued B2 and bilateral entorhinal cortex values among bilinguals not observed on Cued A2.
- The LASSI-L cued recall procedure promotes the use of semantic clustering to maximize encoding.
- The cueing in Cued A2 helps to reach maximum store retrieval, and in Cued B2, the cueing helps to reach maximum store retrieval of a new list and to recover from PSI.

Conclusions



- The superior performance of bilinguals over monolinguals on these two tasks suggest that **bilinguals, perhaps by using two languages regularly, develop a different and possibly more efficient semantic association system** that influences verbal recall (Navarrete, Del Prato, & Mahon, 2012).

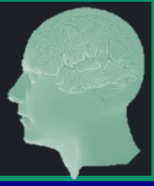
Conclusions



Other interpretations:

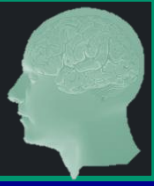
- Bilinguals, by having to control which language is active, **may develop more efficient task-monitoring and task-control mechanisms**, potentially influencing other cognitive tasks (Bialystok, Craik, & Luk, 2008; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009).

Conclusions



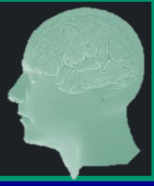
- The observed memory advantage for bilinguals in Cued B2 may imply the use of general mechanisms of cognitive control, resulting from the use of two languages.
- Cued B2 requires the cued recall of words from List B, which are semantically related to List A. The recall therefore also requires the inhibition of List A.

Conclusions



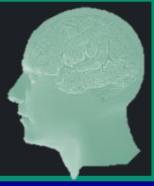
- Better performance in **the SCW was associated with better capacity to retrieve words using semantic cueing in Cued B2 in bilinguals** but not in monolinguals.
- However, in the monolingual group, this correlation was marginally significant, therefore we cannot rule out the importance of inhibitory control in the retrieval process of both languages groups.

Conclusions



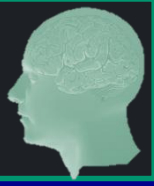
- **<u>Similar scores in the SCW between the two language groups seems to indicate similar degrees of inhibitory control</u>**.
- Future research should determine whether the active use of two languages influences the associations between inhibitory control and memory retrieval in cases of aMCI

Limitations



- The majority of the participants in the **monolingual group were English speakers**, and most **bilinguals chose to be tested in Spanish**. Therefore, language of evaluation could be a contributing variable.
- This **study is cross-sectional**, so the protective effect of bilingualism in memory tests was only evaluated across individuals at one-time point.
- **Unequal distribution** of males and females and of monolinguals and bilinguals in our sample.

Limitations



- Only **72% of monolinguals and 62% of bilinguals had MRI data available**.
- Due to the small proportion of the total variance in verbal memory tests associated with bilingualism, we used p values higher than .01 for significance. **Future studies** are required to confirm our findings, **using a larger sample**.

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16th MCI Symposium, Special Topic Workshop and Forum

THANK YOU VERY MUCH!

¡MUCHAS GRACIAS!