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New Technologies in Assessment and Neuropsychological Rehabilitation

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Abstract

There is increasing use of technological innovations in assessment and neuropsychological rehabilitation in research and clinical practice. Thus, the purpose of this narrative review is to present what and how new technologies has been historically embedded in clinical and experimental neuropsychology, with a demonstrated academic production increased in the last 10 years. The literature presents that neuropsychological assessment highlights the use of computerized versions of instruments which traditionally are used in pencil and paper; cognitive simulations, artificial intelligence, and problem solving tasks. However, computerized tests are the most established technologies in this field. Further, a considerable part of the studies are performed in adults and elderly people, but few validations in children. In rehabilitation, the use of new technologies is more diversified, such as electronic devices and cell phones, tablet computers, video games, virtual reality, robots, and videofeedback neurofeedback, transcranial direct current stimulation, among others. In neuropsychological rehabilitation, the new technologies have facilitated the development of compensatory strategies and real-world simulations. From this review we discuss the new possibilities of technological interfaces in neuropsychology, as well the need for development and validation of computerized batteries and more dynamic and versatile rehabilitation protocols.

Keywords: Neuropsychological assessment, neuropsychological rehabilitation; technologies.

Novas Tecnologias na Avaliação e Reabilitação Neuropsicológica

Resumo

Nas últimas décadas, observa-se um crescente uso de inovações tecnológicas na avaliação e reabilitação neuropsicológica em pesquisas e na prática clínica. Sendo assim, o objetivo da presente revisão narrativa é apresentar quais são e como as novas tecnologias vem sendo inseridas historicamente na neuropsicologia clínica e experimental, com um aumento da produção acadêmica evidenciada nos últimos 10 anos. A literatura evidencia que a avaliação neuropsicológica destaca o uso de versões computadorizadas de instrumentos, que tradicionalmente utilizavam o lápis e papel; simulações cognitivas; inteligência artificial; e tarefas de resolução de problemas. Contudo, a que se mostra mais consolidada é o uso de baterias de testes computadorizados. Além disso, uma parte considerável de estudos é feito com adultos e idosos,

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sendo as validações para crianças mais escassas. Na reabilitação, o uso de inovações tecnológicas se mostra mais diversificado, tais como a utilização de dispositivos eletrônicos e celulares, computadores e *tablets*, videogames, realidade virtual, robôs, video*feedback* e neuro*feedback*, estimulação transcraniana por corrente contínua e direta, entre outros. Na reabilitação neuropsicológica, as novas tecnologias têm facilitado o desenvolvimento de estratégias compensatórias e simulações de situações do cotidiano. A partir desta revisão discute-se sobre as novas possibilidades das interfaces tecnológicas na neuropsicologia bem como a necessidade do desenvolvimento e validação de baterias computadorizadas e protocolos de reabilitação mais dinâmicos e versáteis.

Palavras-chave: Avaliação neuropsicológica, reabilitação neuropsicológica, tecnologias.

Las Nuevas Tecnologías en la Rehabilitación Neuropsicológica y Evaluación

Resumen

En las últimas décadas, hay un uso creciente de las innovaciones tecnológicas en la evaluación y rehabilitación neuropsicológica en la práctica clínica y la investigación. Por lo tanto, el propósito de esta revisión narrativa es presentar qué y cómo las nuevas tecnologías se han incorporado históricamente en neuropsicología clínica y experimental, con una producción académica demostrada aumentado en los ultimos 10 años. La literatura muestra que o más consolidado es el uso de baterías de pruebas computarizadas. Además, una parte considerable de los estudios se realizan con los adultos y ancianos, y con los ninos una validacion escasa. En la rehabilitación, la utilización de innovaciones tecnológicas se muestra más diversificada. Los estudios apuntan a utilizar: los dispositivos electrónicos y teléfonos celulares, y computadoras *tablet*, videojuegos, realidad virtual, robots y neuro*feedback* video*feedback*, estimulación transcraneal de corriente continua y directa, entre otros. En la rehabilitación neuropsicológica, las nuevas tecnologías han facilitado el desarrollo de estrategias de compensación, simulaciones de situaciones reales. De esta revisión se discute que otros estudios deben llevarse a cabo para el desarrollo y validación de constructo de las baterías computarizadas y protocolos de rehabilitación que utilizan las nuevas tecnologías de tratamiento de la información y la comunicación

Palabras clave: Evaluación neuropsicológica, rehabilitación neuropsicológica, las tecnologias.

Function-related changes in cognition pertain to many neurological, psychiatric disorders and medical conditions (Capovilla, 2006), such as Autism (Billard, Robins, Nadel, & Dautenhahn, 2007), Attention Deficit Hyperactivity Disorder (ADHD; Coutinho, Mattos, Araújo, & Duchesne, 2007), Schizophrenia (Ritsner, Blumenkrantz, Dubinsky, & Dwolatzky, 2006), Dementia (Hammers et al., 2012) and Hashimoto's Encephalopathy (Brooks & Barlow, 2011). These changes can be seen through cognition-based assessment protocols. By defining a cognitive profile, it is possible to make and create diagnostic assumptions that will lead to the indication of therapies (Lezak, 1995; Weintraub, 2000). One of these interventions is a rehabilitation program, aiming at the recovery of the impaired functions or their compensation (Fuentes, Malloy-Diniz, Camargo, & Consenza, 2007; Rufo-Campos, 2006).

In terms of assessment and neuropsychological rehabilitation, traditionally, paper and pencil tasks and batteries are used in cognitive evaluation. However, in the last decades, protocols involving new technologies both in researches and clinical practices have emerged (Gonzalez et al., 2003; Horesh, 2001). These new technologies use computers, internet, smartphones, tablets, videogames and virtual reality.

According to Soto-Pérez, Martín, Angel, and Jiménez Gómez (2010), historically, cognitive neuropsychology is a branch of psychology that has always been influenced by cognitive sciences and by the information processing theories, artificial intelligence and, most recently, neural networks. These computer models stand out in the beginning of cognitive neuropsychology, where technological advances led to its main scientific findings.

The purpose of this literature review is to show which are and how technological innovations are being historically inserted into clinical and experimental neuropsychology. Review papers, development studies and clinical validation of the introduction of these new technologies into the context of assessment and neuropsychological rehabilitation will be presented.

Methodology

The paper is a historical and narrative review of the literature regarding innovation and technology in clinical neuropsychology. As search strategy, the issue was investigated in the following literature from the past 10 years: "PubMed", PsycInfo" and "Scielo". In addition, we have added to the search classic authors and studies pertaining to the validation of instruments that were used as basis for current tools. Following the selection of papers, two themes were defined: (a) assessment and (b) rehabilitation. The main technological innovations of neuropsychology were mentioned and described in these categories.

Neuropsychological Assessment and the Use of New Technologies

Literature shows how neuropsychological assessment strives to follow technological advances (Joly, Martins, Abreu, Souza, & Cozza, 2004). Joly et al. (2004) point out: the use of computer versions of tools that, traditionally, used pencil and paper; cognitive simulation; artificial intelligence; and problem-solving tasks. Recently, other studies shows: (a) the internet and videoconferencing as possibilities in the neuropsychological assessment process (Bernardo-Ramos, Franco-Martíns, & Soto-Pérez, 2012); (b) interactive voice response systems, with phone and computer cognition tests (D. I. Miller, Talbot, Gagnon, & Messier, 2013); (c) as well as virtual reality, such as Virtual Reality Lateralized Attention Test –VRLAT (Buxbaum, Dawson, & Linsley, 2012), used to assess hemispatial neglect through virtually simulated real life situations based on attention demands.

Computer test batteries stand out and are largely consolidated in literature. Many advantages and some limitations are specifically found in regards to the use of these tests. Some of the advantages are:

1. Computer tests help standardizing the specifications for stimuli presentation and the gathering of responses, leading to a more severe control of the assessment conditions, which leads to greater psychometric reliability (Capovilla, 2006; Conklin et al., 2013; Ritsner et al., 2006; P. Schatz & Browndyke, 2002);
2. Another advantage refers to the size of the sample; authors such as Hervey, Greenfield and Gualtieri (2012) refers to the efficacy of computer test batteries and claim tradition tests (interview-related pencil and paper) hinder large-scale studies;
3. Quick and easy recording of latencies and response types (Askar et al., 2012; Brooks & Sherman, 2012);
4. They enable the development of many forms of the same test; they reduce financial costs such as paper-related costs (Charchat-Fichman, Nitrini, Caramelli, & Sameshima, 2000);
5. They reduce the examiner's subjectivity effects and enable automatic performance correction (Cernich, Brennana, Barker, & Bleiberg, 2007; Charchat, Nitrini, Caramelli, & Sameshima, 2001; Ritsner et al., 2006; P. Schatz & Browndyke, 2002; Woo, 2008);
6. Greater accuracy in finding cognitive changes (Mattos, 1998; Wild, Howieson, Webbe, Seelye, & Kaye, 2008). Specific and complex variants, such as reaction time (RT) in milliseconds stand out among these measures. According to Charchat et al. (2001), RT allows more accurate and detailed assessment of cognition, and it helps avoiding the learning effect, which allows reusing the

test and better monitoring of any eventual changes. This way, computer tests would more accurately supply response time and processing speed measures (Coppel, 2011).

The following stand out among disadvantages: (a) poorly designed interaction interfaces; (b) decreased face to face interaction between the physician and the patient; (c) practical and technical limitations, such as: because it is automatic, the examiner cannot interrupt or stop the test; (d) the use of the mouse, the keyboard or touch screen systems for the participants' responses limits the participation of disabled people or with motor deficits; (e) most tests depend on sight, because the questions are presented on the computer screen, while many traditional tests can take place orally. For instance, by reading a list of words so that the patient can recall them later (Elwood, 2001; P. Schatz & Browndyke, 2002).

Despite limitations, the advantages presented are quite significant. With these advantages, technology plays a more important role in the cognition, leading to early diagnosis and follow-up of the clinical evolution of many diseases (Charchat et al., 2001; Woo, 2008). In this sense, having adequate neuropsychological assessment tools is essential.

Computer-Based Tests: Populations and Cognitive Functions Assessed

Given the advantages and limitations of computer-based tests, these tests must be designed taking into account the inherent individual differences of the different target populations (P. Schatz & Browndyke, 2002). A great deal of validations and studies regarding computer-based tests and batteries have involved adults and elderly and children-related validations are rare (Rohlman et al., 2008).

Batteries found for children emphasize attention tasks, such as response time and ongoing performance. Ongoing performance is assessed through omission errors (when the target stimulus is not found), persistence (in the case of impulsive response) and improper stimulus (when non-target stimulus is found). One of the most widely accepted tools to assess the attention behavior and ADHD diagnosis is the Continuous Performance Test (CPT; Bloch et al., 2012). It measures sustained and selective attention and impulsivity (Conners, 2002). Continuous performance tests can take place in many ways. In children, a very common test is The Test of Variables of Attention – TOVA (Bloch et al., 2012; Dupuy & Greenberg, 1993). This model can also be used through more specific tasks, as shown by a 2012 study (Lufi & Fichman, 2012). The authors built mathematic computer tasks with visual stimuli, referred to as Mathematics Continuous Performance Test (MATH-CPT). A. M. Schatz, Ballantyne, and Trauner (2001) points out this test model would be greatly useful and adequate to assess ADHD patients.

In Brazil, the main computer test validated for the assessment of children and teenagers is Tavis-III (Duchesne & Mattos, 1997). This test battery assesses concentration, selective and alternant attention in three tasks. Coutinho et al. (2007) used Tavis-III to assess children and teenagers with and without ADHD. The authors worked with 102 participants diagnosed with ADHD, who were compared against 678 people from the control group. Analyses also showed the high specificity and sensibility of the test towards ADHD-diagnosed patients.

Recently, other studies involving children are directed at issues other than the Attention deficit hyperactivity disorder diagnoses. Brooks and Sherman (2012) present research data with patients sent to a neurology outpatient clinic with many different diagnoses, such as epilepsy and head injury, using the CNS VITAL SIGNS test battery. Another paper reports a case study with a 14-year old where cognitive monitoring and initial assessment take place with the same computer-based test battery (CNS VITAL SIGNS) for a Hashimoto's encephalopathy case (an autoimmune disease; Brooks & Barlow, 2011). The significance of computer-based testing can also be seen in teenagers with brain tumors in face of the secondary cognitive impact. Conklin and others (2013) use Impact, a computer-based battery that tests attention, memory and processing speed. Still in this context, CANTAB studies, firstly designed for the elderly (Sahakian & Owen, 1992), have shown their potential to assess executive functions in children (Fried, Hirshfeld-Becker, Petty, Batchelder, & Biederman, 2012; Luciana, 2003).

As for the elderly, computer-based tests have been designed and used to assess cognitive impairment and the effect of medications (Caramelli et al., 2004; Charchat et al., 2001; Powell, Kaplan, Whitla, Catlin, & Funkenstein, 1993; Tornatore, Hill, Laboff, & McGann, 2005).

Wild and others (2008) identified 11 computer-based test batteries to assess the elderly, including MCI and dementia, such as: Microcog (Powell et al., 1993); MCI Screen, CANS-MCI (Tornatore et al., 2005); a Cognitive Stability Index – CSI (Erlanger et al., 2002) variance to screen and monitor changes; CNTB (Computerized Neuropsychological Test Battery); Mindstreans (Dwolatzky et al., 2003); the CNSVS battery, CNS Vital Signs (Gualtieri & Johnson, 2006); CogState; COGDRAS (Cognitive Drug Research Computerized Assessment System; Simpson, Surmon, Wesnes, & Wilcock, 1991), which has not been specifically designed to be used with the elderly, but is being adjusted to be used with patients suffering from dementia, as well as the ANAM (Automated Neuropsychological Assessment Metrics; Reeves, Winter, Bleiberg, & Kane, 2007).

Most of these tests surveyed by Wild and others (2008) are still being used, and its use has been increasing among many populations, such as, for instance, Cogstate (Hammers et al., 2012), used to screen dementia and mild cognitive impairment; and ANAM. The reliability of ANAM with patients with Parkinson has been recently validated (Hawkins et al., 2012), with varying statistical reliability in sub-tests to assess that population, yet effective. In Brazil, CompCog, designed by the cognitive neurology and behavior at University of São Paulo (USP), is highly sensitive and specific for the early diagnosis of Alzheimer's (Charchat et al., 2001).

In adults, the main evidences found in literature are clinical validations of the computer-based tests for psychiatric disorders and HIV-related cognitive declined. Test batteries such as Mindstream (Ritsner et al., 2006) and IntegNeuro (Williams et al., 2008) are sensitive and are used to find cognitive deficits in patients suffering from schizophrenia. Tests such as the Groton Maze Learning Test – GLMT (Pietrzak et al., 2008), CalCAP (Gonzalez et al., 2003), CogState (Overton et al., 2011) and Microcog (Fama, Rosenbloom, Nichols, Pfefferbaum, & Sullivan, 2009) are effective in HIV-related studies.

Ritsner et al. (2006) noticed that patients suffering from schizophrenia performed worse than the healthy control group in the Mindstream. Williams and others (2008) show the efficacy of IntegNeuro in the first episode of schizophrenia. Studies with HIV positive patients also take place through response time battery tests, such as CalCAP (Gonzalez et al., 2003). In this study, mild specificity (77%) and sensitiveness (68%) were found to assess cognitive impairment in HIV patients compared to traditional tests. But studies with battery tests such as CogState (Overton et al., 2011) and Microcog (Fama et al., 2009) are also found.

Figure 1 shows the description of the tests, computerization of paper and pencil in tests most commonly found across literature and mentioned in this section, representing tests used in aging pathologies and psychiatric disorders in children, teenagers or adults

Neuropsychological Rehabilitation and New Technologies

Neuropsychological rehabilitation is a broad, interactive and two-way approach where the patient is an active agent in this process. The physical, psychological, social and professional well-being of the patient is the aim of the joint work of team professionals, family, society members and the patient at issue (McLellan, 1991). According to the World Health Organization (WHO, 1980), rehabilitation is aimed at reducing the impact of disability and disabling conditions, thus enabling disabled people to ideally take part in the society. For Wilson (1996), neuropsychological rehabilitation enables treat-

<table>
<tr><td>ANAM (Reeves et al., 2007)</td><td colspan="3">Battery used to assess the accuracy and attention speed, memory and thought.</td></tr>
<tr><td>BTNC (Charchat, 1999)
and CompCog
(Charchat et al., 2001)</td><td colspan="3">Six neuropsychological tests have been designed to assess primary memory, short-term memory, response time and implicit learning. The tests involve simple response time tests, choice response time, implicit learning, short-term word learning, short-term picture learning and short-term face learning.
A brief battery referred to as CompCog was designed for the early diagnosis of Alzheimer’s, including response time and remembering faces as cognitive markers.</td></tr>
<tr><td>CANTAB
(Fray, Robbins, & Sahakian, 1996; Wild et al., 2008)</td><td colspan="3">The battery includes: work memory and executive functions; visual and spatial memory, attention and response time; verbal memory and decision-making processes. These are assessed through 13 tests. It was firstly designed to diagnose dementia.</td></tr>
<tr><td>CNS Vital Signs
(Gualtieri & Johnson, 2006; Wild et al., 2008)</td><td colspan="3">This test includes seven tests involving: memory, psychomotor speed, response time, cognitive flexibility and complex attention.</td></tr>
<tr><td>CNTB
(Cutler et al., 1993;
Wild et al., 2008)</td><td colspan="3">This battery is comprised of 11 subtests that assess motor speed, information processing, attention, verbal and spatial memory, language and spatial skills. The Computerized Neuropsychological Test Battery (CNTB) is one of the first attempts to test cognitive functions in a computer.</td></tr>
<tr><td>Continuous Performance Test
(Conners, 2002)</td><td>It assesses sustained and selective attention and impulsivity.</td><td>Example 1: The Test of Variables of Attention – TOVA (Dupuy & Greenberg, 1993)</td><td>Example 2: Mathematics Continuous Performance Test - MATH-CPT (Lufi & Fichman, 2012)</td></tr>
<tr><td>COGDRAS-D (Simpson et al.,_
1991, Wild et al., 2008)</td><td colspan="3">Battery designed to assess positive and negative effects of drugs over cognition. Adjusted to be used with dementia. The battery includes eight subtests.</td></tr>
<tr><td>CogState (Hammers et al., 2012; Wild et al, 2008)</td><td colspan="3">Subtests include simple, choice and complex response time, continuous monitoring, work memory, relationships, incidental and associative learning.</td></tr>
<tr><td>Cognitive Stability Index -CSI (Erlanger et al., 2002; Wild et al., 2008)</td><td colspan="3">It includes four components (memory, attention, response speed and processing speed) based on 10 subtests. Authors suggest the Cognitive Stability Index (CSI) to screen and monitor changes.</td></tr>
<tr><td>MCIS (Wild et al., 2008)</td><td colspan="3">Computer-based version of the CERAD word list task.</td></tr>
<tr><td>MicroCog
(Powell et al., 1993)</td><td colspan="3">One of the first commercially developed computer-based batteries to detect early signs of cognitive impairment. It assesses memory, attention, response time, skills, visual and spatial thinking and calculation skills.</td></tr>
<tr><td>Mindstreams
(Ritsner et al., 2006;
Wild et al., 2008)</td><td colspan="3">Designed to detect MCI. This battery is comprised of 9 subtests: verbal memory, non-verbal memory, response inhibition, Stroop interference, problem solving, visual and spatial images, verbal rhymes, naming, processing speed and visual and motor planning. Many of these tests are paper and pencil adaptations.</td></tr>
<tr><td>CalCAP (E. N. Miller, 1996; E. N. Miller, Satz, & Visscher, 1991)</td><td colspan="3">Response time per choice – Digits and sequential response Time.</td></tr>
<tr><td>Groton Maze Learning
Test -GLMT
(Pietrzak et al., 2008)</td><td colspan="3">Groton Maze Learning Test (GMLT) is a recent computer-based neuropsychological measure that assesses short-term, primary memory and visual and spatial information. It is also sensitive to finding errors and persistence and delay in the processing of information in healthy adults.</td></tr>
<tr><td>IntegNeuro
(Williams et al., 2008)</td><td colspan="3">It assesses motor function, attention, learning and memory, fluency, executive function and estimated intelligence.</td></tr>
<tr><td>TAVIS-III
(Duchesne & Mattos, 1997)</td><td colspan="3">It assesses the concentration, selective skills and selective attention in three tasks.</td></tr>
</table>

Figure 1. Brief description of computer-based tests and batteries.

ing emotional, behavioral, personality and motor impairments, as well as the patient's cognitive deficits. That is, it brings functional adaptability and environmental integration to the patient (Abrisqueta-Gomez, 2006).

Despite the improper use of the expression "neuropsychological rehabilitation" as a synonym for "cognitive rehabilitation", Prigatano (1997) points out cognitive rehabilitation is only one of the five neuropsychological rehabilitation components, which would also include psychotherapy, the definition of a therapeutic environment, psychoeducation and the work with family members and the patient. This way, according to Wilson (1996), cognitive rehabilitation will enable patients and family members to live with, deal with, reduce or overcome cognitive impairments arising from neurological lesions, such as linguistic, perceptual, attention, memory, executive and praxic impairments.

Zangwill (1947) and, later, Prigatano (1986) found three training approaches for the cognitive rehabilitation: (a) compensation; (b) replacement; and (c) direct retraining. In general, compensation approach involves implementing strategies and resources that enable the patient to deal with or avoid the impairment. Through replacement, it is possible to incorporate alternate systems to perform tasks usually mediated by the affected systems. And, finally, direct retraining relates to the specific train of impaired cognitive functions. Prigatano (1986) also defends a fourth approach, using each one of these principles, which would lead to the recovery of the cognition.

Similarly, Sohlberg e Mateer (1989) distinguish rehabilitation in three basic approaches: (a) general stimulus – use of cognitive training materials without specific theoretical guidance; (b) functional adaptation – retraining takes place in the functional context of ecologic daily life and work situations; and (c) specific process – based on cognitive theoretical models, a series of training tasks is provided, hierarchically organized and aimed at specific components of cognitive processes. Still, the authors describe some essential principles pertaining to cognitive rehabilitation, such as, for instance, a theoretically guided model, repetitive tasks, hierarchical organization of tasks and directed treatment.

To reach these goals, cognitive rehabilitation uses compensation techniques and cognitive strategies such as cognitive stimulation, training and exercises in an attempt to reduce the problems faced by the patient on a daily basis. With the advance of technologies, other resources and devices have been used in rehabilitation, providing new alternatives for old practices.

The use of technology in neuropsychological researches and clinical practices takes place through many different ways, mediated by the internet or not: electronic devices and smartphones (Svoboda & Richards, 2009), computers and tablets (Stuifbergen et al., 2012), videogames (Belchior et al., 2013), virtual and augmented reality (Bohil, Alicea, & Biocca, 2011), robots (Billard et al., 2007), video feedback and neurofeedback (Soekadar, Birbaumer, & Cohen, 2011), transcranial direct current stimulation (Kang, Kim, & Paik, 2012), among many others. Next, some possibilities for the use of technology in the rehabilitation process will be discussed and exemplified.

Many daily electronic pieces of equipment are used, in special, in attention, memory and executive functions rehabilitation. Alarm clocks, timers, pagers, cameras, voice recorders, fixed and mobile phones, computers, tablets, PCs, smartphones applications and web 2.0 technology resources are powerful tools in the application of some compensation techniques. These technological resources enable the user to perform daily tasks with greater autonomy and improve the patient's and family members' life quality (Inglis et al., 2004).

In addition, these devices can be used as organization and monitoring tools in patients suffering from executive deficits, providing to-do lists and daily and weekly plans, as well as acting as external, auxiliary memory, helping the patients not to forget appointments or helping patients with prospective memory impairment not to forget their meds. Wilson, Evans, Emslie and Malinek (1997), for instance, report the most common messages made available by this system are "*good morning, today is the X, date Y*", "*don't forget your meds*" and "*please insert your appointments*". These messages helps elderly people that shows mnemonic damages in daily tasks. However, not all elderly people are familiar with the technology employed in some devices such as computers or smartphones. In this case, it would be better to use simpler devices, such as clocks or voice recorders. For patients who are more familiar with technology, applications for computers, smartphones or tablets are available, helping, for instance, to remember, to organize (Astrid Tasks/To-do List®) and to file information (Evernote®), to manage time, money and medications (Pillboxie®), to get dressed (iDress for weather®) and to store passwords (Keeper Password & Data Vault®). All of them can be used together with other electronic devices with the same system and shared and monitored by other people.

Linked to a young culture, current videogames are for all, regardless of gender and age. More and more modern and versatile, computer games and videogames are quite known and widespread in the health branch, says Kato (2010). Treatments related to distraction and management of the pain in patients suffering from burns and the use to encourage boring, repetitive occupational therapy tasks are some common uses (Griffiths, 2005). Innovations found in computer games and videogames have disseminated the use of new equipment, such as, for instance, Nintendo® Wii videogame console, the *Dance Dance Revolution (DDR)® dance platform and the Kinect Xbox® motion sense input device. Besides being interactive, intuitive and easy to use, they are pleasant to all ages.*

Despite the negative media trend to link videogames to greater violence and obesity risks, researchers have investigated the advantages of games and its elements (Rivero, Querino, & Starling-Alves, 2012). If they were merely seen as entertainment in the past, today videogames are used as specific rehabilitation training tools and cognitive skill changing tools, such as visual perception, motor skills, attention and decision-making processes (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Green & Bavelier, 2003; Nouchi et al., 2012). In view of advances in researches and deeper knowledge regarding videogame, new uses arise. Different studies are being performed in terms of work memory in children with Attention Deficit Hyperactivity Disorder – ADHD (Gray et al., 2012), for autistic individuals to work on facial recognition (Tanaka et al., 2010) and to improve the self-esteem and well being of the elderly (Gamberini, Alcaniz, et al., 2008). For instance, Tanaka and others (2012) have designed a battery of emotional skills named Let's Face It! with 3 subtests related to the relationship between the name of the emotion and the image, combination of facial expressions and recognition of face parts.

According to Gamberini, Barresi, Majer and Scarpetta, (2008) and Kellar, Watters and Duffy (2005), computer games and videogames are funny and encouraging, are aesthetically attractive, provide immediate action feedback, can adjust to the person's level and ensure actions are repeated until they become automatic. All these factors are essential for the patient to engage in the rehabilitation.

Another technology that has been increasing is virtual reality (VR). Although VR systems are new in neuropsychology, they were widely used in professional training programs, such as flight simulators. VR interfaces enable safe training, in special in situations when real practice would be dangerous, expensive or it would be difficult to monitor or control the task to be performed, as it happens with firefighters, divers, skydivers or even surgeons (Rose, Brooks, & Rizzo, 2005). This way, this technology allows users to interact in a three-dimension scenario through computer techniques and equipment such as headphones, head-mounted displays and eyeglasses and handhelds, recreating the feeling of reality – even if temporary. One of the most important elements for the involvement in this virtual world is the immersion feeling. With interfaces or devices that augment the sensory input, cognitive and perceptive systems lead one to believe he is in a different place than where he physically is. That is, the body experiences the sensation of being inserted into the scene (Freeman et al., 2006).

By creating realistic, dynamic and embracing scenarios, VR has offered new experiences in some diseases, providing grounds for the monitoring and training of the individual's behavioral responses. Virtual environments working with specific mental or motor-related impairments, as shown in posttraumatic stress disorder (PTSD), panic and phobias (Botella et al., 2007), Parkinson's (Ma et al., 2011), intellectual impairment (Pérez-Salas, 2008), autism (Parsons & Cobb, 2011) and ADHD (Pollak et al., 2009). One of the advantages of this technology is the reduction in the difference between the laboratory environment and a real situation. This way, the treatment can employ the virtual interface regardless of the challenges or fears, since the tasks can be gradually made more complex. The motivational factor must also be taken into account. As it is a new technology, ignorance or unawareness can be common in this virtual environment, which can lead to greater interest and curiosity.

Augmented reality (AR) has also aided in the assessment and rehabilitation process by providing unique techniques, still not found in traditional neuropsychological methods (Rizzo et al., 2000). Some AR uses have been developed aimed at cognitive processes, including attention processes, spatial skills, memory and executive functions (Grealy, Johnson, & Rushton, 1999; Pugnetti et al., 1998). For instance, in children with ADHD, it is possible to assess and train attention focus at virtual classrooms and without distractions (Rizzo et al., 2000). Similarly, these virtual environments can help in the functional training of instrumental activities of daily living (IADL). In these environments, the patient can practice how to cook meals, how to recognize common objects, how to simulate purchases or practice how to use public transportation in a greener way (Rose et al., 2005).

Conclusion

The use differences of new technologies in the neuropsychological assessment and rehabilitation precisely lie on their advantages and limitations (Charchat-Fichman et al., 2000). The most evident advantage in neuropsychological assessment is timely control in the introduction of stimuli, recording latency and duration of responses in milliseconds (Soto-Pérez et al., 2010). This advantage enables recording the response time and the information processing speed with greater accuracy than traditional tests employing paper and pencil (Charchat-Fichman et al., 2000; Kay & Starbuck, 1997). In rehabilitation, the new technologies have enabled the development of compensation strategies and the simulation of daily life situations, leading to greener training procedures (Rizzo et al., 2000).

Main limitations refer to the need to monitor the patient's interaction with the new technologies to procure qualitative data and to find any comprehension difficulties and preserving instructions in the work memory (Charchat-Fichman et al., 2000; Kay & Starbuck, 1997). Another problem found is resistance and anxiety in view of innovation generated by these technologies, and this limitation is the main challenge for the next years, in special for the elderly (Browndyke et al., 2002). The implicit training of new methodologies and the use of more intuitive novelties, such as touchscreen and tablets, can reduce resistance (Ott et al., 2008).

Despite the increasing use of new technologies in rehabilitation, in special videogames and augmented reality, there are very few empirical studies regarding the efficacy and power of generalization of these strategies in the daily lives of patients (Rivero et al., 2012). New studies must be performed for the development and validation of computer-based batteries and rehabilitation protocols employing new information processing technologies and communication. Cultural adjustments, considering education, socioeconomic level and age must be included in the validation studies of computer-based paradigms.

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