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## Goal-Oriented Attention Self-Regulation (GOALS) training in older adults

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### ABSTRACT

#### Abstract

**Objectives:** A common cognitive complaint of older adulthood is distractibility, or decline in ability to concentrate and maintain focus, yet few evidence-based interventions exist to address these deficits. We implemented a pilot trial of an evidence-based executive function training program, to investigate whether training in applied goal-directed attention regulation and problem solving would enhance executive control abilities in a sample of cognitively normal older adults with self-reported complaints of concentration problems.

**Method:** Consecutively recruited participants were placed into small groups and randomized to either Goal-Oriented Attentional Self-Regulation training (GOALS;  $N=15$ ) or a closely matched Brain Health Education program (BHE;  $N=15$ ).

**Results:** GOALS participants significantly improved on: neurocognitive measures of mental flexibility ( $p=0.03$ , partial eta squared = 0.23); real-world setting functional performance measures of: task failures ( $p=0.02$ , Cohen's  $d=0.88$ ), task rule breaks ( $p=0.02$ , Cohen's  $d=1.06$ ), and execution ( $p=0.04$ , Cohen's  $d=0.76$ ); and in-lab functional assessment of goal-directed behaviour divergent thinking scale ( $p=0.03$ , Cohen's  $d=0.95$ ). All participants improved on a neurocognitive measure of planning ( $p=0.01$ , partial eta squared = 0.031). BHE participants' improvement over and above GOALS participants was limited to: rule adherence on the real world task ( $p=0.04$ , Cohen's  $d=0.99$ ), and evaluator rating ( $p=0.03$ , Cohen's  $d=0.56$ ), and average score ( $p=0.02$ , Cohen's  $d=0.71$ ) on the in-lab functional task.

**Conclusion:** Participation in GOALS training can enhance executive control, and lead to real-world functional improvements, for cognitively normal older adults with self-reported attention difficulties.

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### KEYWORDS

Aging; cognitive training; rehabilitation; executive function; attention

## Introduction

Poor goal direction, or difficulty concentrating and 'staying on task' in a distracting environment, is a common complaint in advanced age (de Braek, Hurks, van Boxtel, Dijkstra, Jolles, 2009; Weaver Cargin, Collie, Masters, & Maruff, 2008). Such subjective reports are consistent with an emerging consensus in the cognitive aging literature that executive control processes necessary for maintaining goal direction are particularly susceptible to decline across the lifespan (e.g. Gazzaley, Cooney, Rissman, & D'Esposito, 2005; Hasher & Zacks, 1988; see Turner & D'Esposito, 2010, for a review). Unfortunately, few published interventions targeting executive control functioning are supported by Class I evidence (i.e. randomized control studies), necessary for adoption as clinical practice standard in clinical populations (Cicerone et al., 2011, and see Turner & Levine, 2004; Turner & D'Esposito, 2010; and Novakovic-Agopian & Abrams, 2014, for reviews). While there are no similar reviews explicitly targeting executive function interventions in typical aging cohorts, the largest published cognitive training trial in this population (The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) trial, Ball et al., 2002, Willis et al., 2006) does provide some reason for cautious optimism. While the authors did not describe their training as an executive control intervention per se, this

trial did demonstrate lasting impacts of a targeted training protocol to enhance reasoning ability, arguably one aspect executive functioning. The results of this trial showed that reasoning training combined with memory and speed of processing training was associated with durable improvements in real world functional outcomes in older adulthood (see Tennstedt & Unverzagt, 2013 for a review).

Goal-Oriented Attention Self-Regulation Training (GOALS, Novakovic-Agopian et al., 2011) is a targeted executive control training program that teaches attention regulation and problem solving strategies and applies in-lab training to participant-defined, real-life goals. We recently reported functional brain changes in older adults associated with participation in GOALS (Adnan, Chen, Novakovic-Agopian, D'Esposito, & Turner, 2017) in a subsample of the participants in our current study. Here we report the neurocognitive and functional changes associated with GOALS training in cognitively normal older adults with complaints of problems with concentration or distractibility.

### Executive control and selective attention

Selective processing of goal-relevant information, a central component of executive control, filters information based

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The work of Tatjana Novakovic-Agopian, Erica Kornblith, Michelle Madore, Anthony J.W. Chen, & Mark D'Esposito was authored as part of his official duties as an Employee of the United States Government and is therefore a work of the United States Government. In accordance with 17 USC. 105, no copyright protection is available for such works under US Law. Areeba Adnan & Gary R. Turner hereby waive their right to assert copyright, but not their right to be named as co-authors in the article.

on goal-relevance. This type of processing facilitates access to finite processing resources, while filtering non-relevant distractions (Awh & Vogel, 2008; Baddeley, 2001; Cowan & Morey, 2006; Repovš & Baddeley, 2006). Pathways from perception to action require selecting information for processing, as well as maintaining and protecting this information from disruption during working memory, learning, decision-making, and/or problem-solving. If one cannot hold key information relative to the goal, or protect it from distracting information, then it follows logically that subsequent actions are less likely to be guided efficiently or effectively towards goal attainment (Novakovic-Agopian & Abrams, 2014; Chen & Novakovic-Agopian, 2012). Interventions to improve filtering based on goal-relevance – i.e. enhancing this attention gateway – may improve goal-directed behaviour across a broad array of functional domains.

### **Attention regulation in older adulthood**

Normal aging is associated with reduced ability to inhibit attention to goal-irrelevant stimuli, resulting in reduced goal-directed thought and action. The inhibition hypothesis of cognitive aging (Hasher & Zacks, 1988) argues that, in a perceptually noisy environment, older adults are less able to inhibit processing of distracting stimuli, leaving fewer processing resources for relevant information and ultimately leading to off-task behaviours and goal neglect (Duncan, 1986). Gazzaley et al. (2005) investigated the neural basis of these age-related changes using functional MRI (fMRI). They reported that older adults failed to suppress neural response in visual perception regions to stimuli that were irrelevant to task goals. Critically, this suppression deficit resulted in better recognition of irrelevant stimuli on a subsequent memory test, suggesting that these distractor items were processed more deeply by older adults. According to this neuromodulation account, age-related brain changes result in poor top-down modulation of neural responses. Behaviourally, poor filtering of goal-irrelevant information enables distractions to compete for finite processing resources, leading to increased off-task behaviours as actions become separated from intended goals (see Turner & D'Esposito, 2010, for a review of neurocognitive aging theories).

### **Goal-Oriented Attentional Self-Regulation training**

The GOALS training intervention (Novakovic-Agopian et al., 2011, 2018) targets the functioning of the attentional gateway by teaching participants strategies for enhancing attention to goal-relevant stimuli, while suppressing attention to irrelevant and distracting information or thoughts. In contrast to training on laboratory tasks, this protocol teaches attention regulation skills and strategies by continuously promoting their direct application in real-world contexts. The experimental training protocol was based on goal-management and problem-solving interventions that have been applied to patients with brain injury as well as other populations (D'Zurilla & Goldfried, 1971; Levine et al., 2000; Krpan, Levine, Stuss, & Dawson, 2007; Nezu et al., 2007; Rath, Simon, Langenbahn, Sherr, & Diller, 2003;

Robertson, 1996; Schweizer et al. 2008; von Cramon, Cramon, & Mai, 1991). These approaches are combined with mindfulness-based attention regulation strategies and applied to daily life situations as well as meaningful goals identified by participants.

In a previous study, we applied the GOALS intervention to enhance goal-based direction of behaviour in daily life in a cohort of individuals with chronic acquired brain injury and executive dysfunction (Novakovic-Agopian et al., 2011). Individuals who completed GOALS significantly improved on neuropsychological measures of attention and executive control, while participation in a brief educational activity resulted in no such improvements. Critically, training generalized to improved functional performance in complex 'real world' settings (i.e. performance on a low-structure task requiring participants to complete goals in a community setting, such as making a purchase, while following set rules and avoiding distractions). In a separate report we used fMRI to investigate changes in the neural basis of the attention gateway following GOALS training. As predicted, top-down modulation of activity in visual association cortices based on stimulus relevance was increased following GOALS, but not the control training (Chen et al., 2011). In a sample of the cognitively normal older adult participants in this current GOALS training study we have demonstrated functional brain changes in executive control regions (Adnan, Chen, Novakovic-Agopian, D'Esposito, & Turner, 2017). Specifically, covarying activity in lateral prefrontal and parietal brain regions, implicated in cognitive control processes (Spreng, Sepulcre, Turner, Stevens, & Schacter, 2013), was enhanced following GOALS, but not control training. Critically, the extent of functional brain changes predicted performance on a post-training measure of selective attention, suggesting the observed brain changes are behaviourally relevant in older adults.

### **The current study**

Taken together, the inhibition hypothesis and neuromodulation accounts of age-related cognitive decline propose that older adults have reduced capacity to allocate attentional resources based on goal relevance. The GOALS training intervention explicitly trains attention regulation by teaching skills and strategies to improve attentional gating, leading to fewer off-task (i.e. non-goal directed) behaviours. In the current study we recruited a cohort of cognitively normal older adults with self-reported attention difficulties to participate in GOALS training or a closely matched psycho-educational control protocol. The objective of the study was to investigate whether GOALS training improved performance on neuropsychological measures of attention and executive control and functional assessments designed to mimic 'real world' goal-directed tasks. We predicted that (i) participating in GOALS training would improve performance on neuropsychological measures of executive control functioning and (ii) as the protocol explicitly targets the transfer of training gains to real-world contexts, performance improvements would be greatest on the functional measures, reflecting enhanced goal-directed attention in everyday tasks.

**Table 1.** Univariate within-subjects and between-subjects effects of time (pre vs. post-training) and training group on neurocognitive outcomes.

	Pre-training				Post-training						F (1,19)	
	GOALS (n = 10)		BHE (n = 11)		GOALS		BHE					
	M	SD	M	SD	M	SD	M	SD	Group			
										Time	Group X Time	
Working memory	0.73	0.41	0.16	0.70	0.74	0.49	0.34	0.49	6.57* <sup>1</sup>	0.51	1.41	
Mental flexibility	0.45	0.59	0.42	0.28	0.74	0.49	0.34	0.49	1.29	1.75	5.55* <sup>2,3</sup>	
Inhibition	0.85	0.40	0.64	0.28	0.83	0.38	0.62	0.52	1.82	0.04	0.00	
Planning	0.33	0.47	0.53	0.55	0.71	0.42	0.88	0.65	0.87	8.67** <sup>4</sup>	0.02	
AVXE	0.59	0.36	0.39	0.55	0.77	0.46	0.40	0.40	3/70	2.02	1.46	
Processing speed	0.21	0.47	0.05	0.81	0.36	0.84	0.05	0.81	0.44	1.01	0.00	
Motor	−0.43	0.55	−0.33	0.60	−0.22	0.51	−0.39	0.55	0.03	0.30	0.98	
Learning and memory	−0.49	1.08	−0.42	1.15	−0.33	1.00	−0.06	1.05	0.14	2.62	0.38	

\*Significant at the  $p < .05$  level.\*\*Significant at the  $p < .01$  level.

Note. All outcome measures were transformed to z scores before analysis.

<sup>1</sup>Partial eta squared = .26.<sup>2</sup>Participants in GOALS group improved significantly from pre to post-training, compared to BHE.<sup>3</sup>Partial eta squared = .23.<sup>4</sup>Partial eta squared = .31.

## Methods

### Participants

Participants were recruited from the Berkeley Aging Cohort, a pool of older adult volunteers recruited through UC Berkeley and community advertisements. Participants were included in the study if they (1) were right-handed, (2) did not have significant medical, neurological, or psychiatric/substance abuse history, (3) were not taking psychotropic medications, (4) had normal or corrected-to-normal vision; (5) did not evidence active depression as defined by a score  $< 11$  on the Geriatric Depression Scale (GDS; Brink, Yesavage, Lum, Heersema, Adey, & Rose, 1982); and (6) were on a stable medication regime. The sample was 63% female. Average age was 67.63 years, and participants had a mean of 17.89 years of education. Prior to entering into the study, participants were assessed for cognitive status in order to exclude individuals impacted by neurodegenerative or other diseases affecting cognition. All participants obtained Mini Mental Status Exam (MMSE; Folstein, Robins, & Helzer, 1983) scores  $> 27$ , and were independent in activities of daily living. Participants provided informed consent according to the procedures approved by the Institutional Review Board of the University of California, Berkeley.

### Study design

For this pilot trial a total of 30 individuals (19 females and 11 males) were randomly assigned to participate in one of two manualized training protocols: Goal-Oriented Attentional Self-regulation (GOALS) or Brain Health Education (BHE) (See Table 1). Consecutively recruited participants were placed in small groups (average group size was 3 participants) and then the group was randomized to GOALS or BHE. Participants in the GOALS training group ( $N = 15$ ) were aged 60 to 80 ( $M = 67$ ;  $SD = 5.87$ ), with an average of 17.88 years of education ( $SD = 3.59$ ), and participants in the BHE ( $N = 15$ ) intervention were aged 60 to 75 ( $M = 68.08$ ;  $SD = 4.54$ ) with an average of 17.17 years of education ( $SD = 1.53$ ). Independent sample t-tests revealed no significant differences between the two groups in age [ $t(25.29) = -0.55$ ,  $p = 0.59$ ] or education [ $t(21.40) = 0.71$ ,  $p = 0.49$ ]. The GOALS group included eight females and

seven males, whereas the BHE group included nine females and six males. A chi square test revealed no significant differences in gender between both groups,  $\chi^2 = 0.38$ ,  $p = 0.54$ . The GOALS group included 11 individuals identifying as White/Caucasian and two individuals identifying as "other," and ethnicity information was unavailable for two participants. The BHE group included 11 individuals identifying as White/Caucasian, and ethnicity information was unavailable for three participants. Individuals assigned to GOALS had stronger working memory scores at baseline; there were no other baseline differences in cognitive or functional outcome variables between the groups.

### Interventions

GOALS and BHE manualized training protocols were matched for therapist time and training intensity. Each training involves ten two-hour sessions of group-based training over five weeks, three individual one-hour training sessions, and approximately 20 hours of at-home practice (30–60 minutes daily homework). Both are conducted in a small group format with two to five participants, and two therapists per group.

Goal-Oriented Attentional Self-regulation (GOALS) Training (Figure 1).

The GOALS intervention emphasizes two key components. First, regulation of distractibility is addressed with attention regulation training. This aspect of the training emphasizes principles of applied mindfulness-based attention regulation to redirect cognitive processes towards task-relevant activities even when distracted. The second major component of GOALS training involves the active application of these skills to the identification, selection, and execution of self-generated complex goals. Participants are asked to identify personally relevant and feasible functional goals (e.g. finding an apartment, completing a home improvement project, planning a vacation) as individual and group projects. To ensure consistency of administration, intervention manuals were written for instructors and participants (Instructor and Participant Manuals of Goal-Oriented Attentional Self-Regulation–GOALS; Novakovic-Agopian, Chen, & Rome, 2007).



Session 1	Applied Attention Regulation	Applied Goal Management	Introduction and overview
Session 2			Absentmindedness and mindfulness
Session 3			Progressive information maintenance: Mindfulness exercises
Session 4			Goal selection: Options for group and individual projects
Session 5			Breaking down projects into sub-tasks, creating timeline. Apply to group and individual projects
Session 6			Execution and dealing with procrastination
Session 7			Staying on tasks, error correction and adjustments
Session 8			Project progress review and adjustments
Session 9			Individual project presentation
Session 10			Group project presentation and graduation celebration

Figure 1. GOALS training sessions.

Session 1	Introduction and Basic Brain Anatomy
Session 2	Neuroplasticity
Session 3	Movement, Vision, and Language
Session 4	Memory
Session 5	Attention and Executive Functions
Session 6	Sleep and the Brain
Session 7	Diet and Physical Activity and the Brain
Session 8	Stress and the Brain
Session 9	Emotions and the Brain
Session 10	Social Bonds and the Brain/ Lessons Learned

Figure 2. Brain Health Education workshop sessions.

At a broad level, the main components of GOALS include mindfulness-based attention regulation training, emphasized in the first half of the intervention, and goal management strategies applied to participant-defined goals, emphasized in the second half of the intervention. Please see Novakovic-Agopian et al. (2018) for a more detailed description of the GOALS intervention.

Brain Health Education (BHE) comparison training (Figure 2). Brain Health Education (BHE) is an active comparison designed to be engaging and provide information about brain health and functioning. Although session materials address sleep, diet, and effects of stress, they are educational in nature. Group leaders do not assist participants with making connections between the material presented and possible positive effects on their own daily functioning, or how to integrate into their daily lives. Furthermore, the presumed active ingredients of GOALS training, which include applied problem-solving and attention regulation, are not part of BHE intervention. Homework consists of reading articles related to session content and watching DVDs about brain functions and health.

### Measures

Participants were evaluated with neuropsychological and ecologically valid functional measures at pre- and post-GOALS or BHE group intervention. These measures were administered by the same evaluator at both time points. Evaluators were blinded to participants' treatment

condition, and evaluators and therapists were separate individuals.

### Neuropsychological assessments

The current study used a neuropsychological battery designed to assess performance in complex attention regulation/executive function, cognitive domains that are commonly affected by aging and targeted by GOALS training. *Working memory* was assessed with (1) Auditory Consonant Trigrams (Stuss, Stethem, & Pelchat, 1988) requiring recall of three consonants after counting backward by threes (e.g. 100, 97, 94, etc.) from a specified number for a variable amount of time, and (2) the Letter Number Sequencing subtest from the Wechsler Adult Intelligence Scale, Third Edition (WAIS III; Wechsler, 1997), requiring mental reordering of scrambled letter-number series of increasing lengths. *Inhibition* of automatic responding was assessed with Stroop Inhibition task (time and errors) from the Delis-Kaplan Executive Function System (DKEFS; Delis, Kaplan, & Kramer, 2001), in which words are printed in dissonant ink color and participants are instructed to name the color of the ink instead of providing the more automatic response of reading the word. *Mental flexibility* was assessed with (1) Trail Making Test-Part B (Heaton, Grant, & Mathews, 1991), requiring rapid alternation between letters and numbers to connect them in order; (2) Design Fluency-Switching (DKEFS; Delis et al., 2001), requiring alternating between empty and filled dots while generating different designs using four lines; (3) Verbal Fluency Switching (DKEFS; Delis et al., 2001) requiring the generation of words

that belong to two specified categories and alternating between them; and (4) DKEFS (Delis et al., 2001) Stroop Inhibition-Switching (time and errors), during which the participant is presented with words printed in dissonant ink color, some of which are contained in boxes, and the participant is instructed to name the color of the ink unless the word is inside the box, in which case they are to read the word. *Planning* was assessed with the DKEFS (Delis et al., 2001) Tower Test (Total Achievement Score), a complex task requiring reproduction of various iterations of tower designs using blocks in the fewest moves possible while following a set of rules, and Mazes (Neuropsychological Assessment Battery (NAB); Stern & White, 2003), in which the participant completes a series of increasingly complex mazes as quickly as possible. A composite executive function variable (AVXE) was constructed using Z scores on measures from the Planning, Inhibition, Working Memory, and Mental Flexibility domains.

Participants' performance in episodic memory and information processing speed, cognitive domains commonly affected by aging (Park, Polk, Mikels, Taylor, & Marshuetz, 2001) but not targeted by the intervention, was also assessed as a marker of potential nonspecific changes. *Verbal and visual memory* were assessed with the Hopkins Verbal Learning Test-Revised (HVLT-R; Brandt & Benedict, 2001), requiring participants to learn 12 words presented over three learning trials and to recall them after a 20-25 minute delay, and Brief Visual Memory Test-Revised (BVM-T-R; Benedict, 1997), requiring participants to learn and reproduce six abstract designs over three learning trials, and to reproduce them after a 25-minute delay. *Information processing speed* was assessed with the Trail Making Test-Part A (Heaton, Grant, & Matthews, 1991), a task requiring rapid sequential connection of numbers on a page. *Fine motor speed and coordination* was assessed with Grooved Pegboard (Lafayette Instrument Company, 2002) dominant and non-dominant hands.

To minimize practice effects, alternative test forms (DKEFS Verbal Fluency Switching, HVLT-R, BVM-T-R, Mazes) and/or norms for repeated testing (Auditory Consonant Trigrams) were used for repeated administrations.

#### *Functional assessments*

**Goal Processing Scale.** The Goal Processing Scale (GPS; Novakovic-Agopian et al., 2014) involves the observation and rating of a participant completing a 'real-world' challenging task that engages executive control using a scoring system to quantify observations. This measure is administered to one participant at a time. Participants are instructed to gather and compare information about three different activities (or products/services, as designated on alternate forms) of their choice, using the available means while following specified rules in a limited time (30 minutes). Participants work in an office equipped with a computer with Internet access, a telephone, telephone book, blank paper, pen, calculator, and clock. They are given an instructions page, which contains the key requirements of the task and the task rules. The instructions are read aloud by the evaluator, who is present in the room during the entire evaluation. To ensure participants' understanding of the task, the evaluator asks for reiteration of the instructions, and participants are invited to request clarifications as needed. After participants' understanding

of the instructions is confirmed, they are asked to decide on the actual goals and parameters of the task and to identify the steps needed to complete the task (the "planning stage"). During the 30-minute "task execution stage," participants are evaluated on their ability to effectively execute the task on the basis of their identified plan and adherence to task rules.

Subdomains of executive function evaluated during the *planning* stage include the ability to comprehend task instructions and ask for clarifications when needed; to decide on and identify realistic goal(s); and to organize and prioritize steps involved in actual task execution. After the task goals and plan are decided upon, the participants are told to execute the task on the basis of their identified plan and task rules. The domains assessed during the task execution stage include the ability to *initiate* task-directed activities; *maintain attention* on a task both in a non-distracting environment and during the built-in task distractions; *self-monitor performance* (including inhibiting task activities to stop at specified times, review performance, notice, and correct errors); *sequence and switch attention* between and among the identified task subcomponents; demonstrate *flexibility* in approaching alternate solutions when the situation changes (e.g. the ability to continue with specified task goals when the preferred means of obtaining information such as the Internet or phone become unavailable). *Memory*, including both the ability to recall strategies when needed and the ability to correct previously noted errors, is also assessed. The *execution* score reflects the accuracy of completion of identified task goals and effectiveness of time management while executing steps relevant to the identified plan and goals. Finally, an *Average of Main Domains Rated* score is also calculated.

Functional performance in these domains is rated on a scale ranging from 0 (not able) to 10 (absolutely not a problem). The GPS overall performance score (*Average of main domains rated*) is the average of the 7 subdomain scores. For further information about the development and validation of this measure, see Novakovic-Agopian et al. (2014).

**Multiple Errands Test (MET).** The MET is an unstructured functional task that allows clinicians to directly assess a patient's ability to follow outlined rules and complete multiple "real-world" tasks in a limited time period. Although the main subcomponents of the task outlined in Knight, Alderman, and Burgess (2002) were retained, the MET was adapted for use on the UC Berkeley campus. Participants were presented with written instructions and a campus map and asked to complete 12 subtasks in 40 minutes, while following nine specified task rules. The subtasks involved performing different activities (e.g. buying specified items, collecting an envelope with instructions from a specified location, using a campus phone system to reach a specific person); obtaining information (e.g. determining the opening time of the campus store on a Saturday or the name of the US city predicted to reach the highest temperature tomorrow); and stopping ongoing activity to meet the evaluator at a specified place and time. To minimize practice effects, alternate forms were used at baseline and at week five post-training. For example, one of the subtasks at baseline involved buying a bottle of water, and at week five a can of soda. Task performances are rated as follows:

0 = successful completion, 1 = partial completion, and 2 = failure, so that failure of all 12 tasks would result in a maximum score of 24. The nine task rules included the following: not leaving the campus grounds, spending a maximum of \$5.00 (they are given a \$10.00 bill), not entering a building or room without completing part of the task inside, not going back to the same area more than once; buying no more than two items from one location, not talking about things unrelated to the task, and completing a task in the allotted time. The outcome variables produced are *number of task failures*, *number of task rule breaks*, *task rule break frequency*, *social rule breaks*, and *overall execution*. *Task rule break frequency* was assessed as number of repeated task rule breaks. *Social rule breaks* were defined as making inappropriate comments or interacting inappropriately with others during the task. *Execution* was defined as the therapist rating of overall performance.

### Statistical analysis

All scores on neuropsychological variables were standardized via transformation to z-scores before analysis. Scores on functional variables were analyzed in raw score format. All analyses were conducted using SPSS Version 22 (IBM Corp., 2015). Descriptive statistics were calculated for the neuropsychological (individual tests and domain scores) and functional variables for the whole sample and both intervention groups separately (GOALS vs. BHE).

A repeated measures multivariate analysis of variance (MANOVA) was used to compare group performance on neurocognitive domain scores at pre- and post-intervention, and to compare improvement over time for GOALS vs. BHE. Additional MANOVAs were also conducted for each group separately.

Nine participants (five BHE, four GOALS) were excluded from the multivariate neurocognitive analyses due to incomplete data. Specifically, participants were excluded from the MANOVA analyses if greater than or equal to five percent of total neurocognitive data points were missing, and/or if scores were missing on a measure used to calculate one of the neurocognitive domain scores (Howell, 2012).

Analysis of GPS and MET outcome variable distributions in raw score format revealed that the assumptions of MANOVA were violated. As a result, nonparametric Wilcoxon Signed Rank tests were used to compare improvement on functional measures (GPS and MET) for each group separately. Eight participants missing data for all GPS subscales were excluded from that analysis (three GOALS, five BHE); similarly, seven participants were excluded from the MET analysis due to missing data for all outcome variables (two GOALS, five BHE).

Although we have examined a number of cognitive domains and sub-domains, we report nominal p-values, without adjustment for multiple testing consistent with our previous work (see Novakovic-Agopian et al., 2011). Such adjustments are focused on avoidance of one or more results with  $p < 0.05$  in the case where all differences are truly zero (Perneger, 1998; Rothman, 1990; Savitz & Olshan, 1995), which is an unrealistic hypothesis about the state of nature in this context. In addition, adjustment would

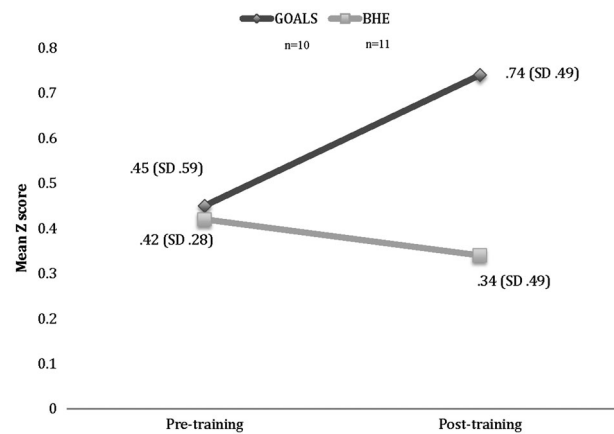


Figure 3. Interaction effect of group and session (pre- vs. post-training) on mental flexibility.

require that each result detract from the others, but there are clear relationships between the domains under study, and these permit coherent sets of findings to reinforce each other rather than detract from one another.

## Results

### Neuropsychological test data

A repeated measures MANOVA was used to compare the impact of GOALS training versus BHE on cognitive performance (Table 1).

Post-training, participants in both groups significantly improved on our measure of planning [ $F(1, 19) = 8.67$ ,  $p = .008$ ; partial  $\eta^2 = .31$ ]. A significant group by session interaction effect was observed for mental flexibility, such that individuals who received GOALS demonstrated increased performance on tasks of mental flexibility compared to those individuals who participated in the BHE intervention [ $F(1, 19) = 5.55$ ,  $p = 0.03$ ; partial  $\eta^2 = .23$ ; Figure 3). Planned comparisons confirmed that the GOALS group showed significant improvement pre to post-training ( $p = 0.02$ ) whereas no significant improvements were identified for BHE ( $p = .46$ ). Conducting the same analysis using a random sample of BHE participants to achieve equal sample sizes ( $n = 10$  for both BHE and GOALS) resulted in a consistent pattern of findings.

### Functional assessment data

Separate Wilcoxon Signed Rank Tests were conducted to assess within-group changes in the GPS sub-domains and MET scores for each group (GOALS; Table 2, BHE; Table 3). The GOALS group demonstrated a statistically significant improvement in divergent thinking abilities ( $z = -2.232$ ,  $p = .026$ ) and BHE group demonstrated an improvement on overall task execution ( $z = -2.193$ ,  $p = .028$ ) as measured by the GPS. On the MET, the GOALS group demonstrated a statistically significant reduction in task failures ( $z = -2.361$ ,  $p = 0.018$ ); decreased task rule breaks ( $z = -2.375$ ,  $p = 0.018$ ); and higher evaluator's rating of the participant's performance ( $z = -2.040$ ,  $p = .041$ ). The BHE group demonstrated reduced frequency of rule-breaks ( $z = -2.055$ ,  $p = .040$ ).

**Table 2.** Nonparametric Wilcoxon Signed Rank Tests for Effect of Training on Functional Task Variables, GOALS.

		Pre-training		Post-training				
MET ( <i>n</i> = 12)		Mean	SD	Mean	SD	<i>z</i>	<i>p</i>	Cohen's <i>d</i>
	Number of task failures	8.00	3.22	5.08	3.42	−2.36	.02*	0.88
	Number of task rule breaks	3.67	1.67	2.08	1.31	−2.38	.02*	1.06
	Task rule break frequency	4.75	2.45	3.08	2.97	−1.55	.12	0.61
	Social rule breaks	.17	.39	.00	.00	−1.41	.16	0.62
	Execution	6.60	1.73	8.01	1.95	−2.04	.04*	0.76
GPS ( <i>n</i> = 11)								
	Planning	8.15	1.53	9.06	.59	−1.89	.06	0.78
	Initiation	10.00	.00	9.06	3.02	−1.00	.32	0.44
	Self-monitoring	6.78	1.98	7.16	1.56	−.62	.53	0.21
	Maintenance of attention	8.18	.81	8.25	1.22	−.71	.48	0.07
	Sequencing and switching of attention	7.68	1.37	8.05	1.49	−.51	.61	0.23
	Divergent thinking	8.36	1.43	9.55	1.04	−2.23	.03*	0.95
	Learning/memory	6.01	2.56	6.22	2.66	−.45	.66	0.08
	Execution	7.55	1.57	7.71	1.62	−.04	.97	0.10
	Average of main domains rated	7.84	.95	8.14	.98	−1.42	.16	0.31

\*Significant at the  $p < .05$  level.**Table 3** Nonparametric Wilcoxon Signed Rank Tests for Effect of Training on Functional Task Variables, BHE.

		Pre-training		Post-training				
MET ( <i>n</i> = 10)		Mean	SD	Mean	SD	<i>z</i>	<i>p</i>	Cohen's <i>d</i>
	Number of task failures	6.60	3.06	4.70	4.42	−1.06	.29	0.50
	Number of task rule breaks	3.70	1.34	2.60	1.78	−1.61	.11	0.70
	Task rule break frequency	5.80	2.39	3.30	2.67	−2.06	.04*	0.99
	Social rule breaks	.10	.32	.20	.63	−.45	.66	0.20
	Execution	6.82	1.52	7.70	2.20	−1.07	.25	0.47
GPS ( <i>n</i> = 10)								
	Planning	8.57	.83	8.54	1.09	−.18	.86	0.03
	Initiation	10.00	.00	9.00	3.16	−1.00	.32	0.45
	Self-monitoring	6.02	1.45	7.57	1.67	−1.84	.07	0.99
	Maintenance of attention	6.25	1.65	7.10	1.14	−1.47	.14	0.60
	Sequencing and switching of attention	7.35	1.45	8.00	1.27	−1.62	.11	0.48
	Divergent thinking	7.80	2.04	8.10	1.37	−.60	.55	0.17
	Learning/memory	4.31	2.27	6.39	2.41	−1.96	.05	0.89
	Execution	6.78	1.83	7.78	1.72	−2.19	.03*	0.56
	Average of main domains rated	7.13	1.07	7.81	.83	−2.29	.02*	0.71

\*Significant at the  $p < .05$  level.

## Discussion

We recently reported functional brain changes and associated attentional improvements following goal-directed attention training in a sub-sample of the cognitively normal older adults with self-reported attention difficulties studied here (Adnan et al., 2017). We now report the results of participation in the same GOALS training on standard neuropsychological assessments and 'real-world' functional tasks. Consistent with hypotheses, participants in GOALS training improved significantly more on neuropsychological measures of executive control functioning compared to participants in the BHE control intervention. GOALS participants also evidenced fewer rule-breaks, task failures and higher evaluator ratings on a functional, real-world task. There were no statistically significant gains detected on neuropsychological measures for participants in BHE, although improved task adherence and evaluator ratings were observed on the functional task.

Drawing upon behavioural and brain-based theories of cognitive aging, which suggest that capacity to allocate and modulate attention based on goal-relevance declines in older adulthood (Gazzaley, Cooney, Rissman, & D'Esposito, 2005), we reasoned that cognitively intact older adults would benefit from participation in GOALS training specifically in the domain of attention regulation and control (Hypothesis 1). This would be consistent with our

recent findings demonstrating functional brain changes in executive control regions following GOALS training in a sub-sample of the current study cohort (Adnan et al., 2017). Further, as the protocol explicitly targets transfer to real-world settings, we hypothesized that training benefits would be greatest for more ecologically-valid real-world measures of goal-direction (Hypothesis 2). Our findings partially support these hypotheses.

Following GOALS training, older adults improved on neuropsychological measures of mental flexibility and a related functional measure of divergent thinking. Flexibility is a critical aspect of attention regulation, as resources must be reallocated and reoriented to follow shifting goal-hierarchies and priorities that are an inherent aspect of adaptive functioning in real-world contexts. Mental flexibility is known to decline in older adulthood (Gold, Powell, Xuan, Jicha, & Smith, 2010). The meta-cognitive strategy to 'stop-relax-refocus' as well as the mindfulness techniques may have increased participants' ability to reorient their attentional focus away from distracting stimuli or thoughts, and return to the present goal. This enables activation of the goal state and instantiates goal-directed control of current and future behaviour.

Also consistent with predictions, we observed the greatest changes in post-training performance on a real-world functional measure of goal-direction, the MET (Knight et al., 2002). Derived from the six-elements test (Burgess et al.,



2006), the MET is recognized as one of the few ecologically-valid measures of executive functioning in a real-world setting. The test has been shown to be sensitive to damage to the lateral frontal lobes, regions that have been implicated in the top-down modulation of posterior perceptual regions based on goal relevance (Lorenc, Lee, Chen, & D'Esposito, 2015). In the current study, the MET presented participants with a challenging task setting involving numerous salient distractors, requiring constant refocusing of attention to the task goals. We designed a site-specific version of the MET, which required participants to independently traverse the busy UC Berkeley campus, observed but unsupervised, relying only on task and rule lists. Successful completion required participants to overcome naturally occurring obstacles, such as unexpected store closings or student protest marches, and myriad distractions to complete common daily tasks, while ensuring adherence to the rule list. The strategies and skills taught in GOALS explicitly target improvement in these abilities and foster their use in real-world settings. The reduction in task-failures and rule breaks observed in the GOALS group provide strong evidence that the participants were able to successfully apply the GOALS strategies during this task. This finding is particularly important with respect to demonstrating far transfer of our findings, with gains evident beyond the laboratory, on a measure approximating executive functioning in real world contexts. There is evidence for training transfer following executive control training to other non-trained, laboratory-based tasks (e.g. Kray & Feher, 2017 and see Karbach & Kray, 2009 for a further discussion), although the evidence remains mixed (e.g. Goghari & Lawlor-Savage, 2017). More recently, in a large meta-analytic review, evidence for far transfer from cognitive training to gains in real-world mobility performance has been reported (Marusic, Verghese, & Mahoney, 2018). Taken together with the findings reported here, we suggest that cognitive training, and strategy-based, executive function training, specifically, may promote the far transfer of training gains to real world functional tasks in a typically aging population.

Two previous studies investigated the impact of a similar goal-oriented training program on executive control functioning in older adulthood. van Hooren and colleagues (van Hooren et al., 2007) reported reduced annoyance and less anxiety with respect to executive control problems in their treatment group as compared to a wait-list control. Levine and colleagues (Levine, et al., 2007) reported improvements on simulated real-life tasks (e.g. planning a carpool) as well as self-reported declines in executive control problems. However, participants in the Levine et al. (2007) study took part in memory and psychosocial training interventions as well as Goal Management Training, making it difficult to attribute training-related gains specifically to the executive control intervention. Further, these earlier studies used waitlist control groups as compared to the closely matched active control group included in the current study. Although wait-list control groups are useful to control for practice effects associated with repeated testing, they do not control for factors such as therapist engagement and social interactions, which leaves open the possibility that post-treatment improvements are related factors

shared by all in-person interventions, and not the intervention directly.

The results of the current study closely align with the results of a recent systematic review of similar Goal Management Training (GMT) interventions in acquired brain injury (Krasny-Pacini, Chevignard, & Evans, 2014). This review concluded that combining GMT with personal goal setting and daily-life training activities led to greater training benefits. The application of the 'stop-relax-refocus' metacognitive strategy to personally-relevant goals, and real-world individual and group projects, are core aspects of the GOALS protocol. We suggest that these training elements were critical to effecting the changes in real-world functional outcome measures observed here.

Results showing improvement on some outcome measures after participation in the control training likely reflect our inclusion of a comprehensive, and highly engaging, psycho-educational control intervention, closely matched to the GOALS protocol in training and therapist time. Further, the control protocol included didactic sessions on maintaining brain health (e.g. sleep hygiene, nutrition, exercise, and memory strategies). Additionally, as reported in Table 1, the GOALS intervention group had significantly higher working memory performance at baseline, potentially limiting the opportunity for training-related gains in this group. As noted, all participants were well-educated, most with post-secondary or graduate degrees, and may have been near ceiling performance on measures of complex cognition at baseline.

Although these factors, combined with the small sample size in our groups, may have limited our ability to detect additional group by time interactions, the significant gains in post-training outcomes observed within the GOALS group highlight the efficacy of this intervention for improving specific control processes (mental flexibility) and functional outcomes related to goal-directed cognition. Of note, the observed gains were specific to the training target (i.e. executive control processes) and did not generalize to performance on non-executive tasks, consistent with our recent findings of functional brain changes within executive control regions in this group (Adnan et al., 2017).

## Conclusion

Our findings demonstrate that this theory-driven (Duncan, 1986) and brain-based (Gazzaley et al., 2005) intervention approach, combining metacognitive strategy training with an emphasis on the transfer of training gains to functional tasks, can lead to real-world improvements in cognitively intact older adults. Goal-directed behaviour is critical for maintaining functional independence in older adulthood. Interventions to enhance or preserve goal-direction in this population, such as the GOALS program described here, will be critically necessary given the rapid aging of Western societies and increasing public policy pressures to help older adults 'age in place'. Prolonging functional independence preserves the dignity and agency of older adults, reduces the burden on caregivers and families, and lessens economic costs to the health care system. These findings suggest that cognitive training may be a cost-efficient and effective approach to enhance goal-direction and maintain functional independence in older adulthood.

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