Cognitive training involving simulations of instrumental activities of daily living following acquired brain injury: a pilot study with the NeuroAIreh@b platform

J Câmara[1,2,3], T Paulino[2,3], M Spínola[1,2,3], D Branco[2,3], M Cameirão[2,3], A L Faria[2,3], L Ferreira[2,3], A Moreira[1], A R Silva[1], M Vilar[1], M R Simões[1], S Bermúdez[2,3], E Fermé[2,3]

[1]Faculdade de Psicologia e de Ciências da Educação, Universidade de Coimbra
Rua do Colégio Novo, Coimbra, Portugal
[2]Polo do NOVA Laboratory for Computer Science and Informatics (LINCS), Universidade da Madeira
Caminho da Penteada, Funchal, Portugal
[3]Agência Regional para o Desenvolvimento da Investigação, Tecnologia e Inovação (ARDITI)
Caminho da Penteada, Funchal, Portugal

[1]*joana.camara@arditi.pt*

ABSTRACT

In this pilot study, we sought to evaluate the feasibility and short-term efficacy of a novel ecologically valid cognitive training (CT) system – the NeuroAIreh@b platform – delivered via tablet in a sample of acquired brain injury (ABI) patients (stroke and traumatic brain injury). So far, ten ABI patients have completed the one-month CT intervention; our findings indicate that patients revealed a significant improvement in verbal memory (Free and Cued Selective Reminding Test (FCSRT)-total immediate recall trial)) and in self-reported functional abilities (Adults and Older Adults Functional Assessment Inventory (IAFAI total score)) at post-intervention. Despite our small sample size and the short intervention phase, we verified that there was a generalization of training gains to activities of daily living. We hypothesized that this may result from the similarity of the training context with day-to-day activities.

1. INTRODUCTION

Acquired brain injuries (ABI), such as stroke and traumatic brain injury (TBI), are major causes of long-term cognitive and motor disability, compromising the individual's autonomy to reintegrate into the family, occupational and social environments (Cicerone et al., 2019; Messinis et al., 2019). Cognitive deficits following ABI are quite prevalent and represent a research priority. Cognitive training (CT) interventions delivered through new technologies are promising solutions to mitigate ABI-related cognitive deficits. These interventions allow the integration of ecologically valid training content that intends to facilitate the generalization of therapeutic gains to everyday life (Faria et al., 2016, 2020). Other technological innovations, such as the use of artificial intelligence (AI) to optimize CT, are set to help neuropsychologists to personalize CT according to patients' characteristics efficiently (e.g., neuropsychological profile, session-to-session performance) (Solana et al., 2014). Herein we present a clinical pilot study using the NeuroAIreh@b platform, which is currently under development. Some of this platform's features, namely the ecologically valid content and gamification factors, are already implemented. This pilot study aimed to assess the feasibility and short-term clinical impact of the NeuroAIreh@b platform prototype version in a sample of chronic patients with ABI.

2. METHODS

We expect to recruit 20 ABI patients from the Madeira Health Service and the Neuropsychology Clinical Service of the University of Coimbra. Up to now, fourteen patients with ABI (Stroke=11; TBI=3) met the inclusion criteria and were submitted to baseline multidimensional neuropsychological assessments (NPA). Then, patients enrolled in a one-month intervention with the NeuroAIreh@b platform, encompassing eight 45-minutes CT sessions presented in a tablet. During computerized CT sessions, patients performed four types of cognitive training tasks (CTTs) inspired by instrumental activities of daily living (IADLs) (e.g., selecting the right ingredients for a given recipe, paying for groceries in the supermarket, and organizing the kitchen after preparing a meal), with varying content and parameterization. These were implemented through the following tasks: Reh@Search (cancellation), Reh@Org (action-sequencing), Reh@Pay (calculation), and Reh@Cat (categorization) (cf. Figure 1). In this pilot study, psychologists manually adapted task difficulty (i.e., individual task parameters) according to patients' session-to-session performance. Post-NPAs were conducted to assess the pilot intervention's short-term efficacy.

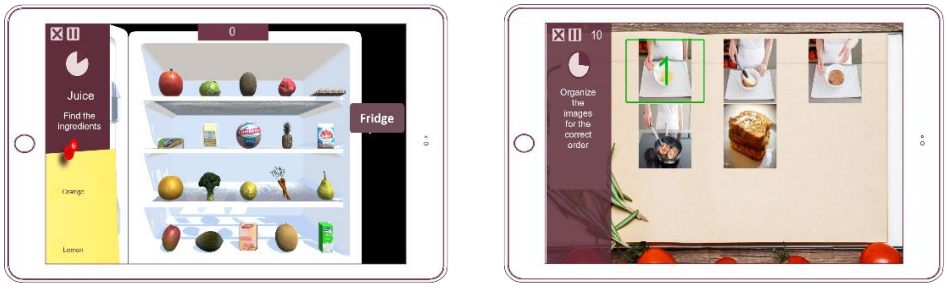

Figure 1. *Examples of CTTs available in the NeuroAIreh@b platform: a) Reh@Search (cancellation task); and b) Reh@Org (action-sequencing task).*

3. RESULTS

So far, ten chronic ABI patients (Stroke=9; TBI=1; Female=5; Male=5; Age (Mean, Standard Deviation)=58±6.68; Years of schooling (Mean, Standard Deviation)=7.80±3.43) have completed the one-month computerized CT intervention.

***Table 1**. NPA scores (presented as Medians and interquartile ranges) at baseline and post-intervention. Within-groups statistically significant results are highlighted in bold.*

Instruments	Baseline	Post	Change from baseline	Significance
MoCA	18 (7.25)	20.5 (6.25)	+2.5	*p*=.108
Digit Symbol	30 (17.25)	36 (29)	+6	*p*=.075
Symbol Search	9.5 (13)	16.5 (12.5)	+7	*p*=.514
TP total score	8.05 (8.97)	9.65 (9.5)		*p*=.074
FCSRT-total immediate recall trial	23 (11.25)	36.5 (16)	+13.5	***p*=.005**
FCSRT-total delayed recall trial	9 (5.25)	10.5 (7.5)	+1.5	*p*=.202
Semantic verbal fluency (Animals)	9.5 (10)	16.5 (6)	+7	*p*=.682
Phonemic verbal fluency (Letters P+M+R)	8.5 (15.5)	11 (17.25)	+2.5	*p*=.258
ROCFT – Copy trial	28.5 (16.88)	32 (12)	+3.5	*p*=.122
ROCFT – 3-minutes immediate recall trial	8.5 (16.62)	10 (10.75)	+1.5	*p*=.671
BDI-II	4.5 (16)	3.5 (9)	-1	*p*=.123
QOLIBRI	55.37 (22.10)	59.25 (22.6)	+3.88	*p*=.109
IAFAI total score	30.51 (33.65)	21.57 (33.02)	-8.94	***p*=.028**

Note: MoCA-Montreal Cognitive Assessment; TP-Toulouse Piéron; FCSRT-Free and Cued Selective Reminding Test; ROCFT-Rey Osterrieth Complex Figure Test; BDI-II-Beck Depression Inventory II; QOLIBRI-Quality of Life after Brain Injury; IAFAI-Adults and Older Adults Functional Assessment Inventory.

A within-groups analysis using the Wilcoxon signed rank test showed statistically significant improvements in the FCSRT – total immediate recall trial score (*p*=.005) and in the IAFAI total score (*p*=.028) at post-intervention.

4. CONCLUSIONS

Overall, we found that the ecologically valid CT implemented in the NeuroAIreh@b platform can be beneficial in the chronic phase of ABI, leading to s short-term gains in verbal memory (immediate recall), as measured by FCSRT, and functional abilities, as measured by IAFAI, possibly due to the resemblance of the training environment to daily life demands. These preliminary results are encouraging and highlight the benefits of incorporating IADLs based content within computerized CT. The number of patients who completed training with the NeuroAIreh@b platform will be updated, as well as global clinical findings, upon the re-examination of the total sample data collected prior to this work's presentation. Patients' performance data in all CT sessions will inform AI algorithms on how to modulate the CTTs parameterization and difficulty adjustment according to patients' neuropsychological profile and the collected session-to-session performance. These AI algorithms are currently being developed through regression models between neuropsychological profile data and performance data to improve personalization and provide optimal CT. We expect that in the future, the AI algorithms can provide optimal CTTs to ABI patients with specific neuropsychological deficits, thus, assisting neuropsychologists in clinical decision-making.

Acknowledgements: This work is supported by Fundação para a Ciência e Tecnologia through a PhD grant (SFRH/145919/2019) awarded to Joana Câmara, NOVA LINCS UIDB/04516/2020, BRaNT project PTDC/CCI-COM/31046/2017, and through the INTERREG project MACBIOIDI2 (MAC2/1.1b/352).

5. REFERENCES

Cicerone, KD, Goldin, Y, Ganci, K, Rosenbaum, A, Wethe, JV, Langenbahn, DM, ..., Harley, JP, (2019), Evidence-based cognitive rehabilitation: systematic review of the literature from 2009 through 2014. *Arch Phys Med Rehabil*, **8**, *100*, pp.1515–1533.

Faria, AL, Andrade, A, Soares, L, (2016), Benefits of virtual reality based cognitive rehabilitation through simulated activities of daily living: a randomized controlled trial with stroke patients. *J. Neuroeng. Rehabilitation*, **1**, *13*, pp. 1–12.

Faria, AL, Pinho, MS, Bermúdez i Badia, S, (2020), A comparison of two personalization and adaptive cognitive rehabilitation approaches: a randomized controlled trial with chronic stroke patients. *J. Neuroeng. Rehabilitation*, 1, *17*, pp.1–15.

Messinis, L, Kosmidis, MH, Nasios, G, Dardiotis, E, Tsaousides, T, (2019), Cognitive neurorehabilitation in acquired neurological brain injury. *Behav. Neurol*, pp.1–4.

Solana, J, Cáceres, C, García-Molina, A, Chausa, P, Opisso, E, Roig-Rovira, T, Menasalvas, E., Tormos-Munoz, JM, Gómez, EJ, (2014), Intelligent Therapy Assistant (ITA) for cognitive rehabilitation in patients with acquired brain injury. *BMC Med. Inform. Decis. Mak*., **1**, *14*, pp.1–13.

ICDVRAT 2022

Publication Agreement and Assignment of Copyright

Agreement: We are pleased to have the privilege of publishing your article in the forthcoming 14th International Conference on Disability, Virtual Reality and Associated Technologies 2022 ("ICDVRAT"). By submission of your abstract, you hereby grant to the ICDVRAT all your right, title, and interest including copyright in and to the abstract as it appears in the Proceedings of the ICDVRAT ("the Abstract"). Management of the copyright for all abstracts will be maintained by ICDVRAT.

Rights Reserved by Author(s): You hereby retain and reserve for yourself a non-exclusive license: 1.) to photocopy the Abstract for your use in your own teaching activities; and 2.) to publish the Abstract, or permit it to be published, as part of any book you may write, or in any anthology of which you are an editor, in which your Abstract is included or which expands or elaborates on the Abstract, unless the anthology is drawn primarily from ICDVRAT. As a condition of reserving this right, you agree that ICDVRAT will be given first publication credit, and proper copyright notice will be displayed on the work (both on the work as a whole and, where applicable, on the Article as well) whenever such publication occurs.

Rights of ICDVRAT: This agreement means that ICDVRAT will have the following exclusive rights among others: 1.) to license abstracts, quotations, extracts, reprints and/or translations of the work for publication; 2.) to license reprints of the Abstract to third persons for educational photocopying; 3.) to license others to create abstracts of the Abstract; 4.) to license secondary publishers to reproduce the Abstract in print, microform, or any computer readable form including electronic on-line databases. This includes licensing the Abstract for inclusion in an anthology from ICDVRAT 2022.

Warranties: You warrant that the Abstract has not been published before in any form, that you have made no license or other transfer to anyone with respect to your copyright in it, and that you are its sole author(s), and generally that you have the right to make the grants you make to ICDVRAT. Any exceptions are to be noted below. You also warrant that the Abstract does not libel anyone, invade anyone's privacy, infringe anyone's copyright, or otherwise violate any statutory or common law right of anyone. You agree to indemnify ICDVRAT against any claim or action alleging facts which, if true, constitute a breach of any of the foregoing warranties.

Concerning U.S. Government Employees: Some of the foregoing grants and warranties will not apply if the Abstract was written by U.S. Government employees acting within the scope of their employment. U.S. Government employees may reserve the right to reproduce the Abstract for U.S. Government purposes by making a request at the time of submission of the Abstract. If no copyright can be asserted in this work and it should be considered in the public domain, the ICDVRAT should be notified at the time of submission of the Abstract.

In Conclusion: This is the entire agreement between you and ICDVRAT and it may only be modified in writing. It will bind and benefit our respective successors in interest, including assignees, and our licenses, provided that you may not assign this agreement without our prior written consent. It will terminate if we do not publish your article in ICDVRAT 2022 book of abstracts.