The interactive support of Cognitive Reserve and Semantic Knowledge in Proper Name retrieval

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Abstract

Cognitive reserve (CR) refers to acquired experience that modulates resistance to physiological aging or brain damage. A relatively neglected issue is whether or not CR affects cognitive abilities equally. One relevant component of CR seems to be the richness of connections in semantic knowledge.

We examined, in N=66 healthy older adults, the potential influence of CR and semantic knowledge on the ability to retrieve proper names and common nouns. These two name categories have different semantic organizations, whereby proper names are characterized by a weaker semantic link to the information they refer to.

Controlling for age, CR and semantic knowledge were linearly and positively associated with common noun retrieval. On the other hand, CR assisted proper name retrieval in older adults with a weaker semantic profile, while semantic knowledge assisted proper name retrieval in older adults with lower CR.

This study contributes to define the cognitive underpinnings of CR.

Keywords: cognitive reserve, semantic knowledge, proper names, common nouns.

INTRODUCTION

Cognitive reserve (Stern, 2009), the capital of knowledge and experiences individuals acquire over their lifespan, modulates the manifestation of age-related or pathological changes. Education, measured in years of schooling, has often been used as a proxy of CR. However, while education is important, it is only a component of CR and it is mostly acquired in school relatively early in life. It is now widely acknowledged that CR derives from a combination of education, occupational attainment, learning in different contexts, and additional life experiences including leisure activities (Fratiglioni et al., 2004; Garibotto et al., 2008; Livingston et al., 2017; Mondini et al., 2021; Nucci et al., 2012; Reed et al., 2011; Stern et al., 2018; Ward et al., 2015).

Evidence supports the notion that higher levels of CR, as measured by proxy variables reflective of lifetime experiences, are associated with better cognitive performance (Pettigrew & Soldan, 2019; Stern et al., 2018). From a clinical point of view, CR is important because it is believed to protect for some time from the effects of cerebral deterioration. High CR would allow the use of a larger and more effective repertory of compensatory cognitive strategies (Stern, 2009; Stern et al., 2018). In this way, CR would concur to find flexible solutions for day-to-day problems (Bhat, 2015) thus delaying the symptoms of decline.

An important and relatively unexplored issue is that the protection offered by CR does not appear to affect cognitive performance equally in all domains (Montemurro, Mondini, and Arcara 2021). In other words, it is still uncertain whether CR plays a beneficial role on all cognitive abilities irrespective of their nature. Recent research, indeed, seems to show that this may not be the case: while efficiency in most abilities, like attention, executive functions, working memory, and orientation, is directly and positively related to the amount of CR, evidence has been found that other abilities do not seem to be as sensitive (Lavrencic et al., 2018; Pettigrew & Soldan, 2019). For instance, Arcara and colleagues (2017) showed that CR (including education, working and leisure activities) does not predict aging performance in basic mathematical abilities (which were in fact predicted only by education; see also Zamarian et al., 2020). The reason for this result, may be that, in contrast to other contents of knowledge, basic math notions are specific and learned early at school in a systematic way.

What precisely makes a given cognitive task less sustainable by CR needs further exploring. The investigation of those cognitive functions that do not seem influenced by CR, still largely missing, may help answer this question, also providing the opportunity to better understand the cognitive underpinnings and limits of CR.

It is reasonable to think that a major component of CR is the strength and richness of connections in semantic knowledge. Knowledge of objects, word meanings, facts and people without connection to any particular time or place are essential in building up a semantic repository of information (Montefinese, 2019; Tulving, 1972). Learning experiences over the lifespan may contribute to a large share of one's semantic knowledge and this is true especially in aging, where, for example, a richer vocabulary may increase efficiency in accessing semantic knowledge (Juncos-Rabadán et al., 2010) and compensate for failures in retrieval of names. Semantic memory is resistant to age, at least compared to episodic memory (Nyberg et al., 1996; St-Laurent et al., 2011), and its interaction with CR is not clear yet (Paolieri et al., 2018). Interestingly, a sort of "semantic reserve" has been proposed, in which CR has been shown to have a stronger relationship with semantic abilities than with episodic memory and executive functions (Reed et al., 2011). What may make episodic memory less resistant to age than semantic memory is the fact that its content, unlike in the case of semantic memory, consists of relatively isolated chunks of information that hold together in an "episodic", thus accidental, non-systematic fashion. For this reason, associations in episodic memory would be much weaker than associations in semantic memory, where the organization in robust association

networks makes the content less prone to deterioration (e.g., Levine et al., 2002). The distinction between episodic and semantic memory has an analogous counterpart at the lexical level, where memory for proper names (PN) must be distinguished from memory for common nouns (CN). As explained below, memory for PN shares some properties with episodic memory.

Importantly for the present study, evidence is recently emerging that a domain where CR does not seem to protect against age or pathology, is indeed the retrieval of PN as opposed to the retrieval of CN (Delazer et al., 2020; Mondini & Semenza, 2016; Montemurro et al., 2018, 2019). What is it that makes memory for PN less sensitive to CR than memory for CN? The peculiarity of PN has been indeed the center of intensive debates for a long time.

It is widely agreed that PN retrieval is based on relatively poor and weaker connections within general semantic knowledge. This has been long underlined in the philosophical tradition (Frege, 1994; Kripke, 1972), which maintains that, unlike CN, PN are “purely referring expressions” and bear little, if any, description of their reference. Semenza and colleagues (1998) described this concept by observing that in the act of naming, names are either activated by attributes that have a high probability of being linked to one another, thus constituting a strong network in the case of CN, or activated by attributes that happen to be linked together incidentally only by virtue of belonging to entities that are unique in the case of PN. It would be this last peculiarity that makes the link between PN and its referent more weak and harder to retrieve. In psycholinguistics this difference has also been expressed by pointing out that, while CN have “type reference” and indicate categories, PN have “token reference” and indicate individual entities (Jackendoff, 1983).

Reflecting these different properties areas of relative specialization within the semantic system may exist for non-unique entities in contrast to unique entities like, for instance, individual persons or places. The theoretical models (e.g., Semenza, 2006, 2009) based on this distinction are supported by neuropsychological observations (Gentileschi et al., 2001; Kay & Hanley, 2002; Lyons et al., 2006; Miceli et al., 2000; Semenza et al., 1998). Thus single cases of PN anomia and their behavioral correlates have been described (Semenza & Zettin, 1988, 1989). These findings further suggested that relatively distinct semantic systems activate the lexicon independently and that this activation can be selectively impaired (Semenza, 2009).

Empirical evidence has also been provided (Brédart & Valentine, 1998; Brédart, 2017; Cohen & Burke, 1993; McWeeny et al., 1987; Pelamatti et al., 2003; Semenza, 2009; Semenza & Zettin, 1988, 1989) supporting the theory according to which what makes PN fragile is their lack of descriptiveness. Brédart and Valentine, (1998), for example, contrasted naming of pictures of well-known cartoon characters that had either descriptive names (e.g., Big Bird, Snow White) or nondescriptive names (e.g., Garfield, Charlie Brown). Nondescriptive names were found more difficult to retrieve.

Greater problems with PN have been singled out as one of the earliest signs of Mild Cognitive Impairment (MCI) and Alzheimer's disease (AD) (Delazer et al., 2003; Facal et al., 2016; Juncos-Rabadán et al., 2010, 2013; Semenza et al., 2003; Semenza et al., 1998). Even normally aging people have problems with PN retrieval: a vast literature on aging shows that older adults are particularly impaired in this task. Spontaneous complaints and formal investigations in psycholinguistics have revealed that in older adults memory for PN declines to an even greater extent than other types of memory (Burke et al., 2004; Gillian Cohen, 1990; Gillian Cohen & Faulkner, 1986; Cross & Burke, 2004; Feyereisen, 1997; Greene & Hodges, 1996; James, 2004; Maylor, 1990, 1997; Sunderland et al., 1986). In particular, some studies have found that the age-related increase in retrieval failures for PN is disproportionately greater than for other types of words or information (e.g., Burke, 1991; Evrard, 2002; James et al., 2008; Rastle & Burke, 1996; Rendell et al., 2005). Following Brédart and Valentine's (1998) suggestions, Fogler and collaborators (Fogler et al., 2010; Fogler & James, 2007) explored the

relationship between name descriptiveness and retrieval. They found that older adults were particularly impaired in retrieving nondescriptive names, thus confirming that what makes PN fragile is their lack of descriptiveness. Consistently, Montemurro and colleagues (2018, 2019) and Delazer and colleagues (2020) showed how PN retrieval is weakly related to CR in aging, and suggested that this finding should be attributed to PN having poor semantic interconnections.

The present study thus aimed to investigate in depth the hypothesis that richness and strength of semantic connections would be an important underpinning of CR as reported above. For the first time a measure of semantic abilities was taken along with measures of PN and CN retrieval and related to the amount of CR. Interestingly, Darby and colleagues (2017) have shown that in patients with MCI and AD the beneficial contribute of CR may depend on the semantic components of the cognitive task. However, the tasks that were used to establish this relationship were two lexical retrieval tasks: semantic fluency (animal names in a minute; a bad performance in this task has been related to the risk of developing into dementia - Williams-Gray et al., 2007) and the Boston Naming Test. Thus, semantic knowledge was measured through lexical aspects, without any measurement of conceptual abilities.

In our investigation, the estimation of CR involved a widely used composite measure of CR derived from education, working activities and leisure time activities (CRIq; Nucci et al., 2012). Semantic knowledge was assessed by measuring access to the semantic links between concepts by using the Pyramids and Palm Trees test. We predicted that the influence of CR would be modulated by the strength of these links. Memory for PN, because of their weaker links with the entities they refer to, was expected to be less directly related to CR and to semantic memory than memory for CN.

METHOD

Participants and Materials

Sixty-six healthy older adults participated in the study (44 females and 22 males), mean age 77.30 years (± 7.56) with mean education of 10.56 years (± 5.45). Their medical history showed no symptoms of major psychiatric disease or neurological impairment. They were administered, in a counterbalanced order, the Montreal Cognitive Assessment (MoCA), the Pyramids and Palm Trees test (PPT), the Cognitive Reserve Index questionnaire (CRIq), and the PN and the CN retrieval tasks.

For the MoCA, the PPT, and the name retrieval tasks, the total score was recorded: each point corresponded to an accurate response at each item of the task, thus the higher the score the better the performance on the tests.

The MoCA (Nasreddine et al., 2005) is a well-known and widely used screening test to evaluate the general cognitive status of older adults and assess their possible initial decline.

The Pyramids and Palm Trees Test (Gamboz et al., 2009; Howard & Patterson, 1992) measures the ability to access semantic information about pictures, necessary for the identification of analogies by conceptually linking two perceptually and functionally distinct entities. The PPT (Howard & Patterson, 1992) is a commonly used test of associative semantic knowledge comprising 52 items. Participants are shown a stimulus (e.g., a pyramid) and asked to match it to either of two images: a target (e.g., a palm trees) or a distractor (e.g., a fir trees). Participants were required to use their semantic knowledge to select the correct match. The PPT requires respondents to recognize each of the items presented and to retrieve, activate, and compare the corresponding semantic information to identify the matches.

The PN and the CN retrieval tasks (Montemurro et al., 2019) measure the ability to retrieve the names of well-known characters and the nouns of common objects. The set of pictures included in the PN retrieval task is made of 30 colored images of famous characters chosen from a variety of settings such as politics (e.g., Vladimir Putin, Angela Merkel) and movies (e.g., Sean Connery, Marilyn Monroe) and balanced across male/female, international/local characters. The set of pictures included in the CN retrieval task is made of 30 colored pictures balanced across living and non-living entities. The pictures of both the PN and CN retrieval tasks have been balanced on psycholinguistic rating scales, to obtain two tasks balanced on Difficulty, Age of Acquisition, and Familiarity.

The CRIq (Nucci et al., 2012) is a semi-structured interview. Its score is an estimation of cognitively stimulating life experiences and corresponds to the average of the three sub-scores, standardized and transposed to a scale with a mean of 100 and a standard deviation of 15; this standardized index of CR (i.e., CRI) is informative in both clinical and research contexts. CRI total score is grouped into three sections: CRI-Education, reflecting years of formal education; CRI-Working Activity, referring to the cognitive load and personal responsibility of an occupation combined with the number of years it has been carried out; and CRI-Leisure Time, reflecting frequency and amount of intellectual, social and physical activities (e.g., reading newspapers or books, playing music, participation in charitable activities, traveling, doing sports, etc.). Moreover, the CRI score includes items about life-long experiences that require a certain cognitive load (e.g., years of bank account management). CRI total score was entered in the analyses as it encompasses a wide range of life-experiences that concur in building up the amount of CR (e.g., Fratiglioni, Paillard-Borg, & Winblad, 2004).

The participants took part in the study voluntarily and written informed consent was obtained from all of them. The study was approved by the Local Ethical Committee of the School of Psychology of the University of Padova and conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Analyses

We performed a descriptive analysis considering the socio-demographic variables (Age, Education, CRI) and the cognitive scores of participants (MoCA, PN and CN, and PPT score). A Welch Two Sample t-test was carried out to compare participants' performance on PN and CN retrieval tasks.

Generalized Linear Models were used for the analyses (Hastie & Tibshirani, 1986). The dependent variable was the score on PN and on CN retrieval, entered in a continuous form. We first explored the data by including one predictor at a time in the models, then we analyzed the comparison among models. The independent variables entered in the models were Age, CRI, participants' score on the PPT, and Name Category (with two levels: PN and CN).

Pearson's correlation was performed between the predictors, CRI and PPT, before entering them in interaction with each other. Additionally, for a check of collinearity across predictors, we obtained the Variance Inflation Factor (VIF) associated with each variable.

Model 1 included Age of participants. Model 2 included Age and Name Category. Model 3 included Age and Name Category, with CRI and PPT representing the two variables of theoretical interest. Then, we tested Model 4, which included the factors of Model 3 and CRI and PPT as interaction terms. Finally, to test our research hypothesis we built Model 5, including all our variables of interest (Name Category, CRI and PPT) in interaction, while controlling for participants' Age. Age was kept constant to allow us to control for possible age-related effects on name retrieval performance. Especially in the more advanced Age stages,

retrieval was expected to be affected by age-related effects; this would allow us to reliably interpret the potential interaction among Name Category, CRI and PPT.

The models were compared to one another by means of the *lrtest* function, suitable for likelihood ratio test (Zeileis & Hothorn, 2002). The Akaike's Information Criterion (AIC; Sakamoto et al., 1986) was used to check model plausibility. AIC estimates the relative amount of information lost by a model: the less information a model loses (i.e., the lower the AIC value), the higher the quality of that model. We reported the estimated coefficient (*B*), the standard error (*SE*), *t* values, Chi-square and p-values for the parameters included in the models. The statistical analyses were performed in R version 3.3.1 (2016-06-21; R Core Team, 2018).

RESULTS

Five participants were not included in the within-group analysis, as their scores on the MoCA test were below the cut-off of the Italian normative data (Conti et al., 2015). All participants included in the analyses fell within the non-clinical population. For a description of the demographic characteristics of participants, see Table 1.

Table 1. Descriptive statistics of the group of healthy older adults assessed for the study.

The table reports a description (in terms of MEAN, SD = standard deviation; MIN = minimum value; MAX = maximum value) of socio-demographic variables like Age, CRI = Cognitive Reserve Index), and of cognitive variables, like the MoCA = score obtained on the Montreal Cognitive Assessment and the Proper and Common name retrieval tasks.

	MEAN	SD	MIN	MAX
Age	73.3	7.76	65	98
Education	10.56	5.56	3	21
CRI	116.36	27.56	67	172
MoCA (/30)	23.84	4.05	14	30
Pyramids and Palms Trees (/52)	47.52	5.35	29	52
Proper Names (/30)	17.22	8.77	0	30
Common Nouns (/30)	20.09	6.59	3	29

A Welch Two Sample t-test showed PN as significantly more difficult to retrieve than CN ($t = 2.07$, $p = 0.04$; Cohen's $d = 0.37$). As expected, Pearson's correlation analysis showed, that cognitive variables correlated with each other: PN and CN ($N = 66$; $r = 0.77$; $p < 0.001$), PN and PPN ($N = 66$; $r = 0.48$; $p < 0.001$), and CN with PPN ($N = 66$; $r = 0.71$; $p < 0.001$). Pearson's correlation also revealed that PPT and CRI were correlated ($N = 66$; $r = 0.51$; $p < 0.001$), but no harmful collinearity was observed between them (CRI, VIF = 1.50; PPT, VIF = 1.46), and with Age (VIF= 1.25), as predictors considered in the models.

The comparison among models computed with AIC showed the best model fit for Model 5, which explained our data significantly better than Model 4 ($\chi^2 = 14.03$, $p = 0.007$) (see Table 2). Model 5 showed a statistically significant effect of Age on name retrieval ($B = -0.45$; $SE = 0.06$; $t = -7.47$; $p < 0.001$), and, importantly, a significant interaction among Name Category, CRI, and PPT. The main effect of Age in the model of interest, Model 5, indicated that the worst naming performance occurred at the oldest Age (Figure 1).

Table 2. Description of the models used for analyses and results of model comparison.

The table reports a description of the variables entered in the multiple regression models. The Akaike Information Criterion (AIC) is a single score that can be used to determine which of multiple models is most likely to be the best model for a given dataset: the lower the AIC, the better the model fit. Likelihood Test is expressed in terms of Chi-square and p-value associated to it. NAM_CAT (i.e., Name Category) = factorial variable with two levels: Proper Names and Common Nouns; CRI = Cognitive Reserve Index, PPT = Pyramids and Palm Trees test.

		Akaike Information Criterion (AIC)	Likelihood Test	
			Chi-square	<i>p-value</i>
Model 1	AGE	814.84	75.78	<0.001
Model 2	AGE + NAM_CAT	810.63	6.21	0.01
Model 3	AGE + NAM_CAT + CRI + PPT	765.26	49.36	<0.001
Model 4	AGE + NAM_CAT + CRI:PPT	763.06	4.21	0.04
Model 5	AGE + NAM_CAT:CRI:PPT	759.23	9.83	0.02

Figure 1. The effect of Age on Name Retrieval in healthy older adults shown in the best model fit (Model 5).

The variable Age was entered in all the regression models, as important variable to consider when addressing name retrieval. In the model of interest and the best fitting one (Model 5), Age showed a significant effect on name retrieval. On the X-axis the Age in years units. On the Y-axis = the raw scores on the name retrieval tasks. Confidence Interval level set to 95%.

Model 5 showed a statistically significant effect of Name Category ($B = -81.10$; $SE = 32.77$; $t = -2.47$; $p = 0.014$), with participants' performance being worse in PN than CN retrieval. The main effects of CRI ($B = -0.21$; $SE = 0.23$; $t = -0.09$; $p = 0.928$), the main effect of PPT ($B = 0.31$; $SE = 0.50$; $t = 0.61$; $p = 0.540$) and their interaction were not significant ($B = 0.00$; $SE = 0.00$; $t = 0.32$; $p = 0.751$). Instead, we found significant interactions between Name Category and CRI ($B = 0.88$; $SE = 0.32$; $t = 2.71$; $p = 0.007$) and between Name Category and PPT ($B = 1.48$, $SE = 0.68$, $t = 2.15$, $p = 0.033$). A sensitivity power analysis (G*Power 3 software; Faul et al., 2007) showed that a sample size of 66 participants was large enough to provide a power of 0.8 to achieve a statistically significant effect ($\alpha = 0.05$) and a medium effect size ($f^2 = 0.12$, $df = 61$).

The interaction between Name Category and CRI indicated a strong positive relationship between CRI and PN retrieval, while the interaction between Name Category and PPT indicated that there was a stronger positive relationship between semantic knowledge and CN retrieval compared to PN (see Figure 2).

Figure 2. Pyramid and Palm Trees scores and Name Retrieval of PN and CN.

The figure depicts the significant different relationship between PN (Proper Names) and CN (Common Nouns). On the X-axis, the PPT = Pyramid and Palm Trees test score is represented. On the Y-axis = the score on the name retrieval tasks. Confidence Interval level set at 95%.

Importantly for the purpose of the study, results showed, controlling for Age, a significant three-way interaction among Name Category, CRI, and PPT ($B = -0.01$, $SE = 0.006$, $t = -2.53$, $p = 0.012$), indicating an interaction between CRI and PPT in older adults' performance that was higher for PN rather than CN retrieval. This result remained significant in an additional analysis when the interaction between CRI and PPT was entered in two distinct models (with the two noun categories entered separately). For visualization purposes, the interaction between the two continuous variables (CRI and PPT in Figure 3) CRI was divided in three levels: twelve participants were in the first CRI level, twenty-three were in the second CRI level, and thirty-one in the third CRI level. We inspected Model 5 by exploring the statistical effect of CRI on PN, both when CRI was between 117.6 and 140 and when it was over 140, and PN retrieval was consistently better as CRI increased.

In particular, the pattern of the three-way interaction between CRI, PPT and Name Category found in Model 5 suggests that higher values of CRI predicted better PN retrieval when PPT was in the lower range, whereas when CRI is low, higher values of PPT predicted better PN retrieval; moreover PPT did not significantly impact on PN retrieval in participants with higher CRI levels (the green and blue lines on the left panel of Figure 3). By contrast, in the case of CN retrieval, high PPT and high CRI were jointly required for a better performance.

Figure 3 shows the main result of the study: the statistical interaction effect between cognitive reserve (CRI) and semantic knowledge (PPT), which interplayed in a complex way in the retrieval of PN: CR seemed to exert a greater support on PN retrieval in older adults with weaker semantic profile (low PPT), while semantic knowledge seemed to exert a greater support on PN retrieval in older adults with lower CR. The graph is correctly interpreted in terms of interaction between the two continuous variables. Table 3 includes an additional description of the three CRI levels depicted in Figure 3.

Figure 3. Interaction effect between Cognitive Reserve Index, Pyramid and Palm Trees scores and Name Category. PN = Proper Name retrieval task; CN = Proper Name retrieval task. On the X-axis the PPT score = Pyramid and Palm Trees test score. On the Y-axis = the scores on the name retrieval tasks. Colored lines indicate different levels of CRI = Cognitive Reserve Index. Confidence Interval level set to 95%. CRI was centered over quartiles (lower, median and upper) of the distribution for a better interpretation of the interaction (SjPlot package in R).

Table 3. CRI levels: description of the three levels of CRI

Additional analysis characterizing the three CRI levels. CRI = Cognitive Reserve Index as derived from the Cognitive Reserve Index questionnaire. The rows report the values of Age, Education and PPT (Pyramids and Palm Trees test) score.

	High CRI level 13 women, 18 males		Medium CRI level 8 women, 19 males		Low CRI level 5 women, 7 males	
	Mean	SD	Mean	SD	Mean	SD
Age	74.21	5.05	77.82	6.45	84.33	6.06
Education	16	2.98	9.16	4.04	4.51	1.16
PPT	51.58	0.46	47.04	4.11	41.83	6.52

DISCUSSION

In this study, we intended to investigate the different role of CR, estimated through a life-experience proxy, and of semantic knowledge, measured with a test targeting conceptual semantic abilities, in modulating PN and CN retrieval in older adults at different ages. Some of our results are consistent with the previous literature insofar as they confirm what has been known for some time, that is, that PN are harder to retrieve than CN. Indeed, our best fitting model shows that as a person's age increases their name retrieval ability declines, in line with the literature reported in the Introduction.

Previous studies have shown that CR (estimated through education) can be associated with semantic abilities (Darby et al., 2017). In aging, the ability to retrieve PN and CN was related to the potential modulatory contribute of CR (Delazer et al., 2020; Montemurro et al., 2018, 2019) on cognition. Based on this premise, we investigated to what extent CR and semantic knowledge may be interconnected.

Previous studies did not include a measure of semantic knowledge. The novel crucial finding of our research is a positive relationship of semantic knowledge (measured with PPT) with CR (measured with CRIq), indicating, in line with recent evidence (Paolieri et al., 2018), that CR may be partially sustained by semantic memory. This finding is highlighted by the results of our best fitting model, in which we studied the interactive contribute of CR and semantic knowledge on PN and CN retrieval. The model revealed that CN are supported more than PN by semantic knowledge, consistent with the idea that PN are purely referring expressions (e.g., Burke, 1991; Semenza, 2009; Semenza & Zettin, 1989).

Importantly, our results show that CR and semantics are not related to PN retrieval in a simple way, unlike what happens for CN. CN retrieval benefitted from the combined contribute of high CR and high semantic knowledge (PPT) while PN retrieval did not. In fact, PN retrieval was supported by high CR indices in the case of low semantic abilities. Conversely, PN retrieval was supported by high semantic abilities in case of low CR indices. This finding is consistent with the literature showing that the effects of CR may depend on the characteristics of the task (Ansado et al., 2013; Arcara et al., 2017; Montemurro et al., 2021).

As a measure of semantic knowledge, PPT might not have captured all its aspects, and other semantic tests, for instance category judgments, may yield different outcomes. However, it is noteworthy that our results indicate that the knowledge that sustains CR could extend beyond the strength of stored semantic relationships. They also indicate that CR may encompass knowledge less formally organized in memory, likely helped by an episodic memory component as well, in line with recent findings (Pitts et al., 2021). Facts about famous characters' life events could, to some extent, positively contribute to the compensatory role of CR (thus facilitating PN retrieval in older adults). We did not measure the strength of episodic memory of our participants, but this should perhaps be considered in future research. In other words, material learned in an episodic fashion may be of help with PN when semantic memory is weak. This is in line with Martins et al.'s (2010) previous findings, where PN have been proposed as able to carry episodic information about their reference.

The present study not only confirms the potential modulatory CR contribute on name retrieval, but also that such effect is not clear-cut across name categories. Moreover, our study provides new insights on the nature of CR insofar it contributes to elucidating the relationship of CR with the strength of links between concepts. This seems a significant step forward in furthering the understanding of the cognitive underpinnings of CR.

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