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Impact of Bottom-up Cognitive Remediation on Functioning in Schizophrenia

Şizofrenide Aşağıdan Yukarıya Bilişsel Onarımın İşlevsellik Üzerindeki Etkisi

Rukiyye Meryem Osmanoğlu[1], Şaziye Senem Başgül[1]

[1]Hasan Kalyoncu University, Gaziantep

ABSTRACT

In patients with schizophrenia, a chronic psychiatric disorder, cognitive impairments have a significant impact on functioning as well as symptoms. Cognitive remediation (cognitive remediation) interventions are a treatment approach that aims to improve cognitive functioning in patients with schizophrenia. These interventions can be categorized as "bottom-up" approaches that directly target cognitive functions and "top-down" approaches that indirectly affect cognitive functions. In this study, the contribution of bottom-up cognitive remediation interventions to functioning in schizophrenia was examined. The study provides evidence that bottom-up cognitive remediation interventions can improve cognitive functioning, social functioning and quality of life in patients with schizophrenia. When the literature is reviewed, it is observed that there is no research or programs about bottom-up cognitive remediation interventions in Türkiye. It is recommended that programs for bottom-up cognitive remediation interventions should be developed and utilized in Türkiye and they should be incorporated with the current therapy and rehabilitation approaches. It is important to benefit from technological opportunities, to increase the duration and intensity of interventions, to consider the issue of motivation and to ensure the integration of interventions into daily life, in creation of future bottom-up cognitive remediation intervention programs, in order to increase effectiveness, sustainability and cost-efficiency.
Keywords: Schizophrenia, cognitive remediation, functioning, bottom-up approach, cognitive rehabilitation

ÖZ

Kronik bir psikiyatrik bozukluk olan şizofreni hastalarında bilişsel bozukluklar, hastalık semptomlarının yanı sıra işlevsellikte de önemli bir etkiye sahiptir. Bilişsel onarım (cognitive remediation- BO) müdahaleleri, şizofreni hastalarında bilişsel işlevleri iyileştirmeyi amaçlayan bir tedavi yaklaşımıdır. Bu müdahaleler, bilişsel fonksiyonları doğrudan hedef alan "aşağıdan yukarıya" ve bilişsel işlevleri dolaylı olarak etkileyen "yukarıdan aşağıya" yaklaşımlar olarak sınıflandırılabilir. Bu çalışmada, şizofrenide aşağıdan yukarıya bilişsel onarım müdahalelerinin işlevselliğe katkısı incelenmiştir. Çalışmada, aşağıdan yukarıya bilişsel onarım müdahalelerinin, şizofreni hastalarında bilişsel işlevleri, sosyal işlevselliği ve yaşam kalitesini iyileştirebileceğine dair kanıtlar incelenmiştir. Alanyazın incelendiğinde ülkemizde aşağıdan yukarıya bilişsel onarım müdahalelerine yönelik araştırma ve programların bulunmadığı görülmüştür. Ülkemizde de aşağıdan yukarıya bilişsel onarıma yönelik programlar geliştirilmesi ve halihazırda uygulanan terapi ve rehabilitasyon çalışmalarına bu tür bilişsel onarım müdahalelerinin eklenmesi önerilmektedir. Gelecekte oluşturulabilecek aşağıdan yukarıya bilişsel onarım müdahale programlarında teknolojik imkanlardan faydalanılması, müdahalelerin süresi ve yoğunluğunun artırılması, motivasyon konusunun göz önünde bulundurulması ve müdahalelerin günlük yaşama entegrasyonunun sağlanabilmesinin etkililik, sürdürülebilirlik ve maliyet açısından önemli olduğu düşünülmektedir.
Anahtar sözcükler: Şizofreni, bilişsel onarım, işlevsellik, aşağıdan yukarıya yaklaşım, bilişsel rehabilitasyon

Introduction

The view of schizophrenia as a cognitive disorder dates back to a hundred years ago, with the definition of schizophrenia as "dementia praecox", that is, "cognitive impairment that begins at an early age" (Kraepelin 1919, Kaneko and Keshavan 2012). Since then, the treatment of positive symptoms has continued to be one of the main goals of treatment, and the primary benefit of most antipsychotics has been the relief of positive symptoms (Adcock et al. 2009). With the treatment of positive symptoms, it has been observed that cognitive and functional deterioration continued independent of positive symptoms (Keefe et al. 2006). In addition, individuals in the first stage of psychosis have been found to have neurocognitive impairments of similar profile and magnitude to those found in later stages (Heinrichs and Zakzanis 1998, Mesholam-Gately et al. 2009).

Address for Correspondence: Rukiyye Meryem Osmanoğlu, Hasan Kalyoncu University, Graduate School of Education, Department of Clinical Psychology, Gaziantep, Türkiye **E-mail:** rmsoydemir@gmail.com
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Cognitive deficits are also observed in the prodromal phase preceding the onset of the first episode; individuals who are at clinically high risk for psychosis show a general cognitive deficit in addition to specific impairments in the areas of verbal memory and executive function (Lencz et al. 2006). Unaffected first-degree relatives of schizophrenia patients show a pattern of cognitive deficits similar to the patients, indicating that patients' cognitive impairments are not secondary only to schizophrenia symptoms (negative and positive symptoms) or treatment (Cannon et al. 1994, Heydebrand 2006). In other words, cognitive impairments in schizophrenia are a phenomenon that needs to be handled on its own, independent of negative symptoms, positive symptoms, and treatment side effects (Kaneko and Keshavan 2012). While first-generation antipsychotics can relieve the positive symptoms of schizophrenia, they appear to have a low-to-moderate effect on cognitive performance. Second-generation antipsychotics have also been found to have low-to-moderate effects on cognitive performance (Mishara and Goldberg 2004, Keefe et al. 2007, Davidson et al. 2009, Hill et al. 2010).

Cognitive deficits in schizophrenia are independent of positive symptoms and moderately related to negative symptoms and are among the most important causes of problems that may arise in terms of employment, independent living, social and community functioning. Negative symptoms and cognitive deficits together explain a significant part of the problems with functioning in schizophrenia (Ventura et al. 2009, Strassnig et al. 2018). The link between cognitive performance and functioning was found to be stronger than the link between psychosis symptoms and functioning (Green et al. 2000, 2004, Gold et al. 2002, Fett et al. 2011). Many findings support that neurocognition predicts more variance in almost all areas of social functioning than many symptoms and other clinical factors (Milev et al. 2005, Bowie et al. 2006, 2008, 2010). Therefore, it is a critical research priority for the literature to identify treatment modalities that improve cognition and thus reduce the functional losses of daily life associated with schizophrenia. In this study, (1) the scope and the effects of neurocognitive deficits in schizophrenia, (2) cognitive remediation interventions in schizophrenia, (3) bottom-up cognitive remediation interventions, (4) interventions related to cognitive remediation applied in Türkiye and their importance in terms of occupational and social and daily life functionality of schizophrenia patients will be discussed. Then, in this context, future intervention programs and the feasibility of these programs will be discussed.

Neurocognitive Deficits, Social Functioning, and Related Interventions in Schizophrenia

Neurocognitive deficits in schizophrenia are studied by neuropsychological test batteries, electroencephalography (EEG), and functional magnetic resonance imaging (fMRI) (Best and Bowie 2017). Eight areas of cognitive impairment in schizophrenia have been identified by the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS), seven of which are; (1) processing speed, (2) attention/vigilance, (3) working memory, (4) verbal learning and memory, (5) visual learning and memory, (6) reasoning and problem solving, and (7) verbal comprehension are defined as neurocognition, while the eighth is (8) social cognition (Green et al. 2004). Neuropsychological tests indicate that in addition to motor skills, attention, spatial skills, language ability, memory and executive functions, a general cognitive impairment is seen in schizophrenia. A meta-analysis study indicates that the area with the most impairment (within the scope of neurocognition) is verbal memory (Heinrichs and Zakzanis 1998). In addition, it was found that deterioration in verbal memory stood out as a differentiating factor between those who remained in a risk state and those who turned into psychotic disorder (Lencz et al. 2006). The other two areas with the most deterioration were found to be processing speed and working memory (Gebreegziabhere et al. 2022). Impairments in social cognition, on the other hand, were found to be the strongest predictors of impairments in functioning within these eight cognitive impairment domains (Fett et al. 2011, Cowman et al. 2021, Kharawala et al. 2022).

In fMRI studies, it was observed that the activation of the dorsal lateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC) was reduced in individuals with schizophrenia. DLPFC activation is associated with cognitive task performance, and ACC is responsible for monitoring task performance and dynamically adjusting DLPFC activation to meet task demands. In addition to decreased activation in DLPFC and ACC, schizophrenia was associated with increased activation of other prefrontal cortex regions (e.g., ventral lateral prefrontal cortex). This indicates dysfunctional distributions in frontal network processing (Minzenberg et al. 2009).

EEG results showed evidence of abnormalities in early sensory processing in schizophrenia. When the second of the two paired auditory stimuli is presented, sensory gating, defined as suppression in the amplitude of P50 (positive deviation that occurs 50 ms after stimulus onset), has been shown to be consistently impaired in schizophrenia (Atagun et al. 2020). In addition, when auditory stimuli are initiated, the decreases in the N100 component, observed in patients with schizophrenia, indicate a problem with sensory processing (Rosburg

2018). Similarly, individuals with schizophrenia show mismatch negativity (MMN), a reduced brain response to novelty, when an abnormal auditory stimulus is added to a sequence of predictable and repetitive auditory stimuli. MMN anomalies indicate context-dependent anomalies in auditory information processing and auditory sensory memory. MMN deficits are considered as a clinically useful biomarker in the context of schizophrenia, helping to predict the course of the disease and treatment response (Kasai et al. 2002, Umbricht and Krljes 2005, Erickson et al. 2016, Biagianti et al. 2017, Haigh et al. 2017). Anomalies in MMN have been found to predict social, occupational and daily life functionality better than other neurocognitive models and measures (Wynn et al. 2010, Lee et al. 2014).

The concept of recovery in schizophrenia refers to clinical recovery and functional recovery especially in the context of social functioning. According to recent findings, about half of people with the diagnosis of schizophrenia show improvement or significant improvement in the long term. These findings are promising for functional recovery. There are many factors that predict recovery in schizophrenia. These include demographic, clinical and therapeutic characteristics and socioeconomic variables. Antipsychotics are one of the main elements of the treatment of schizophrenia, but their support with psychosocial interventions is considered important for clinical course and functional recovery. In this context, psychosocial interventions and rehabilitation interventions should become part of the standard treatment of schizophrenia as evidence-based practices (Vita and Barlati 2018).

A range of evidence-based cognitive and psychosocial therapies have been established to help patients with schizophrenia manage their symptoms, improve their social functioning, maintain a healthy lifestyle, and find meaningful work (Dixon et al. 2010, Fisher et al. 2013, Mueser et al. 2013, Bowie et al., 2020). Individuals with schizophrenia can be detected when they are at risk. Sometimes interventions are initiated after the first-episode psychosis and continued after the support system (Fisher et al. 2013, Mueser et al. 2013). Cognitive Behavioral Therapy (CBT) has been shown to help people with schizophrenia adhere to medication, cope with auditory hallucinations and other psychotic symptoms, cope with stress, develop social skills, and maintain their jobs (Wykes et al. 2008). Social interventions aim to prevent occupational problems, enhance social functioning, raising awareness and support systems by family psychoeducation and prevent traumatization. CBT and other social interventions mostly focus on auditory-verbal and social cognitive rehabilitation (Wykes et al. 2008, Mueser et al. 2013, Thomas et al. 2014, Knott et al. 2020). Cognitive impairments can directly affect daily functioning, as well as indirectly affect how well a person responds to rehabilitation programs (Fu et al. 2017). In terms of addressing cognitive impairments, cognitive remediation programs based on the principle of neuroplasticity have been established (Fisher et al. 2013, Thomas et al. 2014).

Cognitive Remediation in Schizophrenia

Cognitive remediation programs are computer- or human-based methods that aim to restore cognitive abilities and help manage negative and positive symptoms. Cognitive remediation is defined as a behavioral training intervention that aims to increase functioning by targeting cognitive deficits (attention, memory, executive functions, social cognition, or metacognition) using learning principles (Bowie et al., 2020). The effectiveness of cognitive remediation is enhanced when it is presented in a context that is supportive and offers the opportunity to extend to everyday functioning (real-life context). Cognitive remediation has been found to be effective for cognitive and behavioral improvement in individuals with schizophrenia, early-onset schizophrenia, and individuals high-risk for schizophrenia (Penadés et al. 2006, McGurk et al. 2007, Fisher et al. 2013, Kambeitz-Ilankovic et al. 2019, Prikken et al. 2019, Lejeune et al. 2021). Interventions mostly focus on the auditory-verbal and socio-cognitive areas, which are considered to be the most impaired areas. (Penadés et al. 2006, Adcock et al. 2009, Smith et al. 2009, Fisher et al. 2009, 2013, Popov et al. 2011, Sacks et al. 2013,). Meta-analysis studies show that cognitive remediation is effective in improving cognitive skills in many areas, including processing speed, working memory, and learning (McGurk et al. 2007, Wykes et al. 2011, Cella et al. 2020). Cognitive remediation refers to a wide range of interventions aimed at enhancing the functioning of patients with schizophrenia by improving patients' neurocognitive abilities (Best and Bowie 2017). Cognitive remediation applications are roughly divided into (1) bottom-up approaches and (2) top-down approaches according to therapeutic goals. Since it is not possible for targeted therapeutic interventions to activate only one system in the brain, these phrases are named in reference to the primary therapy goal of the intervention (Adcock et al. 2009).

Bottom-up approaches argue that sensory processing deficits exist in patients with schizophrenia, that they are the root of impairments in higher-order cognitive activities, and that sensory processing impairments should be addressed specifically (Adcock et al. 2009). These neuroplasticity-based applications have been shown to

improve auditory-verbal abilities (auditory-verbal memory, auditory-verbal working memory, auditory-verbal learning) (Fisher et al. 2009) and auditory neural responses (M100) assessed by magnetoencephalography (MEG) (Adcock et al. 2009, Dale et al. 2010) and sensory gating (M50) (Popov et al. 2011) in schizophrenia. These neurocognitive-based auditory training approaches have also been shown to restore prefrontal functions and higher-order cognition (Biagianti et al. 2016, Dale et al. 2016). Bottom-up-based training for auditory, visual, and social cognitive processes has improved working memory function and permanently improved cognition and functionality in people with schizophrenia (Subramaniam et al. 2014).

Top-down methods are based on the assumption that focusing on training of complex capabilities will simultaneously engage and train component processes such as attention and processing speed. Top-down cognitive remediation interventions were associated with cognitive functioning in patients with schizophrenia with increased activation in the prefrontal cortex and in regions that support attention and working memory (Haut et al. 2010, Bor et al. 2011).

In order for cognitive remediation practices to result in permanent social functional changes, it is important that they are applied over a period of time (Kaneko and Keshavan 2012). For example, a meta-analysis of cognitive remediation in schizophrenia found that increased training hours were associated with a greater effect size on verbal learning and verbal memory (McGurk et al. 2007). It suggests that the relatively low intensity and short duration of some cognitive remediation studies to date may explain the fact that the lasting and significant benefits of cognitive remediation have not yet been fully documented in meta-analyses (Vinogradov et al. 2012).

It is argued that cognitive remediation approaches are more effective when they start "bottom-up" with simple exercises and progress to more complex tasks (top-down) (Kaneko and Keshavan 2012). In patients with schizophrenia, deficits in basic perceptual skills have been shown to predict difficulties in performing more complex cognitive operations (Van Merrienboer and Sweller 2005, Dale et al. 2010, Leitman et al. 2010). In this context, there is an increasing emphasis in the literature on the idea that trainings that target basic sensory processes and simple cognitive functions will ultimately contribute to higher-level cognitive processing and thus to social cognition and social, occupational and spiritual functioning (Adcock et al. 2009, Javitt 2009a, Kaneko and Keshavan 2012, Luo et al. 2021).

It should not be forgotten that the application of cognitive remediation applications under optimal conditions, specific to the needs of the individual, encorperated with other treatment and rehabilitation approaches, will contribute to increases in general, occupational and social functioning (Yıldız 2021). Factors contributing to the effectiveness of cognitive remediation practices include intervention at an early age, having relatively better cognitive functioning indicators before the application, high motivation, positive affect, having a lower level of positive symptoms, use of medication that support cognitive processes, conducting the applications with the active support and guidance of the therapist (as an alternative to being only computer-based), additional interventions that support cognitive development (e.g., exercise, rehabilitation, and cognitive-behavioral therapies), application of additional neuromodulation interventions (e.g., transcranial magnetic stimulation) (Tripathi et al. 2018, Lejeune et al. 2021).

Compared to other commonly used treatments for schizophrenia, cognitive remediation has been shown to have better effects on outcome measures of occupational, social, and mental functioning. Compared to pharmacotherapy and CBT in terms of social functioning, psychotherapeutic cognitive remediation appears to elicit a change almost twice as large (Penadés et al. 2006, Best and Bowie 2017). While CBT and pharmacological interventions for the treatment of schizophrenia have been widely funded and utilized, support for cognitive remediation is much more limited, despite outstanding results on functioning in everyday life. It is thought that cognitive remediation may support functional recovery more than current other supportive treatment options and should be more widely adopted in the treatment of schizophrenia. It is crucial to expand the use of cognitive remediation practices in treating schizophrenia, with a focus on prioritizing and intensively applying bottom-up approaches within these interventions. (Javitt 2009a, Kaneko and Keshavan 2012, Best and Bowie 2017).

Bottom-Up Cognitive Remediation in Schizophrenia: Sensory Training Interventions

Bottom-up sensory training interventions in schizophrenia have been developed based on findings that disruption of processes in early sensory regions significantly impairs the type and complexity of information available for subsequent processing. According to this: (1) Impairments in P50, N100 and MMN indicate auditory sensory processing problems in schizophrenia. (2) fMRI and EEG studies indicate visual sensory processing impairments that lead to difficulties in motion perception, object recognition, and reading (Javitt

2009a, 2009b). The potential higher-order consequences of these fundamental perceptual deficits include: (1) in auditory sensory deficits, challenges with phonetic processing, prosodic processing (a complex interpretive process involving elements like pitch, word stress, pauses at key syntactic points, and lengthening of final syllables near boundaries), emotion recognition, and certain attention issues related to speech; and (2) in visual sensory deficits, difficulties with motion perception, visual completion (identifying objects from partial information), face recognition, and interpreting facial expressions (Javitt 2009a). These bottom-up outcomes were found to be directly related to outcomes for social functioning (Sergi and Green 2003, Kawakubo et al. 2007, Light et al. 2007, Javitt 2009a). Therefore, bottom-up cognitive remediation is seen as a logical first step in improving cognitive and functional difficulties. For example, social cognition is closely related to the ability to interpret facial expressions and tone of voice (Leitman et al. 2005, 2007, 2010). If patients are unable to process faces correctly or the pitch changes that allow them to interpret tone of voice due to early visual deficits, then it will be difficult to try to improve social cognition with a top-down approach (Javitt 2009b).

In one study, intensive auditory training applied with the bottom-up method was found to be more effective than cognitive training intervention applied with the top-down method for sensory gating, verbal learning and memory (Popov et al. 2011). In a meta-analysis study, the effectiveness of bottom-up sensory cognitive remediation interventions in the literature were examined among 25 clinical studies. It was observed that only 5 of these 25 randomized controlled trials included visual training, while the vast majority of the studies focused on auditory training. In addition, almost all the clinical studies examining the effectiveness of auditory training used the Brain Fitness program of Posit Science. In the study, it was concluded that sensory development interventions are effective in high-level general cognitive areas such as verbal learning, verbal memory, processing speed, working memory, problem solving, and attention. Higher-level cognitive improvements were usually observed towards the end of the studies or during follow-up measurements. Of the 18 studies that measured functional outcomes, only 3 reported positive improvements in social and occupational life (Donde et al. 2019). On the other hand, improvements observed in verbal skills and general cognition, especially the improvements of the neural systems supporting verbal cognition indicate sensory training programs improve social cognitive functions and may support social and psychological functioning in the long term. (Vinogradov 2009). It is also considered important that sensory training interventions are supported by top-down cognitive remediation approaches as well as various psychosocial approaches so that the sensory gains from the interventions are transferred to daily life (Best and Bowie 2017, Star 2021).

When current meta-analysis studies on cognitive remediation are examined, it is seen that only seven of the 67 studies included in a meta-analysis study studied cognitive remediation from bottom to top (Altman et al., 2023). Of the 36 studies included in another meta-analysis study, three were bottom-up cognitive remediation studies (Seccomandi et al., 2020). Again, it is seen that at most one-tenth of the 143 studies included in a comprehensive and up-to-date meta-analysis study are related to the bottom-up cognitive remediation study (Vita et al., 2021). Based on the findings of the literature, it can be said that approximately one out of every ten cognitive remediation studies conducted is a bottom-up cognitive remediation study.

Although top-down cognitive remediation interventions involve many types of programs and modalities (e.g., clinician, computer, mobile app, virtual reality) (Alvarez-Jimenez et al. 2014, Ben-Zeev et al. 2014, Rus-Calafell et al. 2018, Thomas et al. 2019, Schroeder et al. 2022), most bottom-up cognitive remediation programs that offer cognitive enhancement through sensory training are computer-based and conducted with the same software (Donde et al. 2019). In this context, it is important to develop and disseminate new intervention programs. In addition to such computer-based applications, applications based on tablets, virtual reality applications, and phone applications will increase accessibility and sustainability, while helping to reduce costs (Rus-Calafell et al. 2018, Thomas et al. 2019). It has been observed that the positive cognitive effects demonstrated in sensory enhancement studies decrease in the long term. Lifelong sustainability is important in these programs.

Overall, this section emphasizes the importance of sensory deficits and bottom-up cognitive remediation interventions in the general cognitive impairment in schizophrenia in the context of social functioning in schizophrenia. It is thought that if patients perceive and process the world around them distinctively, they will create distinctive reactions. Therefore, optimal cognitive remediation interventions in schizophrenia require the development of not only metacognitive mechanisms but also sensory-perceptual mechanisms. Researchers and clinicians should be aware of the impact of these early deficiencies on patients' ability to interact effectively with the complex world that surrounds them, and they should be concerned about the effective treatment and rehabilitation of such deficiencies (Adcock et al. 2009, Javitt 2009a). It is predicted that the inclusion of more elements of daily life in intervention programs will increase the effectiveness of the intervention. Hence, there is a need for interventions that are life-embedded, daily and sustainable.

Bottom-Up Cognitive Remediation Interventions in Schizophrenia in Türkiye

Programs carried out to increase social and mental functionality for individuals with schizophrenia in Türkiye include psychosocial rehabilitation studies (Arslan et al. 2015), individual or group cognitive behavioral therapy as well as other psychotherapy applications (Mortan 2009, Kaygusuz et al. 2015, Bilgin and Özaslan 2018, Yıldız 2019, Çapar Çiftçi 2021), psychoeducation practices about medication and illness (Duman et al. 2007), social skills training (Aşik 2016), family psychoeducation (Polat 2020), vocational rehabilitation (İncedere and Yıldız 2021, Yılmaz 2021), occupational and art therapies (Ünlü and Ünlü 2017, Spring 2023). Occupational therapy practices carried out in Türkiye include practices that aim to integrate schizophrenia patients into society from an anti-stigmatization perspective. Daily living activities and social life activities are among the methods frequently used by occupational therapists. In addition, the studies of occupational therapists on improving cognitive abilities such as attention, memory, orientation and praxis brings positive results. Occupational therapists, in cooperation with the family, carry out environmental and activity modifications, considering the needs and wishes of the individual (Üstünkaya and Asqaraova 2023).

The studies on social skills training practices (Yıldız et al. 2002, 2004), which can be considered among the firsts in the field in Türkiye, can be given as an example of top-down cognitive remediation studies conducted in Türkiye. A study that aims to improve social cognition and functionality through culturally adapted video training is another good example top-down cognitive remediation study. In the study, it was observed that targeting social cognition with video training strategies (top-down cognitive remediation) was more effective than therapeutic intervention that helped people integrate their life stories (Gürcan et al. 2021). Increasing studies on such cognitive remediation programs by utilizing technological advances is thought to be important in the context of addressing functionality in patients with schizophrenia.

On the other hand, when the literature is examined, there is no study on bottom-up cognitive remediation in schizophrenia in Türkiye. The programs currently implemented contribute to the top-down cognitive training of individuals with schizophrenia. However, impairments in bottom-up sensory processes are crucial the cognitive elements that need to be addressed. Addressing cognitive impairments in the sensory domain is expected to increase the effectiveness of other intervention programs (Adcock et al. 2009, Sacks et al. 2013, Best and Bowie 2017). Bottom-up sensory development studies can be applied together with the current interventions and new intervention programs can be developed in this regard. In the literature, intervention practices have begun to emphasize the use of technology and cognitive remediation (Fisher et al. 2010, 2015, Sacks et al. 2013, Firth et al. 2016, Lejeune et al. 2021, Vita et al. 2021, Schroeder et al. 2022). It is recommended to develop and disseminate such applications in Türkiye.

Conclusion

Recovery in schizophrenia is closely related to neurological cognition, social cognition, negative symptoms, positive symptoms, and their functional outcomes. Therefore, it is important to assess these variables in developing effective rehabilitation interventions. Many psychosocial and behavioral interventions have proven effective (e.g. cognitive remediation in reducing the effects of cognitive impairments; social skills training in reducing the effects of negative symptoms; psychoeducation in increasing adherence to treatment and preventing relapses; cognitive behavioral therapies in reducing the severity or stress associated with positive symptoms). All these interventions aim to support the healing process by promoting active empowerment in individuals with schizophrenia (Morin & Franck, 2017).

Neurocognitive deficits are rated as the strongest predictor of social functioning for people with schizophrenia (Green et al. 2000, Gold et al. 2002, Fett et al. 2011, Harvey et al. 2022), and cognitive remediation refers to a variety of behavioral interventions designed to improve neurocognitive abilities and increase functionality (Adcock et al. 2009, Best and Bowie 2017). cognitive remediation programs may vary depending on the goal of the intervention and the modality in which the treatment is delivered. cognitive remediation can target perceptual skills in a "bottom-up" training perspective, executive function skills in a "top-down" training perspective or improve cognitive skills in general (Kaneko and Keshavan 2012, Best and Bowie 2017, Tripathi et al. 2018).

In the literature, more than 140 cognitive remediation studies have been conducted so far in clinical and rehabilitation practices, and it is seen that there is a general trend towards cognitive remediation practices (Wykes et al. 2011, Mueser et al. 2013, Lejeune et al. 2021, Vita et al. 2021, Onitsuka et al. 2022). Research shows that cognitive remediation practices are effective in improving higher-order cognition, basic sensory

processes, and ultimately social functioning in patients with schizophrenia. Previously, it was thought that the observed sensory impairments in schizophrenia may be due to impairments in higher-order cognition (Frith 1979, Blakemore et al. 2000). Currently sensory impairments are targeted with bottom-up interventions. However, it is seen that such studies remain in the minority, approximately one out of every ten studies (Seccomandi et al. 2020, Vita et al. 2021, Altman et al. 2023).

In Türkiye, currently, there are no cognitive remediation studies conducted with bottom-up interventions. It is predicted that the development of cognitive remediation studies that can be developed by taking inspiration from the findings and suggestions obtained in the literature and their integration to the currently applied therapy and psychosocial support studies will contribute to the daily life, social and occupational functioning of schizophrenia patients (Bowie et al., 2020).

Research shows that individuals with schizophrenia have preserved their basic selective attention mechanisms. However, when tasks require a high degree of top-down control, they fail at attention tasks. It is seen that individuals with schizophrenia can exhibit intact performance in implicit memory and implicit gradual learning tasks. On the other hand, it is seen that they have difficulties in procedural learning, learning with positive reinforcement and generalizing the information learned with positive reinforcement (Gold et al. 2009). It is important to create bottom-up sensory training cognitive remediation programs taking these issues into account.

Daily living skills mediate the relationship between cognitive deficits and functioning. This means that cognitive remediation may be associated with improvements in functioning to the extent that it affects daily living skills. In addition, negative symptoms and depression in schizophrenia are associated with functioning independent of cognitive deficits. Therefore, while cognitive remediation program CRs are promising in helping with functionality, they may not be enough to improve functionality on their own. In order to increase functioning in schizophrenia, it is necessary to adopt a comprehensive treatment strategy that includes the treatment of negative and emotional symptoms, including skill acquisition (Bowie & Harvey, 2006).

Therapy, rehabilitation, and cognitive remediation programs targeting social, occupational, and mental functioning in patients with schizophrenia are difficult to access in clinical settings due to a variety of reasons, including the lack of practitioners trained in these methodologies, the lack of funding for psychological interventions, and the low level of participation and continuity in treatments, even when they are available (Bowie and Harvey 2006, Berry and Haddock 2008, Drake et al. 2009, Mojtabai et al. 2009, Kazdin and Blase 2011, Thomas et al. 2014). To compensate for this, as technology advances, online, social media, and/or mobile technology interventions (Granholm et al. 2012, Alvarez-Jimenez et al. 2014, Ben-Zeev et al. 2014, Firth et al. 2016), virtual/augmented reality and brain/computer interfaces (Fernández-Caballero et al. 2017, Jahn et al. 2021, Rus-Calafell et al. 2018, Schroeder et al. 2022), computerized cognitive auditory training modules (Adcock et al. 2009, Dale et al. 2010, Keefe et al. 2012, Sacks et al. 2013, Thomas et al. 2014, Fisher et al. 2015), computerized social cognition training (Sacks et al. 2013, Thomas et al. 2019, Schroeder et al. 2022), neurofeedback training (Hirano and Tamura 2021) have been developed. However, most interventions are clinical-based and costly, involve expensive equipment, are available for a limited time, and are not accessible to everyone (Thomas et al. 2014, 2019, Fernández-Caballero et al. 2017, Rus-Calafell et al. 2018).

There are also some issues with participation, volunteering, dropouts, and the intrusive nature of some practices. Mobile-based interventions have proven to be highly practical, but continuity is voluntary and may not be sustained for life. Based on these, it can be said that cost, accessibility and sustainability are major problems that researchers and practitioners face in developing and studying bottom-up cognitive remediation programs. The development of cost-effective, lifelong, non-intrusive, adaptable, engaging, sustainable approaches that improve cognitive functionality and reduce social functional losses in schizophrenia is an important research goal (Adcock et al. 2009, Dixon et al. 2010, Kazdin and Blase 2011, Rus-Calafell et al. 2018, Thomas et al. 2019).

Bottom-up sensory training cognitive remediation interventions to be developed need to take these issues into account as well. It is thought that thanks to current technological advances, bottom-up cognitive remediation interventions can become more economical, motivating and sustainable than it was ever possible before. It is thought that the use of computer-based, virtual reality-based, mobile/tablet application-based interventions in the development of sensory training cognitive remediation interventions is important in terms of budget and sustainability. In addition, it is recommended to develop interventions that are suitable for and transferrable to daily life with considering motivational factors as well.

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