OBIE TRAINING THROUGH GAMING: COGNITIVE ENHANCEMENT AND DIGITAL TECHNOLOGIES

Elkhonon Goldberg, PhD, ABPP-CN

Prof. Elkhonon Goldberg is a cognitive neuroscientist and clinical neuropsychologist; Director, Luria Neuroscience Institute; Clinical Professor, Department of Neurology, NYU Grossman School of Medicine; and Diplomate, American Board of Professional Psychology in Clinical Neuropsychology. He is the author of *Creativity: The Human Brain in the Age of Innovation; The New Executive Brain: Frontal Lobes in a Complex World; and The Wisdom Paradox: How Your Mind Can Grow Stronger as Your Brain Grows Older*

Aging population 1950-2050. With increased societal wellbeing and constantly advancing medical care, people live longer. The combination of increased life expectancy and declining birth rates in developing country leads to an increasing size of the senior and geriatric population as a share of total population. Population aging has been a pervasive, incremental phenomenon of the modern times worldwide with only few exceptions. According to the United Nations predictions, the rate of population aging in the 21st century will exceed that of the 20th century. The number of people aged 60 or over has tripled since 1950, and may reach 2.1 billion by 2050 (1).

Aging population and COVID-19. In these days of global pandemic, the senior and geriatric population segments are particularly vulnerable. They are susceptible to infection with the virus, often suffer from the underlying conditions aggravating the course of illness, and the disease is likely to take especially dangerous, even lethal forms. Nursing home residents have been the group most severely affected by COVID-19 worldwide. Therefore, providing services to the seniors during the pandemic is fraught with unique and daunting challenges.

Actual solutions: Therapy and leisure time. In response to population aging, an extensive network of services and institutions has developed. These include nursing homes, assisted living facilities, senior day care centers, etc. Various therapies and activities are provided in such centers. Both group and individual activities are practiced. These may include individual physical, occupational, and speech therapies, as well as group activities to encourage socialization. However, the repertoire of such activities is often limited; they often fail to take full advantage of the state-of-the-art digital technologies; the therapists run out of tools and are at a loss how to engage the clients in a meaningful and impactful way. Similar issues arise with respect to the seniors' leisure time. All too often, they find themselves being bored and disengaged, which further contributes to their cognitive decline. The pandemic further complicates and exacerbates the problem. The seniors cannot be visited by their families, their mobility is further restricted, and the extra precautions against infection further limit the range of activities available to them. As a result, they have even more unaccounted time on their hands, with even fewer things to do.

OBIE TRAINING THROUGH GAMING: COGNITIVE ENHANCEMENT AND DIGITAL TECHNOLOGIES

Elkhonon Goldberg, PhD, ABPP-CN

Aging: Cognitive, physical and social decline. The issue of cognitive decline in the seniors, and how to forestall or at least to mitigate it, has been a growing concern for scientists, clinicians, and the general public. Aging, the "golden years" of life, comes at a prize, cognitive decline being part of it. This is not inevitable, and so-called "successful aging" is possible with only minimal or no cognitive decline. Nonetheless, in a large segment of aging population significant cognitive decline is present. In many cases it takes a clinically significant form of dementia; but it may be present even as part of normal aging.

Digital technologies are increasingly used to combat the cognitive decline of aging, and the challenge is to find the optimal, most effective ways of using these technologies. All too often the issues of cognitive, physical, and social wellbeing in the senior population are addressed piecemeal, via fragmented, poorly integrated therapies. However, in order to be truly successful, therapies should be multimodal, with close integration of cognitive, physical, and social stimulation.

Obie: New generation of enhancement tools for the aging. This is precisely what makes Obie different and sets it apart from other tools available to therapists in institutions for the aging. Obie is a suite of attractively designed games, targeting a wide range of cognitive functions. While other cognitive games are played on computer or tablet screens, Obie's games are projected on a large physical area. As a result, by its very design, Obie enables physical action and social interaction as part of cognitive activities. It permits, and in fact encourages, close integration of the three essential components – cognitive, physical, and social, - within one activity. No other cognitive enhancement system makes such integration possible. Having been an active contributor to the field of cognitive enhancement for the seniors, I was so impressed with Obie's potential that I decided to join forces with the Obie team in creating the new generation of cognitive enhancement tools for the aging. By merging the existing Obie team's expertise in creative game design and digital technology with my expertise in cognitive neuroscience and neuropsychology, we are well positioned to create the next generation of tools for cognitive enhancement and stimulating leisure time. We will improve and expand Obie's existing repertoire of games, design data bases and analytics to track and analyze participants' performance, and devise training algorithms optimal for the seniors in a culturally localized and personalized way.

Context: Games as a tool for cognitive enhancement. To fully appreciate Obie's unique place and potential in the cognitive enhancement space for the ageing, it is helpful to briefly review the general state of the field and the issues that arise within it. The use of specially designed games as a tool of cognitive enhancement has been gaining increasing popularity over the last few decades. The trend has been driven by a confluence of several factors: modern society becoming increasingly knowledge and information driven, where (unlike even a few generations ago) brain power is more important than brawn power, hence the imperative to protect and enhance it; growing societal awareness of, and concern about, dementias, such as Alzheimer's disease, Lewy body disease, and others; advent and ubiquity of digital technologies, which drastically increased the ability to deliver diverse content in flexible and dynamic ways not possible with paper and pencil; as well as the growing embrace and validation of the concept of activity-driven neuroplasticity, which posits that vigorous and structured

cognitive activity may change the neural substrates engaged, and by so doing improve its function and, to a degree, protect it from decay caused by neurological illness or even by aging. Of course, neuroplasticity may involve multiple processes, such as synaptogenesis, angiogenesis, neurogenesis, modification of neurotransmission, and it is often difficult to determine which of these multiple factors, or a combination thereof, are responsible for the observed effects of cognitive enhancement.

Several broad applications of cognitive enhancement through gaming have emerged: (a) specialized professional education and training, e.g. in the medical field or in the military; (b) general cognitive enhancement, e.g. in the aging population with the go al of warding off aging-associated cognitive decline; and (c) as a form of rehabilitation of cognitive impairment caused by neurological, neuropsychiatric, neurogeriatric, or neurodevelopmental disorders. Regardless of the specific application, it is important to ensure that cognitive game design is driven by the state-of-the art knowledge of neuroscience and neuropsychology. A comprehensive review of the state of the cognitive enhancement field can be found in The SharpBrains Guide to Brain Fitness by A. Fernandez and E. Goldberg (2).

Several companies emerged as the leaders in the field of cognitive enhancement in aging. These include BrainHQ, Lumosity and BrainWell, among others. Cognitive games offered by these and other companies are designed by teams which included neuroscientists, and they target a range of cognitive domains. They also incorporate complex algorithms, which design personalized training regimens based on the player's goals and performance. Performance analytics are also built in, collecting and processing data along multiple parameters. The games can be played on personal computers, tablets, and mobile devices. Some providers, like BrainWell, enable smooth transition between laptops and mobile devices.

Cognitive training: Games impacting real life performance. While cognitive gaming approach is being increasingly embraced, several concerns persist. Foremost among them is the concern about the generalizability of training effects. For the most part, the games themselves usually have no intrinsic value. They are valuable only insofar as they improve cognition in real-life situations and challenges. It is not enough to demonstrate that the participant's performance improves on the cognitive game itself, it is important to demonstrate that the improvement occurs also in real life, or at least on independent measures with a known high correlation with real-life performance (e.g. mainstream neuropsychological tests). In that context, the distinction is often made between "near transfer" (generalization effect to situations which closely resemble the game) and "far transfer" (performance improvement on a wide range of cognitive tasks different from the game itself). Obviously, the broader the transfer, the more valuable the training effect.

Cognitive training in aging population. For a long time the dominant assumption had been that even when the participant's performance improves on the cognitive games, no or very little meaningful generalization takes place. This assumption was proven incorrect. Today, a large and growing body of evidence exists that generalization can take place, both in normal aging (3) and in a wide range of clinical populations (4, 5). Furthermore, not only "near" but also "far" transfer was observed both in young and in senior populations (6). Various cognitive functions could be improved in the aged population through cognitive training, including memory (7) and executive functions (8). Furthermore, the beneficial effect of cognitive training on cognition can be long-lasting, the effect measured in years (9, 10). What's even more impressive, cognitive training can improve fluid intelligence (11).

Cognitive training in clinical populations. As pointed out earlier, therapeutic effects of cognitive training have also been demonstrated in various clinical populations, such as Alzheimer's disease (4), mild neurocognitive impairment (12), traumatic brain injury (13), and schizophrenia (14). These findings imply that cognitive training can be beneficial for a wide range of neurological and psychiatric disorders.

Cognitive exercise can have generalized effect. However, even failure to demonstrate the generalization of cognitive training does not always mean that it didn't take place. Such a "false negative," failure to detect generalization when it actually took place, may be a result of an overly narrowly or incorrectly phrased research question. Indeed, presence or absence of generalization is usually assessed by measuring the participants' performance on independent cognitive tasks or tests. The number of such independent measures in any given research study is typically very small, and is often limited to one. Overly narrow or incorrectly chosen independent measures can very easily miss a real generalization effect.

Cognitive exercise can actually change the brain. Furthermore, evidence exists that targeted cognitive exercises can actually change the underlying neural substrate, both structurally, biochemically, and physiologically. This may be manifested in the increase of both grey and white matter volume in the brain regions engaged in targeted cognitive activities (15), in the increase in baseline neurotransmitter levels (16), and in the increase of baseline levels of physiological activity, like glucose metabolism level in the brain (17). Furthermore, similar effects were demonstrated in clinical populations, e.g. in Parkinson's disease (18).

Such evidence is of crucial importance, since the brain is for the most part a general-purpose machine, rather than a collection of narrowly dedicated modules. While narrow modularity is present in phylogenetically old brain structures, e.g. the thalamus, and to a degree even in primary sensory and motor cortices, association cortex critical for most complex cognition, is devoid of such narrow functional compartmentalization as is indeed a general-purpose neural net, potentially capable of supporting an open-ended range of cognitive skills. Therefore, any structural, physiological, or biochemical changes at this level of neural organization must by necessity translate into broad functional changes, rather than narrow ones.

The challenge: Creating practical effect while maintaining game attractiveness. Another concern is often voiced with respect to the games' attractiveness, level of interest and aesthetic appeal that they may engender in a player. All too often, in their pursuit of scientific rigor, designers forget that in order for the cognitive games to have an effect, they have to be played; and in order to be played, they have to be attractive. A game that is not played cannot have an effect; and a boring game is not going to be played for very long. If members of the target audience, whether these are patients recovering from the effects of traumatic brain injury, aging individuals diagnosed with early dementia, or cognitively intact ones anxious to ward off age-related cognitive decline, find the games boring or unattractive, they will simply stop playing them. Therefore, a balance between a sound scientific foundation and the game's aesthetics and entertainment value must be carefully maintained in its design. Based on my own observations and my patients' feedback, some of the most rigorously designed and scientifically vetted cognitive games are also most notoriously boring, and after a while the participants simply stop playing them. In this regard, Obie stands out by the appealing visual and auditory aesthetics of its games.

Physical mobility and social engagement are also important. Yet another factor worthy of consideration, is that cognition is not the only area in need of support and enhancement in the aging individuals and in diverse clinical populations alike. Physical engagement and mobility and social engagement are equally important. In fact, evidence exists that both physical activities and social engagement are among the most important factors in conferring a protective effect on cognition in the aging population (19). This was demonstrated in the famous MacArthur Studies of Successful Aging and in a number of other influential studies (20, 21).

Combining the critical factors in game design for the seniors. To be maximally therapeutically effective, a suite of games must combine several features. It has to be (a) cognitively challenging and target a wide range of cognitive functions; (b) aesthetically attractive and interesting to ensure the participants' ongoing engagement; (c) include a physical mobility component; (d) enable and encourage social interaction.

Most available cognitive enhancement games fail to meet all four requirements. They are usually designed with significant neuroscientific input, but are often lacking in their aesthetics and captivating quality. The physical component is usually altogether absent, since the games are played while sitting in a static position in front of a computer terminal. The social component is also lacking, since the games are not designed for group participation and are played by each participant in a solitary fashion.

Obie: The next generation of therapy and leisure time for the seniors. Against this background, Obie games stand out in several respects.

- With their combination of visual and acoustic aesthetics, they are **attractive and engaging.**
- The physical field of play is not limited to a computer or mobile device screen, but involves a large surface **permitting physical immersion and motion.**
- Both by design and by virtue of the physical projection size, the games permit, and in some cases actually encourage, the **participation of several individuals playing together.**
- The size of Obie games projections is a unique and critical factor. You cannot step into a computer game delivered on a laptop, tablet, or mobile device. But you can literally step into an Obie game, either by yourself or with other players, bringing the level of immersion and physicality to a whole different level. Thus, **a unique combination of cognitive, physical, and social engagement is achieved on the Obie platform.**
- Furthermore, because Obie technology is based on the projection of light, contact with device shared by many people is limited, which **significantly decreases the risk of infection.**
- The **technology** is very well **advanced** and extremely **user-friendly.**

To conclude, Obie is unlike any other cognitive gaming platform. The experience it offers is somewhere between advanced computer games and virtual reality. It draws the player into a physical environment, which is perceptually rich, cognitively challenging, physically and socially inviting, and safe. Obie offers a uniquely promising tool of cognitive enhancement both in healthy seniors determined to protect themselves from cognitive decline; in the seniors suffering from various degrees of cognitive decline; and in a wide range of clinical conditions.

References

1. World Population Ageing: 1950-2050, United Nations Population Division.
2. A. Fernandez and E. Goldberg (2013). *The SharpBrains Guide to Brain Fitness,* 2nd edition. SharpBrains
3. J. Anguera et al (2013). Video game training enhances cognitive control in older adults. *Nature, 501*(7465), 97-101.
4. JW Williams et al (2010) Preventing Alzheimer's disease and cognitive decline. NIH Evidence Report. AHRQ publication.
5. E. Goldberg (2015). Computerized brain training – What's the evidence? Invited address at the 13th Annual Conference of the American Academy of Clinical Neuropsychology, San Francisco, CA
6. Y. Bremer et al (2012) Working-memory training in younger and older adults. *Frontiers in Human Neuroscience,* 6.
7. H.W. Mahnke (2006). Memory enhancement in healthy older adults using a brain plasticity-based training proram. *PNAS* 103(33), 12523-12528.
8. R. Nouchi et al (2006). Brain-training game improves executive functions and processing speed in the elderly. *PLoS One* 7(1).
9. K. Ball et al (2002). Effects of cognitive training interventions with older adults. *JAMA*, 288(18), 2271-2281.
10. S.L. Willis et al (2006). Long-term effects of cognitive training on everyday functional outcomes in older adults. *JAMA*, 298(23), 2805-2814.
11. S.M. Jaeggi (2008) Improving fluid intelligence with training on working memory. *PNAS* 105(19): 629-6833.
12. M. Finn and S. McDonald (2011). Computerized cognitive training for older persons with MCI. *Brain Impairment,* 12(3), 187-199.
13. A. Lundqvist (2012) Computerized training of working memory in a group of patients suffering from acquired traumatic brain injury, *OJTR*, 26 (4-5), 423-424.
14. S.R. Gurk et al (2007). A meta-analysis of cognitive remediation in schizophrenia. *American Journal of Psychiatry,* 164(12), 1791-1802.
15. B. Draganski et al (2004). Neuroplasticity: changes in grey matter induced by training. *Nature, 427*: 311-312.
16. F. McNab et al (2009) Changes in cortical dopamine D1 receptor binding associated with cognitive training. *Science* (5915):800-2.
17. W.D. Heiss et al (1994) Long-term effects of phosphatidylserine, pyritinol, and cognitive training in Alzheimer's disease: a neurosychological, EEG, and PET investigation. *Dementia*. 5: 88-98.
18. B. Sehm et al (2014) Structural brain plasticity in Parkinson's disease induced by balance training. *Neurobiology of Aging,* 35(1): 323-9.

19. L. Fratiglioni et al (2004) An active and socially integrated lifestyle in late life might protect against dementia. *Lancet Neurology,* 3: 343-353.

20. Seeman TE, Lusignolo TM, Albert M, Berkman L .(2001) Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. Health *Psychology* 2001; 20: 243–55.

21. Yaffe K, Barnes D, Nevitt M, Lui LY, Covinsky K.(2001). A prospective study of physical activity and cognitive decline in elderly women: women who walk. Arch Intern Med 2001; 161: 1703–08.