# SMART Program in Chronic Stroke

*Asha Vas, PhD, OT, CBIST; Alisa Woods, MS, CCC-SLP; Molly Keebler, MS, CCC-SLP; and Stephen Spees, BS*

## ABSTRACT

**Introduction:** Long-term functional cognitive impairments are common sequelae of stroke, often resulting in decreased participation in daily life activities. Earlier research showed the benefits of training paradigms targeted at memory, attention, and some executive functions.

**Methods:** The current study examined the feasibility of a functionally relevant training program called Strategic Memory Advanced Reasoning Training (SMART). The SMART program teaches strategies to improve abstract reasoning skills and has been shown to enhance aspects of functional cognition, strengthen brain networks, and improve participation in daily life activities across clinical populations. The current study describes the benefits of the SMART program in adults ($N$ = 12) between 54 and 77 years (64.46 ± 8.14 years) with chronic stroke. Participants had 10 sessions of the SMART program over a period of 6 weeks.

**Results:** The findings showed significant gains in abstract reasoning ($p < .05$) and participation in daily activities after the SMART program. These gains were relatively stable 6 months later.

**Conclusion:** These findings offer the promise of cognitive gains, even years after stroke. Limitations of the study include a small sample size, potential confounding as a result of additional ongoing therapy, and a relatively short period of follow-up. Further research is needed to examine the benefits of the SMART program. **[*Annals of International Occupational Therapy*. 2020;3(3):109-118.]**

A stroke often results in cognitive impairments that affect daily life (Sun, Tan, & Yu, 2014). Both short- and long-term cognitive sequelae are well documented (Hoffmann, 2001). After rehabilitation during the acute stage, stroke survivors seldom receive long-term therapy unless there is a change in their medical condition (Winstein et al., 2016). Factors associated with favorable long-term outcomes include smaller lesions, higher educational level, relatively mild severity of stroke, and younger age (Nys et al., 2005; Van Zandvoort, De Haan, & Kappelle, 2001). Addi-

*Dr. Vas is Associate Professor, School of Occupational Therapy, Texas Woman's University, Dallas, Texas. Ms. Woods is Associate Clinical Professor, School of Occupational Therapy, Texas Woman's University, Dallas, Texas. Ms. Keebler is Head of Community Programs, Center for BrainHealth, University of Texas at Dallas, Dallas, Texas. Mr. Spees is graduate student, School of Occupational Therapy, Texas Woman's University, Dallas, Texas.*

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*Address correspondence to Asha Vas, PhD, OT, CBIST, Associate Professor, School of Occupational Therapy, Texas Woman's University, 5500 Southwestern Medical Avenue, Dallas, TX 75235; e-mail: avas@twu.edu.*

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tionally, the laterality of the stroke affects recovery. Long-term outcomes are better after damage to the right side of the brain compared with the left side (Hochstenbach, den Otter, & Mulder 2003; Kase et al., 1998; Tatemichi et al., 1994). Findings on recovery patterns with no therapy or intervention after rehabilitation for chronic stroke are not very encouraging. Although some survivors maintain gains made during rehabilitation and may even show improvement, nearly half of patients with chronic stroke have long-term motor and cognitive challenges. Additionally, declines in home management, social participation, and work and employment are often reported among patients with both right- and left-sided strokes (Meyer et al., 2015; Wolfe et al., 2011).

Among other factors, cognitive impairment, especially executive function, is common after both right- and left-sided strokes (Skidmore et al., 2010). These long-term sequelae significantly affect functional cognition. Functional cognition is defined as the way "an individual utilizes and integrates his or her thinking and processing skills to accomplish everyday activities in clinical and community living environments" (American Occupational Therapy Association [AOTA], 2013, 2017). That is, functional cognition is the interplay between thinking processes and functional performance (Giles, Edwards, Morrison, Baum, & Wolf, 2017). Cognitive functions, especially those mediated by the frontal lobes (often referred to as "executive functions" or "higher-order functions") play a critical role in optimal functional performance (Lux, 2007). Examples of these cognitive domains include attention, initiation, reasoning, problem solving, social participation, goal setting, and self-regulation. Previous research examined the benefits of programs targeted at improving memory, attention, and executive functions.

Memory strategies such as the use of external compensatory aids (e.g., memory journals, notepads, electronic recorders) and the use of internalized strategies (e.g., visual imagery) were reported to assist patients with stroke in compensating for memory deficits (Cicerone et al., 2011). The use of virtual environments also has shown positive effects on verbal, visual, and spatial memory (Members of the Task Force on Cognitive Rehabilitation et al., 2005). Errorless learning techniques showed short-term benefits in remembering specific skills and knowledge, although with limited generalization to untrained tasks (Loetscher & Lincoln, 2013; Winstein et al., 2016).

Similarly, benefits are reported after attention training programs. One such example is the Attention Process Training (APT) program (Kertesz, 1982; Shewan & Kertesz, 1980). This is a hierarchical program in which the therapist guides an individual to attend to initially less cognitive demanding tasks (e.g., listening to one specific sound or identifying one number or shape). Based on performance on the simpler tasks, the individual is gradually introduced to tasks requiring complex levels of attention (e.g., divided attention) in the presence of distractions. Benefits of APT in improving sustained and divided attention were documented in stroke populations (Barker-Collo et al., 2009; Loetscher & Lincoln, 2013). Computer-based interventions to improve working memory also have proven beneficial in improving attention and memory (Lundqvist, Grundström, Samuelson, & Rönnberg, 2010; Westerberg et al., 2007). These training programs often involve focusing on specific auditory or visuospatial stimuli, identifying the position (right or left) of numbers or letters on a computer screen, and determining whether two numbers or letters are the same or different. Training in working memory could include activities such as spelling words or arranging a series of words in alphabetical order (Vallat et al., 2005). Benefits of these training programs include short-term gains in attention, memory, task completion, and reports of self-perceived health (Faria et al., 2018).

More research is needed to examine the benefits of executive function training programs exclusively for stroke survivors. A meta-analysis by Chung, Pollock, Campbell, Durward, and Hagen (2013) reported limited to no benefits of executive function programs after stroke. However, other systematic reviews (Pohjasvaara et al., 2002; Poulin, Korner-Bitensky, Dawson, & Bherer, 2012; Salter et al., 2012; Teasell & Hussein, 2015) that used a broader range of evidence (e.g., stroke and traumatic brain injury [TBI]) found limited but encouraging evidence suggesting that cognitive interventions may improve different aspects of executive functioning, such as problem solving, reasoning, decision making, goal management, multitasking, and planning. For example, during analogical problem-solving training, individuals are presented with common, everyday problems and are taught to draw analogies to solve similar problems (Man, Soong, Tam, & Hui-Chan, 2006). This training program led to gains in the trained domain of problem-solving abilities as well as gains that were generalized to instrumental activities of daily living. In another study, researchers reported short-term gains with using a pager (often used to compensate for memory problems) to improve the executive functions of organizing and prioritizing appointments and managing medications (Fish, Manly, Emslie, Evans, & Wilson, 2008). Studies of Goal Management Training (GMT) (Levine et al., 2000) and Cognitive Orientation to daily Occupational Performance (CO-OP) (Ahn, 2017) also showed moderate gains in improving problem-solving and goal management skills. During GMT, individuals learn to stop ongoing tasks and behaviors periodically to reflect on the goal and the subgoals of their task and self-monitor their performance. The training consists of instructional material, interactive tasks, discussion of real-life difficulties, and homework assignments. During CO-OP, a guided discovery process, clients are trained to self-identify problems and generate solutions through varied strategies. Critical components of the program include self-selection of goals, dynamic performance analyses, cognitive strategy training, guided discovery, and caregiver training (Skidmore et al., 2011). The limited evidence from these studies provides support for mastery of targeted executive processes with the potential to generalize to other executive functions and eventually to improve function. The current study examined the feasibility of a training program known as Strategic Memory Advanced Reasoning Training (SMART) to teach strategies to strengthen reasoning skills and facilitate functional cognition.

Findings from the SMART program show improved executive functions and gains in functional cognition in various clinical populations, including patients with TBI, attention deficit disorder, and mild cognitive impairment (Chapman & Mudar, 2014). In one study, the benefits of the SMART program were compared with the findings in an active control group of adults with TBI and moderate functional deficits. A total of 28 participants (14 in the SMART group and 14 in the active control group) who were 20 to 65 years and at chronic stages of TBI recovery completed their respective training. Both the SMART group and the control group had 12 sessions (60-75 minutes each, provided over a period of 6-8 weeks). The SMART group showed significant improvement in executive functions and participation in daily life tasks, both immediately after training and 6 months later (Vas, Chapman, Cook, Elliott, & Keebler, 2011). In a similar study that included civilians and veterans, gains extended to psychological well-being and positive neural changes that reflected neural repair and improved brain network connectivity (Vas et al., 2016). In addition, with the SMART program, gains were reported in adolescents with TBI. Cook, Chapman, Elliott, Evenson, and Vinton (2014) compared the effects of the SMART program versus rote memory learning on the ability to abstract meanings, recall facts, and use executive functions (i.e., working memory, inhibition) in 20 adolescents (12-20 years) 6 months or longer after TBI. Participants completed eight 45-minute sessions over a period of 1 month. After training, the SMART group ($n$ = 10) showed significant improvement in the ability to abstract meanings in addition to increased fact recall. This group also showed significant generalization to the untrained executive functions of working memory and inhibition. The memory training group ($n$ = 10) showed improved fact recall, but did not show significant gains in the ability to abstract meanings or in other executive functions (Cook et al., 2014).

The current study introduces the use of the SMART program for stroke survivors in chronic stages of recovery. Specifically, this study examined the effect of the SMART program on functionally relevant abstract reasoning and participation in real-life functions. A case study was published on the larger study (Vas et al., 2017).

## SMART PROGRAM

The SMART program trains participants in metacognitive strategies to improve the cognitive domains of (a) strategic attention, (b) integrative reasoning, and (c) innovation.

Strategic attention strategies focus on the effective management of information that is relevant to daily life (e.g., news stories, conversations) by blocking distractions and less relevant information. Participants are informed of the negative effects of multitasking (i.e., focusing on two or more tasks that require complex attention) on cognitive performance and productivity. The importance of taking mental breaks to prevent cognitive overload is integral to strategic attention training.

Integrative reasoning strategies build on the strategies of strategic attention to initiate abstract reasoning. Specifically, the strategies focus on synthesizing information (e.g., medical information, news stories) at a gist level rather than registering it verbatim. The term "gist" in neurocognitive and linguistic research is defined as the ability to synthesize written, verbal, and/or visual information into abstracted meanings that are not explicitly stated (Chapman, 1995). The construct of gist has been used to characterize abstract thinking skills among both healthy adults and clinical populations that include adults with stroke and mild cognitive impairment, adolescents with attention deficit hyperactivity disorder, and youth with TBI (Chapman et al., 2002; Gamino & Chapman, 2009; Gamino, Chapman, & Cook, 2009; Glosser & Deser, 1991; Ulatowska, Allard, & Chapman, 1990; Ulatowska, Chapman, Highley, & Prince, 1998). Gist-based processing draws on the ability to abstract the essence of information. With regard to goal attainment (e.g., planning a weekend trip, making a Thanksgiving meal), integrative reasoning teaches participants to zoom out and look at the "big picture" of the task and then zoom in to identify only the critical details or the steps that are needed to accomplish the goal.

Innovation strategies further enhance cognitive flexibility and fluid thinking. Performance in the areas of goal management and information processing is optimized by adopting divergent perspectives (Vas et al., 2011). Innovation works hand in hand with integrative reasoning by emphasizing the need to derive multiple interpretations (e.g., movies, news stories) and solutions (e.g., making an alternate plan for a weekend trip because of bad weather). Practicing innovation increases abstract reasoning and provides opportunities for problem solving. One key strategy practiced with innovation is to engage stronger metacognitive skills to learn from both mistakes and successes by reviewing one's own behaviors and determining where revising decisions and actions could lead to better outcomes.

The strategies are applied to real-life contexts, including performing household chores (e.g., kitchen tasks), managing finances and health care, processing news stories, generating take-home messages from religious services, developing new hobbies, engaging in community events (e.g., participating in leisure activities), and socializing. Training materials are partly preselected and include texts such as newspaper and magazine articles, pictures, paintings, and audio/video clips to illustrate the strategies. Application of these strategies to enhance functional cognition is the critical element of the program. For example, one of the three strategic attention strategies asks participants to identify the "least important tasks" from a long list of "to-do" tasks. This exercise facilitates strategic prioritization of the most important tasks and limits distractions that hinder optimal completion of tasks. One of the three integrated reasoning strategies asks participants to identify the "gist" of a news story versus highlight the details of "who, what, and where" that are explicitly stated. Homework assignments that involve real-life applications are given after each session. This carryover of the strategies promotes mastery and adaptation, key elements of the occupational therapy approach. In essence, the program provides a cognitive tool kit to promote function. The program can be administered in both group and individual formats. The current study used a group format.

# METHODS

The study was approved by the institutional review board at Texas Woman's University. Informed consent was obtained from all participants in accordance with the guidelines of the institutional review board. All participants received remuneration for participating in the study.

## Participants

Of the 15 participants who were recruited for the study, 12 completed the program, including the training and testing procedures. Of the three participants who did not complete the study, one, recruited from the community, dropped out of the study immediately after pre-SMART testing for unknown reasons. Another participant, recruited from the stroke center, left midway through the program after receiving a part-time job offer. The third participant, recruited from the community, did not complete the study because of unexpected family issues. All of the participants were in chronic stages of recovery (at least 1 year post-stroke; **Tables 1-2**). All participants had left hemispheric stroke, although the study was open to those with either right or left hemispheric stroke. We believe that this homogeneity of participants occurred because most of those (12 of 15) who agreed to participate in the study were from The Stroke Center—Dallas. The center offers individual and group therapy sessions for clients with varying degrees of language impairment and/or aphasia after a stroke. Participants attend one to three language therapy sessions each week. The focus of treatment at the center is on word finding, motor speech, agrammatism, reading, writing, auditory comprehension, motor speech, fluency, and voice. Of the three participants who were recruited from the community, one had left hemispheric stroke, another had right hemispheric stroke (and discontinued the study immediately after pre-SMART testing), and the third had mild right hemispheric stroke (and discontinued the study because of a family issue). These three participants were not receiving any other therapy at the time of the study. Because the SMART program involved group participation, the inclusion criteria included functional language skills (reading, writing, and verbal communication) sufficient to participate in a group setting. Although no formal language screening was done as part of the study, 11 of the 12 participants were screened by a speech-language pathologist for group participation at the center. Specifically, participants are screened

TABLE 1

**Information on Individual Participants**

| Participant number | Age, years | Gender | Hand dominance | Education, years | Race | Diagnosis (per available records) | Years post-stroke | Aphasia diagnosis (per available records) |
|---|---|---|---|---|---|---|---|---|
| 1 | 54 | Male | Right | 12 | Asian American | Ischemia—left posterior cerebral artery | 2 | Moderate anomia |
| 2 | 54 | Male | Right | 13 | Black | Occlusion—left hemisphere | 3.2 | Mild cognitive deficits |
| 3 | 54 | Male | Left | 16 | White | Ischemia—left hemisphere | 4 | Moderate Broca's aphasia |
| 4 | 57 | Female | Right | 13 | Black | Ischemia—left hemisphere | 2.1 | Mild cognitive deficits |
| 5 | 65 | Male | Right | 18 | White | Ischemia—left hemisphere | 10 | Mild Broca's aphasia |
| 6 | 65 | Male | Right | 16 | White | Ischemia—left hemisphere | 5 | Mild Broca's aphasia |
| 7 | 67 | Female | Right | 20 | White | Occlusion—left middle cerebral artery | 5.5 | Mild Wernicke's aphasia |
| 8 | 68 | Male | Right | 16 | Black | Occlusion—left middle cerebral artery | 2.2 | Mild anomia, mild cognitive deficits |
| 9 | 69 | Male | Right | 13 | Black | Ischemia—left hemisphere | 2.7 | Mild anomia |
| 10 | 71 | Male | Left | 16 | White | Occlusion—left hemisphere | 2.5 | Mild Wernicke's aphasia |
| 11 | 73 | Female | Right | 16 | Black | Ischemia—left hemisphere | 1.8 | Mild cognitive deficits |
| 12 | 77 | Female | Right | 12 | Black | Ischemia—left hemisphere | 1.9 | Mild anomia |

for reading comprehension on the Western Aphasia Battery-Part 2 (Kertesz, 1982). Based on performance on the battery and the clinical judgment of the clinicians and researchers involved in the study (i.e., licensed occupational therapists and speech-language pathologists), participants were recruited for the study. Researchers considered both verbal and nonverbal behaviors that are deemed appropriate and relevant to group participation. During SMART group participation, we did not encounter significant impairments in following verbal instructions, basic reading skills, and group interactions (verbal and nonverbal) that hindered engagement in the sessions. Exclusion criteria included a history of a learning disability, significant psychiatric illness, and a complex medical history that could hinder participation in a group program.

## Procedures

The study included testing and training procedures.

**Testing.** Each participant was tested three times: pre-, post-, and 6 months post-SMART. Testing included measures of (a) abstract reasoning, (b) standardized cognitive measures, and (c) real-life functions. The main outcome measure of abstract reasoning was examined with the Test of Strategic Learning (TOSL) (Chapman, Zientz, Rackley, Keebler, & Vas, 2016). The TOSL measure examines the number of abstracted ideas (included in a summary format) that a participant generates from a text of approximately 600 words. The participant is provided with a copy of the text to read. The researcher reads the text aloud, and the participant follows a copy. On completion of reading, the text is removed so that

TABLE 2

**Participant Demographics (*N* = 12)**

| | Years | |
|---|---|---|
| **Variable** | ***M (SD)*** | **Minimum-maximum** |
| Age | 64.46 (8.14) | 54-77 |
| Time since stroke | 3.99 (3) | 1.83-10.00 |
| Education | 15.08 (2.50) | 12-20 |

the participant cannot refer to it. Then the participant provides the abstracted ideas in the form of a written synopsis or summary. The TOSL measure has a manualized objective scoring system wherein each self-generated abstracted idea (that is not stated in the text) receives 1 point and verbatim or paraphrased ideas do not receive any credit. Three different texts were randomly used for the three assessment periods. Summaries were scored by two trained examiners who were blinded to the participants' testing period (i.e., scorers did not know whether the summaries were generated pre-, post-, or 6 months post-SMART). Interrater reliability of the scores, assessed with intraclass correlation coefficients, was nearly 90% (Cronbach's alpha = 0.94; confidence interval = 0.70-0.99).

As part of the larger study, select cognitive domains of working memory, attention, inhibition, fluency, and memory were examined with a standardized Woodcock Johnson Cognitive and Oral Abilities battery (Schrank, McGrew, & Mather, 2014) and the Delis-Kaplan Executive Function System (Delis, 2001). Performance on these measures is under analysis and hence is not reported in the current article.

Daily functionality was examined with self-reported measures of the Community Integration Questionnaire (CIQ) and the Return to Normal Living Index (RNLI). These measures are widely used in rehabilitation research as proxy measures of global function and functional outcomes in adults with brain injury (Corrigan & Deming, 1995; Wood-Dauphinee, Opzoomer, Williams, Marchand, & Spitzer, 1988). The CIQ reflects an individual's functioning based on responses to 15 questions related to participation in activities at home and in social and educational or vocational settings. Scores on the CIQ range from 0 to 29, with 29 indicating higher levels of integration (Willer, Ottenbacher, & Coad, 1994). The RNLI assesses the degree of reintegration into normal social activities in adults with traumatic or incapacitating illness (Wood-Dauphinee & Williams, 1987). The RNLI index includes the functional domains of mobility (indoor, community, and distance), self-care, daily activity (work and school), recreational and social activities, family roles, personal relationships, presentation of the self to others, and general coping skills. Each domain is accompanied by a visual analog scale (0-10 points) that is anchored by the statements "does not describe my situation" (1 or minimal integration) and "fully describes my situation" (10 or complete integration). Individual item scores are summed to provide a total score out of 110 points that is proportionally converted to create a score out of 100 points (Wood-Dauphinee & Williams, 1987). The RNLI was included only during the second half of the study because the CIQ was limited in characterizing mobility (e.g., indoor and community) issues and we learned about the RNLI at this time.

**Training.** The SMART program is presented in a PowerPoint format. The training includes 10 to 12 sessions (60 minutes each) administered over a period of 4 to 6 weeks. Group size varies from four to six participants. The first three sessions are instructional, and the researcher introduces the strategies, starting with strategic attention, followed by integrated reasoning and innovation. After the three sessions, participants actively engage in group and individual activities to apply these strategies to material presented in class (e.g., movie clips, news) and brainstorm ways to apply these strategies to their own real-life tasks (e.g., organizing a garage, planning an event). All 12 participants completed the training program. We anticipate that this high level of participant retention is related to the convenience of our study location. Testing and training were conducted in the same building as the stroke center. Participants did not have to make additional trips to participate in the study; they came early or stayed late after sessions at the stroke center.

TABLE 3

**Pretest and Posttest SMART Scores**

| Outcome measure | Pre-SMART | | Post-SMART | | 6 months post-SMART | |
|---|---|---|---|---|---|---|
| | *M (SD)* | Minimum-maximum | *M (SD)* | Minimum-maximum | *M (SD)* | Minimum-maximum |
| TOSL | 1.08 (0.79) | 0-2 | 2.33 (1.55) | 0-3 | 2.08 (1.31) | 0-4 |
| CIQ | 16.33 (5.60) | 10.00-26.75 | 18.50 (5.42) | 10-29 | 20.04 (5.61) | 10-29 |
| RNLI | 86.00 (21.82) | 59.40-110.00 | 85.00 (20.14) | 58.50-108.30 | 90.88 (20.33) | 59.40-110.00 |

*Note*. CIQ = Community Integration Questionnaire; RNLI = Return to Normal Living Index; SMART = Strategic Memory Advanced Reasoning Training; TOSL = Test of Strategic Learning.

### Statistical Analysis

Scores for the TOSL and CIQ were obtained for all 12 participants. However, RNLI data were available for only six participants. Because of the small sample size, Friedman nonparametric analyses were conducted to compare TOSL, CIQ, and RNLI scores over three time points. Wilcoxon signed-rank analyses were used to examine the exact differences between each two time points. Data were analyzed with IBM SPSS, version 25 (IBM Corporation, 2017). Significance was set at $p < .05$.

## RESULTS

Overall scores on the TOSL, CIQ, and RNLI were measured pre-SMART, post-SMART, and at 6-month follow-up. The TOSL score increased significantly from pre-SMART ($M$ = 1.08, $SD$ = 0.79) to post-SMART ($M$ = 2.33, $SD$ = 1.55; $Z$ = -2.04, $p$ = .041). There was also an increase in scores from pre-SMART (**Table 3**) to 6-month follow-up ($M$ = 2.08, $SD$ = 1.31), but the difference did not reach significance ($p$ = .079). This result is shown in **Figure A** (available in the online version of the article). With regard to the CIQ, a Friedman test showed significant changes over time ($p$ = .003). Wilcoxon signed-rank tests showed that CIQ scores were significantly increased from pre-SMART ($M$ = 16.33, $SD$ = 5.60) to post-SMART ($M$ = 18.50, $SD$ = 5.42; $Z$ = -2.04, $p$ = .041). As seen in **Figure B** (available in the online version of the article), a significant increase also was seen at 6-month follow-up ($M$ = 20.04, $SD$ = 5.61) compared with pre-SMART ($Z$ = -3.06, $p$ = .002). However, no significant changes were observed in RNLI scores over the three time points (**Figure C**, available in the online version of the article).

## DISCUSSION

Functional cognition can be strengthened, even years after a stroke. This finding was shown in earlier studies of the SMART program for other clinical populations, and the current pilot study expands these findings to include stroke populations (Chapman & Mudar, 2014; Vas et al., 2011, 2016). The positive change in the TOSL score appears minimal (from one idea to two ideas), but it is meaningful and clinically relevant. Generating a novel idea (i.e., abstract reasoning) draws on intentional cognitive effort. Earlier research showed significant positive associations between abstract reasoning and executive functions of inhibition, switching, and working memory (Vas, Spence, & Chapman, 2015).

Continual use of the strategies in varied functional contexts could facilitate ease in using the strategies. As one participant reported, "I see many things with a different lens now, a movie or even my little balcony garden." This flexible thinking also was evident during application of strategic attention strategies in daily function. Traditionally, during cognitive training sessions, individuals are trained to highlight important tasks. Although the SMART program integrates prioritizing, an earlier step of "blocking less relevant tasks" is emphasized. This ability to identify less relevant tasks (vs. the standard practice of highlighting the most important tasks) draws on the cognitive processes of inhibition and problem solving.

Positive trends in CIQ scores show generalized gains in functional cognition. Most of the gains were evident in social participation and home management scores. Homework assignments included increased participation in social events (e.g., attending support groups) and household chores (e.g., vacuuming, grocery shopping). The participants chose their tasks. During SMART sessions, several participants stated that the strategies helped with "creative time management" and "forming new habits again." One participant adapted her knitting skills to make caps for nursing home residents, and another participant resumed leading Bible study groups (that he had stopped leading several years ago after his stroke). One participant who continued to struggle with dressing tasks and reaching corner kitchen cabinets reported using creative problem solving. At 6-month follow-up, most participants reported using the strategies beyond completing the SMART program. No significant changes in RNLI scores could be attributed to the smaller sample size and the insufficient range across social and physical domains and subscales.

Generalized gains of top-down cognitive training programs are increasingly supported by positive changes in neural, cognitive, and daily functionality in populations with acquired brain injury (Levine et al., 2000; Novakovic-Agopian et al., 2011). A top-down approach, such as the SMART program, draws on effortful global functionally relevant cognitive processes versus a specific process that is impaired. Engaging in abstract reasoning (i.e., gist-based thinking) draws on frontal network activation, which could strengthen executive functions (Chapman, Spence, Aslan, & Keebler, 2017).

Integrating the SMART program into rehabilitation protocols or supplementing it with existing programs could offer the promise of improving abstract reasoning, even in chronic stages of stroke recovery. With advances in research methods, including neuroimaging, it is timely to exploit options to improve functional cognition and optimize the quality of life of the increasing number of stroke survivors.

### Limitations and Future Research

The current pilot findings, although promising, need further validation to address at least six limitations. First, the homogeneity of the sample makes it difficult to broaden the findings to all stroke populations. All participants in the study had a left hemisphere stroke (although inclusion of participants with only this type of stroke was not intended). Therefore, the current findings cannot be generalized to different stroke populations, especially patients with right hemispheric stroke. Second, we did not analyze the contribution of language therapy sessions at the stroke center. It is likely that the current findings may be confounded with gains made during language therapy sessions. Improving community recruitment efforts, including participants with both right and left hemisphere stroke, and controlling for additional therapies could address this problem. Third, it is unclear whether the participants had deficits in abstract reasoning before they started the program. Future studies could include deficits in abstract reasoning (measured on standardized metrics) as inclusion criteria. Fourth, the current study used questionnaires that represented self-perception of gains (if any). Assessment of real-life task performance could provide a more accurate characterization of benefits to daily functionality. Fifth, gains made on social integration measures were observed only at 6-month follow-up. Future studies could assess the need for either increased frequency or a greater number of SMART sessions. Sixth, the small sample size limits generalizability of the findings to a larger stroke population. Future studies could examine the benefits of the SMART program (a) at longer intervals after the SMART program (e.g., 1 year after training), (b) among patients with both right and left hemispheric stroke, and (c) in real-life or simulated daily functional tasks.

## CONCLUSION

Strategies used in the SMART program can strengthen cognitive abilities. More importantly, these cognitive strategies must be used in multiple functional contexts to offer opportunities for repetition that enhances adaptability and habit formation. Improved cognition could lead to a sense of empowerment and improved quality of life for survivors of stroke.

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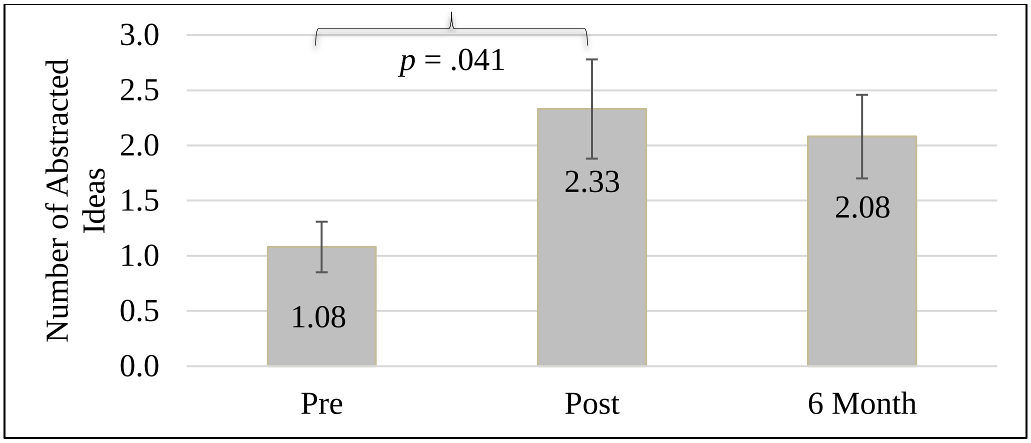


**Figure A. Mean of Test of Strategic Learning (TOSL) scores across SMART testing periods**

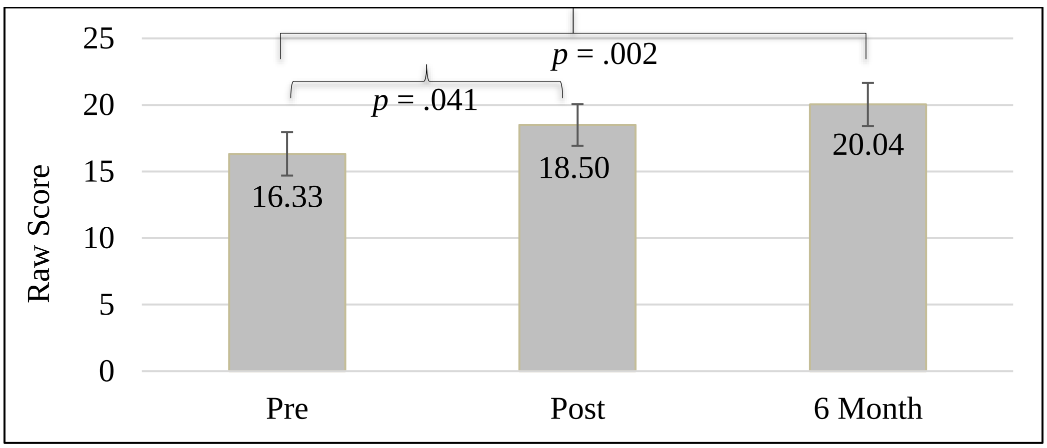


**Figure B. Mean of Community Integration Questionnaire (CIQ) scores across SMART testing periods**

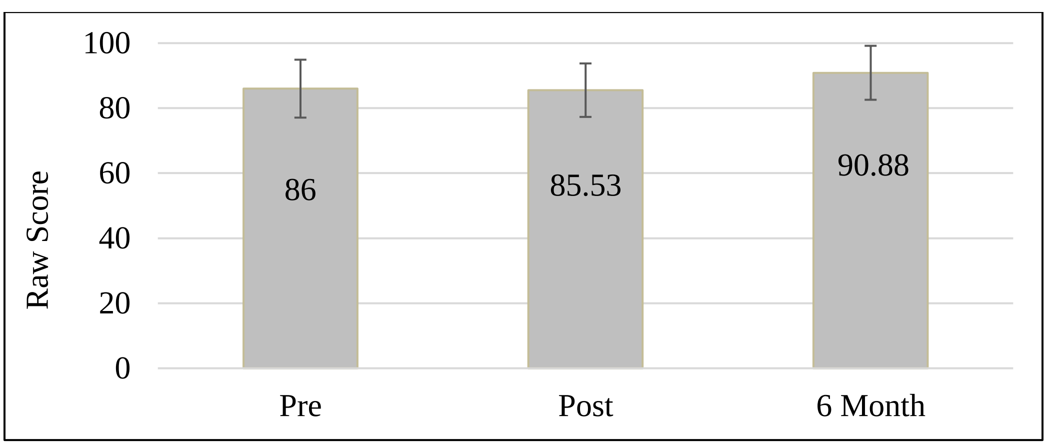


**Figure C. Mean of Return to Normal Living Index (RNLI) Scores across SMART testing periods**