

An evaluation of the SWAN game-based approach to re-building numeracy skills in aphasia

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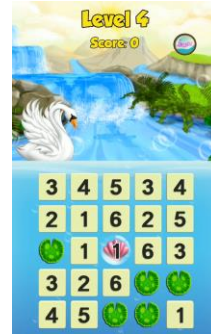
Introduction

Difficulty understanding and communicating numbers is a common problem for people with aphasia post stroke.¹ Individuals may have difficulties with transcoding (e.g. they are unable to name numbers aloud, or at least not without writing them or counting on their fingers) and counting.



Despite the frequency of number difficulties, and the impact of these on individuals' everyday lives and independence,² there are few therapies targeting this area.

The current study aimed to explore the effects of a novel digital game-based intervention, SWAN, on the numeracy abilities of a group of people with aphasia.



Intervention

The SWAN therapy game addresses numeracy difficulties by enhancing foundational number language: the Arabic numeral sequence (i.e. counting) and the relationship between the spoken number name and Arabic numeral (i.e. transcoding).

There are two key components to the intervention:

- Number sequences in the game increase in range and complexity, corresponding to the pattern observed in children's learning⁴
- Repeated opportunities for users to link the phonological form with each Arabic numeral selected in a sequence, exploiting the benefits of mass practice⁵

Rather than embedding the intervention within a game, the game itself is the intervention. In the main game the player has to create a sequence by selecting the tiles on the screen (providing counting practice); as tiles are selected the number name is played. Additional "bonus" games provide further practice in targeted foundational skills (see figure 3).

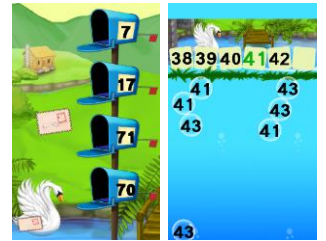


Figure 3. Screenshots of the two SWAN bonus games

Methods

Participants

- 18 adults (5 women) with chronic aphasia
- Ages ranged from 37 to 77 years (M = 61.4).
- Range of aphasia severity.
- All reported problems with numbers in everyday life

Outcome Measures

Assessment of proximal skills:

- Transcoding (ID, reading, writing)
- Counting (forwards and backwards)

Assessment of distal skills:

- Addition (with and without carrying)
- Subtraction (with and without carrying)
- Functional numeracy test (see figure 1)



Figure 1. Example item from functional numeracy test

Language assessment: Western Aphasia Battery-R³

Control assessment: Bespoke analogical reasoning task

All assessments were completed online over Zoom.

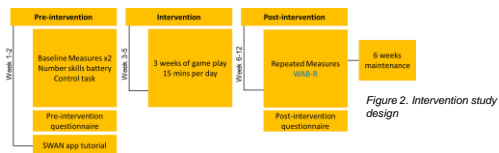


Figure 2. Intervention study design

Results

Pre-intervention abilities

Baseline performance on tests of proximal skills revealed three groups:

- Relatively good performance across tasks (N=4)
- Relatively poor performance across tasks (N=7)
- Mixed profile – most with strengths in transcoding, poor counting (N=8)

Individuals in the poor numeracy group had significantly poorer language scores than the other two groups ($H(2) = 6.69, p = 0.04$) (see figure 4).

Gameplay

Game exposure and rate of play were related to baseline number processing skills:

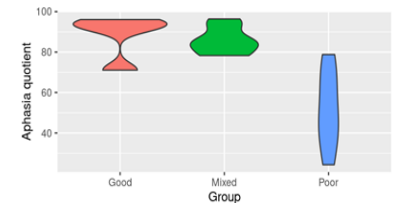
- Participants with good numeracy skills completed more game levels than the other two groups ($H(2) = 8.11, p = 0.02, \eta^2 = 0.41$)
- Those with poor skills played significantly more slowly - as measured by "time per tile" ($H(2) = 12.18, p < 0.01, \eta^2 = 0.68$)

Outcomes

In order to detect improvements attributable to intervention, data were analysed using the item-based weighted statistics method, designed for use in single case intervention studies⁶.

- 12 participants (distributed across all numeracy groups) showed gains on proximal and/or distal tasks
- Four participants showed gains in the control task as well as other measures, indicating a general improvement in performance
- Only two participants failed to show any significant gains on outcome measures
- No participants made gains on the functional assessment

Figure 4. Violin plots showing the relation between number processing groups and aphasia quotients.



Discussion

1. Our findings highlight **the importance of considering numeracy abilities** in assessment and intervention with adults with aphasia: individuals present with a variety of strengths and difficulties.
2. They suggest **SWAN is an effective tool** in motivating users and providing mass practice in number sequence selection, though more practice may be needed to facilitate functional change.
3. Positive **effects were found across all number processing abilities**, suggesting the intervention may be effective for supporting individuals with a wide range of difficulties.
4. Participants **enjoyed the game** and reported **gains in confidence with numbers** after playing.

References

- [1] De Luccia, G. & Ortiz, K. (2014). Ability of aphasic individuals to perform numerical processing and calculation tasks. *Arquivos de neuro-psiquiatria*, 72, 197-202.; [2] Benn, Y., Jayes, M., Casassus, M., Williams, M., Jenkinson, C., McGowan, E., & Conroy, P. (2021). A qualitative study into the experience of living with acalculia after stroke or acquired brain injury. <https://doi.org/10.31234/osf.io/tek6f>; [3] Kertesz, A. (2007). *The Western Aphasia Battery-Re; vised*. San Antonio, Texas. PsychCorp.; [4] Fuson KC (1988). *Children's counting and concepts of number*. New York: Springer-Verlag; [5] Middleton, E., Rawson, K., Verkuile, J. (2019) Retrieval practice and spacing effects in multi-session treatment of naming impairment in aphasia. *Cortex*, 119, 386-400; [6] Howard, D., Best, W., Nickels, L. (2015) Optimising the design of intervention studies: critiques and ways forward. *Aphasiology*, 16, 151-168.