# Prefrontal Transcranial Direct Current Stimulation Preferentially Improves Declarative Memory, but not Working Memory in Older Adults

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## Introduction

- Transcranial Direct Current Stimulation (tDCS) is a noninvasive means of electrical brain stimulation that we have previously shown to enhance working memory (WM) training performance (Au et al. 2016). These effects were shown to be sensitive to spacing (i.e., greater gains over a weekend vs. consecutive training days) and time (effects persisted up to a year), which are hallmark features reflecting consolidation processes.
- Animal work also shows that tDCS may enhance memory consolidation (Podda et al. 2016)
- The present study seeks to demonstrate whether our previous findings may have been driven by consolidation. To do so, we added a declarative memory (DM) task, which is more classically used to study consolidation, to our training regimen and attempted to replicate our previous spacing and long-term effects.
- Predictions:
-Delayed recall > Immediate Recall
-DM > WM
-More spacing > Less spacing

## Methods

- 53 older adults between the ages of 65 and 85 were recruited from the University of Michigan and UC-Irvine and were randomized into different training (active/sham) and spacing (daily/every other day) conditions.
- Participants trained for five consecutive days on a memory intervention (Fig 1). We measured specific and non-specific training effects pre and post-intervention, and at a 3-month follow-up. Non-specific transfer to other DM and WM tasks were absent and not shown here.
- Stimulation was administered via an Oasis Pro (Mind Alive Inc.) tDCS device. The anode was placed over the left DLPFC and the cathode was placed over the right supraorbital ridge.

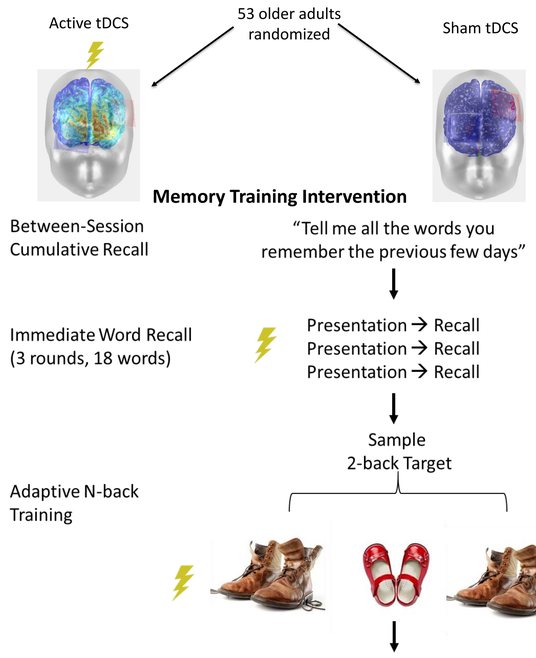


**Figure 1: Schematic of training intervention.**
The between-session cumulative recall took place at the beginning of each session (including post-test and follow-up) starting from Training Day 2. Lightning bolts represent administration o tDCS.

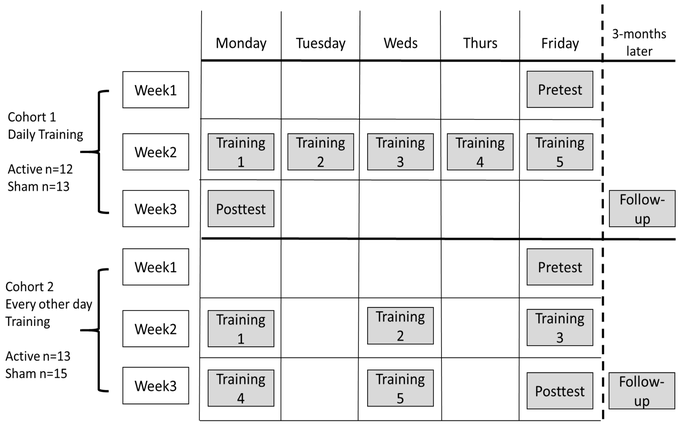


**Figure 2: Study Timeline**

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## Results

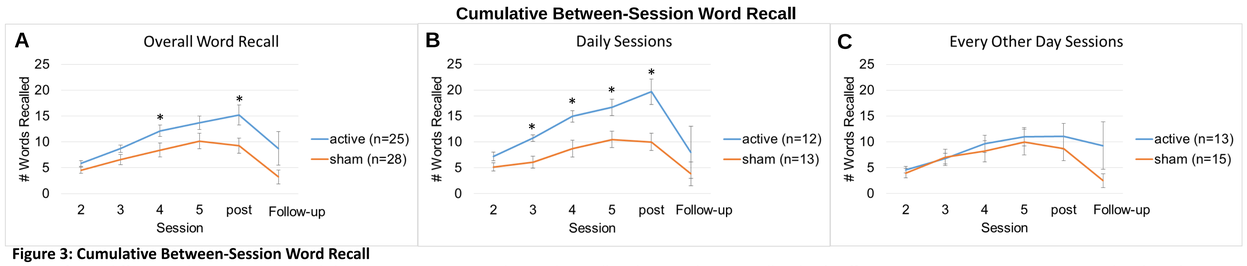


**Figure 3: Cumulative Between-Session Word Recall**
A) Significant differences between active and sham tDCS groups were observed overall in the cumulative recall task. B) Differences were even more pronounced in the subgroup receiving daily training. C) No effects were found with every other day training. Asterisks represent significant differences ($p<0.05$). N=12/13 (active/sham) at follow-up in overall group because not all participants have returned for their 3-month follow-up yet. N=7/6 for the Daily subgroup, and n=5/7 for the every other day subgroup.

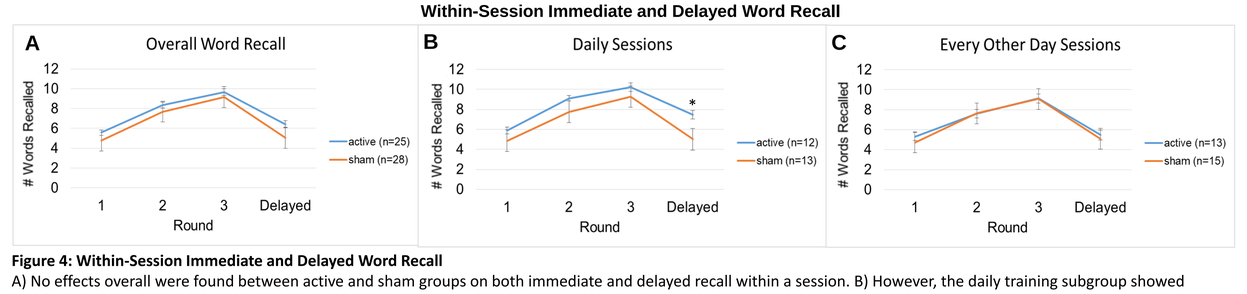


**Figure 4: Within-Session Immediate and Delayed Word Recall**
A) No effects overall were found between active and sham groups on both immediate and delayed recall within a session. B) However, the daily training subgroup showed significant effects during delayed but not immediate recall. C) No effects were found in the every other day training group. Asterisks represent significant differences ($p<0.05$)

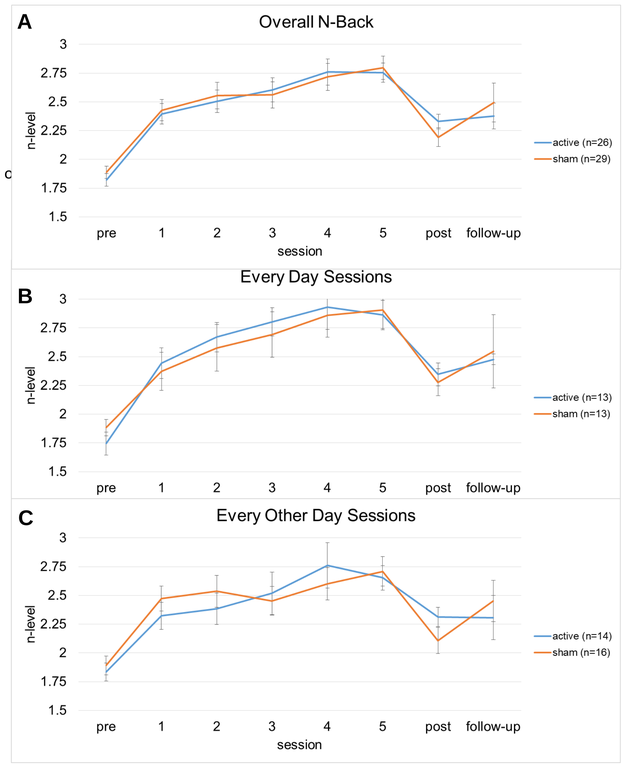


**Figure 5: N-back Training**
A-C) No effects were found between active and sham groups, regardless of spacing conditions. N=12/13 (active/sham) at follow-up in overall group because not all participants have returned for their 3-month follow-up yet. N=7/6 for the Daily subgroup, and n=5/7 for the every other day subgroup.

## Discussion

- Consistent with our predictions that tDCS would interact with consolidation processes, we found strong effects on DM that were most apparent after a time delay and sensitive to spacing. No effects were found on immediate memory or WM.
- Although tDCS was sensitive to spacing, the direction of effects (Daily > Every other day) was opposite of what we predicted based on our previous younger adult work.
- Reconsolidation operates most effectively within a narrow window that maximizes spacing but minimizes forgetting between learning sessions. Thus, daily training may be a more optimal schedule for older adults on our DM task vs. younger adults on a WM task.

## Conclusion

- Despite little to no apparent benefit of tDCS *during* task performance, the delayed effects are strong and reliable.
- We posit that tDCS applied during learning interacts with downstream consolidation processes that serve to strengthen task-relevant networks after the fact.