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SHORT PAPER

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Control beliefs and susceptibility to the promises of memory improvement

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Summary

Brain training is increasingly popular, and many believe in the efficacy of such programs without empirical evidence. We examined whether instructions promising memory improvement would influence subjective and objective cognition. Participants (n = 145; age: M = 50.64) were randomly assigned to a memory improvement or memory task condition. Participants completed demographic and perceived control over cognition measures, in addition to cognitive tasks and subjective cognition items for 7 days. Participants in the improvement condition reported significantly greater memory increases than those in the memory task condition. This effect was moderated by perceived control over cognition; participants in the improvement condition with high control beliefs were significantly more likely than those with low control beliefs or those in the task condition to report better memory. Individuals with higher control beliefs may be more susceptible to the claims of brain training programs, which is significant given that such programs are increasingly popular and commercially available.

KEYWORDS

brain training, category fluency, control beliefs, immediate recall, subjective cognition

1 | BACKGROUND AND OBJECTIVES

A main concern of middle-aged and older adults is memory loss (Lachman, 2004), and some individuals may experience memory decline as early as middle age (Singh-Manoux et al., 2012). An increasingly older society will likely seek strategies to preserve cognitive function and maintain independence. Because there are no known pharmacological therapies effective for slowing or reversing memory declines, there is increasingly interest in behavioral interventions that can improve cognitive performance and minimize declines. Thus, a growing area of research has examined the role of cognitive exercises (i.e., “brain training” or “cognitive training”) as a way to stave off decline and maintain cognitive functioning in middle and older adulthood. There is inconsistent evidence for the effectiveness of these programs, and some have used anecdotal evidence or exaggerated claims (e.g., Federal Trade Commission v. Lumos Labs, Inc., 2016). The goal of the present study was to examine susceptibility to such claims about memory improvement using an experimental design.

Approximately 30 years of research have examined the efficacy of cognitive and brain training programs, and programs involving intense practice and challenging tasks can be effective in improving specific cognitive skills (e.g., Rebok et al., 2014). Despite the documented efficacy for some programs, brain training programs vary widely in method (e.g., length and type of training) with some commercially available and others developed primarily for research purposes (Buitenweg, Murre, & Ridderinkhof, 2012). Among those that have been studied, training has been associated with significant improvement in objective and self-reported performance across a range of cognitive domains (Mahncke et al., 2006; Nouchi et al., 2012; Smith et al., 2009) with some benefits remaining for as long as 10 years (Rebok et al., 2014).

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A review of computerized cognitive training programs among older adults found training to be generally effective with effect sizes varying from 0.06 to 7.14 (Kueider, Parisi, Gross, & Rebok, 2012).

The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) program (Ball et al., 2002; Willis et al., 2006) is an evidence-based cognitive training program that incorporates memory, reasoning, and speed of processing training for 10 60- to 75-min sessions over the course of 5 or 6 weeks. Research has demonstrated a number of positive outcomes associated with ACTIVE training. For example, speed of processing and reasoning training, both parts of the ACTIVE program, have been associated with reduced at-fault automobile collision involvement and maintenance of driving abilities (Ball, Edwards, Ross, & McGwin, 2010; Edwards et al., 2009; Ross, Freed, Edwards, Phillips, & Ball, 2016). Speed of processing training, in particular, has been associated with improvements on instrumental activities of daily living (Edwards et al., 2005) and a 29% lower risk of dementia over 10 years compared with a control condition (Edwards et al., 2017). Components of the ACTIVE study are now available commercially as part of the brainHQ program online from the Posit Science Corporation. The founder of Posit Science, Michael Merzenich, has demonstrated with colleagues the effectiveness of specific brain training programs for improving targeted tasks as well as improvement in other generalized areas related to memory; effects were sustained for up to 3 years (Mahncke et al., 2006).

Despite demonstrated efficacy for some evidence-based programs, such as ACTIVE (Shah, Weinborn, Verdile, Sohrabi, & Martins, 2017), many other commercially available programs exist without empirical support to demonstrate their effectiveness (Kable et al., 2017). A recent review (Simons et al., 2016) of brain training research identified that most of the benefits of brain training are tied to the trained tasks with little or no transfer to untrained tasks (or distantly related tasks) and that some of the published research is lacking in designs that can lead to strong conclusions as to the efficacy. The efficacy of brain training has also been challenged due to lack of research investigating individual differences in response to training and transfer to everyday cognitive functioning (Buitenweg et al., 2012; Owen et al., 2010). Thus, caution should be utilized as there are inconsistent findings and many commercially available programs that are unsupported by research.

Furthermore, some have warned that brain training software has created an exploitive "marketplace of memory" in an increasingly aging society that is acutely aware of their memory changes (George & Whitehouse, 2011; Halamish, McGillivray, & Castel, 2011) and fears memory decline. Some programs are expensive and may be financially burdensome for low or fixed income older adults. However, despite these criticisms, due to its increasing popularity and scientific evidence, brain training may be considered within the context of many options for maintaining healthy cognition in old age, including physical exercise, social engagement, and promoting self-efficacy (Agrigoroaei & Lachman, 2011; Berry, 1999; George & Whitehouse, 2011). Thus, research is needed to better understand older adults' perceptions of brain training.

As previously mentioned, criticisms of commercial brain training programs include concerns that the messages and promises used to market brain training programs are misleading, as evidenced by a recent Federal Trade Commission investigation and lawsuit for false advertising. As a result of the investigation, a large commercial retailer of brain training software, Lumosity, was forced to remove language so as not to overstate the effects (e.g., the program offers "protection against mild cognitive impairment and Alzheimer's disease"; Federal Trade Commission v. Lumos Labs, Inc., 2016). Some brain training programs also describe their software as helping you to get a "better brain" through the "science of neuroplasticity" (Luminosity.com, 2015). Given these recent instances, research is needed to better understand susceptibility to the promises of brain training. Simons et al. (2016) point out in their review of brain training programs that most evaluation studies do not use experimental designs with a control group and do not evaluate the role of performance expectations. Although there is extensive research examining the efficacy of brain and cognitive training, less is known about susceptibility to claims about memory improvement in relation to reported and actual cognitive performance. The purpose of the current study is to investigate whether individuals are susceptible to claims used to market brain training programs and, in particular, whether there are individual differences in susceptibility. Some brain training programs have been criticized for relying on anecdotal reports of individuals' perceived improvement to demonstrate efficacy. Reports like these are subject to demand characteristics, that is, reports of improvement due to the investigator's expectations (McCambridge, de Bruin, & Witton, 2012). Self-reports may also be subject to wishful thinking or the effects of cognitive dissonance in order to rationalize the amount of money and time spent on the products.

Additional perspectives from social and cognitive psychology can help to better understand how the language used to present tasks can affect an individual's objective and perceived performance. Regarding objective performance, when task instructions emphasize "memory," "memory task," or "memory test," this may activate stereotypes about memory and aging and thus have a detrimental effect on older adults' cognitive performance (Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Desrichard & Köpetz, 2005; Hasher, Zacks, & Rahhal, 1999). This is supported by research on stereotype threat which suggests that people may indeed perform worse, thereby confirming a stereotype, when they are made aware of negative biases associated with their group (Steele & Aronson, 1995). Older adults tend to do worse when age-related stereotypes about memory are activated (Chasteen et al., 2005; Hess, Auman, Colcombe, & Rahhal, 2003; Horton, Baker, Pearce, & Deakin, 2008; Kang & Chasteen, 2009). Perceptions of performance may also be negatively affected when stereotypes are presented. Conversely, in the case of brain training, language that highlights the potential benefits may enhance a person's perception of performance due to the expectation that it will be helpful to actual performance.

Furthermore, Bandura's concept of self-efficacy provides a framework for understanding the potential for individual differences in susceptibility to claims of brain training. According to Bandura (1994), self-efficacy is defined as a person's beliefs about whether they have the ability to accomplish goals and desired outcomes in

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their life (e.g., improve their memory). Individuals with higher self-efficacy may perceive greater control over their cognition and may be more susceptible to verbal persuasion and to thinking their cognition has improved, or they may even objectively demonstrate greater improvement due to greater motivation (Payne et al., 2011). Previous research from the ACTIVE study (Parisi, Gross, Marsiske, Willis, & Rebok, 2017) examined relationships between control beliefs and cognition across 10 years among individuals who completed cognitive training. Although their study did not find support for the influence of control beliefs at baseline on cognition over time, there was evidence for the reverse; cognition at baseline influenced control beliefs over time. The current study adds to this literature by examining whether perceived cognition, in addition to objective cognition, is influenced by the language used to describe brain training programs and whether this relationship varies as a function of individual differences in age, educational attainment, and beliefs about control.

1.1 | Current study

The current study examined whether a claim similar to that used to describe brain training programs would affect subjective memory as well as objective performance in the context of a 7-day daily diary study. Participants were assigned to either a memory improvement condition, which included language similar to brain training programs, or a memory task condition with instructions that did not mention memory improvement. It was hypothesized that participants in the memory improvement condition would report improvements in beliefs about performance compared with the memory task condition, in response to demand characteristics. Given that the actual task involved minimal practice and did not include skills training, we did not expect a significant improvement in objective cognitive performance in either condition. Conversely, we hypothesized that the memory task condition would be associated with worse beliefs about performance and worse actual performance, based on the possibility of activating stereotype threat (Steele & Aronson, 1995).

As previously mentioned, there is limited research examining individual differences in response to brain training programs (Payne et al., 2011; Sharpe, Holup, Hansen, & Edwards, 2014). Therefore, we also examined whether age, education, and perceived control over cognition were moderators of the susceptibility to the training claim manipulation. It was hypothesized that middle-age and older adults would be more susceptible to claims of brain training programs than younger adults. Given that older adults typically have greater fear and beliefs surrounding memory problems and decline (Lachman, 2004; Lineweaver & Hertzog, 1998), they may be more motivated to find ways to maintain their functioning. Whereas younger adults may not be concerned about their memory abilities, middle-aged and older adults may be seeking to minimize actual or perceived age-related losses. In addition, individuals with higher education were also hypothesized to be more susceptible to the claims of brain training programs based on past work suggesting they are more sensitive to declines in memory (Caracciolo, Gatz, Xu, Pedersen, & Fratiglioni, 2012) and potentially more motivated to improve suspected losses. Finally, those with greater perceived control over their cognition were expected to be more susceptible to the language used to describe brain training programs due to higher levels of self-efficacy, greater motivation to improve, and stronger beliefs about their ability to minimize age-related losses in memory and cognition (Lachman, 2006).

2 | RESEARCH DESIGN AND METHODS

2.1 | Participants

Participants (n = 145) were recruited via convenience sampling in the Greater Boston area for a daily diary study. Participants ranged in age from 22 to 94 (M = 50.64, SD = 19.10), 60% were female, and they had, on average, 15 years of education (M = 15.06, SD = 2.58). Participant characteristics and the correlations between all study variables are reported in Table 1. Participants could earn a total of \$100 (\$10 for every daily questionnaire mailed back on time and an additional \$30 for returning all study materials). For information regarding recruitment, a description of this data has been published elsewhere (Robinson & Lachman, 2018).

2.2 | Procedure

Participants were asked to take part in a study regarding "memory and daily activities in adulthood" and were informed during the informed consent process that there are "several components" to this study including "answering questionnaires, reporting daily activities and experiences in a diary, once a day for one week, and also doing memory tasks over the phone." Participants were randomly assigned to one of two experimental conditions (memory improvement and memory task) using stratified random sampling by age, gender, and education. All participants completed a background questionnaire that included demographic questions, perceived control over cognition, and other psychosocial measures. Within approximately 1 week of completing the background questionnaire, participants completed seven consecutive days of daily diaries at home with a written survey along with a brief telephone call each night. For all participants, the daily phone calls included objective cognitive tasks (immediate word recall and category fluency) and three subjective cognitive items.

2.2.1 | Memory instruction manipulation

Participants in the memory improvement and memory task conditions experienced different instructions during the telephone calls prior to completing the category fluency task (the first cognitive task). Every day for the 7 days of data collection, participants in the memory improvement condition were instructed as follows: "This is a brain training exercise. This kind of brain exercise can make you more mentally fit and improve your memory. It can sharpen your mind and improve your brain health." Participants were then instructed how to complete the task (i.e., that they will receive the name of a category

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TABLE 1 Participants characteristics and intercorrelations between all study variables

	Variable	M or %	*SD*	Min	Max	1	2	3	4	5	6	7	8
Background variables													
1	Age	50.50	19.06	22	94	1							
2	Gender (female) %	60				0.09	1						
3	Education in years	15.07	2.56	10	20	0.10	−0.09	1					
4	Control over cognition	3.79	0.97	1	6	−0.16	−0.15	0.09	1				
Daily variables (person-mean)													
5	How good is your memory today?	3.10	0.38	1	5	0.04	−0.12	0.02	0.09	1			
6	How much do you think you can improve your memory?	2.97	0.89	1	5	−0.14	**−0.17**	0.08	**0.24**	**0.27**	1		
7	Compared to yesterday, how do you think your memory has improved?	1.69	0.61	1	5	−0.08	−0.08	**−0.19**	**0.18**	**0.61**	**0.41**	1	
8	Immediate recall	9.47	1.65	5	14	**−0.29**	−0.05	**0.39**	0.10	0.12	0.02	0.03	1
9	Category fluency	14.48	3.65	6	25	−0.15	−0.04	**0.42**	0.12	−0.02	0.04	**−0.20**	**0.56**

Note. M: mean; SD: standard deviation. Gender is coded as 1 = male and 2 = female. Correlation coefficients that are significant at the 0.05 *p* value are displayed in bold font.

and that they are asked to say as many words as they can think of in 1 min); the instructions for how to complete the task were the same regardless of condition. Before beginning the task, the memory improvement group was told, “We want to see how much you can improve your memory by doing this brain exercise.”

In the memory task condition, participants were first instructed as follows every day for the 7 days of data collection: “This is a memory task. This kind of task is a good indicator of your memory and can show how well you remember things. It can provide evidence of your memory and demonstrate your recall skills.” They were then given instructions on how to complete the category fluency task (same instructions as in memory improvement condition). Then, before beginning, the memory task group was told, “We want to see how many items you can remember in this category memory task.”

2.3 | Materials

2.3.1 | Demographic variables

Age, gender, and education were measured in the background questionnaire and included as covariates. Age and education were measured continuously as the number of years.

2.3.2 | Perceived control over cognition

In the background questionnaire, participants were asked several questions about their sense of control over their cognition using the Personality in Intellectual Aging Contexts scale (Lachman, 1983). Participants self-reported how much they agree or disagree with the statements “It's inevitable that my intellectual functioning will decline as I get older,” “The older I get the harder it is to think clearly,” “As long as I exercise my mind I will always be on top of things (reverse-coded),” “I don't remember things as well as I used to,” and “There's not much I can do to keep my memory from going downhill.” Responses were on a 6-point Likert scale from 1 (strongly agree) to 6 (strongly disagree). Scores for the five items were averaged to create a composite (Cronbach's α = 0.77).

2.3.3 | Daily objective cognition

Participants completed a 15-item word list immediate recall task followed by a 60-s verbal category fluency task every day for seven consecutive days via telephone. For the immediate recall task (Hawkins, Dean, & Pearlson, 2004), participants were read a list of 15 words and then were given one and a half minutes to recall those words. The number of total unique items was used for analyses with scores ranging from 0 to 15; higher scores indicated better performance. The category fluency task was adapted from Battig and Montague (1969). Participants were given the name of a category and were instructed to “name all the things you can think of, as fast as you can.” The categories differed each day for the category fluency task and were as follows: Day 1: Colors, Day 2: Furniture, Day 3: Countries, Day 4: Sports, Day 5: Articles of clothing, Day 6: Musical Instruments, and Day 7: Insects. The total number of unique words was used for the study analyses and higher scores indicated better performance. Test–retest reliability was examined using intercorrelations for all daily objective cognition data. Correlations for all daily immediate recall variables were significant at the $p < 0.05$ level (ranging from $r = 0.31$ to $r = 0.55$). Correlations for all daily category fluency variables were also significant (ranging from $r = 0.23$ to $r = 0.57$).

2.3.4 | Subjective cognition

Participants were asked each day during the daily telephone calls about their memory that day. Specifically, participants were asked, “How good was your memory today?” with answer choices on a

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5-point Likert scale (1 = *a lot worse than usual*, 2 = *a little worse than usual*, 3 = *the same as usual*, 4 = *a little better than usual*, and 5 = *much better than usual*). Participants were then asked "How much do you think you can improve your memory?" and "Compared to yesterday, how much do you think your memory has improved?" with answer choices for both items on a 5-point Likert scale (1 = *not at all*, 2 = *a little*, 3 = *moderately*, 4 = *quite a bit*, and 5 = *a lot*).

2.4 | Data analysis

Multilevel analysis was conducted using SAS Version 9.4 to examine whether there were condition differences in objective and subjective cognition. Multilevel analyses (Raudenbush & Bryk, 2002) was conducted in the current study due to the ability to simultaneously estimate within-person and between-person predictors for study designs with repeated measures (Level 1 data) nested within person-level data (Level 2 data). Therefore, this type of daily diary study design allows us to simultaneously examine the influence of both level one predictors (i.e., factors that vary within people over a short period of time such as from 1 day to the next) as well as level two predictors (i.e., factors that are relatively stable participant characteristics across the 7 days such as gender or baseline control beliefs). Because our question was to simultaneously examine the effects of both of these types of predictors while controlling for the other (i.e., whether participants reported better subjective cognition across the 7 days and whether certain types of participants such as those with higher baseline control beliefs reported better subjective cognition), MLM was the appropriate analysis. In addition, MLM solves the issue of nonindependence of observations because measures across time (within people) are not independent. Many statistical models (such as analysis of variance and linear regression) assume independent observations (or, more technically, independent residuals). Also, MLM allows for the examination of data from persons with some missing data. In the current study, participants completed 92% of days (934 days out of 1,015 total possible days). On average, participants completed 6.4 daily diaries out of the seven total possible diaries, and 88% of participants completed at least six diaries. As shown in Equations 1 and 2 below, group, time, and group by time were entered as predictors of subjective and objective cognition.

$$\begin{aligned} \textit{daily subjective cognition}_{ij} = \gamma_{00} &+ \gamma_{01}\,\textit{age}_j + \gamma_{02}\,\textit{gender}_j + \gamma_{03}\,\textit{education}_j \\ &+ \gamma_{03}\,\textit{objective cognition}_j + \gamma_{10}\,\textit{day}_{ij} \\ &+ \gamma_{04}\,\textit{group}_j + \gamma_{14}\,\textit{day}_{ij}\,\text{group}_j + u_{0j} + e_{ij}, \end{aligned} \tag{1}$$

$$\begin{aligned} \textit{daily objective cognition}_{ij} = \gamma_{00} &+ \gamma_{01}\,\textit{age}_j + \gamma_{02}\,\textit{gender}_j + \gamma_{03}\,\textit{education}_j \\ &+ \gamma_{03}\,\textit{subjective cognition}_j + \gamma_{10}\,\textit{day}_{ij} \\ &+ \gamma_{04}\,\textit{group}_j + \gamma_{14}\,\textit{day}_{ij}\,\text{group}_j + u_{0j} + e_{ij}. \end{aligned} \tag{2}$$

Age, sex, and education were included as covariates in all models. In the model predicting subjective cognition, the person-means for daily cognition (immediate recall and category fluency) were also entered as covariates, and in the model predicting objective cognition, the person-mean for daily subjective cognition was also included. Age and control over cognition were then entered as moderators of the group (γ_{04}*group*$_j$), time (γ_{10}*day*$_{ij}$), and group by time relationships (γ_{14}*day*$_{ij}$group$_j$). Analyses were run with age included as both a linear and quadratic term.

Prior to conducting main analyses, unconditional models were run to estimate the intraclass correlation coefficient (ICC) for all subjective and objective cognition outcome variables. ICC is computed prior to conducting multilevel analysis to demonstrate the amount of variation that exists for the dependent variable(s) within-person and also between-person. Specifically, the analysis determines how much participants vary from day to day and also from person to person for the subjective and objective cognition variables. Thus, an ICC can determine whether there is substantial variation within-person variation for dependent variables to justify the use of MLM; MLM subsequently examines factors associated with variation in the dependent variables. The ICC determined that for category fluency, 28% of the variation was between-persons and 72% within-persons. For immediate word recall, 42% of the variation was between-persons and 58% within-persons. For the first subjective cognition question, "How good is your memory?", 8% of the variation was between-persons and 92% within-persons. For the question "Compared to yesterday, how much has your memory improved?", 33% of the variation was between-persons and 67% within-persons. Thus, all of the dependent variables varied substantially within-person justifying the use of MLM.

3 | RESULTS

Prior to conducting multilevel analyses, independent samples *t*-test and χ^2 were conducted to examine the differences on the demographic characteristics between the two randomly assigned groups. There were no differences between the two groups in terms of age, gender, education, or perceived control over cognition.

3.1 | Objective cognition

Multilevel analyses examined whether group, time, and group by time were predictors of daily objective cognition. This analysis examined whether the conditions differed, whether participants changed over the course of the 7 days of data collection, and whether there were condition differences in change across the data collection. Demographic factors and the person-mean of daily subjective cognition were included as covariates in the adjusted models. In the unadjusted and adjusted models predicting both category fluency and immediate word recall, there were no effects for group, time, or group by time (see Table 2, Step 1). Thus, as expected, participants in the improvement condition did not perform better over the 7 days. However, contrary to expectations, participants in the control group also remained stable rather than performing worse, as expected. As expected, higher

TABLE 2 Group, time, group by time, and the moderating effect of control predicting objective cognition

	Step 1				Step 2			
	Immediate recall		Category fluency		Immediate recall		Category fluency	
Effect	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Intercept	**4.53**	**1.20**	**7.32**	**2.81**	4.75	2.56	**15.70**	**6.35**
Gender	0.06	0.25	−0.01	0.57	0.06	0.25	0.04	0.58
Education	**0.29**	**0.05**	**0.57**	**0.11**	**0.29**	**0.05**	**0.54**	**0.11**
Age	**−0.03**	**0.01**	**−0.04**	**0.01**	**−0.03**	**0.01**	**−0.04**	**0.01**
Subjective cognition (PM)	0.26	0.20	−0.87	0.47	0.26	0.21	**−0.96**	**0.48**
Group	0.24	0.33	−0.77	0.84	0.25	1.37	−5.90	3.45
Day	−0.08	0.09	−0.08	0.28	−0.08	0.41	−1.00	1.17
Group * Day	0.00	0.06	0.26	0.16	−0.03	0.24	0.67	0.69
Control over cognition					−0.05	0.57	−2.04	1.44
Control over cognition * Group					−0.01	0.35	1.34	0.88
Control over cognition * Day					0.00	0.10	0.23	0.29
Control over cognition * Group * Day					0.01	0.06	−0.10	0.18

Note. Bold indicates significant at the $p < 0.05$ level. PM: person-mean; SE: standard error.

education and younger age were both associated with better immediate recall and category fluency.

3.1.1 | Moderating effects

We then examined whether age was a moderator of group, time, and group by time effects on objective cognition. To better understand the potential effects of age, age was examined as a linear effect and as a quadratic effect, and as a categorical variable with age in three groups (young, middle-aged, and older adults). There were no significant moderating effects for age, and there were also no moderating effects for education. Finally, we examined control over cognition as a moderator of the group, time, and group by time effects on objective cognition, and there were no moderating effects of control over cognition (see Table 2, Step 2). Collectively, these results demonstrated that the above-reported stability for objective cognition for both conditions was consistent for participants regardless of age, education, or reported control over cognition.

3.2 | Subjective cognition

Multilevel analyses examined whether group, time, and group by time were predictors of subjective cognition (see Table 3 for adjusted analyses for all three subjective cognitive items). Covariates included demographic factors and the person-means for daily objective cognition (immediate recall and category fluency).

First, we examined group, time, and group by time as predictors of the subjective cognition item, “How good is your memory today?” measured each day over the seven daily diary interviews. There was a significant effect of time in both the unadjusted and adjusted analyses where participants (regardless of group) reported their memory as significantly better over the course of the week (see Table 3, Step 1). There was no significant effect of group or group by time (Est. = −0.05, $SE = 0.03$, $p = 0.058$).

We then examined group, time, and group by time as predictors of the subjective cognition item “How much do you think you can improve your memory?” measured each day over the seven daily diary interviews. There were no significant group, time, or group by time effects (see Table 3, Step 1).

Lastly, we examined group, time, and group by time as predictors of the subjective cognition item, “Compared to yesterday, how much do you think your memory has improved?” The results revealed a significant effect of time and group by time in unadjusted and adjusted models (see Table 3, Step 1). The interaction effect shows that, as expected, participants in the memory improvement group reported greater increases in their self-reported memory compared with the memory task group.

3.2.1 | Moderating effects

We next examined whether age, education, and perceived control over cognition were moderators of the group, time, and group by time effects of subjective cognition. Neither age nor education were significant moderators for any of three subjective cognition items. Therefore, regardless of age or education level, the above reported findings for subjective cognition remained.

However, there was a significant moderating effect of perceived control over cognition in the group by time effect (see Table 3, Step 2 and Figure 1) for one of the subjective cognition items (“Compared to yesterday, how much do you think your memory has improved?”). Figure 1 illustrates these findings, using one standard deviation above and below the mean for illustrative purposes. This interaction effect shows that the group by time effect was qualified by control beliefs. This interaction effect demonstrated that participants in the memory

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TABLE 3 Group, time, group by time, and the moderating effect of control predicting subjective cognition[a]

	Step 1						Step 2					
	How good is your memory today?		In general, how much do you think you can improve your memory?		Compared to yesterday, how much do you think your memory has improved?		How good is your memory today?		In general, how much do you think you can improve your memory?		Compared to yesterday, how much do you think your memory has improved?	
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Intercept	**2.91**	**0.32**	**2.73**	**0.65**	**2.12**	**0.48**	**3.65**	**0.87**	2.38	1.28	**3.56**	**1.05**
Gender	−0.12	0.06	−0.20	0.15	−0.13	0.10	−0.11	0.07	−0.13	1.15	−0.09	0.10
Education	−0.02	0.01	0.05	0.03	**−0.05**	**0.02**	−0.02	0.01	0.04	0.03	**−0.05**	**0.02**
Age	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	−0.01	0.00	0.00	0.00
Category fluency (PM)	−0.01	0.01	0.00	0.02	**−0.04**	**0.02**	−0.01	0.01	0.00	0.02	**−0.04**	**0.02**
Immediate recall (PM)	**0.06**	**0.02**	−0.03	0.06	**0.08**	**0.04**	**0.06**	**0.02**	−0.02	0.06	**0.09**	**0.04**
Group	0.10	0.12	0.06	0.16	0.19	0.14	−0.41	0.49	−0.33	0.66	−1.04	0.57
Day	**0.10**	**0.04**	0.01	0.04	**0.14**	**0.04**	−0.11	0.18	−0.14	0.18	**−0.35**	**0.18**
Group * Day	−0.05	0.03	−0.01	0.03	**−0.08**	**0.03**	0.09	0.11	0.12	0.12	**0.24**	**0.10**
Control over cognition							−0.20	0.21	0.06	0.27	−0.39	0.24
Control over cognition * Group							0.13	0.12	0.12	0.17	**0.33**	**0.14**
Control over cognition * Day							0.06	0.05	0.04	0.05	**0.13**	**0.04**
Control over cognition * Group * Day							−0.03	0.03	0.03	0.03	**−0.08**	**0.03**

Note. Bold indicates significant at the $p < 0.05$ level.

[a]Higher scores for subjective cognition are associated with better self-reports of memory. PM: person-mean; SE: standard error.

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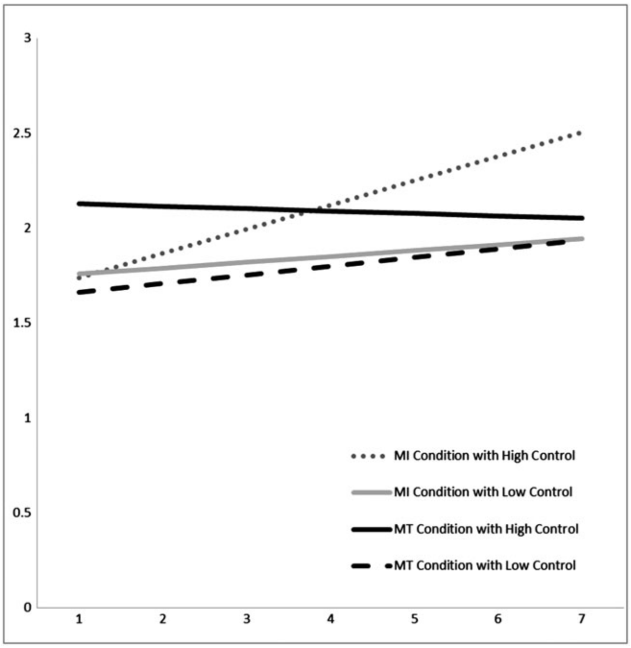

FIGURE 1 Moderating effect of perceived control of cognition in the effect of condition over 7 days. MI: memory improvement condition; MT: memory task condition. For illustrative purposes only, high and low control were computed as one standard deviation above and below the mean

improvement condition who had high perceived control over cognition showed increases in their beliefs about memory improvement over the course of 7 days. In contrast, those who had low control beliefs and individuals in the memory task condition showed no change over time.

4 | DISCUSSION AND IMPLICATIONS

This study investigated whether instructions similar to those used to describe the potential benefits of brain training programs affect subjective and objective cognitive performance and whether some individuals are more susceptible to such claims. The memory improvement condition included language similar to that used to describe brain training programs, using phrases like "exercise your brain" and "mentally fit." Conversely, the memory task condition emphasized that the "task" would be a "good indicator of your memory" similar to instructions used in stereotype threat manipulations. As expected, there was no change in objective cognition but there was a significant change in perceived cognition for participants in the memory improvement condition. Participants reported greater improvements in their memory "compared to yesterday" than the memory task group. Contrary to expectations that there would be a decrease in perceptions of performance and actual objective performance, there was no change in two of the three subjective cognition items nor was there any change in objective cognition for the participants in the memory task condition. All participants increased for one of the three subjective cognition items (i.e., "how good is your memory") over the course of the 7 days.

As expected, given the limited nature of the cognitive task practice, participants did not demonstrate any change in their objective cognitive performance over the course of the 7 days of the study. It is important to note that the purpose of the current study was not to engage participants in a brain training program. Rather, we were interested in examining susceptibility to claims about cognitive improvement, and whether there were individual differences therein. For the memory task condition, we expected that participants would lower their perceptions of their memory ability and possibly perform worse over time, based on stereotype threat theory (Steele & Aronson, 1995). However, we did not find this to be true, perhaps because our study did not exclusively focus on older adults who may be especially susceptible to stereotype threat for cognitive tasks (Chasteen et al., 2005).

We also examined the role of individual differences in susceptibility to the instructional manipulation. We found that increases in subjective cognition were qualified by the participants' perceived control over their cognition such that for participants with a high sense of control, being in the memory improvement group was associated with reporting better subjective cognition. In contrast, having low control beliefs or being in the memory task condition was associated with little or no change in perceptions of cognition. Consistent with work on control beliefs (Lachman, Neupert, & Agrigoroaei, 2011), participants who believe they have little control over their cognitive decline would likely not expect to see any change; thus, their belief in their cognitive abilities remained flat. However, in line with Bandura's (1994) self-efficacy theory, those who do believe they have control over their cognitive decline may increase their self-efficacy due to persuasion, demand characteristics, expectations that their performance is a result of their actions, and motivation to report improvement.

Foroughi, Monfort, Paczynski, McKnight, and Greenwood (2016) also recently examined susceptibility to brain training. They examined placebo effects in terms of objective cognition for cognitive training by having participants self-select to an experimental condition that either emphasized brain training or not during recruitment (Foroughi et al., 2016). As they expected, individuals who self-selected into the "brain training" group improved in fluid intelligence that the authors explain as an expectancy effect because both groups completed the same training. Presubjective and postsubjective cognition were not included in their study. At baseline, individuals who self-selected into the "brain training" group also had greater beliefs that intelligence is malleable and, as the authors explain, had different characteristics than the participants in the control condition. In our study, participants did not complete a training program; therefore, we did not expect and did not find any improvements in objective cognition. As mentioned earlier and in line with our study, individuals exposed to the optimism and possibility for improvement emphasized in the description of brain training programs may report performance gains due to persuasion and demands of the situation.

Contrary to our hypothesis, the effects of the instructional manipulation did not vary by age. Previous work (Hess & Hinson, 2006) examining stereotype threat across the adult lifespan identified that for individuals in their 40s, the salience of negative aspects of aging

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enhanced performance in line with a stereotype lift effect and that participants in midlife experienced a negative stereotype threat effect. Though we examined linear and quadratic effects of age, our findings did not support a stereotype threat effect.

We also found that all participants, regardless of condition, reported improved ratings on the "how good is your memory today" question during the study. This question is in contrast to our findings of significant differences for the self-report item, "Compared to yesterday, how much has your memory improved?" Although both questions assess subjective cognition, the latter question provides an anchor for comparison and may be more sensitive to perceptions of change specifically in the context of the repeated exposure to brain training programs. In addition, although the moderating effect of perceived control over cognition was not significant for the former item and thus should be considered with caution, the *p* value for the interaction effect was 0.058 and when graphed, the findings were in the same direction as the latter item.

Some limitations of the current study should be noted. We cannot rule out the possible influence of other factors (e.g., prior brain training experience, personality, or mental health factors) altering the effect of the instructional manipulation experienced by the participants. Our current study design only included 7 days, which is a limited time frame for either objective or perceived cognitive improvement. We chose a daily diary protocol to best simulate daily training conducted at home that participants may experience when using commercial training software. Additionally, the items used to operationalize subjective cognition were single-item measures; however, they have been used in previous large survey studies as a meaningful assessment of perceived performance (Rickenbach, Agrigoroaei, & Lachman, 2015).

Because of the increasing popularity of commercialized brain training programs and the widespread availability of program and phone applications that have limited empirical support, research is needed that examines to what extent adults are susceptible to memory improvement and the promises of brain training. Although there is research and recent recommendations from the National Academies of Science, Engineering, and Medicine (2017) that supports some types of cognitive and brain training programs for minimizing cognitive decline, not all programs are evidence-based. Furthermore, there are many behaviors (e.g., social engagement, and physical activity) that can promote healthy aging and help older adults' to manage their concerns about potential memory loss and normative changes in cognitive aging, which may be incompatible with spending time and money on brain training. Our study demonstrated the effects that an instructional manipulation can have on participant's perception of their cognitive improvements. This study underscores the importance of scrutiny in evaluating the efficacy of brain training programs that base their advertising, in part, on anecdotal evidence. There is a need for caution in the marketing of brain training programs that do not have empirical evidence to support their claims. Furthermore, some individuals, in particular those with a high sense of control, who believe that their actions are effective in leading to desired outcomes, may be more affected by exaggerated claims.

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