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Sutter, Christine ; Zöllig, Jacqueline ; Martin, Mike

Abstract: Background: There is evidence for specific age-related deficits in tasks of verbal fluency. Objective: The aim of the present study was to evaluate training and transfer effects after 3 weeks of telephone-based verbal fluency training in old age. Methods: Participants were assigned to one of three training groups, an active control group, or a no-contact control group. Training consisted of 15 sessions of 6 min each over a period of 3 weeks. For the training tasks, different versions of the verbal fluency task were used, each targeting a specific underlying cognitive process (i.e., processing speed, shifting, or inhibition). To measure transfer effects, a neuropsychological test battery including Digit Symbol Substitution, Trail Making, Go/No-Go, Digit Span, N-Back, and a verbal learning and memory test was administered before and after training. Results: Our findings revealed training gains for initial letter fluency training and phonemic switching training, but not for excluded letter fluency training. Moreover, after initial letter fluency training and phonemic switching training, transfer to other verbal fluency tasks was found. In addition, phonemic switching training led to improvement in an untrained short-term memory task. Conclusion: The findings demonstrate that a telephone-based cognitive intervention of overall 90 min significantly improved cognitive performance in healthy older adults above and beyond the improvements in the active control group. The findings provide the basis for cognitive interventions that could easily be integrated into everyday lifestyles and are still targeting specific cognitive functions.

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Plasticity of verbal fluency in older adults: A 90 minutes telephone-based intervention

Christine Sutter[1], Jacqueline Zöllig[1,2], and Mike Martin[1]

[1]Department of Psychology, University of Zurich, 8050 Zurich, Switzerland.

[2]International Normal Aging and Plasticity Imaging Center (INAPIC), University of Zurich, 8006 Zurich, Switzerland.

Correspondence concerning this article should be addressed to Christine Sutter, Department of Psychology, University of Zurich, Binzmühlestrasse 14/24, CH-8050 Zurich, Switzerland.Phone: +41 44 635 74 33. Fax: +41 44 635 74 19. E-mail: c.sutter@psychologie.uzh.ch

Abstract

Background: There is evidence for specific age-related deficits in tasks of verbal fluency. **Objective:** The aim of the present study was to evaluate training and transfer effects after three weeks of telephone-based verbal fluency training in old age. **Methods:** Participants were assigned to one of three training groups, an active control group, or a no-contact control group. Training consisted of 15 sessions of six minutes each over a period of three weeks. For the training tasks, different versions of the verbal fluency task were used, each targeting a specific underlying cognitive process (i.e., processing speed, shifting, or inhibition). To measure transfer effects, a neuropsychological test battery including Digit Symbol Substitution, Trail Making, Go/No-Go, Digit Span, N-Back, and a verbal learning and memory test was administered before and after training. **Results:** Our findings revealed training gains for initial letter fluency training and phonemic switching training, but not for excluded letter fluency training. Moreover, after initial letter fluency training and phonemic switching training, transfer to other verbal fluency tasks was found. In addition, phonemic switching training led to improvement in an untrained short-term memory task. **Conclusion:** The findings demonstrate that a telephone-based cognitive intervention of overall 90 minutes significantly improved cognitive performance in healthy older adults above and beyond the improvements in the active control group. The findings provide the basis for cognitive interventions that could easily be integrated into everyday lifestyles and are still targeting specific cognitive functions.

Keywords: verbal fluency, cognitive training, transfer, old age

PLASTICITY OF VERBAL FLUENCY IN OLDER ADULTS: A 90 MINUTES TELEPHONE-BASED INTERVENTION

Verbal fluency is a popular neuropsychological test in which participants are typically asked to generate as many words as possible from a specific semantic or phonemic category (i.e., "animals" or "words that start with a designated letter") [1]. The task has high diagnostic utility [1,2] and is frequently used in cognitive aging research [3]. As older adults commonly report word finding difficulties [4], verbal fluency is often used to examine access to phonemic and semantic information under the condition of time constraints [2]. There is consensus that verbal fluency is highly age sensitive [1,5-7]. Therefore, the aim of the present study was to develop an intervention to improve verbal fluency performance in healthy older adults.

A decline in verbal fluency performance with advancing age has been reported for both, phonemic and semantic fluency. Although some studies suggested that semantic fluency is generally more affected by age [6,8], there is also evidence for age-related differences in phonemic fluency. For example, an age-related decrease in performance has been observed for initial letter fluency [9] and excluded letter fluency [10]. This age-related reduction in verbal fluency performance could be associated with several cognitive processes that are required for successful verbal fluency performance and for which an age-related decrease has been reported. The following processes have been suggested as important for verbal fluency performance [11]: Monitoring, inhibition of previously recalled words, and self-generation of cues to produce new words. Other cognitive variables discussed are processing speed [12], switching between two mental sets [13], and retrieval from long-term memory and short-term memory [14]. All of these cognitive processes could explain age-related differences in verbal fluency task performance. However, the extent to which these processes are associated with verbal fluency performance in healthy older adults also depends on the verbal fluency task used. Examining three subtests of phonemic fluency more closely, there are three processes that have been linked to each subtest. As an illustration, the *subtest initial letter fluency* requires generating as many words as possible within a time limit. For this task, processing speed accounts for age-related differences in performance [9]. This is in accord with the processing speed theory stating that with increasing age a decrease in processing speed leads to age-related differences in cognitive functions [15]. In fact, older adults produce fewer words in initial letter fluency compared to younger adults and processing speed mediates this age effect [12]. In contrast, the *subtest excluded letter fluency* which requires to produce words not involving a designated letter has been suggested to require inhibitory processes [16] which show an age-related decline [17]. Finally, the *subtest phonemic switching fluency* in which participants are required to switch between two given initial letters involves shifting between two mental sets or categories and is frequently used as a variant of task-switching [18] which shows age-related performance declines [19]. Consequently, these three subtests of phonemic fluency involve different underlying processes which, in turn, have also been found to be age-sensitive. It must be noted, however, that each of these three cognitive processes is not exclusively associated with one of the three verbal fluency subtests, as all of these subtests impose demands on processing speed, shifting and inhibition, albeit not to the same extent.

Based on these relations, the present study concentrates on how to improve verbal fluency performance in healthy older adults. By using the three variants of verbal fluency (initial letter fluency, excluded letter fluency, and phonemic switching fluency), we target the different underlying cognitive processes discussed (i.e., processing speed, shifting, and inhibition). Thus, with this intervention, we examined the extent to which verbal fluency is modifiable in a short-term intervention and in which verbal fluency task and its underlying core process the largest effects can be achieved.

More specifically, we aimed at investigating whether (1) we find training gains in all three training tasks and whether these training gains differ across the three training groups, (2) we find transfer effects to other verbal fluency tasks and (3) we find transfer effects to untrained tasks. Accordingly, on the continuum of transfer effects, we studied transfer with tasks that are similar to the trained task and differ only in specific items (i.e., other verbal fluency tasks), and with untrained tasks that are dissimilar. For these untrained tasks and for all three training groups, we predicted training-specific improvements in tasks that involve the same underlying processes as the trained task. That is, for the group receiving training in initial letter fluency and, thus, processing speed, we predicted improvements in a processing speed task. For the phonemic switching fluency training group, we predicted performance improvements in a task-switching task. Finally, for the excluded letter fluency training group, we predicted performance improvements in an inhibition task. In addition to the transfer tasks targeting these cognitive functions, we further included measures of short-term memory, long-term memory, and working memory, as all three aspects of memory have been found to be associated with general verbal fluency performance [11,14]. The training and transfer tasks are depicted in Figure 1.

Insert Figure 1 about here

Verbal fluency does not require writing or working on the computer by the participants. Therefore, verbal fluency lends itself very well to be assessed by telephone. Consequently, the training was carried out by telephone, requiring six minutes per daily session and, thus, resulting in a total training time of 90 minutes. Because this one-to-one training over the telephone had a strong social component, we further evaluated if improvements are specific to the training interventions or if similar improvements can be achieved in a social contact group without a specific training intervention. In addition to a no-contact control group, an active control group was included. The engagement task of our active control group is comparable to the tasks used in the intervention study by Goh and Park [20] in which older adults were randomly assigned to different conditions of engagement (i.e., quilting versus digital photography plus social activities). Thus, we compared performance gains of the different training groups with an active control group and a no-contact control group.

To sum up, we wanted to examine if a specific short-term cognitive intervention could lead to significant improvements in cognitive functioning, if the effects vary between different subtests of the training tasks, and if there is a transfer to untrained tasks. If the effectiveness of such a short-term intervention can be demonstrated, the results would provide the basis for cognitive interventions in old age that could be both ability-specific and possible to integrate into the lifestyle of aging adults.

Methods

Participants

Participants were 105 older adults (M = 72.3; SD = 5.7; range = 64 - 92 years). Eighty-four participants were randomly assigned to one of three training groups or an active control group, and 21 participants were assigned to a no-contact control group (see Figure 2). The participants were recruited at a lecture for senior citizens at the University of Zurich and through the distribution of flyers. All participants were native German speakers. The study was approved by the institutional ethics committee. Written informed consent was obtained from all participants and they received CHF 10 (approx. 11 USD) for their participation. Three participants dropped out during data collection because of their inability to complete the training and one was excluded from data analysis due to incomplete responses; therefore, the analyses are based on the data of 101 participants.

Insert Figure 2 about here

Procedure and Interventions

We invited participants to the laboratory for a *pretesting session* in which baseline performance on a battery of cognitive tests was assessed. Individual testing lasted about two hours. *Training interventions* and control activity were carried out via telephone and required 15 sessions, each session lasting six minutes. Participants of the three training groups worked on two verbal fluency tasks in each session. To assess training gains throughout the training, the same letters were repeated in the training sessions 1, 6, and 11. In order to complete the three weeks of training and to maximize transfer effects, training sessions continued until session 15. Some basic rules had to be observed by all three training groups, that is, no proper names, no words including the same word stem, and only words that would appear in a German newspaper or book were allowed. Furthermore, it was emphasized that participants should avoid perseverations. The three training interventions were based on phonemic fluency tasks, because we were interested in targeting specific cognitive processes that have been linked to different variants of phonemic fluency. We refrained from including semantic fluency into the training protocol. Participants of the active control group followed the same schedule as the three training groups (see Table 1). To analyze the improvements after training, a *posttesting session* with the identical tests from the pretesting session was carried out. Participants were assigned to the following groups:

Initial letter fluency training group (A). Participants were asked to generate as many words as possible with a given initial letter (e.g., “P”) within three minutes.

Phonemic switching fluency training group (B). Participants were asked to alternate between two given initial letters (e.g., “H” and “T”) within three minutes. The importance of switching between the two letters was emphasized in the instruction.

Excluded letter fluency training group (C). Participants were asked to generate words without a given letter (e.g., words without the letter “n”) within three minutes. The instruction emphasized the importance of not committing errors and of inhibiting false reactions.

Active control group (D). Participants were asked about their opinion, thoughts and experiences on a given topic (e.g., “movies” or “traveling”) for the same amount of time. Although this group underwent general activation, this activity was not intended to improve a specific cognitive process.

No-contact control group (E). The no-contact control group was invited to the pre- and posttesting session but did not receive any training or further social contact.

Insert Table 1 about here

Cognitive Assessment

All participants were required to perform a battery of cognitive tests including paper-pencil as well as computerized tests. Training-related transfer effects were examined with other verbal fluency tasks and untrained tasks.

Transfer to other verbal fluency tasks. To assess transfer, four subtests of a German word fluency test [Regensburg Word Fluency Test, 21] were used. *Letter fluency* was assessed by asking participants to generate as many words as possible, beginning with the letter *S* (initial letter fluency), and alternately starting with *G* and *R* (phonemic switching). *Category fluency* was assessed by asking participants to generate as many words as possible of the semantic category of animals (animal naming), and alternately between sports and fruits (semantic switching). Furthermore, *excluded letter fluency* [10] was used in the testing session. This task requires participants to generate words not containing a specific letter (i.e., the letter *e*). The outcome measure of all five verbal fluency tasks was the number of correct responses produced during three minutes. In addition to the total number of correct responses, the number of perseverative errors (i.e., the same word repeated) and rule-breaking errors (words that would not appear in a German newspaper or book, words including the same word stem, and proper names) were not included in the total verbal fluency score.

Transfer to untrained tasks. To assess transfer to untrained tasks, performance on six different cognitive measures was assessed for all five groups.

Processing speed. To investigate transfer to a task of processing speed, the *Digit Symbol Substitution Test* of the Nuremberg Aging Inventory (NAI) [22] was used. The test is intended to assess the general cognitive slowing in old age [15] by assigning nine simple symbols to the numbers 1 to 9 during 90 seconds. The outcome measure was the total score of the items correctly assigned.

Shifting. We used the Trail Making Test [23] to assess transfer to a shifting task. In form A of this test, participants are asked to connect numbers in ascending order (e.g., 1, 2, 3, etc.). Form B requires to alternately connect numbers and letters in ascending order (e.g., 1, A, 2, B, 3, C, etc.). The time to complete part B minus the time to complete part A was used for further analyses.

Inhibition. To assess transfer to an inhibition task, a computerized testing version of the Go/No-Go task, implemented with the Tests of Attentional Performance (TAP, version 2.1) [24], was used. This subtest assesses the ability to suppress a reaction triggered by external stimuli in favor of an internally controlled behavior. The participants are required to respond as quickly as possible to an appropriate target (i.e., a horizontal cross), while controlling an inappropriate impulse (i.e., not to respond to the fixed cross). Performance in this task was assessed as the mean of correct answers.

Short-term memory. To assess short-term memory, the Digit Span Forward and Backward task was used. In these tests, also adapted from the NAI [22], participants are required to repeat the digits in the same order (i.e., forward) or in reversed order (i.e., backward) as verbally presented by the experimenter. The total digit span (forward plus backward) was used for analysis.

Working memory. To assess working memory, we used the N-back test [25] from the Tests of Attentional Performance [24]. A sequence of numbers is presented on a screen one after the other and participants are required to indicate for each number whether or not it is equal to the penultimate number (i.e., 2-back) by pressing the 'yes' or 'no' button in front of them. The dependent variable was the mean score of the correct responses.

Long-term memory. Long-term episodic memory free-recall was assessed using the Verbal Learning and Memory Test [Verbaler Lern- und Merkfähigkeitstest (VLMT), 26], an adapted German version of the Rey Auditory Verbal Learning Test [27]. The participants were asked to repeat all the words of a previously learned list consisting of 15 words which were read to them one at a time at a pace of one word per second. The words were repeated on five consecutive trials. Recall was tested after a 20-minutes delay. We included this measure of delayed recall in our analyses.

Negative Emotional Questionnaires. Two questionnaires were used to assess negative emotions. The short-version of the German Geriatric Depression Scale (GDS) [28] was used to assess depressive symptoms and the state scale of the State-Trait Anxiety Inventory (STAI) [29] was used to assess participants' anxiety. On a 4 point-scale (1= *not at all*, 2 = *a little*, 3 = *quite*, 4 = *very much*) participants indicated how they were feeling during the testing sessions (e.g., "I am calm").

Data Analysis

Prior to analysis, we tested all variables for normal distribution with the Shapiro-Wilk's test. To test for differences between the five groups in demographic characteristics as well as baseline performance, we applied one-way analyses of variances (ANOVAs). To evaluate the effects of training, we applied repeated-measures ANOVA including the training sessions 1, 6, and 11. In addition, planned comparisons on the three training sessions were carried out.

To measure transfer effects to verbal fluency tasks and untrained tasks, only training groups that showed training gains were included in the analysis. We applied repeated-measures ANOVA with the performance measures at pre- and posttesting session as dependent variables. To interpret the training improvements between the different groups, we chose the interaction terms (i.e., group x time). To disentangle significant interactions, four contrasts were specified: 1) any activity (i.e., verbal fluency training groups and the active control group) versus no activity (A, B, D vs. E), 2) verbal fluency training versus control activity (A, B vs. D), 3) each verbal fluency training versus control activity (A vs. D, B vs. D), and 4) verbal fluency trainings compared to each other (A vs. B). Excluded letter fluency (C) training was excluded from contrast analyses due to non-significant training improvements.

Results

Baseline Data

Participants of the three training groups and the two control groups did not differ significantly with respect to age, years of education, depression, or state anxiety at pre- and posttest. In addition, there were no significant differences between the five groups in the baseline measures of all cognitive measures at pretest ($p. < .01$), except for performance on the Digit Symbol Substitution Test (phonemic switching training group vs. active control group, B vs. D, $p. < .05$, with the latter showing a better performance). Therefore, this test was included as a covariate for analyses on the transfer tasks.

Insert Table 2 about here

Training Gains

Analyses revealed a significant main effect of time for the group receiving initial letter fluency training (A), $F(2,36) = 38.83$, $p < .001$, $\eta^2 = .68$, indicating that participants improved performance during training. Contrasts revealed that performance increased from session one to session six, $F(1,18) = 29.27$, $p < .001$, $\eta^2 = .62$, and from session six to session eleven $F(1,18) = 15.09$, $p = .001$, $\eta^2 = .46$. Furthermore, a significant main effect of time was found for the group receiving phonemic switching training (B), $F(2,40) = 49.348$, $p < .001$, $\eta^2 = .71$. Again, contrasts revealed that performance increased from session one to session six, $F(1,20) = 36.43$, $p < .001$, $\eta^2 = .65$, and from session six to session eleven $F(1,20) = 24.59$, $p < .001$, $\eta^2 = .55$. Participants of the group receiving excluded letter fluency training (C) did not improve from session one to session eleven, $F(2,36) = 1.94$, $p = .159$, $\eta^2 = .10$, indicating that this group did not benefit from the three weeks of training. Means and standard errors are presented in Figure 3.

Consequently, there was a significant effect of training on the level of training gain, $F(2, 56) = 11.01$, $p < .001$, $\eta^2 = .28$. Whereas training gains of both, initial letter fluency and phonemic switching fluency training were significantly different from training gains of excluded letter fluency training (Bonferroni: initial letter vs. excluded letter, $p < .001$, phonemic switching vs. excluded letter, $p = .001$), training gains of initial letter fluency training were not significantly different from training gains of phonemic switching training (Bonferroni's post-hoc test: initial letter vs. phonemic switching, $p = 1.000$).

Insert Figure 3 about here

Transfer to other verbal fluency tasks

Because participants of the group receiving excluded letter fluency training did not show significant performance improvement during training, we did not consider this group for further analyses of transfer effects. Therefore, a 4 x 2 repeated-measures ANOVA with group as between-subjects factor and time (pretest, posttest) as within-subject factor was conducted to assess whether the groups differed in the five verbal fluency tasks used (see Table 3). In all tasks except for the excluded letter fluency task, the group x time interactions were significant (phonemic switching fluency, $p < .001$, initial letter fluency, $p = .001$; animal naming, $p = .038$ and semantic switching fluency, $p = .022$), indicating that the change in performance from pretest to posttest was different between groups.

Of the four contrasts specified (see also Table 3), we first compared any activity including the active control group to no activity (A, B, D vs. E; contrast 1). Results revealed that the change over time was significantly smaller for the no-contact control group compared to the average change in all other groups in the following tests: initial letter fluency ($t = 2.71$, $p = .008$, $\eta^2 = .09$), animal naming ($t = 2.60$, $p = .011$, $\eta^2 = .08$.), and phonemic switching fluency ($t = 3.26$, $p = .002$, $\eta^2 = .12$). This indicates that verbal fluency training or social contact significantly increased performance on these tasks compared to having no contact between the pre- and posttest. No significant finding emerged comparing the training groups including the active control group versus the no-contact control group on the semantic switching fluency tasks.

Furthermore, we compared the two training groups versus the active control group (A, B vs. D; contrast 2). This contrast was significant for the initial letter fluency task ($t = 2.86$, $p = .005$, $\eta^2 = .09$) and phonemic switching fluency task ($t = 2.42$, $p = .018$, $\eta^2 = .07$), indicating that the change in performance over time in the active control group was significantly lower than the average change in performance seen in the two verbal fluency training groups. However, for the semantic fluency task, findings were reversed. On this task, the active control group performed better than the two training groups ($t = 2.72$, $p = .008$, $\eta^2 = .09$).

In addition, comparing performance after initial letter fluency training with performance after control activity (A vs. D; contrast 3a), revealed a significant finding on initial letter fluency ($t = 2.69$, $p = .009$, $\eta^2 = .08$) and on semantic switching fluency ($t = 2.99$, $p = .004$, $\eta^2 = .10$). While on initial letter fluency the group receiving initial letter fluency was found to perform better, on the semantic switching fluency task it was the control activity group that outperformed the fluency training group. Comparing performance after phonemic switching training with performance after control activity (B vs. D; contrast 3b) revealed a significant finding on initial letter fluency (t = 2.25, p = .027, η^2 = .06), and phonemic switching fluency (t = 3.64, p < .001, η^2 = .14), indicating that the participants of the phonemic switching training group performed significantly better on both tasks compared to the active control group.

Finally, we compared performance on each verbal fluency task after initial letter fluency training with performance after phonemic switching training (A vs. B; contrast 4). Results revealed a significant difference between the two groups on phonemic switching fluency (t = 2.98, p = .004, η^2 = .10), indicating that the phonemic switching fluency training further increased performance score on this task compared to the initial letter fluency training. No significant difference was found on the remaining four verbal fluency tasks.

Insert Table 3 about here

Transfer to untrained tasks

To examine generalization of training gains to standardized neuropsychological measures of cognitive functions (see Table 4), we chose tests according to the core processes of each verbal fluency subtest intended to be targeted in the training (processing speed, shifting, and inhibition). Furthermore, memory measures (short-term memory, working memory, and long-term memory) were included as these have been found to be related to verbal fluency performance [11,14].

A 4 x 2 repeated-measures ANOVA with group as between-subjects factor and time (pretest, posttest) as within-subject factor was conducted to assess whether the four groups differed in these six tests. For the Trail Making Test, Go/No-Go, N-Back, and episodic free recall, no significant interaction effect emerged (all *p*s > .05). However, a significant interaction was found on the Digit Span task ($p < .05$). We specified three contrasts to compare the four groups. First, comparison of the three activity conditions (initial letter fluency training, phonemic switching training and control activity) versus the no-contact control condition (A, B, D vs. E) revealed no differences in performance on the Digit Span task. Second, comparison of the two verbal fluency training conditions versus the control activity (A, B vs. D) revealed a significant difference ($t = 2.74$, $p = .008$, $n^2 = .09$). Third, we compared each training group separately with the active control group (A vs. D; B vs. D). Comparing performance after receiving initial letter fluency training revealed a marginally significant finding ($t = 1.97$, $p = .052$, $n^2 = .05$), and comparing performance after receiving phonemic switching training revealed a significant finding ($t = 2.75$, $p = .007$, $n^2 = .09$). Fourth, comparing the two training groups, we did not find a significant difference in performance on the Digit Span task.

Insert Table 4 about here

Discussion

The aim of the present study was to develop an intervention to improve verbal fluency performance in old age. A further aim was to design a non-traditional intervention that is short, easy to integrate in every-day life, and not relying on computer-based software. Besides training gains, we investigated whether we find training related improvements in other verbal fluency tasks as well as in untrained tasks.

More specifically, we predicted finding training gains in all three training tasks, and that these training gains differ across the three training groups. We found improvement throughout training for both, initial letter fluency training and phonemic switching training, suggesting that verbal fluency is improvable in healthy old age even after only three-weeks of intervention with a total training time of 90-minutes. The training gains in both groups were more or less the same. However, we did not find any performance improvement after excluded letter fluency training. On this task, participants started at a relatively high level, compared to the amount of words produced by participants of the other two training groups. As there were no differences between groups at pretest, except on the Digit Symbol Substitution Test, it seems most likely that the excluded letter fluency task we used was relatively easy for older adults.

We had predicted transfer to other verbal fluency tasks. Analyses with the groups receiving initial letter training or phonemic switching training revealed transfer to tasks that were similar to the trained tasks. Moreover, the two training tasks led to different results. Initial letter fluency training led to transfer to only initial letter fluency administered with another initial letter than in the training. In contrast, training gains after phonemic switching training were not tied to the specific items of the training task, as these participants additionally increased performance on initial letter fluency.

Finally, we predicted transfer to untrained tasks, some of which involved the same underlying processes as targeted in the training (processing speed, shifting and inhibition). Consistent with our previous findings regarding performance improvements on verbal fluency after phonemic switching training, we found transfer to the Digit Span task for this group. Interestingly, participants showed performance improvements that were greater compared to the other four groups. This was the only significant finding for transfer to untrained tasks and, although it is promising, a note of caution is required. Nevertheless, this finding is in line with previous studies that reported improvements in several cognitive functions following task-switching or dual-task training [e.g., 30,31]. Our results extend these findings by demonstrating that task-switching in the context of verbal fluency could reveal performance improvements. The larger transfer effects after phonemic switching fluency training compared to the initial letter fluency training might be explained by the fact that, in addition to shifting processes, this training also required processing speed abilities, for example when switching between letters as fast as possible.

Our study further revealed an unexpected finding: the active control group improved performance in semantic switching fluency. The task chosen, talking about a specific topic, may have led to an activation of semantic knowledge. This task was designed to be similar to the trained tasks in all aspects, but without focusing on a specific cognitive process. It might have been better to include a non-semantic task as control activity. However, the fact that the active control group also showed an improvement is in concordance with previous findings on cognitive engagement. In fact, Stine-Morrow, Parisi, Morrow, and Park [32] found cognitive performance enhancement after an intervention on engaged lifestyles. In addition, our finding also fits the hypotheses of the “Synapse Program” proposed by Goh and Park [20]. In this intervention study, older adults were randomly assigned to different conditions of engagement, for example quilting or digital photography, with the idea of general cognitive activation. Furthermore, as could be seen from Table 3, it is also not a negative transfer, in the sense that the three training groups would not be able to improve performance because of the training task interfering with the transfer task. Instead, the active control group improved performance above and beyond the two training groups and the no-contact control group.

From the findings of this study several implications can be drawn. First, we have demonstrated performance improvements of older adults through a 90 minutes training intervention using different versions of verbal fluency. Second, this study shows that the gains from such a short-term intervention can, although in a limited way, transfer to other, non-trained tasks. Given that we observed improvements across session 1 to 11, increasing the number of training sessions might lead to more transfer effects. Regarding practical implications, from collected reports of participants we know that the participants enjoyed to participate and looked forward to their daily phone call. Further applications of this training could be possible, for example as an activity for patients with mild cognitive impairment.

Because the tasks are easy to administer and do not require many resources, they could be applied by caregivers. Thus both, verbal fluency tasks as well as providing a specific topic to talk for several minutes could be integrated in everyday lifestyles. However, before such applications can be unreservedly recommended more research is needed that supports or even extends the efficacy of the training intervention.

A limitation of this study is that we did not evaluate if the training effects would be maintained several months following the intervention. Unfortunately, we did not collect any data that addresses this issue, as our aim was to show verbal fluency plasticity and transfer to cognitive abilities in the first place. A further limitation of this study is that the no-contact control group was not recruited together with the other intervention groups. However, baseline performance of the no-contact control group did not differ from the four activity groups, including the Digit Symbol Substitution Test. Ideally, performance of the no-contact control group would have been assessed in a wait condition, providing training after the posttest. Finally, some studies have also shown evidence for age-related stability in phonemic fluency performance [33,34]. This has been attributed to the fact that verbal fluency is recognized as a crystallized ability, along with general knowledge and vocabulary, which are largely influenced by education and acculturation [35]. Therefore, crystallized skills may be important determinants of the magnitude and direction of age effects on verbal fluency performance, especially on phonemic fluency performance.

Based on our findings, future studies might want to investigate if an increase in the number of sessions has a positive effect on transfer to other cognitive abilities and if training gains persist in a follow-up study. In addition, neuroimaging data that assess changes in the neural correlates of the trained function could provide insights into the specificity of the training effects and their neural basis. Furthermore, one might wonder why we did not include semantic fluency, as this variant has been identified to be more age-sensitive. In the first part, we were targeting some of the underlying cognitive processes that could be more easily targeted with phonemic fluency training. Future studies, however, could investigate the effectiveness of semantic fluency training and whether participants improve performance to a similar degree.

In conclusion, of main interest in this study was whether verbal fluency performance could be improved through a simple short-term intervention. The largest training gains and the most improvements on transfer tasks were observed after phonemic switching training. Finally on a broader level, the demonstration that performance benefits could be achieved in a short-term telephone-based intervention has practical utility, given that word finding difficulties are frequently reported by healthy older adults [4] and an impairment in verbal fluency performance is also found in patients with early Alzheimer’s disease [36].

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Tables

Table 1. *Training Schedule*

	Initial letter fluency training (A)		Phonemic switching fluency training (B)		Excluded letter fluency training (C)		Control activity (D)
	Task 1	Task 2	Task 1	Task 2	Task 1	Task 2	Task 1
Session 1	**P**	D	**H-T**	P-D	**n**	i	Movies
Session 2	A	V	M-L	B-A	g	p	Books
Session 3	H	Z	E-F	U-N	b	f	Traveling
Session 4	B	J	K-L	I-U	k	r	Mountains
Session 5	M	O	A-M	T-O	m	s	Leisure
Session 6	**P**	E	**H-T**	K-P	**n**	u	Favorite dish
Session 7	U	F	A-I	D-O	l	a	Seasons
Session 8	K	D	F-N	U-B	h	t	Commercials
Session 9	T	I	M-E	Z-L	o	g	Family
Session 10	H	B	D-K	N-I	d	i	Animals
Session 11	**P**	M	**H-T**	A-Z	**n**	k	Job
Session 12	L	E	M-P	E-D	s	t	Wishes
Session 13	W	F	L-M;	U-I	u	a	Politics
Session 14	N	T	F-K	E-P	p	l	Art

Session 15	I	A	B-A	L-O	f	h	Role models

Note. Task 1 of Session 1, 6, and 11 were used to analyze training gains.

Table 2. *Mean Subject Characteristics*

	Initial letter fluency training (A)	Phonemic switching fluency training (B)	Excluded letter fluency training (C)	Active control (D)	No-contact control (E)	Overall	*p*-value
Age	72.45 (4.81)	73.52 (7.00)	72.00 (5.24)	72.57 (5.66)	70.81 (5.42)	72.27 (5.66)	.643
Years of education	10.21 (3.26)	10.19 (2.89)	9.66 (1.75)	9.90 (2.26)	10.14 (1.80)	10.02 (2.42)	.948
Gender (in percent)							.133
Male	47.4	38.1	52.6	23.8	38.1	44.6	
Female	52.6	61.9	47.4	76.2	61.9	55.4	
GDS score							
pre	1.37 (1.30)	1.29 (1.71)	1.95 (1.78)	1.55 (1.72)	0.93 (1.21)	1.41 (1.56)	.342
post	2.00 (4.45)	1.92 (1.93)	0.93 (1.54)	1.12 (1.82)	0.81 (1.12)	1.33 (2.42)	.373
STAI-state score							
pre	28.84 (6.59)	30.52 (6.92)	32.68 (8.83)	32.76 (8.67)	30.67 (7.43)	31.11 (7.72)	.473
post	28.79 7.66)	30.68 (6.82)	28.57 (4.79)	32.67 (9.69)	29.29 (6.19)	30.01 (7.24)	.338

Note. Standard errors are in parentheses. The *p*-values refer to the comparison of all five groups. GDS = Geriatric Depression Scale. STAI = State Trait Anxiety Inventory.

Table 3. *Mean Test Scores on Verbal Fluency Tasks*

	Initial letter fluency training (A) M(SD)		Phonemic switching fluency training (B) M(SD)		Active control (D) M(SD)		No-contact control (E) M(SD)		*p*-value (η^2)	*Contrast 1 (A, B, D vs. E) p-value* (η^2)	*Contrast 2 (A, B vs. D) p-value* (η^2)	*Contrast 3a (A vs. D) p-value* (η^2)	*Contrast 3b (B vs. D) p-value* (η^2)	*Contras 4 (A vs. B) p-value* (η^2)
	Pre	Post	Pre	Post	Pre	Post	Pre	Post						
Initial letter	23.84	37.47	26.29	38.52	26.29	32.38	25.90	30.47	**.001**	**.008**	**.005**	**.009**	**.027**	.621
	(8.44)	(11.78)	(8.02)	(14.42)	(12.26)	(12.21)	(7.96)	(10.54)	**(.18)**	(.09)	(.09)	**(.08)**	**(.06)**	(.01)
Animal naming	40.15	42.79	39.04	45.29	39.81	44.38	43.57	42.38	**.038**	**.011**	.953	.477	.531	.189
	(10.51)	(9.38)	(9.69)	(10.10)	(10.94)	(10.13)	(8.27)	(11.48)	**(.10)**	(.08)	(.01)	(.01)	(.01)	(.02)
Excluded letter	24.79	31.89	23.14	30.81	27.14	31.90	24.76	26.81	**.140**					
	(8.08)	(8.06)	(7.18)	(9.58)	(8.79)	(10.33)	(7.36)	(6.65)	**(.07)**					
Phonemic switching	26.95	32.37	26.43	38.05	26.19	30.42	25.14	26.81	**< .001**	**.002**	**.018**	.571	**< .001**	**.004**
	(7.47)	(8.85)	(7.47)	(11.46)	(7.43)	(8.15)	(7.63)	(7.23)	**(.23)**	(.12)	(.07)	(.01)	**(.14)**	**(.10)**
Semantic switching	26.10	26.95	25.14	27.71	25.19	29.90	26.24	27.24	**.022**	.103	**.008**	**.004**	.094	.186
	(4.81)	(4.95)	(5.27)	(5.66)	(5.33)	(6.34)	(4.06)	(5.60)	**(.11)**	(.03)	(.09)	**(.10)**	(.04)	(.02)

Note. The *p*-values refer to the interaction (group x time), controlling for performance on the Digit Symbol Substitution Test. Planned comparisons for the significant interactions were as follows: Contrast 1) initial letter fluency training, phonemic switching fluency training, active control vs. no-contact control (A, B, D vs. E), Contrast 2) initial letter fluency training, phonemic switching fluency training vs. active control (A,B vs. D), Contrast 3a) initial letter fluency training vs. active control (A vs. D), Contrast 3b) phonemic switching fluency training vs. active control (B vs. D), Contrast 4) initial letter fluency training vs. phonemic switching fluency training (A vs. B).

Table 4. *Mean Test Scores on Untrained Transfer Tasks*

	Initial letter fluency training (A) M(SD)		Phonemic switching fluency training (B) M(SD)		Active control (D) M(SD)		No-contact control (E) M(SD)		*p*-value η^2
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	
Trail Making Test (B-A)	52.71 (22.78)	46.14 (18.94)	51.00 (18.53)	48.89 (30.36)	58.14 (23.68)	49.85 (26.67)	57.33 (32.03)	38.95 (14.83)	.256 (.05)
Go/No-Go	19.84 (.50)	19.89 (.31)	19.95 (.21)	19.71 (.90)	19.14 (3.07)	20.00 (0.00)	19.76 (0.62)	20.00 (0.00)	.084 (.08)
Digit Span	10.05 (1.54)	11.10 (2.13)	10.61 (1.77)	12.00 (2.46)	10.90 (2.07)	11.05 (2.08)	11.00 (1.52)	11.42 (1.61)	**.012** (.13)
N-Back	11.73 (2.58)	11.05 (3.88)	11.85 (2.80)	12.70 (2.27)	12.43 (2.29)	12.71 (2.15)	11.65 (3.15)	12.90 (2.00)	.220 (.06)
Free recall	10.47 (3.39)	12.10 (3.18)	10.45 (3.74)	12.00 (2.80)	10.80 (3.36)	12.60 (2.83)	9.00 (2.93)	10.61 (2.94)	.842 (.01)

Note. The *p*-values refer to the interaction (group x time), controlling for performance on the Digit Symbol Substitution Test.

Figure Captions

Figure 1. Conceptual model of the training intervention for the three training groups.

Figure 2. Flow diagram of the progress through the phases of randomized trial (i.e., training groups, active control group and no-contact control group).

Figure 3. Training gains of the three verbal fluency training groups.