Screening Mild Cognitive Impairment in Older Adults via Meaningful Play

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Abstract

With our rapid aging society, more and more people are suffering from dementia. This increase puts a great strain on the healthcare sector, as well in cost as manpower. This calls for research of reliable and regular assessments that can screen for Mild Cognitive Impairment (MCI), the precursor to dementia. We see that this call is answered with more and more cognitive screening games being developed. However, most of these games are based on existing tests, often lacking in adherence and enticing gameplay. This paper discusses the possibilities of meaningful play, and more specifically, Klondike Solitaire, as a cognitive screening test. We report on the results of an analysis of player actions in Solitaire with 3 health professionals that are experts in the domain of MCI. Results suggest that Klondike Solitaire can be used for such an assessment, and that this would be a valuable additional tool for longitudinal assessment.

Author Keywords

Cognitive Screening; Meaningful Play, Mild Cognitive Impairment; Elderly.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

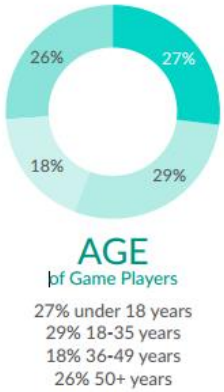

Figure 1. Percentage of gamers, according to The Entertainment Software Association

Introduction

The past year, 236 billion dollars was payed to cover the costs for healthcare, long-term care and hospice of dementia in America. This cost is projected to increase to one trillion dollars in 2050 [6]. In Europe, these costs are estimated at 200 billion euro in 2015 to 250 billion euro in 2030. Up to today, no medicinal treatment is available to prevent or stop Alzheimer's Disease, the most prevalent type of dementia [29]. There are medicinal treatments which slow the progression or improve symptoms, but these are often temporary and effectiveness varies from patient to patient [6,35,46]. However, early detection is beneficiary for the patient. Ensuring the best sources of support, timing of medicinal treatments, careful planning and informed decisions[29,30,37,38].

This is why in the last years, research has shifted towards detection of mild cognitive impairment (MCI). This precursor to dementia affects between 15% and 20% of persons 60 years and older [39]. Currently, a myriad of cognitive batteries exist to assess for cognitive impairments [12,13,20,21,24,33,44]. In addition, short screening tests exist, the most popular being the Mini Mental State Examination (MMSE) [40] and the Montreal Cognitive Assessment (MoCA) [36]. These tests are brief and easy to administer. However, outcomes are dependent on the current state of the patient. The feeling of examination, stress, dehydration or simply tiredness can influence these momentary measurements [2,3,9]. It is also known that these tests are vulnerable to practice effects [14,32,41] and sometimes administrator bias [25].

There are some games that can screen for cognitive impairments. Korn et al. [28] analyzed and compared CANTAB, Cogstate and Hamet, three computerized assessment tools, while presenting a gamified tool called GATRAS. Boletsis and McCallum [8] created Smartkuber, a serious game that screens cognitive health and compared its relationship with MoCA. Manera et al. [31] developed 'Kitchen and cooking', a serious game with the goal to assess and stimulate executive functions. MoCHA (Monitoring Cognitive Health using Apps)[23] is a collection of tablet games that monitor cognitive health for elders with a risk of developing Alzheimer's Disease. Lastly, Tong et al. [42] developed two games and provided proof that supports serious games as a valid cognitive tool.

However, evidence shows that these custom made games are not enjoyable for older adults. Wouters et al. [47] found that many of these serious learning games are not more motivating than conventional methods, contrary to expectations. This is also found with these games designed to assess and stimulate cognitive function. Bozoki et al.[10] found large variations in the amount of time devoted to game play, and a reluctance to pursue more challenging levels. Ballesteros et al. [7] found that long training schedules led to loss of motivation, and Toril et al.[43] note that what motivates older participants to practice the games in the later sessions is not the training per se, but the affective link established with the experimenter. Ackerman et al.[1] found that of the 78 participants, only 7 indicated they would continue playing Wii Big Brain Academy after the study was over, and 49 emphasized they would certainly not. Finally, despite the booming market, long-term adoption of brain training games by seniors has been limited [18,27].

Biography
Karsten Gielis is a PhD Student in Engineering Technology. Together with the geriatrics department of the university hospital in Leuven, he is exploring the possibilities of detecting mild cognitive impairment through tablet games. The goal is to make sure that people can play games that they like, in a familiar environment, while giving them the possibility to be monitored. Karsten studied Engineering Technology in the field of Electronics and ICT and is an Associate Android Developer, certified by Google.

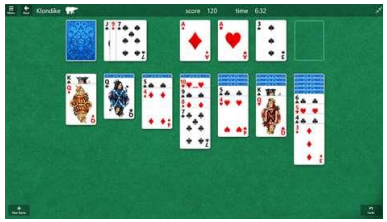

Figure 2. Microsoft Klondike Solitaire

The Silver-haired Gamer

This reluctance to play 'cognitive' games is striking, because research studies show that many older adults game. According to The Entertainment Software Association (Figure 1), as of 2016, 26% of gamers are 50+ years old. This segment is almost as big as the -18 years old and the 18-35 years old segment (respectively 27% and 29%) [22]. Pew Research Center, an independent American Fact Tank, stated that in 2008 in the USA, 40% of people between 50-64 and 23% of people above 65 play games. For Europe, the Interactive Software Federation of Europe reports for 2017 that the reach of gaming increased from 21% to 27% for people between 45 and 64 years old. In fact, older gamers play more hours per week than their mid-aged counterparts (6.2 hours compared to 7.5 hours) [26]. For Australia, the Interactive Games & Entertainment Association (IGEA), reports that 39% of elders aged 65-94 game [11]. Looking at these facts, we suggest that there may be a mismatch between the games that older adults enjoy playing and the types of games that are currently used for the measurement, screening and training of cognitive performance.

Meaningful Play

Therefore, we focus on measuring cognitive impairment through 'meaningful play'. With meaningful play, we point to those games that are already played often and perceived as enjoying and meaningful in and of itself. By using meaningful play as an assessment instrument, older adults can self-monitor without the extra effort of doing a tedious battery of tests.

According to Allaire et al. [4], De Schutter and Maliet [17], and Diez-Orueta et al.[19] meaningful play in elderly life falls into three categories: digital card games (e.g., Solitaire, Free cell), puzzle games (e.g., Crosswords, Sudoku's), and finally Wii games (e.g., Wii bowling, Wii tennis).

Characteristic of meaningful play is that games allow for connectedness [5,15]. This does not imply that these games allow for co-play, rather that the games are part of the social fabric of elderly life. They have been appropriated by older persons and are not part of the reductionist discourse that focuses on gameplay solely to measure decline. While seniors do not play these games for serious/medical purposes, these games may still be used to measure cognitive performance. Such games may equally demand attention, memory, visuospatial processing, reasoning, and executive skills. In addition, they are suitable for frequent and longitudinal monitoring within individuals as these games are played regularly. We hypothesize that *by using games that older adults perceive as inherently meaningful, screening of cognitive impairment will be more frequent and reliable*.

Using Klondike Solitaire to assess MCI

Today, Klondike Solitaire (Figure 2) is the most popular version of Solitaire [34] and particularly enjoyed by older adults [4,16], thus fitting the criteria of meaningful play. Hence, we aim to investigate whether Klondike Solitaire can be used to screen for MCI.

Therefore, first a thorough study of strategies for playing Solitaire was done and an analysis of game play actions was conducted by three researchers in the domain of HCI and neuropsychology. As a result of 22 player actions (e.g. User moves a card onto a card with the same color) were defined in a series of iterations conducted. Next, in collaboration with a

neuropsychologist, ten cognitive functions were specified which are also tested by cognitive screening tests. Next, these 22 player actions were scored for every cognitive function by three different health professionals in the domain of mild cognitive impairment (a geriatric professor and 2 neuropsychologist that screen patients who visit the memory clinic). Scoring could vary between 0 (not correlated), 1 (weakly), 2 (moderately), and 3 (strongly correlated to the cognitive function). For each player action, the interrater reliability was calculated.

Results of the scoring suggest that primarily Attention, Executive Function, Object Recognition, Abstraction, and Memory are used while playing Solitaire. These cognitive functions are also tested in traditional pen-and-paper cognitive screenings. Hence, these results support the hypothesis that Klondike Solitaire can be used to screen for mild cognitive impairment.

However, it was noted by the healthcare professionals that it would be difficult to determine which cognitive functions are impaired based purely on gameplay alone. Traditional tests are developed to focus on one cognitive function at a time, while player actions in Solitaire gameplay demand multiple cognitive functions simultaneously. Nevertheless, this was not considered a problem as the goal is to screen for cognitive impairments, not to assess cognitive functions.

The format of the tool was described by healthcare professionals as unique, containing advantages from screenings tests (being an indication, low effort, not time consuming for the caregiver) and advantages from test batteries (more thorough). Moreover, health professionals emphasized that the prolonged period of play would make the screening less prone to misleading results due to temporary ailments and effects of the location (hospital environment). In addition, it would allow for detecting cognitive fluctuation, a symptom of vascular and Lewy body dementia which causes temporary changes in cognition, attention, and arousal[45]. Lastly, practice effects would be less present as every Solitaire game is unique.

Discussion and Conclusion

We explored Meaningful Play, and in particular Klondike Solitaire, for the screening of MCI. We hypothesize that by using meaningful play instead of serious games, adherence will be better. Moreover, the natural environment in which this gameplay takes place, combined with the fact that this gameplay lends itself to longitudinal screening, this may lead to more accurate results. This can lead to unique possibilities of monitoring patients in a nearly effortless way.

Our first exploration of game play actions and the cognitive functions that are required to play Klondike Solitaire, suggest that this may be valid. However, we acknowledge that currently, only 3 health professionals were involved. We will repeat this analysis at a larger scale, with more health professionals. As a next step, we will investigate the use of data analytics and in particular machine learning techniques to capture and analyze player actions further. Ultimately, our goal is to design an additional tool for longitudinal screening of mild cognitive impairment. However, general questions arise as how reliable and specific longitudinal monitoring by means of meaningful play is, compared to tailored traditional tests. Questions we aim to answer in following research.

References

1. Phillip L. Ackerman, Ruth Kanfer, and Charles Calderwood. 2010. Use it or lose it? Wii brain exercise practice and reading for domain knowledge. *Psychology and Aging* 25, 4: 753–766.

2. Ana Adan. 2012. Cognitive performance and dehydration. *Journal of the American College of Nutrition* 31, 2: 71–78.

3. Paula Alhola and Päivi Polo-Kantola. 2007. Sleep deprivation: Impact on cognitive performance. *Neuropsychiatric Disease and Treatment* 3, 5: 553–567.

4. Jason C. Allaire, Anne Collins McLaughlin, Amanda Trujillo, Laura A. Whitlock, Landon LaPorte, and Maribeth Gandy. 2013. Successful aging through digital games: Socioemotional differences between older adult gamers and Non-gamers. *Computers in Human Behavior* 29, 4: 1302–1306.

5. Jason C. Allaire, Anne Collins McLaughlin, Amanda Trujillo, Laura A. Whitlock, Landon LaPorte, and Maribeth Gandy. 2013. Successful aging through digital games: Socioemotional differences between older adult gamers and Non-gamers. *Computers in Human Behavior* 29, 4: 1302–1306.

6. Alzheimer's Association. 2016. *2016 Alzheimer's Disease Facts and Figures*. .

7. Soledad Ballesteros, Antonio Prieto, Julia Mayas, et al. 2014. Brain training with non-action video games enhances aspects of cognition in older adults: a randomized controlled trial. *Frontiers in Aging Neuroscience* 6.

8. Costas Boletsis and Simon McCallum. 2016. Smartkuber: A Serious Game for Cognitive Health Screening of Elderly Players. *Games for Health Journal* 5, 4: 241–251.

9. Lyle E. Bourne Jr and Rita A. Yaroush. 2003. *Stress and cognition: A cognitive psychological perspective*. NASA/CR.

10. Andrea Bozoki, Mirjana Radovanovic, Brian Winn, Carrie Heeter, and James C. Anthony. 2013. Effects of a computer-based cognitive exercise program on age-related cognitive decline. *Archives of Gerontology and Geriatrics* 57, 1: 1–7.

11. Jeffrey Brand. 2016. *Digital Australia Report '16*. Bond University.

12. G.A. Carlesimo, C. Caltagirone, G. Gainotti, et al. 2008. The Mental Deterioration Battery: Normative Data, Diagnostic Reliability and Qualitative Analyses of Cognitive Impairment. *European Neurology* 36, 6: 378–384.

13. Kathy J. Christensen, Kristi S. Multhaup, Sherry Nordstrom, and Kathleen Voss. 1991. A cognitive battery for dementia: Development and measurement characteristics. *Psychological Assessment* 3, 2: 168–174.

14. Sarah A. Cooley, Jodi M. Heaps, Jacob D. Bolzenius, et al. 2015. Longitudinal Change in Performance on the Montreal Cognitive Assessment

in Older Adults. *The Clinical Neuropsychologist* 29, 6: 824–835.

15. B. De Schutter, J. A. Brown, and V. Vanden Abeele. 2014. The domestication of digital games in the lives of older adults. *New Media & Society*.

16. Bob De Schutter. 2011. Never Too Old to Play: The Appeal of Digital Games to an Older Audience. *Games and Culture* 6, 2: 155–170.

17. Bob De Schutter and Steven Malliet. 2014. The older player of digital games: A classification based on perceived need satisfaction. *Communications* 39, 1.

18. Unai Diaz-Orueta, David Facal, Henk Herman Nap, and Myrto-Maria Ranga. 2012. What Is the Key for Older People to Show Interest in Playing Digital Learning Games? Initial Qualitative Findings from the LEAGE Project on a Multicultural European Sample. *Games for Health Journal* 1, 2: 115–123.

19. Unai Diaz-Orueta, David Facal, Henk Herman Nap, and Myrto-Maria Ranga. 2012. What Is the Key for Older People to Show Interest in Playing Digital Learning Games? Initial Qualitative Findings from the LEAGE Project on a Multicultural European Sample. *Games for Health Journal* 1, 2: 115–123.

20. Tzvi Dwolatzky, Victor Whitehead, Glen M Doniger, et al. 2003. Validity of a novel computerized cognitive battery for mild cognitive impairment. *BMC Geriatrics* 3, 1.

21. Anikó Égerházi, Roland Berecz, Enikő Bartók, and István Degrell. 2007. Automated Neuropsychological Test Battery (CANTAB) in mild cognitive impairment and in Alzheimer's disease. *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 31, 3: 746–751.

22. Entertainment Software Association. 2016. *Essential facts about the computer and video game industry*. .

23. Ilya Farber, Karl C. Fua, Swati Gupta, and David Pautler. 2016. MoCHA: Designing Games to Monitor Cognitive Health in Elders at Risk for Alzheimer's Disease. ACM Press, 1–5.

24. Dustin Hammers, Elizabeth Spurgeon, Kelly Ryan, et al. 2011. Reliability of Repeated Cognitive Assessment of Dementia Using a Brief Computerized Battery. *American Journal of Alzheimer's Disease & Other Dementiasr* 26, 4: 326–333.

25. S. K. Inouye, C. H. van Dyck, C. A. Alessi, S. Balkin, A. P. Siegal, and R. I. Horwitz. 1990. Clarifying confusion: the confusion assessment method. A new method for detection of delirium. *Annals of Internal Medicine* 113, 12: 941–948.

26. Ipsos Connect. 2017. *The new faces of gaming*. .

27. Holly Jimison, Paul Gorman, Susan Woods, et al. 2008. *Barriers and Drivers of Health Information Technology Use for the Elderly, Chronically III, and Underserved*. Agency for Healthcare Research and Quality (US).

28. Oliver Korn, Leslie Tso, Christos Papagrigoriou, Yannic Sowoidnich, Robert Konrad, and Albrecht Schmidt. 2016. Computerized Assessment of the Skills of Impaired and Elderly Workers: A Tool Survey and Comparative Study. ACM Press, 1–8.

29. Christoph Laske, Hamid R. Sohrabi, Shaun M. Frost, et al. 2015. Innovative diagnostic tools for early detection of Alzheimer's disease. *Alzheimer's & Dementia* 11, 5: 561–578.

30. Bennett P. Leifer. 2003. Early Diagnosis of Alzheimer's Disease: Clinical and Economic Benefits. *Journal of the American Geriatrics Society* 51, 5s2: S281–S288.

31. Valeria Manera, Pierre-David Petit, Alexandre Derreumaux, et al. 2015. "Kitchen and cooking," a serious game for mild cognitive impairment and Alzheimer's disease: a pilot study. *Frontiers in Aging Neuroscience* 7.

32. Melissa Mathews, Erin Abner, Richard Kryscio, et al. 2014. Diagnostic accuracy and practice effects in the National Alzheimer's Coordinating Center Uniform Data Set neuropsychological battery. *Alzheimer's & Dementia* 10, 6: 675–683.

33. P. S. Mathuranath, P. J. Nestor, G. E. Berrios, W. Rakowicz, and J. R. Hodges. 2000. A brief cognitive test battery to differentiate Alzheimer's disease and frontotemporal dementia. *Neurology* 55, 11: 1613–1620.

34. Albert H. Morehead and Geoffrey Mott-Smith. 1983. *The Complete Book of Solitaire and Patience Games: The Most Comprehensive Book of Its Kind: Over 225 Games*. Bantam, New York.

35. Gohar Mushtaq, Nigel H. Greig, Jalaluddin A. Khan, and Mohammad A. Kamal. 2014. Status of acetylcholinesterase and butyrylcholinesterase in Alzheimer's disease and type 2 diabetes mellitus. *CNS & neurological disorders drug targets* 13, 8: 1432–1439.

36. Ziad S. Nasreddine, Natalie A. Phillips, ValÃ©rie BÃ©dirian, et al. 2005. The Montreal Cognitive Assessment, MoCA: A Brief Screening Tool For Mild Cognitive Impairment: MOCA: A BRIEF SCREENING TOOL FOR MCI. *Journal of the American Geriatrics Society* 53, 4: 695–699.

37. Peter J. Nestor, Philip Scheltens, and John R. Hodges. 2004. Advances in the early detection of Alzheimer's disease. *Nature Medicine* 10 Suppl: S34-41.

38. R. C. Petersen, R. Doody, A. Kurz, et al. 2001. Current concepts in mild cognitive impairment. *Archives of Neurology* 58, 12: 1985–1992.

39. Ronald C. Petersen. 2016. Mild Cognitive Impairment: *CONTINUUM: Lifelong Learning in Neurology* 22, 2, Dementia: 404–418.

40. Tom N. Tombaugh and Nancy J. McIntyre. 1992. The Mini-Mental State Examination: A Comprehensive Review. *Journal of the American Geriatrics Society* 40, 9: 922–935.

41. Tom N. Tombaugh and Nancy J. McIntyre. 1992. The Mini-Mental State Examination: A Comprehensive Review. *Journal of the American Geriatrics Society* 40, 9: 922–935.

42. Tiffany Tong, Victor Guana, Andrea Jovanovic, et al. 2015. Rapid Deployment and Evaluation of Mobile Serious Games: A Cognitive Assessment Case Study. *Procedia Computer Science* 69: 96–103.

43. Pilar Toril, José M. Reales, and Soledad Ballesteros. 2014. Video game training enhances cognition of older adults: a meta-analytic study. *Psychology and Aging* 29, 3: 706–716.

44. Teresa Torralva, María Roca, Ezequiel Gleichgerrcht, Tristán Bekinschtein, and Facundo Manes. 2009. A neuropsychological battery to detect specific executive and social cognitive impairments in early frontotemporal dementia. *Brain* 132, 5: 1299–1309.

45. M. P. Walker, G. A. Ayre, J. L. Cummings, et al. 2000. Quantifying fluctuation in dementia with Lewy bodies, Alzheimer's disease, and vascular dementia. *Neurology* 54, 8: 1616–1625.

46. Keith A. Wesnes, Dag Aarsland, Clive Ballard, and Elisabet Londos. 2015. Memantine improves attention and episodic memory in Parkinson's disease dementia and dementia with Lewy bodies: Memantine in Parkinson's dementia and dementia with Lewy bodies. *International Journal of Geriatric Psychiatry* 30, 1: 46–54.

47. Pieter Wouters, Christof van Nimwegen, Herre van Oostendorp, and Erik D. van der Spek. 2013. A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology* 105, 2: 249–265.