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*Review*

# Cognitive Training for the Treatment of Addictions Mediated by Information and Communication Technologies (ICT)

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**Abstract:** This work constitutes a narrative review of the state of knowledge and advances in the intervention and treatment of addictions through the use of information and communication technologies, considering the growing demand for virtuality-mediated strategies that facilitate the approach of problems of public health such as addictions, which increase considerably year after year. To this end, the reader will be provided with a current overview of the drug use trend; subsequently, a conceptualization of the concept of addiction and its understanding from a neurobiological perspective and, finally, the progress in terms of intervention processes and therapeutic approach will be presented; which will imply an approach to the concept of e-health and rehabilitation mediated by information and communication technologies (ICT).

**Keywords:** addictions; cognitive retraining; information and communication technologies; neurorehabilitation

## 1. Introduction

According to the United Nations Office on Drugs and Crime-UNODC (2011), it is estimated that between 149 million and 272 million people worldwide (between 3.3% and 6.1% of the population aged 15 to 64 years) used illicit substances at least once in the previous year and about half are current consumers [1].

In Colombia, according to the Ministry of Social Protection (2018) in the Health Situation Analysis document-ASIS (acronym in Spanish) [2], which incorporates data from the National Study of Psychoactive Substance Consumption (2013) [3], it is established that regarding the use of illegal psychoactive substances (marijuana, cocaine, bazuco, ecstasy, heroin, morphine (without a prescription), hallucinogens (LSD, fungi) and others (for example, Ketamine, Popper, GHB), 12.98% of those surveyed were found to have consumed some at some time in their life and 3.60% (838,991) in the previous year. The year prevalence is 3.12 times higher in men than in women, reaching percentages of 5.90% (667,341) and 1.43% (171,650), respectively, for a male: female ratio of 3.8840. The average age of onset of consumption is 17.74, with almost no difference between men and women. 50% of respondents said they had done it before the age of 17 and 25% before the age of 15. Consumption is more frequent in the group of people between 18 and 24 years old, with 8.70% (347.394) [2].

### *Theoretical Basis*

Drug abuse is a particularly complex problem, because it presents multicausality and is related to the presence of medical, family, social, labor, economic, legal and psychological problems associated

with its misuse [4]. Addiction is defined as a condition in which the behavior can be directed to the pursuit of pleasure or the reduction of discomfort, it manifests itself in a model that meets two conditions: a permanent failure in the control mechanisms and a continuation of the behavior despite negative consequences [5].

Addictions and their intervention cannot be defined from a single discipline because it is a complex problem that involves the participation of multiple levels such as intra and interpersonal, genetic and environmental factors, that is, previous provisions and effects of exposure [6]. Therefore, it cannot be ignored that part of the psychopathology associated with addiction is understood from environmental factors [7], including in these psychosocial characteristics [8,9].

In recent years, the study of addictions to the field of neuropsychology has intensified, which have allowed us to explore the effects that different drugs can cause at the brain level [10]. The incorporation of these neuropsychological findings in clinical practice offers an understanding of the addictive cycle and its maintenance as well as improving the evaluation and design of effective interventions.

At this point, it is convenient to specify the concept of addiction and the theoretical model from which treatment options are approached and introduce the concept of cognitive training, as a therapeutic alternative. From a neurobiological perspective, addiction is defined as the alteration in the regulatory mechanisms of decision making and inhibitory control, generating a loss of control over behavior and an excess of awareness [11]. In the case of addiction to psychoactive substances, drug use has been associated with alterations in the frontal cortical systems responsible for executive functions, which play an important role in decision-making and in the inhibitory control of behavior, leading to alterations in judgment and promoting impulsivity [12,13].

Traditionally, from a neurobiological perspective, two models are distinguished to explain the addiction to psychoactive substances: (a) the theory of damage and decompensation between the motivational system and the executive system and (b) the somatic marker theory. In the first case, the theory states that addiction occurs, due to a discrepancy between the motivational system and the executive system. This means that the addicted person tends to overestimate the reinforcers available in the environment and to present a deficit in the control to inhibit inappropriate behaviors [4]. In the case of the somatic marker theory, addiction is explained as a result of maladaptive decision-making processes based on urgency and the desire to consume, or craving, which functions as an unadjusted emotional marker (in which processing the insula is involved, a region specialized in interceptive processing whose injury causes a drastic interruption of the feeling of "desire" and addictive behavior) and in the selection bias characterized by immediate reinforcement against potential negative consequences [14,15].

In this sense, the treatment of addictions, has evolved towards the incorporation of the processes of stimulation, rehabilitation and neurocognitive training, while addiction is considered as a mental disorder with an important brain disorder, which can be directly remedied (improving brain functioning) and indirectly (improving the use of other therapeutic program activities) [16]. The following question then arises: What have been the proposals for cognitive training for addictions, mediated by technologies that have been implemented since now?

## 2. Materials and Methods

This article is a narrative review of studies that have focused on the executive functioning model for addiction rehabilitation, which was developed through a search on the following databases: PubMed, Lilacs, MedLine, Embase, Science Direct and Bibliomed. A chain search was also performed, and other studies were located through bibliographic reference lists of the studies retrieved in the primary search. Reference lists of systematic review articles or textbooks were also consulted, as well as databases in specialized information and documentation centers. Gray literature was not considered.

The descriptors "Cognitive remediation", "cognitive rehabilitation", "cognitive retraining" were used in both English and Spanish. Articles dating from 1993 to 2019 were compiled. The survey was carried out between April and August 2019 and the first selection of the articles was made by the analysis of the abstracts. Those who did not address the issue (15 in total) were excluded.

Given the need to make a comprehensive review of the evidence on the subject, no inclusion or exclusion criteria were established on the studies and research reports consulted, but, during the investigation, the authors proposed and discussed the inclusion of works taking into account the following characteristics: papers that were related to cognitive training related to addictions or mental disorders that met quality criteria attached to international standards. To systematize the analysis of the quality of the primary studies, data were collected regarding the article (title and date of publication), the authors (nationalities and educational level) and the study (funding, type of study, objectives, analysis, results, limitations and recommendations).

### *2.1. Criteria to Select Revision Studies*

Studies of different designs were selected, classified according to the level of evidence proposed by Stetler et al. [17]. Editorials or opinion articles classified as level VI studies were not considered.

The assessment was qualitative, dichotomously, with "yes" or "no" ratings, according to the presence or absence of the criteria of the checklists of the National Institute of Medicine (NHS). Studies of doubtful quality were considered those in which the answer was "no" in any of the criteria. Independently, two researchers assessed quality, and disagreements regarding a qualification were resolved by a third researcher.

### *2.2. Revision Methods*

The critical evaluation of the articles consisted of the complete reading of the study, its evaluation filling of the data collection instrument. Those studies published in duplicate or found in more than one database were considered only once. The quality of the information was evaluated according to the type of design with the tools of the Critical Appraisal Skills Program (CASP-UK). A total of 40 studies were included in this review. Search results are indicated in Figure 1.

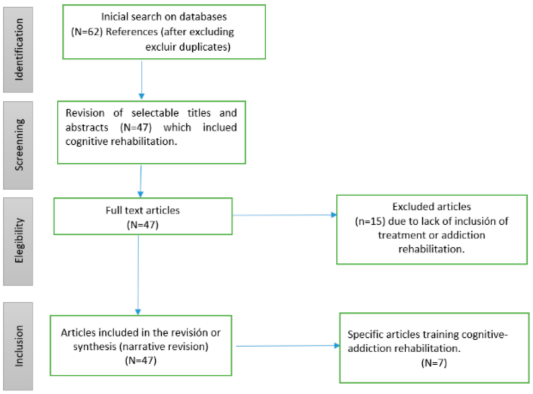


**Figure 1.** Results selection.

The training of cognitive functions is defined as a dynamic process, in which different strategies of neuropsychological stimulation and rehabilitation converge, characterized by individualizing the procedures, focusing on relevant goals for the subject, considering the emotional and social aspects of the patient and constantly evaluating the profits obtained in the process (Table 1) [18–20]. In this sense, cognitive interventions have many names, concepts, objectives and methods, which can be confusing [21]. Generally, the term cognitive rehabilitation is used to refer to the intervention with patients suffering from brain injuries; leaving aside the possibility of intervening in the cognitive functioning of healthy people [22,23]. Due to the variety of terms used, Clare and Woods [22] recommended the division of the wide variety of techniques into three groups: neuropsychological rehabilitation, cognitive stimulation and cognitive training.

**Table 1.** Summary of the Narrative Review.

| Authors | Year | Method | Key Findings | Conclusions |
| --- | --- | --- | --- | --- |
| Mateer et al. [18] | 2006 | Case studies and Literature review | Cognitive rehabilitation strategies that address attention, memory and executive deficits can improve clients' abilities to manage workplace tasks and demands. | Cognitive behavioural therapy is well suited for improving coping skills, helping clients to manage cognitive difficulties and addressing more generalized anxiety and depression in the context of a brain injury. |
| Sohlberg et al. [19] | 2001 | Literature review | The rehabilitation is a group of treatments that include cognitive process training, environmental manipulations and psychotherapy. | Approaches covered encompass behavioral interventions, process-oriented therapies, including cognitive process training, environmental manipulations and psychotherapy. |
| Suárez-Yepes et al. [20] | 2016 | Literature review | From the theoretical review, it was found that the restorative approach is the predominant in the vast majority of interventions reported in the literature. | It was found that very few studies reported clearly and precisely whether there existed improvements in the functionality of the participants. Similarly, few studies reported the inclusion of the family in rehabilitation. |
| Woods et al. [21] | 2006 | Randomized controlled trial of Cognitive Stimulation Therapy (CST) groups, significant improvements in self-reported QoL 201 people with dementia living in residential homes or attending day centres were assessed using the Quality of Life-Alzheimer's Disease (QOL-AD) scale and a range of measures of cognition, dementia level, mood, dependency and communication. | At baseline, higher QoL in dementia was significantly correlated with lower levels of dependency and depression, but not with cognitive function or dementia severity. Improvement in quality of life was associated with being female, low quality of life at baseline, reduced depression and increased cognitive function. | Changes in cognitive function mediated the effects of treatment in improving QoL. These results suggest that while QoL in dementia appears to be independent of level of cognitive function, interventions aimed at improving cognitive function can, nonetheless, have a direct effect on QoL. |
| Clare et al. [22] | 2004 | Literature review | Six studies reporting cognitive training interventions were included. None of studies demonstrated any statistically significant effects in any domain, although there were indications of some modest, non-significant effects in various domains of cognitive functioning. | Data from a single, high-quality trial provide preliminary positive Results regarding the use of contextualised individual cognitive rehabilitation. |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
| --- | --- | --- | --- | --- |
| Holderbaum et al. [23] | 2006 | This is a quantitative research that used a quasi-experimental design; it is correlational and comparative, involving pre- and post-testing and intervention. The sample was formed by 83 elders, split into an Experimental Group (EG) (45 people) and a Control Group (GC) (38 people). | The results from the comparison between groups showed that there was a significant difference regarding the number of errors in the Sternberg Paradigm and Completed Categories of the WCST. Intragroup comparisons showed that the EG had better results after the intervention on the following tests: GDS, RAVLT, Rey Complex Figures (memory), Digit Span and Vocabulary. | Aging is commonly associated to cognitive decline and loss of other abilities, which leads to the need of researching elements that may contribute to preventive cognitive rehabilitation interventions aiming to guarantee the elderly quality of life. |
| Lopes et al. [24] | 2016 | Quantitative research that used a quasi-experimental design; it is correlational and comparative, involving pre- and posttesting and intervention. The sample was formed by 83 elders, split into an Experimental Group (EG) (45 people) and a Control Group (GC) (38 people). | Significant differences were evidenced between the groups regarding health problems ($p = 0.048$) and physical activity ($p = 0.033$). People older in the experimental group were more prone to present diseases, but they also practiced more physical activities that the control group.The GC reduces the number of errors in the paradigm more than the GE, and also significantly changes the weighted score of the Search for Symbols. | The results presented here show the effect of executive training in improving executive function (FE [acronym in Spanish]), which includes the Processing speed. Both the FE and the speed of processing decrease with age [25] Daily activities are strongly related to these functions [26]. |
| Fernández-Calvo et al. [27] | 2011 | The study aims to assess the effi cacy of the Big Brain Academy (BBA), a computerized cognitive training program (CT) based on video games, compared to the Integrated Psychostimulation Program (IPP), a classical CT tool for patients with Alzheimer's disease (AD). A total of 45 patients with AD at the mild stage were randomly assigned to three experimental conditions. | The EABB group showed signifi cantly slower rates of cognitive decline compared to the EAPI and EANT groups. Furthermore, the EABB group reported significantly greater decrease in depressive symptoms in comparison with the EAPI and EANT groups. The BBA program was more effective than IPP to reduce cognitive decline and depressive symptoms in patients with AD. | The results obtained show that the BBA cognitive stimulation program has proved more effective than a Traditional CD program (PPI), so that patients stimulated with BBA showed a significant reduction of cognitive decline and depressive symptomatology in relation to a 'traditional' stimulation group. |
| Muñoz González [28] | 2018 | Review | The purpose is to inform about the benefit of cognitive stimulation as a preventive, economic and effective strategy for the psychogerontological approach of patients with dementia in primary health care. | Cognitive stimulation will improve the quality of life of older adults with dementia and promote individual and family coping with the disease. |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
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| Muñoz-Céspedes et al. [29] | 2004 | Literatures review | The aim of this report is to review the main rehabilitation programs of executive functions and to adapt them to our culture and context from a theoretical-practice perspective. | New ones are needed research that helps us determine the differential effectiveness of some techniques and programs in different groups of patients with alterations in executive functioning. However, the initial results of some recent studies in this direction they are promising. |
| Lubrini et al. [30] | 2009 | Compilation | An intervention process is fundamental to know the in-depth basic theoretical aspects about the memory process to be able to design an appropriate intervention plan. | It is necessary for patients to master the characteristics of the possible mnesic alterations, to know how to evaluate them and how to assess those preserved capabilities. |
| Portellano [31] | 2005 | Literature review | The empirical concept of "function executive" derived mainly from study of patients and animals with lesions in the prefrontal cortex, especially in the dorsolateral portion. | Restoration, recovery and retraining are based on the principle that the practice or repetition of exercises can strengthen the basic cognitive process or function, as well as progressively improve those functions that present some difficulty. |
| Elliott et al. [32] | 2014 | Meta-analysis was performed on 26 studies of memory retraining and recovery that were published between the years of 1985 and 2013. | Results indicated a significant average ($r = 0.51$) in the treatment intervention conditions, as well as a significant average ($r = 0.31$) in the control conditions, in which participants did not receive any treatment. | Results showed that memory rehabilitation was an effective therapeutic intervention, especially for stroke patients and for working memory as a treatment domain. However, the results also indicated that significant memory improvement occurred spontaneously over time. |
| Shin et al. [33] | 2015 | Literature review | At of 350 titles and abstracts were retrieved, and 17 articles were selected for this review. Selected articles were assessed on the level of evidence using the Physiotherapy Evidence Database (PEDro) scale. | Articles assessing the impact of cognitive impairments in memory were most commonly found, and VR interventions elicited positive effects in patients with brain injury. VR can be considered a new tool for cognitive rehabilitation after brain injury. |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
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| Coyle et al. [34] | 2015 | Literature review | The aim of this study was to assess the efficacy of cognitive training, specifically computerized cognitive training (CCT) and virtual reality cognitive training (VRCT), programs for individuals living with mild cognitive impairment (MCI) or dementia, and therefore at high risk of cognitive decline. | CCT and VRCT were moderately effective in long-term improvement of cognition for those at high risk of cognitive decline. Total intervention time did not mediate efficacy. Future research needs to improve study design by including larger samples, longitudinal designs, and a greater range of outcome measures, including functional and quality of life measures, to assess the wider effect of cognitive training on individuals at high risk of cognitive decline. |
| Al Ayubi et al. [35] | 2015 | Analytical study to review the fundamental characteristics of the technologies used in physical activity monitoring and promotion. | Advances in smartphones and the wide usage of social networking systems offer opportunities for the development of innovative interventions to promote physical activity. | The usability results suggest that the system is usable and user satisfaction was high. Deploying the application was shown to be feasible for the promotion of daily physical activity. |
| Depompei et al. [36] | 2008 | These trials were conducted with individuals who had memory and organizational problems as a result of cognitive disorders of traumatic brain injury (TBI) or intellectual disability (ID). | Results indicate that the use of electronic devices can enhance independent behavior. Factors influencing success include: student motivation, audible beep of the device; support for programming and troubleshooting, alterations of functions; and selection of features to motivate. | Based on the result of the studies, an intervention plan for use of Personal Digital Assistants was developed for use by clinicians. |
| Migo et al. [37] | 2014 | A questionnaire on smartphone ownership was given to an opportunity sample of consecutive patients attending a neuropsychiatry and memory disorders outpatient clinic. Data were collected in 2012 and repeated 12 months later in 2013 to assess changes over time. | Exploring how smartphones and their APPs could function as memory aids is likely to be useful for a large enough number of patients to be clinically worthwhile. | The use of mobile devices to deliver healthcare has not yet been exploited in neuropsychological rehabilitation. Smartphones have the potential to serve as multi-functional memory aids. |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
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| Cicerone et al. [38] | 2000 | Literature review | Of the 171 studies evaluated, 29 were rated as Class I, 35 as Class II and 107 as Class III. The overall evidence within each predefined area of intervention was then synthesized, and recommendations were derived based on consideration of the relative strengths of the evidence. The resulting practice parameters were organized into three types of recommendations: Practice Standards, Practice Guidelines and Practice Options. | Overall, support exists for the effectiveness of several forms of cognitive rehabilitation for persons with stroke and TBI. Specific recommendations can be made for remediation of language and perception after left and right hemisphere stroke, respectively, and for the remediation of attention, memory, functional communication and executive functioning after TBI. |
| Schutz et al. [39] | 2007 | Literature review | The construct of 'cognitive rehabilitation' has not been defined in a consensual manner and the variations in usage have produced misunderstanding and controversy. At one extreme, it refers to a paradigm of complex, sophisticated and integrated interventions, and at the other to a poorly conceptualized and largely ineffectual service modality. | A treatment selection standard is proposed, specifying the conditions under which a holistic model or the 'contextualized' training alternative is likely to be more viable. |
| Laatsch et al. [40] | 2007 | This study was to complete a systematic evidence-based review of published cognitive and behavioral treatment studies with pediatric subjects who have a history of an acquired brain injury (ABI). | The studies, involving 366 children and youth with ABI, were classified as one Class I study, fove Class II studies, six Class III studies and 16 Class IV studies. | Despite a limited number of studies, two treatment recommendations and one option were developed from this systematic literature search. |
| McGurk et al. [41] | 2007 | A meta-analysis was conducted of 26 randomized, controlled trials of cognitive remediation in schizophrenia including 1.151 patients. | Cognitive remediation was associated with significant improvements across all three outcomes, with a medium effect size for cognitive performance (0.41), a slightly lower effect size for psychosocial functioning (0.36) and a small effect size for symptoms (0.28). The effects of cognitive remediation on psychosocial functioning were significantly stronger in studies that provided adjunctive psychiatric rehabilitation than in those that provided cognitive remediation alone. | Cognitive remediation produces moderate improvements in cognitive performance and, when combined with psychiatric rehabilitation, also improves functional outcomes. |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
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| O'Brien et al. [42] | 2008 | Literature review | Studies were chosen based on criteria from previous evidence-based reviews. | Cognitive rehabilitation in MS is in its relative infancy. More methodologically rigorous research is needed to determine the effectiveness and efficacy of various cognitive rehabilitation interventions. |
| Wykes et al. [43] | 2002 | Three groups (patients receiving control therapy or CRT and a healthy control group) were investigated in a repeated measures design using the two-back test. Functional magnetic resonance imaging (fMRI) data and a broad assessment of executive functioning were completed at baseline and post-treatment. | fMRI analyses indicate that the control group showed decreased activation but the two patient groups showed an increase in activation over time. The patient group that received successful CRT had significantly increased brain activation in regions associated with working memory, particularly the frontocortical areas. | This is the first time that brain activation changes in a seriously disabled group of patients with schizophrenia can be associated clearly with psychological rather than pharmacological therapy. |
| Goldstein et al. [44] | 2004 | Exploratory and confirmatory statistical approaches to study the severity of neuropsychological (NP) impairment in 42 crack/cocaine addicted subjects and in 112 comparison subjects (40 alcoholics and 72 controls). | Results revealed that (1) cocaine addicted individuals had a generalized mild level of neurocognitive impairment (<1 S.D. below control mean); and (2) controlling for age and education, relative metabolism in the dorsolateral prefrontal cortex significantly predicted the Visual Memory and Verbal Memory factors and relative metabolism in the anterior cingulate gyrus significantly predicted the Attention/Executive factor. | Tasks that simulate real-life decision-making or that target specific putative cognitive-behavioral or motivational-emotional mechanisms might offer greater sensitivity in characterizing the changes that accompany addiction to drugs. |
| Roehrich et al. [45] | 1993 | Four groups of male alcoholics received pre- and posttesting. Between the two testing sessions, the groups received neuropsychological remediation tasks (n = 15), ecologically relevant tasks (n = 15), attention-placebo tasks (n = 16) or no intervention (n = 15). | Results showed that exposure to both types of remediation produced significant cognitive recovery, with skills transferring to posttest neuropsychological measures and RP acquisition. Hence, cognitive remediation may facilitate alcoholism treatment. | Accumulating research has shown that some cognitive deficits in recently abstinent alcoholics (e.g., cognitive flexibility, acquisition of novel skills) improve only with remediation in contrast to the spontaneous, time-dependent rebound seen for other tasks. |
| Allen et al. [46] | 1997 | Literature review | Empirical investigations conducted to date indicate that some cognitive deficiencies secondary to alcoholism are amenable to cognitive rehabilitation, and that this remediation is generalizable. | The current literature suggests that individuals who chronically abuse alcohol exhibit a wide variety of cognitive deficits resulting from cerebral dysfunction that is either directly or indirectly related to their alcohol consumption history. |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
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| Fals-Stewart et al. [47] | 2010 | Patients with substance use disorders entering long-term residential care (N = 160) were randomly assigned to one of two conditions: (a) standard treatment plus computer-assisted cognitive rehabilitation (CACR); (b) an equally intensive attention control condition consisting of standard treatment plus a computer-assisted typing tutorial (CATT). | Mediational analyses revealed the positive comparative effect of CACR on abstinence during the year after treatment was mediated by treatment engagement and length of stay in residence. | |
| Yu et al. [48] | 2012 | Students of two vocational schools and two high schools filled out a questionnaire at a baseline (T0) and a 2-month follow-up (T1) data collection session. Students of one vocational school and one high school downloaded the Once Upon a High app (app group), whereas students from the other vocational school and high school did not (nonapp group). | There were 386 students who participated in the T0 session. After dropout, 246 students took part in T1 data collection procedure. Alcohol was the most frequently consumed psychoactive substance (334/364, 91.8% lifetime use), followed by tobacco (252/386, 65.3%, lifetime use) and cannabis (43/323, 13.3% lifetime use). Decreased self-efficacy (beta = −0.29, $p = 0.04$) and increased daily physical exercise frequencies (beta = 0.04, $p < 0.001$) predicted higher frequencies of past month energy drink consumption, whereas elevated past month alcohol consumption was mainly predicted by a decrease in negative attitudes toward substance users (beta = −13, $p = 0.04$) in the regression models. Once Upon a High was found to be effective only in reducing energy drink consumption (beta = -1.13, $p = 0.04$) after controlling for design effect, whereas perceived utility of the app showed correlation with a decreasing alcohol use (rS (44) = 0.32, $p = 0.03$). | The Once Upon a High app can be a useful tool to assist preventive intervention programs by increasing knowledge and self-efficacy; however, its efficacy in reducing or preventing substance use needs to be improved and further studied. Additional potential impacts of the app need further testing. |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
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| Bickel et al. [49] | 2014 | Forty MUD participants were assigned randomly to either the CCAT group (n = 20), who received 4 weeks of CCAT plus regular detoxification treatment as usual, or the control group (n = 20), who only received the regular detoxification treatment as usual, in drug rehabilitation centers in Shanghai. | Compared to the control group, CCAT improved working memory in the CCAT group ($p = 0.01$). Group × time interactions were observed among DDT, IGT and BART tasks, with rates of discounting delayed rewards, IGT and BART scores ($p < 0.001$) being reduced among those who received CCAT, whereas no changes were found in the control group. | The newly designed CCAT can help to improve cognitive impairment and impulsive control in MUD. Further research is needed to understand the underlying brain mechanisms of the cognitive therapy. |
| Ahn et al. [50] | 2014 | We report the case of a 10 years old patient diagnosed with attention deficit hyperactivity disorder (ADHD) and comorbid video game addiction, who was treated with medication combined with a novel cognitive training method based on video games called the TCT method. | The TCT method is a cognitive training method that enhances cognitive skills such as attention, working memory, processing speed, calculation ability, reasoning and visuomotor coordination. | The purpose of reviewing this case is to highlight that regular cognitive computerized training in ADHD patients may improve some of their cognitive symptoms and might be helpful for treating video game addiction. |
| Ruiz-Manrique et al. [51] | 2014 | An ART app for the Android system and an accessory of bilateral tactile stimulation were developed and will be used in a study with behavioral self-control training. | This paper presented the design and realization of the smart phone based ART application. The design of a pilot study, which is to examine the benefits of a smartphone application providing behavioral self-control training, is also reported in this paper. | N/A |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
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| Kapitány-Fövény et al. [52] | 2018 | Descriptive data were used to characterize the nature of the literature on technology-delivered, CBT-based interventions for alcohol use ("CBT Tech"). | The content of CBT Tech programs varied, ranging from four to 62 sessions/exercises, with many programs combining elements of motivational interviewing (47%). With respect to efficacy, CBT Tech as a stand-alone treatment in contrast to a minimal treatment control showed a positive and statistically significant, albeit small effect (g = 0.20: 95% CI = 0.22, 0.38, kes = 5). When CBT Tech was compared to treatment as usual (TAU), effects were nonsignificant. However, when CBT Tech was tested as an addition to TAU, in contrast to TAU only, the effect size was positive, significant (g = 0.30: 95% CI = 0.10, 0.50, kes = 7), and stable over 12-month follow-up. Only two studies compared CBT Tech to in-person CBT, and this pooled effect size did not suggest superior efficacy. | These Results show a benefit for technology-delivered, CBT-based interventions as a stand-alone therapy for heavy drinking or as an addition to usual care in specialty substance use settings. |
| Zhu et al. [53] | 2018 | This article reviewd emerging evidence for computerized working memory training as an efficacious adjunctive treatment for drug dependence and highlights future challenges and opportunities in the field of working-memory training, including duration of training needed, persistence of improvements and utility of booster sessions, and selection of patients based on degree of deficits. | N/A | N/A |

**Table 1.** *Cont.*

| Authors | Year | Method | Key Findings | Conclusions |
| --- | --- | --- | --- | --- |
| Kiluk et al. [54] | 2019 | We used computational modeling to address these questions in a unique sample of relatively "pure" amphetamine-dependent (N = 38) and heroin-dependent individuals (N = 43) who were currently in protracted abstinence, and in 48 healthy controls (HC). A Bayesian model comparison technique, a simulation method, and parameter recovery tests were used to compare three cognitive models: (1) Prospect Valence Learning with decay reinforcement learning rule (PVL-DecayRI), (2) PVL with delta learning rule (PVL-Delta) and (3) Value-Plus-Perseverance (VPP) model based on a Win-Stay-Lose-Switch (WSLS) strategy. | Computational modeling results suggested that overall, all three groups relied more on RL than on a WSLS strategy. Heroin users displayed reduced loss aversion relative to HC across all three models, which suggests that their decision-making deficits are longstanding (or pre-existing) and may be driven by reduced sensitivity to loss. In contrast, amphetamine users showed comparable cognitive functions to HC with the VPP model, whereas the second best-fitting model with relatively good simulation performance (PVL-DecayRI) revealed increased reward sensitivity relative to HC. | These results suggest that some decision-making deficits persist in protracted abstinence and may be mediated by different mechanisms in opiate and stimulant users. |

Neuropsychological rehabilitation (NR) encompasses strategies such as psychotherapy, family counseling, therapeutic environment, cognitive rehabilitation and patient education. NR treats cognitive difficulties and emotional responses in an integrated manner, taking into account the social context and prior knowledge of the patient [24]. Its objective is the maintenance of cognitive functionality, including motivational, psychological and social aspects, in which patients and their families participate in the rehabilitation process.

On the other hand, cognitive stimulation is based on the stimulation of certain cognitive domains, through tasks structured in difficulty levels, trying to improve or maintain its functioning [27]. Likewise, it is defined as the set of techniques and strategies that optimize the effectiveness of the functioning of cognitive abilities and functions (perception, attention, reasoning, abstraction, memory, language, orientation and praxis) through a series of concrete activities that are planned and structured in what are called stimulation programs [28].

As for cognitive training, it has been shown that a set of tasks and situations that simulate daily activities correspond with the help of several resources (based on the premise, that for the execution of these tasks the patient makes use of their functions cognitive (such as language, memory, attention) when performing them [24]. In this way, cognitive training aims at altered functions, while rehabilitation would be the set of actions aimed at favoring the proper functioning in activities of daily life [16].

Therefore, in cognitive training, there are several strategies that allow improving the ability of people to program their behavior and guide them towards the achievement of objectives [29]. Among these strategies are restoration, recovery and retraining [30], which are based on the principle that the practice or repetition of exercises can strengthen the basic cognitive process or function, as well as, progressively improve that function that presents some difficulty [31].

### *2.3. Cognitive Training and ICT*

Recently, treatments mediated by Information and Communication Technologies (ICT) have been very well received, finding significant differences between traditional cognitive or pencil and paper-training programs and those that incorporate the use of technological tools, such as mobile applications (APP), interactive games and multimedia devices [32]. For example, Shin and Kim [33], during their investigation with patients with cranioencephalic trauma, showed significant differences for ICT-mediated cognitive training, while participants demonstrated improvements in attention and memory processes, compared to those who received a traditional program.

Alternatively, Coyle et al. [34] pointed out that the effects of ICT-mediated cognitive training showed positive effects on cognitive performance in patients at risk of cognitive impairment; however, they highlighted the need to generate studies with samples greater than 25 people from longitudinal designs.

In the case of Al Ayubi et al. [35], with the "PersonA" application, physical exercise was monitored with an accelerometer, personal blog and synchronization to Facebook, demonstrating that the application under this methodology allows monitoring the progress achieved and increasing motivation. Depompei et al. [36] conducted a study where the use of mobile applications helped to improve independence and time management indicating at the end of the process that the expected result was obtained. On the other hand, Migo et al. [37] concluded that smartphones and mobile applications helped memory treatment.

In conclusion, there is evidence on the efficacy of well-designed programs adapted to the reality of the patient, with the majority focusing on people with traumatic brain damage or stroke [38–40] schizophrenics [41] and multiple sclerosis [42], which has led to conclude that cognitive rehabilitation induces structural and functional changes in the brain, especially in the frontocortical areas [43], which would benefit patients with addictions [44].

### 2.4. Neuropsychological Rehabilitation for Addictions

There are few studies in the field of neuropsychological rehabilitation in the treatment of addictions, which makes it much scarcer to find studies that pose such rehabilitation through the use of APPs.

The first studies that refer to addiction rehabilitation are associated with Roehrich and Goldman [45] and Allen et al. [46], who intervened with alcoholic patients, in the late 1990s. The authors suggested the need to explore the effectiveness of these interventions in tasks of daily life and the strengthening of ecological validity. The results obtained in these studies indicate that cognitive rehabilitation therapy increased the ability of participants to benefit from cognitive behavioral treatment, reduced affective discomfort and showed improvements in cognitive performance and there was greater appropriation of relapse prevention therapy.

Fals-Stewart and Lam [47] used the PSS CogReHab (Cognitive Rehabilitation Computer Program) program which was designed to improve cognitive functioning in the areas of memory, attention, problem solving and information processing speed. After the intervention, an evaluation was carried out with the Neuropsychology Asssment Battery-Screnning module and it was shown that the patients who had received the cognitive training were more committed to their treatment, had greater adherence to it and subsequently had better long-term results, reported in indicators of family, social functioning and reduction of legal problems.

In the search on the use of ICT in neuropsychological rehabilitation for the treatment of addictions seven studies were found, which are referenced below.

The first study, of the year 2012, was published in the United States by Yu et al. [48]. It consisted of a pilot study to examine the benefits of a smartphone application that provides training in behavioral self-control in alcoholic patients. The second, also published in the United States, in 2014 by Bickel et al. [49] reviewed the emerging evidence for computerized work memory training as an effective complementary treatment for addictions and highlights future challenges and opportunities in the field of training by making particular emphasis on the sessions to intervene in relation to the patient's deficit.

The third research was published in 2014 in Switzerland by Ahn et al. [50] and showed the intervention of amphetamine and heroin consumers through computational modeling, compared to a control group, which showed deficit in the pre-existing decision making in heroin users and comparable results in executive functions of consumers of amphetamines with the control group.

The fourth study in English was a 2015 case study conducted by Ruiz-Manrique et al. [51] in Spain, using mobile application that improves cognitive skills in a patient with attention deficit and was trained through a videogame. The researchers found significant improvement in attention, working memory, processing speed and visual-motor coordination.

The last three studies are conducted between 2018 and 2019, two of them published in Canada and the most recent in the United States. Kapitány-Fövény et al. [52] presented an interactive application that focuses on the prevention of psychoactive substance use by developing six modules: (1) interactive comics/cartoons, telling recovery stories; (2) quiz game; (3) role play; (4) introduction of psychoactive drugs; (5) information on the somatic and psychological effects of psychoactive substances; (6) list of available treatment units, rehabilitation and self-help groups in Hungary. Zhu et al. [53] concluded that computerized cognitive therapy helps cognitive impairment and impulse control of patients with substance use disorder and invited them to continue with this research line for the understanding of the underlying brain mechanisms of cognitive therapy. Finally, Kiluk et al. [54], through a review of the literature, found results that show benefits in interventions based on Cognitive Behavioral Therapy developed through technology with chronic alcohol consumers.

## 3. Discussion

ICT are well valued by the general population thanks to the alternatives they offer in the possibility of accessing new resources and options to improve people's physical and mental conditions. Proof of this is that they are currently the main access to medical information [55] that includes the possibility

of consulting, accessing information and as a health promotion mechanism; apps are considered as agile, powerful tools, and are increasingly simple for the population to understand [56].

This implies great challenges, first for the use of tools based on science and specifically for the rehabilitation of addicted persons, and secondly, that regulatory policies for their management have to be proposed; hence, the FDA (Food and Drugs Administration) is the body responsible for regulating now not only drugs and products for human use, but also medical and mental health devices that are beginning to expand. This means that there are already lists of mobile medical applications that have been approved by such organization [57] and that guides are built on their management and appropriation. In this regard, a guide has been published to inform manufacturers, distributors and other entities about how the regulation of applications with use for health is oriented [58].

Following this line, some researchers have also worked on creating essential requirements for the development of a medical application; in this regard, Meulendijk et al. [59] proposed the following nine requirements: accessibility, verifiability, portability, privacy, security, safety, stability, reliability and ease of use.

In this sense, APPs can be a support tool for health professionals, and, accompanied by studies that can guarantee the validity and reliability of their incursion in this area, they can be used for the rehabilitation of addictions. However, this research remains scarce. It is important to note that there is evidence that some apps are effective and reliable as an adjunctive treatment in certain neurological pathologies, it is worth noting those focused on healthy habits, evaluation and daily real-time communication between the therapist and the patient, which are points key in the rehabilitation of addictions.

To be more specific in the rehabilitation of addictions, it is necessary to have mobile applications or systematized programs that include neuropsychological rehabilitation and are able to reverse the neuropsychological deficits associated with chronic consumption and be complementary to the psychological therapies that are developed with the patient. The studies reviewed suggest that cognitive training produces modulatory factors for treatment such as adherence, improvement of self-esteem and self-efficacy, greater participation and commitment to treatment by the patient, improvement in daily functioning, reduction of symptoms of discomfort and increased motivation [51], all aspects related to the dropout indicators of many addicted patients.

## 4. Conclusions

ICT-mediated neuropsychology rehabilitation begins to demonstrate important evidence about its constitution as a therapeutic alternative for the treatment of addictions, although it is an area that begins to incorporate studies that support these findings, it is important to expand research on this issue to consolidate the evidence in this regard, as existing studies aim to improve effectiveness and adherence in the treatment of addictive behaviors.

This implies reconsidering the initial stages of addiction treatment towards a motivational psychological approach and the use of cognitive training as a precursor to more demanding therapeutic strategies that imply more complex levels of information processing.

Additionally, the development of functional cognitive rehabilitation programs throughout the treatment could strengthen the withdrawal and functionality of the person after the end of their process without forgetting the importance of training in relapse prevention [60].

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