Memory Self-Efficacy Predicts Responsiveness to Inductive Reasoning Training in Older Adults

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Objectives. In the current study, we assessed the relationship between memory self-efficacy at pretest and responsiveness to inductive reasoning training in a sample of older adults.

Methods. Participants completed a measure of self-efficacy assessing beliefs about memory capacity. Participants were then randomly assigned to a waitlist control group or an inductive reasoning training intervention. Latent change score models were used to examine the moderators of change in inductive reasoning.

Results. Inductive reasoning showed clear improvements in the training group compared with the control. Within the training group, initial memory capacity beliefs significantly predicted change in inductive reasoning such that those with higher levels of capacity beliefs showed greater responsiveness to the intervention. Further analyses revealed that self-efficacy had effects on how trainees allocated time to the training materials over the course of the intervention.

Discussion. Results indicate that self-referential beliefs about cognitive potential may be an important factor contributing to plasticity in adulthood.

Key Words: Aging—Cognitive optimization—Cognitive training—Inductive reasoning—Memory self-efficacy.

O NE of the most robust findings in the cognitive aging literature is that age is normatively associated with monotonic decline in fluid cognition, those abilities that depend on the rapid encoding and transformation of information. However, there is a great deal of interindividual variability in these changes, suggesting that some individuals are able to maintain high levels of cognition across the lifespan and, moreover, that there exists potential for cognitive optimization in later adulthood (Hertzog, Kramer, Wilson, & Lindenberger, 2008). These findings have motivated the development of a wide variety of interventions designed to enrich the cognitive abilities of older adults (Stine-Morrow & Basak, 2011).

One sort of cognitive intervention involves explicit training in isolated cognitive components that are strongly related to general markers of fluid ability, such as working memory, speed of processing, and inductive reasoning. Inductive reasoning, the ability to infer general rules based on specific occurrences, has been known to be an indicator of fluid ability since as early as the 1920s (Spearman, 1927) and is practically significant insofar that it has been related to the proficiency in executing tasks of everyday living among older adults (Wolinsky et al., 2006). Thus, inductive reasoning is one of the fluid abilities most often targeted for training. Process-specific cognitive training interventions for inductive reasoning often produce clear improvement (Ball et al., 2002). At the same time, there are individual differences in the effectiveness of training and it is of great interest to pinpoint the factors that moderate the degree to which older adults gain from cognitive interventions (e.g., initial cognitive ability, preexisting health conditions; Boron, Turiano, Willis, & Schaie, 2007; Unverzagt et al., 2007). In this study, we investigated whether individual differences in self-efficacy beliefs about memory capacity are associated with responsiveness to the targeted training of inductive reasoning.

Generally, self-efficacy is defined as the belief in the capacity to perform in a manner that exercises influence over events in one's life (Bandura, 1997). Individuals who are high in self-efficacy believe they have the capability to achieve desired goals in particular situations. Thus, these individuals are more likely to produce goal-based behaviors that result in positive outcomes. For example, individuals with high levels of self-efficacy beliefs are more likely to adhere to an exercise regimen (Marcus, Eaton, Rossi, & Harlow, 1994) and, as a result, show overall better health (Lachman & Firth, 2004). Memory self-efficacy (MSE), the belief in the effectiveness of one's memory function, is a particularly important construct in cognitive gerontology. Subjective reports of memory failures are widely reported in older adulthood (Jonker, Geerlings, & Schmand, 2000), and although MSE has been shown to predict memory performance (Hertzog, Dixon, & Hultsch, 1990), in many cases, memory complaints are independent of objective measures of memory performance (Jungwirth et al., 2004). This suggests that memory complaints and reports of declines in MSE are not solely the result of actual declines in cognitive ability but may reflect a larger self-regulatory

belief about the ability to perform effectively in demanding situations (West, Bagwell, & Dark-Freudeman, 2008). Although Social Cognitive Theory (Bandura, 1989, 1997) conceptualizes MSE as a domain-specific aspect of self-efficacy (that is, specific to memory), low ratings of successful memory efficacy may be related to lower motivation to engage in demanding tasks, thus negatively impacting engagement in activities that may not explicitly tax memory (Berry, 1999). Thus, poor MSE among older adults may "be an underlying factor that precipitates avoidance of cognitively challenging situations" (Valentijn et al., 2006, p. 165). The implications of this possibility on long-term cognitive maintenance become clear when considering the increasing number of studies suggesting that intellectually engaging lifestyles contribute to successful cognitive aging (Crowe, Andel, Pedersen, Johansson, & Gatz, 2003; Parisi, Stine-Morrow, Noh, & Morrow, 2009; Schooler & Mulatu, 2001; Schooler, Mulatu, & Oates, 1999; Stine-Morrow, Parisi, Morrow, & Park, 2008; Wilson, Scherr, Schneider, Li, & Bennett, 2007).

In a large-scale longitudinal study, Seeman, McAvay, Merrill, Albert, and Rodin (1996) found relationships between self-efficacy beliefs and cognition among older adults such that participants with initially more positive beliefs showed better maintenance of memory performance up to two and a half years later. More recently, Valentijn et al. (2006) found that MSE predicted performance on the visual verbal learning task at a 6-year follow-up. However, the mechanisms whereby self-efficacy beliefs impact cognition are not entirely clear. Considering the recent research on the role of self-efficacy beliefs in effectively executing goal-based behaviors, one potential and as yet untested explanation for the results from these large-scale longitudinal studies is that those with more positive beliefs engage more fully in the cognitive demands inherent in everyday activities, resulting in long-term cognitive enrichment. A similar argument has been made in the literature, suggesting that age-related declines in cognitive self-efficacy (Berry & West, 1993) might result in older adults being less likely to engage in highly demanding situations (Bandura, 1989; Stine-Morrow, 2007; Stine-Morrow, Shake, Miles, & Noh, 2006; West, Bagwell, & Dark-Freudeman, 2005). Thus, positive beliefs about memory function may have an advantageous effect on how older adults gain from tasks that provide opportunities for cognitive enrichment, such as training interventions.

To test this account, we examined whether older adults with initially positive MSE beliefs would show greater change in reasoning abilities within a randomized inductive reasoning training intervention. Accordingly, immersion in a cognitive training program would be expected to accelerate the rate at which opportunities for cognitive engagement are encountered compared with a control group. We therefore expected that adults with initially higher MSE would gain more from the training intervention than those with

relatively low MSE, but that adults in control group (within the short timeframe of our study) would show minimal effects of self-efficacy on change in reasoning. By contrast, if the effects of MSE were independent of opportunities for experience, then no difference in the relationship between MSE and change in reasoning would be expected between the groups.

METHODS

Participants

Participants were 105 community-dwelling older adults from the Champaign–Urbana area. Participants ranged in age from 60 to 94 years (mean = 72.9, SD = 7.7) and had an average of 15.5 years of education (SD = 2.7). Participants were randomly assigned to either an inductive reasoning training program (N = 47) or a waitlist control group (N = 58). Data are reported for those who returned for posttest (N = 42 and 53 in the training and control groups, respectively). The data are reported from the Senior Odyssey project (Stine-Morrow, Parisi, Morrow, Greene, & Park, 2007; Stine-Morrow et al., 2008), an ongoing community-based field experiment investigating the effects of intellectual engagement on cognition. The training group for the current study was a reasoning training intervention against which to compare effects of the engagement intervention.

Training Program

Participants in the training condition completed a 16-week program including logic puzzles and games interleaved with a home-based inductive reasoning training program (Margrett & Willis, 2006) that was adapted from the inductive reasoning training used in the ACTIVE trials (Advanced Cognitive Training for Independent and Vital Elderly; Ball et al., 2002). The reasoning intervention trained participants in recognizing novel patterns and using these patterns to solve problems. Early in the program, participants were given explicit training with the inductive reasoning materials. Subsequently, participants were asked to devote 10 hr per week to completing training booklets at home, which over the course of 16 weeks included sets of logic puzzles that incidentally exercised inductive reasoning skills (e.g., Sudoku, Kakuro) in addition to the inductive reasoning training materials (Margrett & Willis, 2006). Over the course of the training program, participants were given increasingly difficult logic puzzle sets depending on their performance and self-perceived challenge with the previous set. The reasoning materials included both *basic series problems*, in which participants explicitly solved problems that required inference from a serial pattern of words, letters, or numbers and *everyday serial problems*, such as completing a mail order form or answering questions about a bus schedule. Unlike the puzzles, the reasoning training materials were predetermined to increase

in level of difficulty from week to week (Margrett & Willis, 2006).

Among the 47 participants in the training group, 38 (80.1%) participants completed the program. Of the 9 who dropped from the intervention, 4 returned for posttest and 5 did not (see *Analysis*). Among the 58 participants in the control group, 53 (91.4%) were retained; 95% confidence intervals (CIs) were calculated for age, education, MSE, and the baseline composite of inductive reasoning (IR) for the group that was retained. Because the means for the group that dropped from the intervention did not fall outside of the 95% CI for those who retained, we found no evidence for significant differences between these two groups on any of the key variables: age $(M_{\text{Drop}} = 74.1; M_{\text{Retained}} = 72.8,$ 95% CI = ±2.53), education $(M_D = 15.6; M_R = 15.6,$ 95% CI = ±0.79), MSE $(M_D = 2.82, M_R = 2.96,$ 95% CI = ±0.21), or baseline IR $(M_D = -0.33, M_R = .06,$ 95% CI = ±0.42*)*.

Measures

Five instruments were used to identify a latent IR factor (α = .90): the letter sets (maximum score [MS] = 15), number sets (MS = 15), letter series (MS = 20), and word series (MS = 30) tasks (Ekstrom, French, & Harman, 1976) and the Everyday Problem-Solving (EPS; MS = 22) task (Marsiske & Willis, 1995). Collectively, the Ekstrom et al. (1976) tests require participants to identify patterns in a series of items and either generate the next item in the series (letter series and word series) or decide which item did not adhere to the pattern (letter sets and number sets). These measures have been used successfully in previous training studies to assess IR ability (Ball et al., 2002; Margrett & Willis, 2006). In the EPS task, participants were presented with several hypothetical situations in everyday domains ranging from food preparation to transportation. Participants were asked to solve problems, such as calculating how many pills to take over a 2-day period, given information from a prescription drug label. Performance on these measures was scored in terms of number of correct responses within a timed interval.

MSE was measured with the memory capacity beliefs subscale (α = .86), from the Metamemory in Adulthood scale (Dixon, Hertzog, & Hulstch, 1988). The measure included 18 items meant to index the participant's self-perception of memory capacity with ratings of performance on given tasks (scale: 1–5). Sample items for the measure include: "I am good at remembering names" and "I have no trouble remembering where I have put things." Positive scores are associated with higher capacity.

Participants in the training intervention were also asked to keep a daily log reporting the amount of time in half-hour increments that they spent on the training materials. They submitted these logs to laboratory personnel once a week across the 16 weeks. As noted earlier, the trainees were instructed to devote at least 10 hr per week to the training

booklets, but there was considerable variation in how participants allocated their time across the intervention.

Procedure

Participants completed the MSE scale as part of a larger set of measures that were mailed to their homes before random assignment. Participants were then administered the inductive reasoning measures as part of a larger battery of cognitive measures in an individual laboratory session lasting approximately 2 hr. This cognitive battery was completed before random assignment and again within 1 month of the end of training.

Analysis

To determine the effect of the intervention on changes in IR and to examine moderators of change in IR within the training group, we fit latent change score models using structural equation modeling (SEM). Latent change score modeling is an effective way to examine changes in two wave data (Sayer & Cumsille, 2001) and has previously been used to assess effects of training on cognitive abilities among older adults (McArdle & Prindle, 2008). The multiple latent measures of IR were used to define two latent factors that describe change in IR across time: the intercept factor, representing initial individual differences at the first occasion of measurement, and the slope factor, representing the amount of individual change from pretest to posttest. The intercept factor was specified by setting loadings equal to 1 at both pretest and posttest. To specify the slope factor, loadings were set as a contrast between pretest and posttest. For ease of interpretation of the results, model parameters are presented as standardized maximum likelihood estimates (sMLEs) for all path coefficients (see Figures 1 and 2) and maximum likelihood estimates (MLEs) are presented in the text for the latent parameter estimates (i.e., intercept and variance estimates).

We constrained for strict measurement invariance in our models across time points to ensure that the changes at the latent level correspond to actual changes in the construct. The residual variances for each item were allowed to correlate across time points and we fixed item loadings and residual variances to be equal from pretest to posttest. To fit a latent MSE factor, parcels were used as indicators rather than single items to better meet the assumptions of the normal distribution for maximum likelihood parameter estimation. Parcels were built using the item-to-construct technique (see Little et al. 2002). In SEM, parcels are treated as manifest variables and are produced by aggregating across two or more items. The item-to-construct technique uses the factor loadings of a principle components analysis to balance the parcels. Specifically, the four highest loading items were each anchored to one of the four parcels. The four items with the next highest loadings were then anchored to
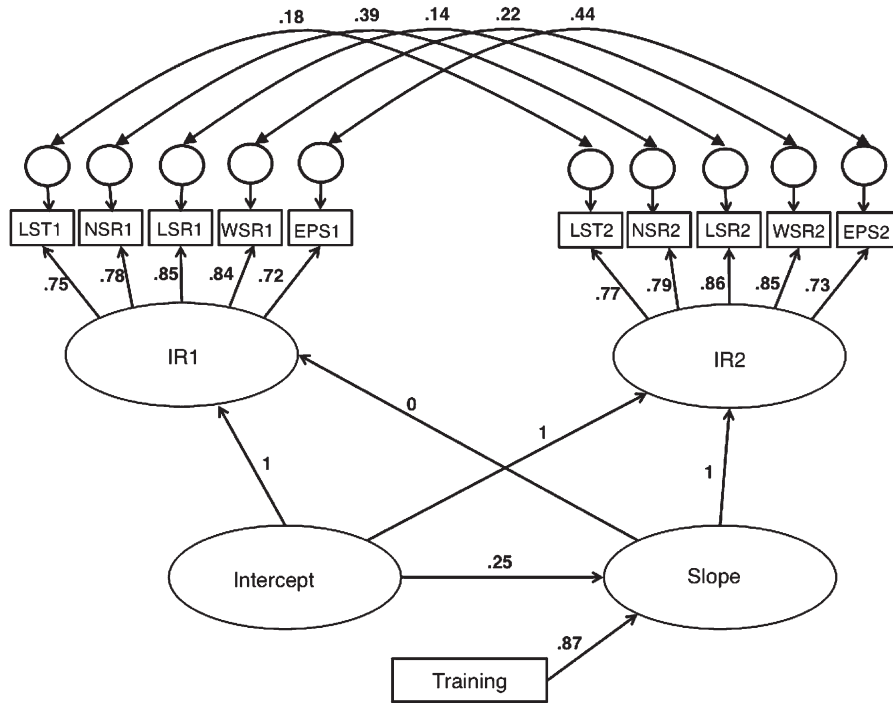
Figure 1. Training (control vs. training) predicting latent change in inductive reasoning. Path coefficients are standardized. LST = letter sets; NSR = number series; LSR = letter series; WSR = word series; EPS = everyday problem solving; IR = latent inductive reasoning.

each parcel in reverse order. This process is rotated through all items to balance the parcels. Each parcel had either four or five items.

Analyses were conducted as intent-to-treat (i.e., participants who dropped from the program were invited back for posttest; Lachin, 2000). To the extent that those who drop from the program return for testing, this serves as a more conservative test of the intervention by providing an estimate of effect size that is less biased by program dropout.

We also used hierarchical linear modeling (HLM) in additional analyses in order to examine the effects of MSE on the amount of time participants allocated to the training. These models were used because the outcome measure is sampled repeatedly across the 16 weeks of the intervention. Number of weeks was nested within subjects, allowing us to account for within-subject variability across the 16 weeks. Therefore, the Level 1 units are measurement occasions (time) and the Level 2 units are individuals. An individual growth model was fit with a random intercept and a random effect for time. This model allows us to estimate the Level 1 random effect (week of the measurement) and Level 2 (subject) effects such as MSE.

RESULTS

Table 1 presents the means, *SE*s, and correlations between the key variables in this study for the control and training groups. There were no initial differences between the training and control groups in age, education, MSE, or baseline inductive reasoning (all ts < 1).

The Effects of Training and Self-Efficacy on Inductive Reasoning

To test for the effect of the intervention, we first fit a model with group membership (control or training) as a predictor of latent change in IR from pretest to posttest. Figure 1 presents the simplified path diagram and standardized path coefficients for this model. This model showed good fit to the data ($\chi^2(48) = 69.48$, Comparative Fit Index [CFI] = .97, Root Mean Square Error of Approximation [RMSEA] = .06). In line with prior findings (Ball et al., 2002; Margrett & Willis, 2006; McArdle & Prindle, 2008), we found that group membership predicted change in inductive reasoning (sMLE = .87, $z = 2.73$, $p < .01$). Specifically, we found significant increases from pretest to posttest in IR in the training group (MLE = 1.03, $SE = .47$, $z = 2.15$, $p < .05$) but no change in the control group (MLE = .33, $SE = .31$, $z = 1.07$, $p > .10$). The effect of the intervention on reasoning abilities ($d = .44$) was similar in magnitude with past IR training interventions (Ball et al., 2002).

Significant variability existed in the slopes within the training group (MLE = .98, $SE = .14$, $z = 7.21$, $p < .001$), suggesting that individuals were differentially responsive to the training. To test whether self-efficacy beliefs predicted variability in responsiveness to the cognitive training, we fit a second model with age and latent MSE predicting change
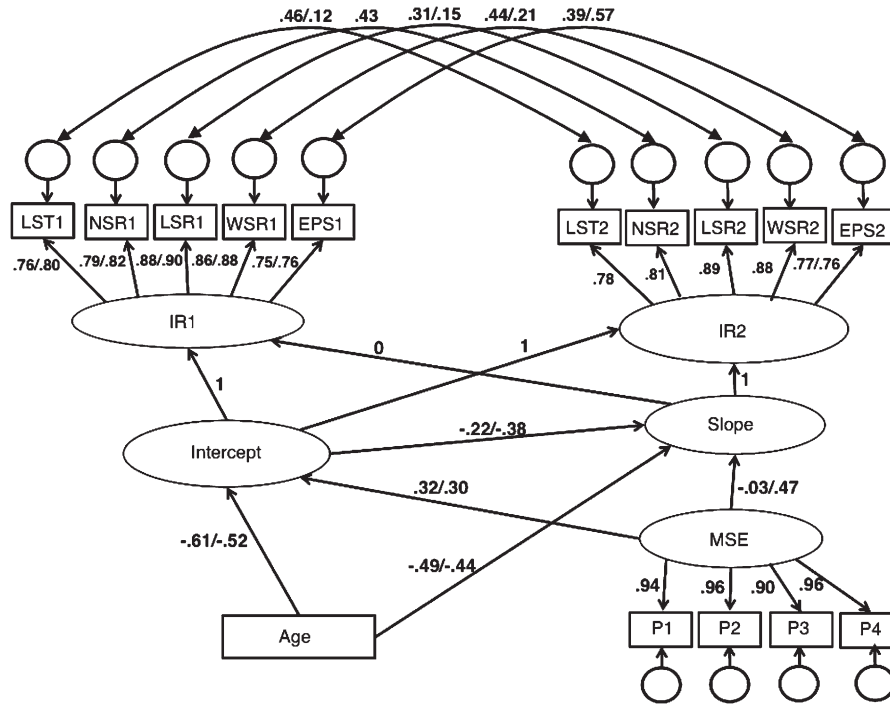
Figure 2. Age and memory self-efficacy predicting latent change in inductive reasoning in the control and training groups. Differences between groups in path coefficients are indicated as control/training. No difference between the control and training groups where only one coefficient is presented. Path coefficients are standardized maximum likelihood estimates. LST = letter sets; NSR = number series; LSR = letter series; WSR = word series; EPS = everyday problem solving; IR = latent inductive reasoning; MSE = memory self-efficacy; P = parcel.

in IR. Figure 2 presents the path diagram for this model, with standardized path coefficients for both the control and training groups. Model fit was good for both the control ($\chi^2(298) = 139.79$, CFI = .93, RMSEA = .05) and training ($\chi^2(298) = 131.60$, CFI = .94, RMSEA = .08) groups. For both groups, age was negatively related to initial IR (sMLE$_{Control}$ = −.61, z_C = −3.53, p_C < .001; sMLE$_{Training}$ = −.52, z_T = −2.96, p_T < .01) and change in IR (sMLE$_C$ = −.49, z_C = −2.34, p_C < .05; sMLE$_T$ = −.44, z_T = −2.16, p_T < .05).

This finding replicates previous research (Ball et al., 2002; Boron et al., 2007) showing that younger age is associated with greater change as a function of cognitive interventions.

The critical test for our hypothesis was whether MSE predicted change in IR in the training group. Over and above age effects, MSE significantly predicted gains in inductive reasoning within the training group (sMLE = .47, z = 2.27, p < .05) but not the control (sMLE = −.03, z = −.14, p > .10). As can be seen from Figure 3, which plots standard

Table 1. Means and Correlations for Age, Education, MSE, and Inductive Reasoning (at time 1 and time 2) for the Control and Training Groups

Variable	Mean (*SE*)	1	2	3	4
Control					
1. Age	72.90 (0.98)				
2. Education	15.70 (0.38)	−.08			
3. MSE	2.96 (0.07)	.15	−.03		
4. IR:T1	45.34 (0.02)	−.45**	.29*	.05	
5. IR:T2	46.52 (0.03)	−.59**	.30*	−.04	.87**
Training					
1. Age	73.00 (1.18)				
2. Education	15.40 (0.38)	.01			
3. MSE	2.87 (0.07)	.12	−.19		
4. %IR: T1	44.24 (0.03)	−.38**	.38*	−.11	
5. %IR: T2	56.29 (0.03)	−.55**	.39*	−.01	.91**

Note. MSE = memory self-efficacy; IR:T1 = Time 1 (pretest) percent accuracy in inductive reasoning tasks; IR:T2 = Time 2 (posttest) percent accuracy in inductive reasoning tasks.
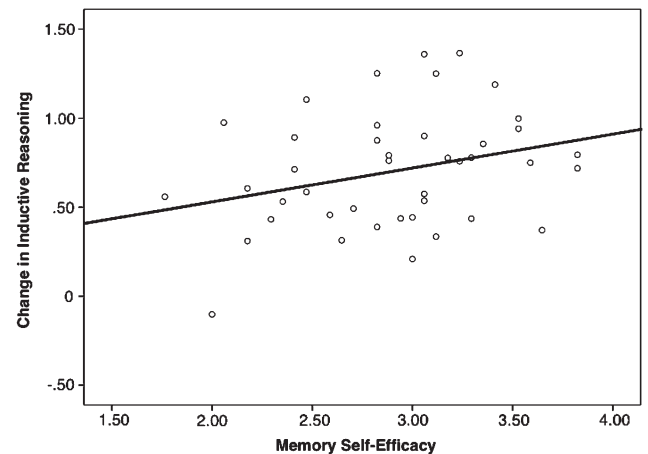
* $p < .05$; ** $p < .01$.

Figure 3. Scatter plot of standard unit change in inductive reasoning by memory self-efficacy for participants in the training group.

unit change in IR by MSE for the training group, a positive relationship existed between initial MSE and change in IR as a result of the training. Our findings confirmed that older adults' self-referential beliefs about cognition are predictive of individual plasticity in cognitive ability; older individuals with higher self-perceptions of memory capacity were more responsive to the training than those with initially less positive perceptions of capacity.

Search for an Underlying Mechanism

Further analyses were aimed at understanding why those with higher ratings of MSE would show such an advantage in training. One possibility is that those with higher self-efficacy allocated more time to the intervention and thus gained more as a consequence of time-on-task. Such a time-on-task hypothesis would suggest that we should not only see differences in the change in performance that can be predicted by initial MSE but also in how participants allocated time, and presumably effort, across the intervention. To examine this, we analyzed the self-reports of the amount of time participants in the training group spent each week on the IR training problems. A small number of trainees who completed the intervention ($N = 3$) did not submit their logs of time allocated to the training materials. Subsequent analyses are reported for the sample of participants in the training group who reported these weekly records ($N = 35$).

HLM was used to examine the independent and joint effects of MSE and week of training on the amount of time allocated to the IR training materials. We included week in the program as a variable in the analysis, reasoning that resistance to such declines reflects perseverance in the training activities. Although MSE did not have a significant main effect on the amount of time allocated to the intervention ($B = -2.60$; $SE = 2.54$; $t(474) = -1.02$, $p > .10$), week did have a significant effect ($B = -2.06$; $SE = 0.44$; $t(474) = -4.69$, $p < .0001$). On average, participants in the training group decreased approximately 1 hr per week in the amount of time they reported spending on program activities. Importantly, however, these effects were moderated by a significant MSE by week cross-level interaction ($B = .62$; $SE = 0.15$; $t(474) = 4.02$, $p < .0001$).

To examine the nature of this effect, we used the simple slopes technique (Preacher, Curran, & Bauer, 2006) to decompose the MSE by week interaction into simple effects of week on the amount of time allocated to the IR training, at conditional levels of MSE. Results indicated that, for those with low MSE (1 SD below the mean), there was a significant decrease in the amount of time participants spent on the training materials each week across the training period ($B = -.63$; $SE = .10$; $z = -5.92$, $p < .001$). However, participants with higher levels of MSE (1 SD above the mean) maintained the same mean level of time allocated to the intervention across the training period ($B = .01$; $SE = .11$; $z = .14$, $p > .10$). Thus, although individuals with more positive self-efficacy beliefs did not allocate more time initially, they showed sustained effort across the full training period, suggesting that individuals with higher MSE persevered with the training materials over the course of the intervention.

We then assessed if time allocated to the training materials was the active mechanism underlying the impact of MSE on training gains. We tested whether the relationship between MSE and change in IR in the training group was mediated by the change in time allocated to the training materials across the 16 weeks. We assessed this mediational relationship by treating initial MSE, change in IR, and change in time allocation as manifest variables and estimating the indirect effect (the effect of MSE on change in IR through its effect on change in time allocation across the 16 weeks) using resampling methods. Specifically, we estimated this indirect effect using the bootstrap procedure described by Preacher and Hayes (2004), resampling 2,000 times. Using this procedure, we derived CIs that are nonparametric and are not based on assumptions from large sampling theory. The Sobel test for the indirect effect was nonsignificant ($B = 0.002$; $z = -.66$). Thus, we found no support for the idea that change in time spent with the training materials over the course of the intervention mediated the relationship between initial MSE and change in IR.

DISCUSSION

The findings from the current study suggest that self-efficacy beliefs are associated with the degree to which individuals can gain from the targeted training of a specific fluid ability. Among participants in the training group, those with higher levels of MSE showed greater performance gains in IR than those with relatively lower MSE. This effect was not found for participants in the control group, who were not given explicit opportunities for cognitive engagement elicited by the training. Additionally, MSE was also found to predict how trainees in the intervention allocated time across the 16 weeks of the intervention. Individuals with lower MSE showed declines in the amount of time they allocated to the training materials across the 16 weeks of the intervention. However, individuals with higher MSE showed evidence for perseverance in the amount of time reported on the training materials.

Our findings are consistent with recent research showing positive relationships between older adults' MSE beliefs and performance in goal-based situations (Stine-Morrow, Miller, & Hertzog, 2006; West & Yassuda, 2004; West et al., 2008). The current study extends prior findings by showing that MSE beliefs predict change in performance in a nonmemory domain. Thus, the relationship between MSE and change in cognition may not be limited to memory but may rather be reflective of change in fluid abilities more globally. At a theoretical level, this finding is interesting for theories of self-efficacy in which MSE is viewed as a domain-specific

indicator of cognitive performance (i.e., restricted to memory). A large literature has considered issues related to the measurement and definition of self-efficacy beliefs about cognition and self-efficacy more generally (Bandura, 1986, 1989, 1997; Berry & West, 1993). Within this literature, there are a number of conceptualizations of the construct of self-efficacy, with some using the term comprehensively, including other constructs such as perceived control and mastery, whereas others adhere to a definition of self-efficacy that is task and domain specific (Bandura, 1997; (Berry, West, & Dennehey, 1989). Considering that there is a marked reduction in confidence about memory performance among older adults (Berry, 1999; Jonker et al., 2000) coupled with widespread negative stereotypes about aging and memory (Hess, 2005; Hess, Auman, Colcombe, & Rahhal, 2003), older adults with negative memory beliefs may not effectively self-regulate behavior even in tasks that do not directly tax memory. Thus, MSE may be an important predictor of cognitive maintenance because negative internalized beliefs about memory may influence older adults to not effectively engage in demanding activities, which ultimately results in less than maximal gains.

At an applied level, findings suggesting that MSE training enhances memory training (see West et al., 2008) may also be extended to other process-specific cognitive training interventions, such as inductive reasoning and speed of processing. The ACTIVE trials have clearly demonstrated that these specific component training interventions show little to no evidence of transfer across other measures of cognition (e.g., speed of processing training does not affect memory or IR; Ball et al., 2002; McArdle & Prindle, 2008). Although there is not strong evidence of transfer of effects as a result of training, it may be that supplementary training aimed at boosting MSE and memory confidence (West et al., 2008) would be useful outside of the domain of memory training interventions. Indeed, our findings demonstrate that individual differences in MSE predict important training-related behaviors and outcomes in an intervention that was specifically meant to train reasoning abilities. Counter to some previous theoretical notions of the domain specificity of MSE, our results suggest that self-efficacy beliefs about memory function are important to consider in cognitive maintenance more broadly. Future research should take advantage of experimental training paradigms using MSE training in conjunction with other component cognitive training to further explore the domain specificity versus domain generality of MSE in older adults.

Trainees with higher MSE beliefs appeared to self-regulate their behavior by persisting in their time spent engaging with the intervention materials across the length of the intervention—a "time-on-task" effect. Similar results were found by Stine-Morrow, Shake, et al. (2006) who demonstrated that MSE had differential effects on participant's performance depending on goal conditions. Older and younger participants read passages under different goal conditions (reading for accuracy vs. reading quickly to get the main points). In the accuracy goal condition, higher MSE was predictive of more time allocated to the text during reading, especially as text difficulty was increased. However, under the speeded condition, higher MSE was predictive of more efficient reading (i.e., reduced time per unit subsequently recalled). Under explicit instructions, older adults with higher MSE not only invested more time in the task but also appeared to be more flexible in adopting appropriate strategies to meet specified goals. In the relatively unrestrictive home-based reasoning training of the current study, it may be that individuals with high self-efficacy used multiple strategies to develop their capacity for inductive reasoning skills. Therefore, efficacious individuals may not have only allocated more time (which we were able to measure to some extent) but may have also utilized different strategies to aid in successful performance and/or invested effort to the training in a more intense fashion, both of which we were not able to directly measure. In other words, our time-on-task findings were important in showing better behavioral engagement among those with high MSE, but unfortunately, we did not have a measure of attentional engagement (see Stine-Morrow, 2007, for a discussion of the distinction). Behavioral engagement may set a lower limit on what can be accomplished with training. However, increased cognitive potential presumably requires active attentional engagement with task demands as well. To better understand mechanisms by which MSE affects performance, future research will need to include measures of both sorts of engagement.

A stronger test of the time-on-task hypothesis would, of course, have been evidence that the relationship between MSE and change in IR was mediated by the amount of time allocated to the intervention materials across the 16 weeks. Although we found that participants with initially higher MSE showed both gains in IR as a result of the training and perseverance in the amount of time they allocated across the span of the training program, we found no direct evidence that perseverance in the training materials mediated the relationship between MSE and change in IR. As discussed earlier, this may be because participants with high MSE utilize several routes through which to optimize performance in the intervention, some of which may be of more importance than others. Given that we have demonstrated in the current study that individual differences in MSE predict training related gains, a goal for future research is to fully specify the behavioral mechanisms through which this occurs.

In some studies, indicators of effortful behavior (e.g., strategy use, persistence) have been found to mediate the relationship between self-efficacy/control beliefs and performance among older adults (Lachman & Andreoletti, 2006), but others have failed to find such relationships (Wells & Esopenko, 2008), suggesting that self-efficacy may have multiple routes through which to optimize performance. There is now a growing body of research aimed at

uncovering the ways through which self-efficacy and control beliefs affect performance and, importantly, in establishing proper metrics of various training related behaviors among older adults (Bagwell & West, 2008; Saczynski, Margrett, & Willis, 2004). Understanding how older adults self-regulate their behavior to optimize training-related gains is an important aim for future research in this domain.

Lastly, one explanation that must be considered is that, in endorsing strong efficacy beliefs, individuals are simply accurate in their self-perceptions of plasticity. That is, it may be that efficacy beliefs to some extent reflect genuine self-knowledge about the capacity for change. However, our finding that self-efficacy beliefs also predicted how trainee's allocated time to the intervention across the 16 weeks suggests that MSE beliefs may reflect more than just meta-knowledge of one's abilities. Thus, we believe the more plausible explanation is that individuals with more positive self-efficacy beliefs habitually allocate more effort within goal-oriented situations (Bandura, 1997), such as training, and thus demonstrate greater behavioral plasticity. Ultimately, more research is necessary to delineate the multiple roles of MSE in engendering plasticity. At the same time, our results present a novel contribution to a literature that has established that MSE is related to both initial cognitive ability and long-term cognitive maintenance by demonstrating that MSE predicts training-related plasticity in cognitive function.

The results of the current study contribute to our understanding of the factors that underlie cognitive plasticity and optimization in adulthood. Biological senescence processes constrain cognitive development in later life within a broad zone of possible trajectories of functioning (see Hertzog et al., 2008 for an in-depth discussion). The current study suggests that older individuals with positive self-referential beliefs may benefit more from engagement in activities that provide opportunities for cognitive enrichment, such as the training intervention, thus increasing the likelihood for an optimal trajectory of cognitive aging.

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