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Cognitive Reserve and Its Effect in Older Adults on Retrieval of Proper Names, Logo Names and Common Nouns

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Previous studies showed that high Cognitive Reserve (CR, years of education and experience and knowledge acquired in life) is correlated with language proficiency as measured with vocabulary size, verbal analogy, and semantic processing. The aim of the present study is to investigate the relationship between CR and the ability in retrieving different categories of words: Proper Names, Logo Names, and Common Nouns. The hypothesis is that CR contributes more in retrieving Common Nouns and Logo Names which are highly semantically interconnected, than retrieving Proper Names which are pure referring expressions. Forty-six Italian healthy older adults underwent the Montreal Cognitive Assessment (MoCA) and their performances spanned from low to high global cognitive profile. They were also administered a picture naming task for Proper Names, Logo Names and Common Nouns. Latency and Accuracy were recorded. CR was measured with the Cognitive Reserve Index (CRI) questionnaire which provides a measure of education, working time activities, and leisure time activities. Participants were significantly faster and more accurate in name retrieval when CR was high. CRI and MoCA as interaction terms predicted naming Latency with a stronger effect of CRI when the global cognitive profile was in the low range. The effect of CRI on Accuracy was lower for Proper Names than for Common Nouns and Logo Names, which did not differ from each other. Our results show that name retrieval Accuracy can be predicted by CR, significantly more in the case of Logo Names and Common Nouns than in the case of Proper Names. As Proper Names have scarce semantic interconnections and are arbitrarily assigned to unique individuals, they are not much influenced by CR. Although Logo Names are also arbitrarily assigned to their bearers, they can be conceptually categorized and thus influenced by reserve. The weak relationship between Proper Names and CR might suggest a proper name task as a useful tool to detect early signs of dementia, in particular for persons with high CR.

Keywords: proper names, common nouns, logo names, cognitive reserve, aging, naming

INTRODUCTION

Exposure to education, working activities and leisure time activities converge into a broader concept called "Cognitive Reserve" (CR) with a protective effect on cognitive functioning. CR mediates between a brain pathology and its clinical outcomes (Stern, 2006, 2012), so that people with high CR may achieve the ability to cope with age-related brain changes, thus delaying the symptoms of dementia (Scarmeas et al., 2001). In the case of globally healthy conditions, CR can provide flexibility in network selection, as it is characterized by networks developing over the lifespan as the result of innate processes (Barulli and Stern, 2013). Previous studies have shown that when the task demand increases, healthy adults recruit more brain networks (Ansado et al., 2013); thus, the load of a cognitive task is as relevant as the integrity of the global cognitive status. The relationship between CR and different types of tasks has shown that older adults with higher CR have a better performance in memory (Erber and Szuchman, 1996), in executive functioning tasks (Roldán-Tapia et al., 2012), as also in language tasks (Hultsch et al., 1993), compared to older adults with lower CR.

We want to investigate whether the CR of older adults and their global cognitive profile could act as predictors of name retrieval performance. Previous studies have already investigated name retrieval in aging, showing significant age-related effects (Rastle and Burke, 1996; Almond and Morrison, 2017). In this context, Almond and Morrison (2017) compared young and older adults in two experimental tests, involving the retrieval of proper names: (1) a face-name association task and (2) a pure-list task. Their results showed evidence of age-related deficits in the face-name association task, which however was claimed to be not highly sensitive for assessing age-related name recall deficits. In their study, however, names and faces used were not famous, either familiar (i.e., participants were instructed to learn names associated to new faces). For assessing name retrieval of familiar faces, some other researches have considered very famous people from local and international cultural settings (e.g., political figures, famous actors, religious figures, etc.), widely known outside their specific domain of fame (e.g., Semenza et al., 2003; Montemurro et al., 2018). In fact, persons with name retrieval deficits can find difficult to retrieve names of entities they know since long time.

Failure in name retrieval is one of patients' main subjective complaints, especially in the case of proper names (Cohen and Burke, 1993). Although deficits in picture naming task can be expected in the later stages of aging (see Feyereisen, 1997), cases of earlier name retrieval deficit are often reported, especially for the category of proper names (Greene and Hodges, 1996; Semenza et al., 2003). Whether CR can modulate proper name retrieval is a relatively recent question (Mondini and Semenza, 2016; Montemurro et al., 2018), which we want to address considering also the global cognitive conditions.

Another research question is to evaluate whether different cognitive processes are diversely sensitive to CR. In fact, it seems that the beneficial effects of high CR do not necessarily help performance in all cognitive tasks; for example, math performance has been shown to be independent from the level of CR in older adults from 65 years old (Arcara et al., 2017).

In order to make a timely diagnosis of dementia, it is important to identify early signs of decline also in patients whose symptoms may be masked by high-level CR (Robertson, 2013). Semenza et al. (2003) have shown that one of the first signs of Alzheimer's dementia can be proper name anomia. However, Mondini and Semenza (2016) and Montemurro et al. (2018) have later reported that proper name retrieval is hardly related to CR.

Mondini and Semenza (2016) analyzed the performance of 40 mildly cognitive impairment patients and first showed that, whereas CR was positively correlated to better global cognitive profile as assessed by the MMSE, CR did not predict name retrieval of famous people in a paper pencil task (Semenza et al., 2003). Authors interpreted this finding as due to the arbitrary link between proper names and bearers. Montemurro et al. (2018) further investigated this phenomenon with a more controlled experimental setting. They used the Italian version (Conti et al., 2015) of the Montreal Cognitive Assessment (MoCa, Nasreddine et al., 2005), which is a more sensitive measure of global cognitive profile, in two groups of participants: healthy elderly and patients with dementia. The correlation between CR and global cognitive profile was confirmed (in patients), while CR did not play any role in naming famous faces in both patients and healthy elderly. This restated the hypothesis of a weak effect of CR in naming proper names due to their poor interconnections in the semantic system, although a preserved cognitive profile. However, in both these studies, only the proper name category was tested, and both used a paper-and-pencil task (Semenza et al., 2003). The present study includes, instead, some novelties: the experimental paradigm is computer-based which is more precise and suitable for stimulus control and repeated measure analysis (Maruish and Moses, 1996). Furthermore, we included a set of Common Nouns and the captivating category of Logo Names.

Darby et al. (2017) showed that patients with Alzheimer's dementia and patients with mild cognitive impairment could benefit from CR in those tasks that require the involvement of executive and semantic functions. The semantic requirement might explain the weak relationship between CR and proper names (Montemurro et al., 2018). Indeed, semantic operations necessary for naming proper names may, at some point of the retrieval process, be different from naming other categories of names. In contrast to common nouns, proper names denote individual entities, and the set of attributes labeled by a proper name are related to one another only by virtue of belonging to unique entities (Semenza, 2009). In this context, different ways of possessing reference might be reflected in different mechanisms of semantic memory: "individual semantics" may refer to proper names, whereas "general semantics" to common nouns (Semenza, 2009).

The theoretical distinction between proper names and common nouns has a long history (e.g., Searle, 1969; Kripke, 1980). These philosophers described the linguistic properties of proper names defining them as expressions which convey reference but not sense. Later, a series of experimental studies contributed to this issue (e.g., Gorno-Tempini et al., 1998; Evrard, 2002; Pelamatti et al., 2003; Semenza, 2006, 2009), reporting disproportionate age-related problem in lexical access to proper names compared to common nouns, especially in production (Brédart et al., 1997). For example, the study of Evrard (2002) showed that healthy elderly compared to younger adults may experience more tip-of-the-tongue states for proper names than for common names. In contrast to common nouns, whose attributes are linked with each other in rich semantic interactions, the link between proper names and their bearers has been considered weak (e.g., Semenza and Zettin, 1989; Burke et al., 1991; Semenza, 2009).

It is well known that proper names possess particular linguistic features, as do brand names (Gontijo et al., 2002), which can also be very familiar, due to people's exposure to commerce and advertising communication. Logo names, a type of brand name, are arbitrarily assigned to products, companies or associations and sometimes acquire popularity. They do not designate unique entities and can be conceptually categorized, similarly to common nouns (Gontijo et al., 2002). Both proper names and some logo names can be considered, at the level of retrieval, pure referential expressions; however, logo names (similarly to common nouns) are generally more related to semantic facts (i.e., repeated and shared knowledge) rather than to episodic facts (i.e., facts related to individual episodic experience with the bearer). In other words, some logo names become very common in our social environment so that they can be conceptually categorized (Gontijo et al., 2002); for example, saying "Mercedes" while looking at its logo, may recall not only car-specific features, but also various models of the same car, which may have different engine powers, different colors, etc.

In the present study we examine, in terms of Latency and Accuracy, the effect of CR on name retrieval in a group of healthy older adults. Assuming a differential semantic interconnection between nouns and bearers, our hypothesis is that, as it is related to semantic richness, CR could show a differential influence in retrieving names with different degrees of semantic name-bearer interconnection. Thus, three categories of names were used in this study: (1) Proper Names, (2) Logo Names, and (3) Common Nouns. We predict that the higher the semantic interconnection between target and bearer, the higher the influence of CR on the task. Logo Names and Common Nouns, which are better related to repeated and shared knowledge of their bearers, are predicted to be more influenced by CR than Proper Names, which are instead weakly connected with their bearers.

METHODS

Participants

A total of forty-six Italian native speakers (28 women, 18 men) aged from 65 to 96 years and with 3 to 21 years of education participated in the study (**Table 1**).

An informal interview allowed to record information about their medical history, which showed no symptoms of psychiatric disease or neurological impairment. They were administered the MoCA, the Cognitive Reserve Index questionnaire (CRIq, Nucci et al., 2012) and a Picture Naming task.

TABLE 1 | Descriptive data of participants: Age, years; Education, years of formal education; MoCA, raw scores at the MoCA test (Nasreddine et al., 2005); CRI, Cognitive Reserve Index (from the Cognitive Reserve Index questionnaire; Nucci et al., 2012); M, mean; SD, standard deviation.

	Participants (N = 46)		
	M	**SD**	**Range**
Age	81.09	7.73	65–96
Education	8.89	4.61	3–21
MoCA	20.63	4.01	14–27
CRI	97.91	23.63	59–152

Materials and Procedure

The MoCA test is a brief neuropsychological tool, which provides a global cognitive profile. It consists of eight sub-tests tapping different cognitive domains (i.e., memory, language, visuospatial skills, executive functions, and orientation in time and space). The MoCA is widely used in clinical practice and is very sensitive to mild cognitive impairment in aging, especially in neurodegenerative diseases. Its administration lasts about 10 min and the maximum score is 30. As reported in **Table 1**, the range of participants' raw scores on the MoCA test ranged from 14 to 27. Each raw score was then adjusted for age and education according to the Italian normative data of Conti et al. (2015). All participants' scores fell within the non-clinical population (i.e., above the adjusted Italian cut-off of 17.36). More specifically, considering the global cognitive performance of our participants, the 19.56% of their adjusted scores fell within the borderline/fragile (but not pathological) group, and the rest of the participants fell within the preserved elderly.

Cognitive Reserve was measured with the Cognitive Reserve Index questionnaire (Nucci et al., 2012), which is a semi-structured interview. It requires approximately 10 min to complete and includes 20 questions grouped into three sections: Education (*CRI-Education*), Working activities (*CRI-WorkingActivity*), and Leisure time activities (*CRI-LeisureTime*). *CRI-Education* is made up of years of formal education and any additional training courses. *CRI-WorkingActivity* refers to the cognitive load and personal responsibility of an occupation, combined with the number of years it has been carried out. Finally, *CRI-LeisureTime* measures the frequency and the amount of intellectual, social and physical activities (e.g., reading newspapers or books, playing music, participation in charitable activities, traveling, doing sports, etc.). Additionally, the questionnaire includes items about life-long experiences that require a certain cognitive load (e.g., years of bank account management). The total CRIq score is an estimation of Cognitive Reserve. It is the average of the three sub-scores standardized and transposed to a scale with a mean of 100 and a standard deviation of 15 (Nucci et al., 2012). This standardized index of Cognitive Reserve (i.e., CRI) is informative in both clinical and research contexts; it derives from the combination of exposures to life activities over time (see Stern, 2006 for more details). Its total score is adjusted for age via a regression-based method to allow comparisons between groups of different ages (see Nucci et al., 2012 for further details).

The Picture Naming task was built to measure naming Latency and naming Accuracy. Picture selection was based on a total of 159 colored images, preliminarily rated on a 1–7 Likert scale according to Familiarity, Difficulty of naming and Age of Acquisition. Pictures represented three categories of entities: very famous persons, well-known Logos, and living, and non-living things.

Pictures of famous persons were chosen from a variety of settings, such as movies (e.g., "Sean Connery," "Marilyn Monroe"), politics (e.g., "Vladimir Putin," "Angela Merkel"), and religious contexts (e.g., "Pope Francis," "Mother Teresa"), to make sure that each of them was known by a large majority of people.

Logos were chosen from a wide range of international and local symbols whose visual representation was very frequent both in Italian and International settings (e.g., sport brands such as "Nike," "Adidas"), car companies (e.g., "Audi" and "Mercedes"), commercial products (e.g., "Rolex" and "Benetton"). We excluded Logos whose visual representation carries the meaning of the name (e.g., "Apple") and Logos whose visual representation carries the initial letter of the name (e.g., "McDonald's").

The pictures of living and non-living things for Common Nouns derived (with few adjustments) from a set of 360 high-quality color images (Moreno-Martínez and Montoro database, 2012).

A group of forty healthy Italian individuals (15 women, 25 men), with no history of neurological or psychiatric disease (mean age = 73.5 ± 7.6; mean education = 10.2 ± 5.1) rated all the pictures. Participants were asked to judge them on a 1–7 Likert scale according to Familiarity, Difficulty of naming and Age of Acquisition. For Familiarity, participants were asked to rate each picture from 1 to 7, where 1 indicated "completely unknown" and 7 indicated "highly familiar" (e.g., Valentine, 1998; Salmon et al., 2010). For Difficulty, participants were asked to rate each image from 1 to 7, where 1 indicated "impossible to name" and 7 indicated "very easy to name" pictures (e.g., Moreno-Martínez and Montoro, 2012). For Age of Acquisition, participants were asked to rate each image from 1 to 7, where 1 indicated "never acquired" and 7 indicated "acquired very early": before 3 years of age (e.g., Valentine, 1998; Salmon et al., 2010). Examples were provided before starting the rating phase. A 1–7 Likert scale was visually available to participants, for each variable, during the entire scoring process. The rating allowed to eventually select 30 pictures for each of the three categories (i.e., Proper Names, Logo Names, and Common Nouns) for the computerized Picture Naming task.

In the Common Noun picture category, Familiarity showed a mean of 5.89 (±0.98; range: 3.33–6.93); Difficulty a mean of 5.08 (± 0.79; range: 3.2 to 5.98); Age of Acquisition a mean of 3.97 (± 0.97; range: 2.2–5.73). In the Proper Name picture category, Familiarity showed a mean of 6.14 (± 0.58; range: 5.05 to 7.01; Difficulty a mean of 5.16 (± 0.54; range: 4.15–6.25); Age of Acquisition a mean of 2.08 (± 0.22; range: 1.75–2.65). In the Logo Name picture category, Familiarity showed a mean of 3.68 (± 1.59; range: 1.53–6.53); Difficulty, a mean of 2.89 (±1.41; range: 0.9–5.53); Age of Acquisition a mean of 1.68 (±0.44; range: 1.13–2.6).

As expected, Logo Name pictures were rated as less familiar than both Proper Names ($B = -2.47$, $p < 0.001$) and Common Noun pictures ($B = -2.47$, $p < 0.001$), which did not differ from each other ($B = 0.26$, $p = 0.36$). Logo Name images were the most difficult to retrieve compared to both famous faces ($B = 2.27$, $p < 0.001$) and Common object images ($B = 2.18$, $p < 0.001$), which did not differ from each other ($B = 0.09$, $p < 0.71$). Finally, Common Noun pictures were acquired significantly earlier than both famous face images ($B = -1.88$, $p < 0.001$) and Logo pictures ($B = -2.3$, $p < 0.001$), while famous face images were acquired earlier than Logo Name pictures ($B = -0.4$, $p < 0.01$).

To sum up, Logo pictures were less familiar, later acquired and more difficult to name than the other two categories. While pictures of famous faces and pictures of Common objects were balanced for the two first psycholinguistic variables, Age of Acquisition was, as expected, higher for famous faces.

The final set of the computerized Picture Naming task consisted of 90 colored images: 30 famous faces for Proper Names, balanced across international/local and male/female characters; 30 pictures for Common Nouns, balanced across living/non-living things; 30 pictures of logos for Logo Names, balanced across international/local subjects (see **Figure 1** for some examples).

Each participant attended a training session before performing the experimental session. Instructions were repeated if necessary. Image dimension was standardized with GIMP software in a 400 × 400 pixel-frame. Pictures were presented randomly; a fixation point appeared on the center of the computer screen for 500 milliseconds, followed by a blank of 150 milliseconds; then the picture was shown in the center of the screen on a white background and remained on the screen until the participant gave a verbal response through the microphone (via voice-key), either naming the picture (correctly or incorrectly) or giving an "I don't know" answer[1]. Latency and Accuracy were recorded. The Picture Naming task was built in E-Prime® and the administration lasted about 10 min.

The participants took part in the study voluntarily. The consent obtained from all participants was both written and informed.

The study was approved by the Local Ethical Committee of the School of Psychology of the University of Padua and conducted in accordance with the principles of the Declaration of Helsinki.

Statistical Analyses

A mixed-effects model approach (Pinheiro and Bates, 2000) was used. The most important advantage of this statistical approach is that it provides awareness about all factors that potentially contribute to the structure of our data (Baayen et al., 2008).

In particular, we used Generalized Linear mixed-effect models (GLMM) as a suitable method for analyzing response times and accuracy distribution (e.g., Baayen et al., 2008; Quené and Van den Bergh, 2008; Baayen and Milin, 2010). Random

[1]A limitation of our study is that the picture naming task did not register different types of errors. Name retrieval errors and recognition errors are two different responses based on different cognitive mechanisms (see Semenza, 2006 for a discussion of recognition and name retrieval errors).

FIGURE 1 | Example of figures of the Picture Naming task: famous character on the left-hand side and Logo image at the center, (https://www.istockphoto.com/ca). Object image on the right-hand side; no permission is required for the use of this image (Moreno-Martínez and Montoro, 2012).

effects for all GLMMs were ID (i.e., subject identity) and TrialList (i.e., picture identity). All Latency analyses were made on participants' correct scores. Accuracy was entered as binomial dependent variable in which the whole set of responses (4.140 data-points, both correct and incorrect) were considered in a repeated-measure design, which avoids the proportion aggregation of binomial data and provide a balanced method of analysis in psycholinguistic (Quené and Van den Bergh, 2008). Fixed effects (i.e., independent variables) for Latency and Accuracy analyses were CRI (as a continuous variable), MoCA score (as a continuous variable) adjusted for age and education, and Category (i.e., Proper Names, Logo Names and Common Nouns). All GLMM analyses started from a null model that included only an intercept; then all the independent variables were added. Likelihood Ratio Test was used for model comparison. Akaike's Information Criterion (AIC; Sakamoto et al., 1986) and Delta-AIC (Burnham and Anderson, 2003) were used to examine model plausibility. Cook's distance (Cook and Weisberg, 1982) was measured to detect influential data and next the whole dataset was considered without excluding any observations.

For the Latency analysis, CRI and MoCA were first entered separately in the null model. Next, these two variables were considered as additional terms and as interaction terms, respectively, in two separate models. The same procedure was followed for the Latency analysis considering CRI and Category as predictors of interest. See **Table 2** for more details about each model.

For the Accuracy analysis, CRI and MoCA were first entered separately as independent variables in the null model. Next, these two variables were considered as additional terms and as interaction terms, respectively, in two separate models. The same procedure was followed for Accuracy considering CRI and Category as independent variables (see **Table 3** for more details about each model).

We assessed the relationship between CRI (i.e., our predictor of interest) and psycholinguistic measures related to the pictures in order to evaluate if higher CRI was correlated with better performance in the case of items that were less familiar, more difficult and acquired later, compared to lower CRI. In addition, we assessed the relationship between Category and Psycholinguistic variables on naming performance, without entering CRI. All the analyses were performed by means of R Software (R Core Team, 2016 version 3.3.1) and GLMM was run by means of lme4-package (Bates et al., 2014), with an α level of 0.05 defining significance.

RESULTS

Results are grouped in four separate sections considering Latency and Accuracy as measures of performance in the Picture Naming task. In the first section, we report results about the effect of Cognitive Reserve on naming performance; in the second, we report the results of Cognitive Reserve and the global cognitive profile as predictors of naming performance; in the third, we report the results of Cognitive Reserve and name Category as predictors of naming performance; and finally in the fourth, we report the results of the analyses in which Cognitive Reserve, Psycholinguistic variables, and Category are entered as predictors of naming performance.

Cognitive Reserve on Naming Performance

CRI (Cognitive Reserve Index) was our measure of CR and was entered as a continuous variable. CRI significantly predicted both naming Latency ($B = -0.01$, $t = -11$; $p < 0.01$) and naming Accuracy ($B = 0.54$, $z = 3.09$; $p < 0.01$), with participants performing better when CRI was higher; see **Figure 2**.

Based on Delta-AIC as a measure to check model plausibility (Burnham and Anderson, 2003), the model with CRI as the only independent variable was 63 times more plausible than the null model for the Latency analysis, and 813 times more plausible than the null model for the Accuracy analysis.

Cognitive Reserve and Global Cognitive Profile on Naming Performance

MoCA (Montreal Cognitive Assessment, a measure of global cognitive profile) was a continuous variable entered in the null model. Based on the interaction between CRI and MoCA, these two independent variables improved the model fit and predicted name retrieval Latency ($B = 0.005$, $t = 7$; $p < 0.001$) with a stronger CRI effect when the cognitive profile score was in the low range (MoCA $<$ 23). The model with the interaction between CRI and MoCA was about 24 times more plausible than the model with CRI as the only independent variable [χ^2

TABLE 2 | Generalized Linear Mixed-Effects Models with name retrieval Response Times as dependent variable.

	Cognitive reserve and global cognitive profile	AIC	AIC w	*Pr(>Chisq)*
Model 0	RT ~ 1 + (1|ID) + (1|TrialList)	22867.2	0.10	–
Model 1	RT ~ MoCA + (1|ID) + (1|TrialList)	22858.9	0.65	<0.001
Model 2	RT ~ CRI + (1|ID) + (1|TrialList)	22869.1	0.01	<0.001
Model 3	RT ~ CRI + MoCA + (1|ID) + (1|TrialList)	22860.9	0.24	0.024
Model 4	RT ~ CRI * MoCA + (1|ID) + (1|TrialList)	22862.7	0.09	<0.001
COGNITIVE RESERVE AND NAME CATEGORIES				
Model 1	RT ~ CAT + (1|ID) + (1|TrialList)	22864.8	0.46	<0.001
Model 3	RT ~ CRI + CAT + (1|ID) + (1|TrialList)	22866.7	0.18	<0.001
Model 4	RT ~ CRI * CAT + (1|ID) + (1|TrialList)	22867	0.15	0.15

Dependent Variable: RT (i.e., name retrieval Response Time in milliseconds. Fixed effects: MoCA, Montreal Cognitive Assessment test (Nasreddine et al., 2005); CRI, Cognitive Reserve Index (Nucci et al., 2012); CAT, name categories (i.e., Proper Names, Logo Names, and Common Nouns). Random Effects: ID, subject identity; Trials, picture identity. AIC, Akaike's Information Criterion; AIC w, AIC weight; Pr (>Chisq), Chi-Square probability associated to the model.

TABLE 3 | Generalized Linear Mixed-Effects Models with name retrieval Accuracy as dependent variable.

	Cognitive reserve and global cognitive profile	AIC	AIC w	*Pr(>Chisq)*
Model 0	ACC ~ 1 + (1|ID) + (1|TrialList)	3995.4	0.01	–
Model 1	ACC ~ MoCA + (1|ID) + (1|TrialList)	3982.1	0.01	<0.001
Model 2	ACC ~ CRI + (1|ID) + (1|TrialList)	3988.7	0.01	<0.001
Model 3	ACC ~ CRI + MoCA + (1|ID) + (1|TrialList)	3974.7	0.54	<0.001
Model 4	ACC ~ CRI * MoCA + (1|ID) + (1|TrialList)	3975.1	0.43	<0.21
COGNITIVE RESERVE AND NAME CATEGORIES				
Model 1	ACC ~ CAT + (1|ID) + (1|TrialList)	3958.1	0.01	<0.001
Model 3	ACC ~ CRI + CAT + (1|ID) + (1|TrialList)	3951.4	0.01	0.002
Model 4	ACC ~ CRI * CAT + (1|ID) + (1|TrialList)	3943	0.98	< 0.01

Dependent Variable: ACC (i.e., Accuracy of name retrieval). Fixed effects: MoCA, Montreal Cognitive Assessment test (Nasreddine et al., 2005); CRI, Cognitive Reserve Index (Nucci et al., 2012); CAT, name categories (i.e., Proper Names, Logo Names, and Common Nouns). Random Effects: ID, subject identity; Trials (picture identity). AIC, Akaike's Information Criterion; AIC w, model averaging; Pr(>Chisq), Chi-Square probability associated to the model.

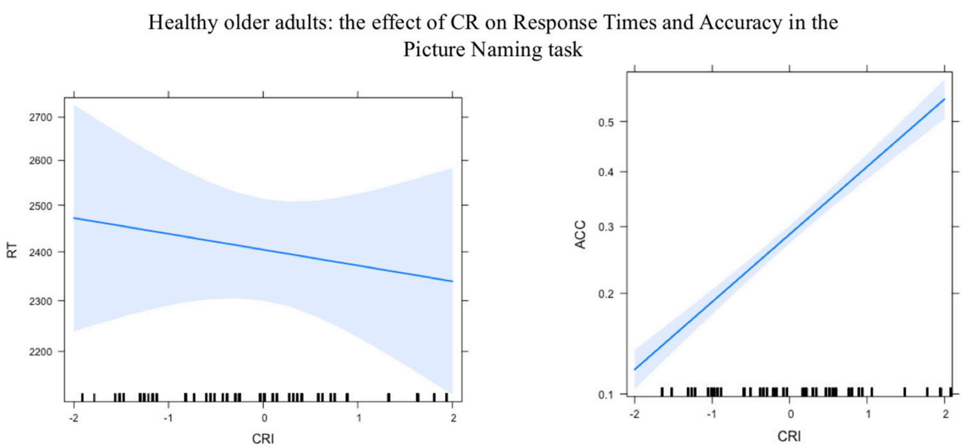

FIGURE 2 | CRI as predictor of name retrieval Response Times and Accuracy in older adults: generalized linear mixed models; Fixed effect, Cognitive Reserve Index (CRI); Dependent variables: RT, Response Times in milliseconds; ACC, Accuracy of name retrieval.

(2) = 10.35, $p < 0.01$]. This suggests that global cognitive profile and CRI taken together strongly predicted name retrieval Latency in older adults.

The MoCA score predicted the overall Accuracy of name retrieval when it was the only independent variable ($B = 0.23$, $z = 4.24$; $p < 0.01$), and adding the CRI to the MoCA improved the model fit [χ^2 (2) = 9.32, $p < 0.001$]. These two variables were then considered as interaction terms and no significant improvement was found ($B = -0.06$, $z = -1.25$; $p = 0.21$). However, the Likelihood Ratio Test carried out to compare the model with CRI and MoCA as interaction terms and the model with MoCA as a single variable showed a better fit for the former

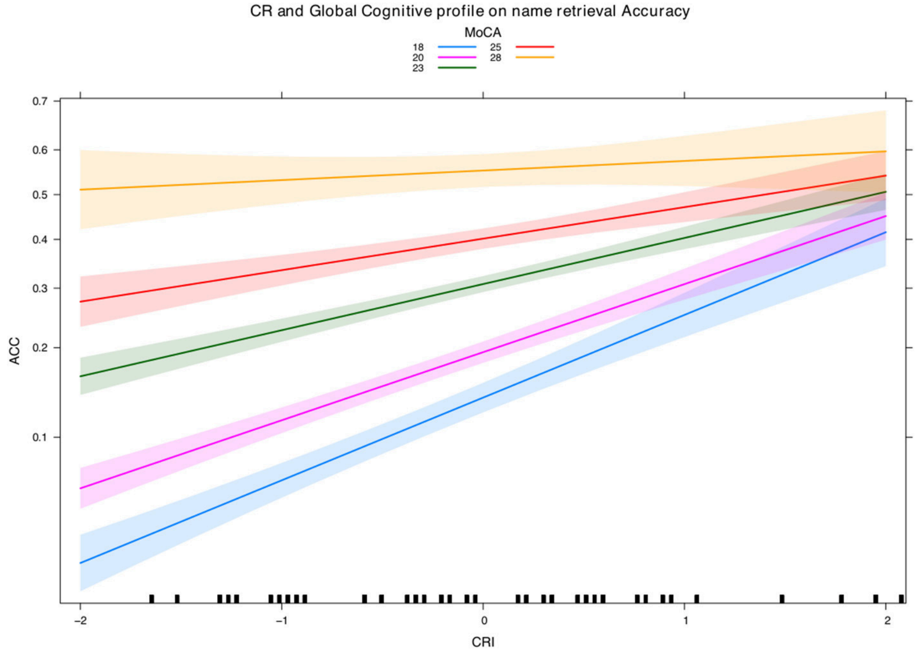

FIGURE 3 | CRI and MoCA as predictors of name retrieval Accuracy in older adults. Generalized Linear Mixed Models; MoCA, Montreal Cognitive Assessment; ACC, Accuracy; CRI, Cognitive Reserve Index.

[χ^2 (2) = 10.85, $p = 0.004$], with a stronger CRI effect when the MoCA score was in the low range (MoCA < 23; **Figure 3**).

Cognitive Reserve on Naming Performance According to Category (Proper Names, Logo Names and Common Nouns)

Entering in the null model Category as the factorial variable (three levels: Proper Names, Logo Names, and Common Nouns) significantly improved the model fit compared with the null model in both Latency [χ^2 (2) = 6.35, $p = 0.04$], and Accuracy χ^2 (2) = 41.26, $p < 0.001$). Common Nouns were retrieved faster and more accurately than Proper Names (Latency: $B = 0.15$, $t = 126$; $p < 0.001$; Accuracy: $B = -0.64$, $z = -2.05$; $p = 0.04$) and also than Logo Names (Latency: $B = 0.16$, $t = 130$; $p < 0.001$; Accuracy: $B = -2.23$, z = −6.94; $p < 0.001$). Proper Names, on the other hand, were retrieved faster and more accurately than Logo Names (Latency: $B = 0.004$, $t = 4$; $p < 0.001$; Accuracy: $B = -1.59$, $z = -4.95$; $p = 0.001$).

When Category and CRI were entered as independent variables in two separate models no effect of CRI was found on Latency across the three categories, either in the case of CRI and Category as additional terms [χ^2 (1) = 0.09, $p = 0.75$], or when CRI and Category were considered as interaction terms [χ^2 (1) = 3.75, $p = 0.15$] (see **Figure 4**).

Table 4 shows the summary result of the model of interest, (i.e., where CRI and Category are entered as interaction terms and Latency is the dependent variable).

In line with our hypothesis, Accuracy showed a significant effect of CRI across name categories. CRI and Category as interaction terms predicted Accuracy ($B = -0.35$, $z = -3.24$; $p < 0.01$) and this model was about 68 times more plausible than the model with CRI and Category entered as additional terms. Entering CRI and Category as interaction terms showed significant improvement in the model fit, compared with entering name Category as the only variable of interest [χ^2 (1) = 21.19, $p < 0.001$]. **Table 5** shows summary results of the model of interest (i.e., based on the model with CRI and Category as interaction terms and Accuracy as dependent variable).

In line with our hypothesis, the effect of CRI on name retrieval Accuracy was significantly lower for Proper Names than for Common Nouns ($B = 0.26$, $z = 2.69$, $p < 0.01$) and Logo Names ($B = 0.35$, $z =$ 3.24, $p < 0.01$). The effect of CRI on Accuracy did not differ when comparing Logo Names and Common Nouns ($B = -0.09$, $z = -0.81$, $p = 0.41$) (**Figure 5**).

Cognitive Reserve and Psycholinguistic Variables

Psycholinguistic variables showed a different role in the three categories on the Accuracy. Participants' performance in the picture naming task was better for higher familiar pictures ($B = 0.38$, $z = 3.05$, $p < 0.01$) and for those whose names that were easier to retrieve ($B = 0.36$, $z = -2.37$, $p = 0.01$), with no significant effect of Age of Acquisition ($B = 0.27$, $z = 1.82$, $p = 0.06$). *Post-hoc* analyses showed that Familiarity predicted Accuracy in Proper Names ($B = 0.66$, $z = 2.42$, $p = 0.01$), but not in Common Nouns ($B = -0.03$, $z = -0.24$, $p = 0.81$) and not in Logo Names ($B = 0.03$, $z = 0.24$, $p = 0.81$). In a similar way, Difficulty predicted Accuracy in Proper Names ($B = -4.58$, $z = -2.91$, $p < 0.01$), but not in Common Nouns

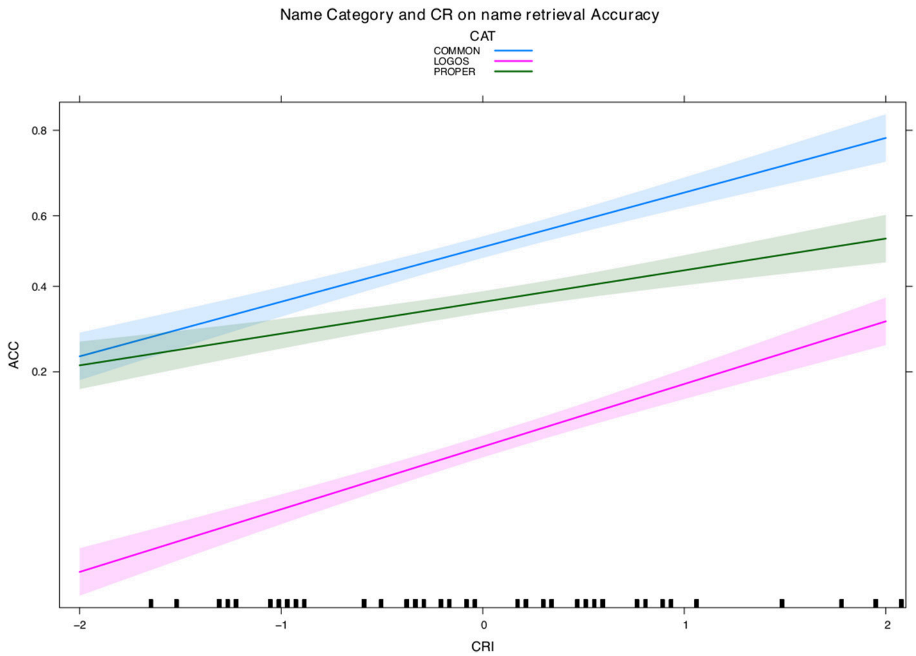

FIGURE 5 | CRI and category as predictors of name retrieval Accuracy in older adults: Generalized Linear Mixed-Model results. CRI, Cognitive Reserve Index; CAT, name category; ACC, Accuracy.

Among the group of older adults that took part in this study, those with higher CR performed better in name retrieval compared with people with lower CR. A recent study (Montemurro et al., 2018) reported that higher CR is associated with the more successful global cognitive performance of older adults with early symptoms of dementia, but not of healthy controls. Consistent with that, the present study shows that CR can affect naming performance depending on the degree of cognitive decline. In particular, name retrieval of participants with early signs of decline seem to have benefitted more from CR, than healthy participants. This result could be explained by the two mechanisms of neural reserve and neural compensation (Barulli and Stern, 2013), where the strong association between CR and name retrieval in case of cognitive decline may reflect the necessity to recruit additional networks to cope with a relatively simple task.

Evidence from previous research based on a comparison between younger and older adults has shown that as the task load increases, healthy older adults recruit brain networks in the same way as their younger counterpart (Ansado et al., 2013). The authors suggested that older adults may first adopt cognitive compensatory mechanisms and then, when compensatory processes are not enough to cope with an increased task demand, healthy older adults make use of their neural reserve (Ansado et al., 2013). Interestingly, their findings suggested that, in older adults, the neural substrates of CR are based on flexible and adaptive neural processes; however, such adaptation of neural responses can be more or less successful depending both on global cognitive condition and the difficulty of the task.

In the present study we used a simple name retrieval task, which might require additional resources only in persons with an impaired global condition, whereas such additional resources might be needed in healthy older adults only if task demand got higher. We analyzed the role of CR in name retrieval, which is frequently impaired in adults who often refer to this problem in terms of "memory loss." Difficulties in retrieving names can be one of the first symptoms reported at the early clinical assessments and may generally depend on a physiological decline (e.g., MacKay and Burke, 1990; Rastle and Burke, 1996; Semenza, 2006). In our study we reported that naming performance across categories showed Logo Names as the most demanding items, but when entering CR in the model, high CR predicted a better name retrieval performance both in the Logo Name and the Common Noun categories. In naming Proper Names, high vs. low CR did not influence performance as it did in the two other name categories. In other words, CR barely modulates Proper name retrieval; it is correlated with better performance in retrieving Common Nouns and Logo Names, which may be both conceptually categorized due to their greater environmental pervasiveness, rather than naming with Proper Names, which are pure referential expressions. Thus, these results underline that CR matters for naming performance only in some cases.

To the best of our knowledge, this is the first study exploring the relationship between CR and name retrieval using the three name categories of proper Names, Logo Names, and Common Nouns. The interest in this relationship derives from previous findings, where proper name anomia was proposed to be a predictor for the onset of dementia (Semenza et al., 2003). In their study, the authors suggested that proper name anomia at the very early stage of dementia might be due to lexical semantic disruption. Although the impact of age-related naming deficits has already been reported in previous studies (e.g., Flicker et al., 1987; Evrard, 2002), the contribution of CR on name retrieval processing in older adults has been addressed only recently (e.g., Mondini and Semenza, 2016; Montemurro et al., 2018).

Proper Names and Common Nouns were considered in light of the well-documented dissociation between proper name and common noun retrieval in older adults (e.g., Cohen and Burke, 1993; Rastle and Burke, 1996; Evrard, 2002; Tsukiura et al., 2011), even if the evidence of a disproportionate deficit for proper names as compared to common nouns has been shown to be controversial (see Maylor, 1997). In line with our hypothesis, we demonstrated that the effect of CR on name retrieval Accuracy was weaker for Proper Names compared to Logo Names and Common Nouns. This result seems to be reflected in the analysis of Response Times (see **Figure 4**), although no statistical difference across name categories was found when considering CR as a predictor.

Common Nouns and Logo Names could highly benefit from CR, as shown in previous studies where CR was associated with semantic task components (see Reed et al., 2011; Darby et al., 2017). Our results showed differences across the three categories for Accuracy but not for Latency, possibly because name retrieval speediness is more generally affected by age-related synaptic delay (MacKay and Burke, 1990; Rastle and Burke, 1996; Jackson et al., 2012). The difference between Accuracy and Latency might be due to high age-related variability when performing a cognitive task that requires reaction speediness (e.g., Anstey, 1999; Christensen et al., 1999; Hultsch et al., 2002; Bielak et al., 2010). For example, in a longitudinal study employing a series of cognitive tasks conducted with 760 elderly individuals, Christensen et al. (1999) found a heterogeneous pattern of speed performance along with increased age-related inter-individual variation.

Our results show that high CR is a predictor of name retrieval Accuracy in the case of less familiar and more difficult names. However, no association was found between CRI and Age of Acquisition. The same result was obtained when excluding from the analysis Logo Names, which were generally rated as acquired later in life. This suggests that name retrieval accuracy does not appear to be sensitive to CR at the point in time when names were acquired, and that CR could be associated with the frequency of occurrence of certain names throughout lifespan experiences. Interestingly, our analysis of the association between psycholinguistic variables and Accuracy across categories shows that Proper Names can be more sensitive to image Familiarity and Difficulty of naming, compared to Common Nouns and Logo Names. These findings suggest that name retrieval Accuracy seems to be modulated not only by Familiarity and Difficulty, but also by CR. Categories, however, showed that name retrieval of those Names that refer to repeated and shared knowledge (i.e., Common Nouns and Logo Names) is better with higher CR, whereas name retrieval of items with poor semantic attributes (i.e., Proper Names) benefit from high image Familiarity and low Difficulty of naming.

Thus, it might be the case that higher CR can help context-driven information processing, as in the case of real living/non-living entities and commercial products, instead of information that are arbitrarily assigned to unique entities, despite their familiarity, or ease of accessing their representation. With this interpretation, context availability might be a very interesting target to explore in the future, in association with the possible effects of CR.

In sum, our results showed that CR predicts overall name retrieval performance and that this effect seems to be higher when the global cognitive profile shows very early symptoms of age-related cognitive decline. Additionally, CR may act as a stronger predictor of name retrieval when names are involved in denser semantic networks (i.e., Logo Names and Common Nouns) compared to lexical labels that are pure referential expressions (i.e., Proper Names). These results suggest that CR, which relies on socially active life-style and exposure to world knowledge, can modulate cognitive performance. On the other hand, our observation of a weak dependence between CR and some cognitive tasks, such as Proper Name retrieval, may make the latter especially useful to detect early symptoms of dementia in individuals with high CR.

Future investigations might further address the proposition that having an active and socially integrated life-style in adulthood may not only enrich cognitive resources in general, but also strengthen some specific cognitive processes, such as name retrieval.

ETHICS STATEMENT

COMITATO ETICO DELLA RICERCA PSICOLOGICA (AREA 17) Dipartimenti/Sezione di Psicologia—Universitàdi Padova, Via Venezia 8, 35131, Padova, FAX. +39-0498276600, e-mail: comitato.etico17@gmail.com; Sito WEB: http://ethos.psy.unipd.it/

Protocollo: 2372 (SOSTITUISCE IL N.2324)

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Numero Univoco: 8696E7DA11D7B45656D6DDCE6CD673B0

Scopo: Richiesta di parere

Titolo: Riserva cognitiva e velocità di denominazione nell'anziano sano e con decadimento cognitivo lieve-moderato: uso di un test computerizzato.

nomi propri nel declino cognitivo.

Proponente

Cognome e nome: Mondini Sara Ruolo: Associato

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Area: Psicologia generale (se altro):

Ricercatori partecipanti: 3

SaM (Docente presso il Dipartimento di Psicologia Generale), Sonia Montemurro (Dottoranda presso il Dipartimento di Psicologia Generale), Chiara Crovace (Studentessa presso il Dipartimento di Psicologia Generale).

Il Comitato Etico, dopo attento esame delle informazioni fornite dal proponente, esprime parere positivo riguardante gli aspetti etici del progetto.

The project has been approved by the Ethical Committee for the Psychological Research of the University of Padova.

Padova, 11/10/2017

AUTHOR CONTRIBUTIONS

SoM: devised the experiment, analyzed the data, and wrote the manuscript. SaM: devised the experiment, discussed data and wrote the manuscript. CC: collected the data. GJ: discussed and wrote the manuscript.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.