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REVIEW

Cognitive Remediation in Schizophrenia

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Abstract Cognitive deficits are routinely evident in schizophrenia, and are of sufficient magnitude to influence functional outcomes in work, social functioning and illness management. Cognitive remediation is an evidenced-based non-pharmacological treatment for the neurocognitive deficits seen in schizophrenia. Narrowly defined, cognitive remediation is a set of cognitive drills or compensatory interventions designed to enhance cognitive functioning, but from the vantage of the psychiatric rehabilitation field, cognitive remediation is a therapy which engages the patient in learning activities that enhance the neurocognitive skills relevant to their chosen recovery goals. Cognitive remediation programs vary in the extent to which they reflect these narrow or broader perspectives but six meta-analytic studies report moderate range effect sizes on cognitive test performance, and daily functioning. Reciprocal interactions between baseline ability level, the type of instructional techniques used, and motivation provide some explanatory power for the heterogeneity in patient response to cognitive remediation.

Keywords Cognitive remediation · Cognition · Psychiatric rehabilitation · Schizophrenia · Cognitive dysfunction

Introduction

Cognitive impairment is a core symptom of schizophrenia that is fully evident at the time of first episode and most pronounced in the areas of attention, verbal memory and executive functioning. While 70–80% of people with schizophrenia show cognitive impairments relative to the general population, close to 100% have cognitive deficits relative to their own premorbid ability level (Gold 2008; Heinrichs and Zakzanis 1998; Wilk et al. 2004). Cognitive impairments in attention, verbal memory and executive functioning have been shown to have prognostic value, in essence predicting whether a person with schizophrenia will be able to meet functional goals (Green et al. 2004). In schizophrenia, impaired cognition has consistently been associated with poor social problem-solving and difficulty in benefiting from rehabilitation services. Psychosocial skills training is intended to teach basic life skills like social interacting, illness management, independent living and leisure skills. People who have more severe attention problems have difficulty acquiring skills in these programs (Bryson and Bell 2003; Kurtz et al. 2008a; Silverstein et al. 2001; Sitzer et al. 2008). They may find it hard to process and remember the information given in groups, and they may not be able to sustain attention for the duration of the sessions.

Cognitive deficits also make it difficult to succeed at work, school and daily living tasks. Most jobs require people to multi-task and prioritize information, and schoolwork requires memory, organization and attention. People with attention and memory problems struggle with independent living tasks, such as remembering appointments, keys and where important items were placed. Problem-solving deficits can affect the ability to organize one's living space so that things are easily found and can make it difficult to maintain a budget and negotiate public transportation.

As awareness of the impact of cognitive deficits on functional outcome has grown, increasing efforts have been devoted to developing behavioral treatments for cognitive impairment. Some of the initial studies addressed whether

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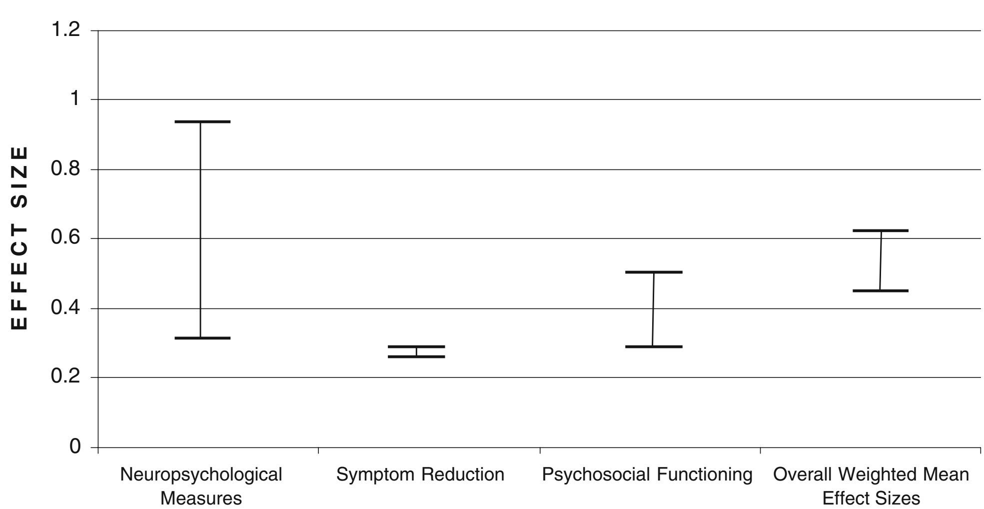
learning capacity in schizophrenia is in fact malleable. This question was approached by examining whether it was possible to train patients on specific tasks such as the Wisconsin Card Sorting test (WCST), where improvement in card sorting in response to sorting instructions was taken as evidence that people with schizophrenia can indeed learn new skills (Bellack et al. 2001; Choi and Kurtz 2009; Green et al. 1992; Kern et al. 1996). As evidence mounted for the large effect sizes for training to task (Kurtz et al. 2001), attention shifted to developing behavioral interventions to target the several cognitive deficits that impact functional outcome. These interventions, known as cognitive remediation (CR), are intended to help people develop the underlying cognitive skills that will make them better able to function in daily tasks, including school, work, social interactions and independent living. For example, the goal may be to help someone become more attentive so that they can better focus on schoolwork, household, or job responsibilities. Much inspiration for treating cognition in schizophrenia came from the field of rehabilitation with neurologically impaired populations. That rich literature has been reviewed elsewhere (eg Cicerone et al. 2005; Rohling et al. 2009) and is beyond the scope of the present article which will instead focus on treatment for cognition in schizophrenia.

Overview of Cognitive Remediation

A number of approaches to remediating cognition in schizophrenia have been developed and studied in the last 15 years. This literature has been reviewed in six meta-analytic studies, which while differing in focus, have with the exception of one (Pilling et al. 2002), all found moderate to large effect sizes (Krabbendam and Aleman 2003; Kurtz et al. 2001; McGurk et al. 2007b; Suslow et al. 2001; Twamley et al. 2003). Not surprisingly, the effect sizes found in these meta-analytic studies varied in accordance with the goal of treatment (See Fig. 1). When the studies had a highly proximal goal of improvement on a training task, the effect size was large. When the goals of training became more distal, and accordingly influenced by a multiplicity of variables, the effect sizes diminished. Still, moderate range effect sizes were found both for cognitive remediation studies that used neuropsychological test results as an outcome measure, and for the studies with the most distal goal of improving daily functioning. Taken together, this literature informs us that improvement in the cognitive performance of people with schizophrenia may generalize both to neuropsychological test performance and to daily activities that require those cognitive skills.

Demonstrating that cognitive remediation can have an immediate beneficial effect on cognition and daily functioning is, however, just the beginning step in identifying and understanding this as an evidenced based treatment. Considerable research has and continues to be devoted to deconstructing mechanisms of action, persistence of effect, heterogeneity of response, dosing variables and feasibility of wide spread dissemination (Kurtz et al. 2007). Answers to some of these questions have emerged. We know for example that remediation effects are durable up to at least 6 months after the therapies are withdrawn, particularly in terms of executive ability, working and verbal memory (Bell et al. 2007b; Hodge et al. 2008; Hogarty et al. 2006; Medalia et al. 2002). Importantly, these neurocognitive gains translate to improvements in social behaviors and symptoms (Wykes et al. 2003), real-world problem-solving ability (Medalia et al. 2002) and occupational outcome (Bell et al. 2007b; Fiszdon et al. 2004; Hodge et al. 2008; McGurk et al. 2005). Schizophrenia patient populations amenable to remediation programs range from acute care and institutionalized settings (Medalia et al. 2000), supportive housing (Medalia et al. 2003), intensive day treatment programs (Bellucci et al. 2003; Kurtz et al. 2004), outpatient VA treatment (Fiszdon et

Fig. 1 The range of weighted mean effect sizes in outcome domains pre-post cognitive remediation. Based on meta-analytic studies providing weighted mean effect sizes: Krabbendam and Aleman 2003; Kurtz et al. 2001; McGurk et al. 2007a, b; Twamley et al. 2003



al. 2005), first-episode psychosis (Gopal and Variend 2005), to people in vocational rehabilitation programs (Bell et al. 2007b; McGurk et al. 2007a). The most recent empirical research suggests that integrating cognitive remediation with other methods of psychiatric rehabilitation (supported employment, social skills training, etc.) may be more effective than individual approaches in achieving overall psychiatric rehabilitation (Bell et al. 2007a; Greig et al. 2007; Spaulding et al. 1999; Wexler and Bell 2005). Indeed, compared with work therapy alone, work therapy programs incorporating cognitive remediation have maintained vocational benefits (more likely to work, held more jobs, worked more weeks, worked more hours and earned more wages) even at 3-year follow-up (McGurk et al. 2007a).

Differing Approaches to Cognitive Remediation

There are different approaches to doing cognitive remediation. Some programs work with one person at a time, using paper and pencil tasks or a specific set of computer exercises. Other programs work with small groups of people, doing verbal and/or computer based exercises. Even within the group based approaches there are differences in whether the whole group does the same task, or each person works at his or her own pace on an individualized program. Verbal group discussions can offer strategies to compensate for deficits, such as using calendars, or the group discussions may emphasize metacognitive processes like learning style. Some group approaches provide exercises to restore a skill, such as problem-solving exercises (Revheim and Marcopulos 2006).

Most CR programs exclusively use one cognitive training software package that may or may not target more than one cognitive skill. At least one CR program takes advantage of the ever increasing array of computer-based cognitive exercises being developed for educational settings and people with psychosis, dementia, or normal age-related cognitive decline (Medalia et al. 2009). Since it can be challenging to identify cognitive exercises that are best suited for a given population and setting, it is helpful to have software selection guidelines. There is a rubric for evaluating software exercises that takes into account not only what cognitive skill is being targeted but also how the exercise does this (Medalia et al. 2009). For example, this rubric considers whether the software exercise is likely to be engaging and motivating, level of difficulty, immediacy and quality of feedback, in addition to whether it targets memory, attention or other cognitive skills.

A few programs employ a coach who organizes living or work environments to be more usable for a cognitively impaired person. This coach may also accompany the patient into the community to observe and guide application of cognitive skills to vocational, educational and social situations. There is tremendous variability in the instructional techniques used—whether peer support or leadership is a feature, whether one or several cognitive processes are targeted and whether the program is "one size fits all" or individualized to fit a given cognitive profile. Frequency of sessions can range from one to 10 hourly sessions a week, while the duration of active treatment typically lasts 3–6 months but can range from several weeks to 2 years, depending on the treatment setting, goals and/or severity of deficits. The relative efficacy of different dosing schedules remains unresolved. Ultimately, each approach to CR may require a different treatment intensity to be effective.

Heterogeneity of Response to Cognitive Remediation

Against this backdrop of evidence to support the use of cognitive remediation is considerable heterogeneity of response to the intervention. Statistically, the distribution of individual study effect sizes reported by reviews in this literature is noticeably homogeneous, with consistent effect sizes ranging from small (d=0.20) to very large (d=1.20). Nevertheless, treatment response to training varies significantly as a function of intervention type and a host of treatment implementation factors. Patients enrolled in remediation programs that focused on strategy learning specific to a certain cognitive skill show slightly greater neurocognitive benefit (d=0.52) compared to rehearsal training programs or programs which focus on the repetition of a series of domain specific exercises (d=0.34) (Krabbendam and Aleman 2003). Therapist qualification, patient baseline work habits, treatment intensity and patient motivation are other apparent moderators which can differentiate those who improve on neuropsychological outcome measures (Medalia and Richardson 2005). Interestingly, contrary to expectations, dosage of sessions does not seem to play a significant role in outcome analysis. Remediation groups receiving on average a total of seven sessions compared to groups receiving as much as a total of 33 sessions share similar training effects (Krabbendam and Aleman 2003), thus illustrating the complexity of delineating factors involved in treatment response.

Nevertheless, understanding the reason for this heterogeneity of response provides an opportunity to identify the factors that might maximize the effectiveness of cognitive remediation. For example, identification of instructional techniques or patient variables that affect treatment outcomes would allow programs to refine their approaches. In this regard it is useful to conceptualize cognitive remediation as a learning activity where people learn to pay attention, to problem solve, to process information quickly and to remember better. Considered from this vantage point, it becomes important to consider the factors that mediate how people learn , so that the heterogeneity of response to cognitive remediation can be better understood. The educational literature may be particularly informative regarding learning a cognitive skill as opposed to a behavioral skill. Educational psychology has made significant contributions to our understanding of how people learn, the conditions under which they learn optimally and the best strategies for effective teaching. Whereas it was once thought that learning is directly correlated with cognitive ability (Cronbach and Snow 1977), it is now recognized that learning results from an interaction of at least three factors, one which is ability and the others are instructional techniques and motivation (Schunk and Zimmerman 2008) (See Fig. 2). It is informative to use this model of reciprocal interactions to understand the heterogeneity of response to cognitive remediation. In the following sections we review how each arm of the reciprocal interactions triangle contributes to a positive cognitive remediation experience for people with schizophrenia.

Instructional Techniques and Cognitive Remediation Outcomes

Cognitive remediation programs are diverse in the instructional approaches they use, and there is evidence that this impacts the success with which they treat cognition. In addition to differentiating rehearsal versus strategy learning programs, as noted above, one of the primary distinctions among various programs involves the underlying core approach to addressing cognitive deficits. Restorative approaches to cognitive remediation attempt to repair impaired cognitive skills directly by using drill and practice exercises, whereas compensatory remediation techniques do not attempt to restore the impaired cognitive skill but rather to compensate for or circumvent the deficit with reliance on intact cognitive skills and environmental and prosthetic supports. Manualized compensatory cognitive training programs (Velligan et al. 2000) often use interventions that promote adaptive behavior in a specific setting (i.e. home, residential facility) by using aides such as instructional calendars and tailored medication containers, or by teaching strategies for remembering tasks and objects (Maples and Velligan 2008). The primary objective that guides this line of intervention is overall rehabilitation, and the outcomes in

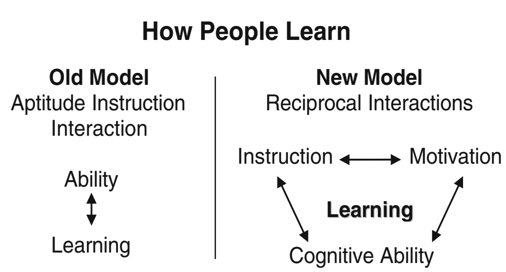


Fig. 2 Model of reciprocal interactions to understand the heterogeneity of response to cognitive remediation in schizophrenia

efficacy trials are measured by functional gains more than neuropsychological performance.

By contrast, recovery models are based on neural plasticity and premises of actual restoration of once compromised neural processes. These neuroscience-based programs entail drill and practice on tasks intended to exercise relatively isolated cognitive skills, with the aim of strengthening or resuscitating neuroanatomical connections linked to core neuropsychological abilities (Lindenmayer et al. 2008; Wexler et al. 2000). Although the restorative model takes into consideration functional gains, in its pure form there is a lack of accompanying interventions oriented to the application of newly developed cognitive skills to real world settings, and the process of automatic generalization is assumed. Restorative models often gauge outcome by task-related neural activation of specific brain regions and normalization of task performance. In functional neuroimaging studies to determine whether there are concomitant brain activation changes as a result of engaging in restorative-based cognitive training, results demonstrated that normalized performance gains following memory training were correlated with increases in task-related activation of the frontocortical areas, particularly the left inferior frontal cortex (Wexler et al. 2000; Wykes et al. 2002). Normalized performance on memory tasks were associated with increased task-related activation of the same brain region that is activated during memory tasks in healthy individuals (Wexler et al. 2000).

Another theoretical axis involves the directional approach to the training curriculum. Although the eventual performance goal is identical, the remediation curriculum can take either a sequential or parallel approach to the objective (Delahunty et al. 1993; Velligan et al. 2006). “Bottom-up” programs gradually progress through a hierarchy of abilities from the so-called elementary cognitive domains of basic attention, reaction time and working memory, to more complex executive abilities such as abstract reasoning, sequencing and problem-solving (Kurtz et al. 2007; Rund and Borg 1999). “Top-down” programs initiate executive exercises from the onset, arguing that basic foundation domains such as attention are being trained simultaneously along with more frontal abilities, and that tasks that simultaneously engage multiple cognitive processes better prepare the patient to use their cognitive skills in real life situations (Medalia and Richardson 2005).

Remediation programs are further delineated by differing treatment parameters, such as whether the instructional techniques promote engagement and motivation to learn (Medalia and Choi 2009) or whether they use computer-based exercises versus training tasks exclusively on paper and pencil (Wykes et al. 2007b). This leads to further dissection, as most computer-based remediation programs are conducted in a relatively cost-effective group format which promotes the advantages of peer facilitators and corrective social interactions, whereas paper-and-pencil training programs are usually conducted individually with a premium on therapist-patient rapport and extensive, ongoing individual feedback. The final axis draws a distinction in how a computer-based curriculum is implemented within a group or individual format. As mentioned previously, there is a wide array of pre-packaged software titles, mostly for use in group treatment settings with a single therapist but also for individual use at home. These packaged software programs provide step-by-step trials and a situated regimen of tasks each based on the preceding step. This ensures a measured learning algorithm to achieve training goals as dictated by the software and the learning principles invested in the software package. In contrast, there are computer-based training programs which allow greater clinician and patient mediation to inform the training process. In sacrificing the measured learning algorithm, this approach ideally allows for a more personalized, flexible and tailored curriculum based on individual or group merits.

Although there is modest evidence to support the use of strategy-based learning instead of mere drill and practice exercises to improve cognition (Krabbendam and Aleman 2003), there is a paucity of empirical data that addresses the relative benefits of one instructional approach over another, particularly in terms of ease and efficacy of dissemination to community based programs. Most of the validated remediation programs to date fall somewhere along these spectrums, incorporating multiple approaches and techniques for patient populations with diverse baseline abilities and treatment settings. For example, a recently developed compensatory intervention provides cognitive training in an outpatient group setting where patients learn and repetitively practice hierarchical “bottom-up” compensatory strategies that emphasize habit learning (Twamley et al. 2008).

Ability Level and Cognitive Remediation Outcomes

Until the mid 20th century, intellectual ability level was thought to be the primary predictor of how much and how quickly people learned in an educational setting. Educational systems used IQ tests to classify students as “slow” versus “gifted” learners, and instructional techniques varied mainly in the quantity and pacing of material presented. The emphasis on ability level as a primary determinant of learning changed as it was recognized that instructional techniques and motivation also play a significant role, but ability level is still recognized as an important predictor of learning outcomes (Schunk 2000, 2004).

It stands to reason then, that pre-treatment ability level could also predict learning outcomes in the setting of cognitive remediation. The degree to which a person is cognitively impaired at the start of cognitive remediation may affect ease of learning a task, which in turn could affect time spent practicing the needed skill and promote frustration and dampen motivation for engaging in CR. Furthermore, the more pervasive impairments found among lower-functioning patients may make learning compensatory strategies difficult. In neurologically impaired populations Given the variability in cognitive functioning in patients diagnosed with schizophrenia, the question of whether and how baseline ability predicts response to CR, is of interest.

There have been a handful of studies that examined whether and how ability level impacted the amount of improvement people with schizophrenia made in cognitive remediation. Typically this would be manifested by a demonstrated effect of baseline performance on the amount of change in cognition that occurs. Researchers have attempted to identify subgroups differentiated by IQ or cognitive profile to manufacture baseline predictors of cognitive remediation response and generalization of the effects to performance-based instrumental-life skills. One study reported that while baseline processing speed, working memory and immediate recall did not predict response to CR, baseline delayed verbal memory performance did differentiate remediation improvers and non-improvers in one of three CR trials (Medalia and Richardson 2005).

It is not only the type of baseline cognitive impairment but also the extent of baseline deficit that predicts response to CR. Fiszdon et al. (2006) found that patients with baseline impairments limited to attention and executive function had a different treatment response from patients with additional impairments in memory and patients with global deficits encompassing language and visual processing deficits. Although all patient subtypes benefited from a 6-month course of drill-and-practice cognitive remediation incorporated in a work therapy program, the patient group with global baseline cognitive deficits benefited from remediation the most by achieving remarkable increases in cognitive task normalization. However, this globally impaired group had difficulty generalizing these noticeable gains to untrained tasks while those less impaired were more successful in generalizing their training.

In longitudinal studies designed to identify which specific baseline cognitive skills predict the capacity to benefit from a year of computer-assisted cognitive remediation and psychiatric rehabilitation, regression models revealed that sustained auditory attention, working memory and verbal learning were essential to benefiting from remediation and improving on performance-based measures of everyday life skills despite controlling for crystallized verbal intelligence (Kurtz et al. 2008a, b). These findings, as a whole, offer support for the consideration of baseline ability in developing and implementing cognitive remediation strategies.

Motivation and Cognitive Remediation Outcomes

The third arm of the triangle of reciprocal interactions is motivation and, more specifically, intrinsic motivation. In the context of a learning environment, intrinsic motivation refers to the desire to engage in a learning activity because it is inherently interesting and engaging. This contrasts with extrinsic motivation, which refers to the motivation to learn because a tangible extrinsic result will occur, for example a prize or money. Considerable research indicates that in a learning environment, intrinsic motivation is associated with greater learning, higher performance persistence, more creativity, higher self-esteem and sense of well-being, and greater engagement in surroundings (Deci and Ryan 2008; Vansteenkiste et al. 2004). Extrinsic motivators, on the other hand, can decrease the amount of learning that takes place, and educators are thus advised to use them judiciously (Dweck 1986; Dweck et al. 2004; Elliot and Dweck 2005).

If one assumes that people with schizophrenia will learn like students without schizophrenia, then in the setting of cognitive remediation, intrinsic motivation should enhance learning outcomes. This is in fact supported by two studies that found dramatic differences in effect size when participants in a cognitive remediation program were divided into high and low intrinsic motivation on the basis of their voluntary, frequent attendance at the program (Choi and Medalia 2005; Medalia and Richardson 2005). Participants in community-based cognitive remediation programs have the option to attend or not, and regular attendance can thus be used as a measure of intrinsic motivation. Both studies found large effect sizes on an untrained clerical task of processing speed for the intrinsically motivated group. By contrast, the participants who were not intrinsically motivated achieved a very small effect size on this outcome measure.

The impact of intrinsic motivation is not limited to neuropsychological outcomes. A recent paper clearly illustrates how intrinsic motivation mediates the impact of neurocognition on psychosocial outcome. Nakagami et al (2008) examined the nature of the relationships among neurocognition, intrinsic motivation, and psychosocial functioning in 120 schizophrenia patients enrolled in outpatient psychosocial rehabilitation. They found that intrinsic motivation strongly mediated the relationship between neurocognition and psychosocial functioning, and this mediation was evidenced by the direct path from neurocognition to functional outcome no longer being statistically significant after the introduction of intrinsic motivation into their latent construct modeling. Interestingly, neurocognition did not influence the relationship between intrinsic motivation and psychosocial functioning, suggesting that intrinsic motivation is vital to strategies for improving functional levels for individuals with schizophrenia.

Given the role of intrinsic motivation in learning, it becomes important to consider the physiological and social contextual variables that can enhance or diminish it. This understanding can then be used to inform the instructional techniques used in a cognitive remediation program, which should in turn enhance the effectiveness of the treatment and improve the ability to disseminate it to community settings where extrinsic motivators like subject reimbursement are not operative. Schizophrenia is associated with a physiologically based decrease in motivation, a symptom which is present in variable degrees in patients, and will influence whether they in fact initiate and then sustain learning behaviors. Investigations by Berridge have highlighted the key function that the dopamine system plays in motivation and reward-seeking behaviors in schizophrenia (Berridge 2004). In Berridge's framework, deficits in dopamine function can lead to disruptions in incentive drives related to the attainment of rewards in task-learning, even if the hedonic response to that reward is intact. This is especially relevant given the predominant view of dopaminergic disturbances in the pathophysiology of schizophrenia. Medication is variably successful at targeting avolition, a negative symptom state that can sometimes be quite severe (Olie et al. 2006); thus it is all the more crucial to consider the social contextual factors that also serve as determinants of intrinsic motivation.

In an educational setting, the social contextual variables that affect intrinsic motivation to learn are manifested as interpersonal context, instructional techniques and the general learning environment. Interpersonal context refers to the relationships between teacher and student and between students and the nature of these interpersonal contexts has been shown to affect attainment of learning goals (Schunk 2000, 2001; Schunk and Pajares 2005). Controlling social contexts that pressure people through the use of incentives, deadlines and authoritarian commentary reduce a sense of autonomy, self-determination, and motivation (Ryan and Deci 2000). Moreover, controlling social contexts result in greater passivity, decreased persistence in learning activities and poorer learning (Grolnick and Ryan 1987; Vansteenkiste et al. 2004). Conversely, social contexts that minimize the salience of external incentives, avoid controlling language and acknowledge the learner's individuality, are more likely to enhance intrinsic motivation, test performance, amount of learning and sense of well-being (Black and Deci 2000; Vansteenkiste et al. 2004).

These principles also apply to people with schizophrenia and arguably to all patients enrolled in rehabilitation programs

(Anthony 2008; King et al. 2007). Indeed from a psychiatric rehabilitation perspective, the relationship between the CR therapist and patient is a key factor in responsiveness to treatment, and creating an autonomy supportive environment would be consistent with the empirically based principles that ground the psychiatric rehabilitation field. Patients in psychiatric rehabilitation programs who are involved in setting their own goals have greater chances of achieving their goals (Anthony et al. 2002; King et al. 2007), a finding that highlights the merits of autonomy supportive treatment environments.

In cognitive remediation programs, autonomy-supportive environments are learning environments where the instructor supports and guides the student's interests and emerging desire to learn, as opposed to administering a generic program of learning. The role of the clinician is not simply to oversee the completion of a prescribed generic template of tasks, say a particular software program given to everyone, but to observe, assess and guide in the use of exercises specific to the individual's needs (Medalia et al. 2009). There is emerging empirical evidence that intrinsic motivation to learn is enhanced in an autonomy supportive CR environment, where people with schizophrenia are allowed to exercise some control over their learning experience, the value of the activity is evident, and opportunities for demonstrating competency exist (Choi and Medalia 2009).

Instructional techniques are another social contextual determinant of intrinsic motivation to learn. There are a number of instructional variables that enhance intrinsic motivation such as personalization, choice and contextualization, that can be embedded into a specific activity or into the overall treatment plan. Contextualization means that rather than presenting material in the abstract, it is put in a context whereby the practical utility and link to everyday life activities are made obvious to the client. For example, in attention remediation, a decontextualized focusing task would require the person to press a button every time a yellow circle appears on the otherwise blank computer screen. A contextualized focusing task would require the person to assume the role of a train conductor in a task which simulated the experience of responding to a track signal. Personalization refers to the tailoring of a learning activity to coincide with topics of high interest value for the client. For example, if the person likes to travel, he is more likely to enjoy a problem solving task that has him negotiating the challenges that arise when driving a delivery truck, rather than doing a task which teaches problem solving by requiring identification of like-colored objects among an array of shapes. Personalization also refers to the learner entering into the task as an identifiable and independent agent, for example signing in by name or assuming a role (stock broker, detective, or musician) in a task that simulates a real world activity.

Learner control refers to the provision of choices within the learning activity, in order to foster self-determination. In memory training, this occurs when the client can choose task features like difficulty level or presence of additional auditory cues when doing a visual memory exercise. Learner control can also be provided by structuring the sessions so that the participant has opportunities to choose their learning activity, as opposed to being told what they have to work on. The numerous software activities available that effectively target specific cognitive skills afford many opportunities to provide participants choice and personalized learning experiences.

Although it was initially unclear if people with schizophrenia responded to these same social contextual and instructional variables as students without schizophrenia, research now indicates that they do. By *contextualizing* the cognitive task into a meaningful game-like context, *personalizing* incidental features of the learning process and providing activity *choices* during the task, adults with schizophrenia acquired more cognitive skill, possessed greater intrinsic motivation for the task as measured by the Intrinsic Motivation Inventory, reported greater feelings of self-competency and demonstrated better attention resource allocation post-treatment than subjects randomized to a condition where these instructional techniques were not used (Choi et al. 2009). This study indicates that people with schizophrenia do indeed have a motivational system which is malleable, and responsive to the same social-contextual cues reported to enhance intrinsic motivation to learn in normals (Cordova and Lepper 1996).

The cognitive remediation literature provides more evidence that people with schizophrenia respond to the same social contextual instructional approaches as unaffected people. The Neuropsychological Educational Approach to Remediation (NEAR) program, which is predicated on the reciprocal interactions model of learning, and uses the above-referenced techniques to enhance motivation, has been found to be effective at treating cognition and easily disseminated (Medalia et al. 2009). For example, in a multi-site community study in Australia, NEAR was noted to be a "readily available, motivating, time effective group intervention", which was easily disseminated into three early intervention outpatient facilities, two chronic inpatient rehabilitation centers and four community outpatient programs. In this wait list controlled study which evaluated treatment outcomes, participants in the program evidenced and sustained significant improvements in memory, sustained attention, executive functioning, and social and occupational outcome at post-test and 4-month follow up (Hodge et al. 2008).

Taking the Model of Reciprocal Interactions into Practice

The model of reciprocal interactions has considerable explanatory powers for understanding the heterogeneity of response to cognitive remediation. It also provides a framework for designing effective cognitive remediation programs. For example, the literature on the role of ability level in response to CR suggests that programs will be most effective if they adapt to meet the differing needs of patients with global versus circumscribed baseline levels of cognitive impairment. Patients with more global baseline deficits do not readily generalize or transfer their cognitive gains to real-world settings (Fiszdon et al. 2006; Kurtz et al. 2008a) suggesting that they will require specific interventions to achieve the goal of functional improvement. These more globally impaired patients may require more time in CR, a greater range of tasks at the low level of difficulty so that they have multiple opportunities to exercise the cognitive skill, and importantly, ample opportunity to receive coaching on how to use the cognitive skill in specific real life situations. The use of contextualized tasks may also be particularly important for these more impaired patients (Cordova and Lepper 1996).

There are a number of ways that a cognitive remediation program can address intrinsic motivation and thereby enhance learning. The learning activities themselves can be designed to be engaging or intrinsically interesting and motivating, so that the person will want to continue the activity. This is particularly relevant to dissemination, since a cognitive remediation program that uses activities that are not engaging may find it difficult to disseminate to clinic situations where there is no extrinsic motivation, like research subject payment, for participating. The overall structure of the sessions can also be designed to enhance intrinsic motivation. For example, treatment approaches that are tailored to individual needs as opposed to following a rigid protocol will allow the person to more readily appreciate the relevance of the tasks for their particular situation. Linking the cognitive remediation program to overall rehabilitation goals like work, socialization or independent living is another way to make clearer the relevance and utility of participation in the program. The expectancy value theory of motivation (Eccles and Wigfield 2002) posits that people will be more intrinsically motivated if they value the tasks as engaging and fun, and as useful to reach their goals. When cognitive remediation is seen as having utility value, in essence value for helping a person achieve his or her recovery goals, the participant will be more intrinsically motivated to learn, and will also learn more.

Generalizing Gains from Cognitive Remediation to Functional Ability

The definitive purpose of cognitive training is not simply to improve neuropsychological test scores but to generalize improvements to enduring real-world application (Medalia and Lim 2004, Silverstein and Wilkniss 2004). The eventual query that always arises in any method or system developed in this field is: what is the mechanism(s) that moves the acquired cognitive gains to non-trained cognitive and functional domains? (Kurtz et al. 2008a; Velligan and Gonzalez 2007; Wexler and Bell 2005) Theories and investigations of generalization can be found in all facets of remediation treatments from neuroscience, motivational research, psycholinguistics, to psychosocial treatments for severe mental illness (Barch 2005; Deng et al. 2008; McGurk et al. 2007b), as the intention is not to merely improve a specific skill or symptom but to ascertain the impact of how that specific skill or symptom contributes to an overarching behavioral goal. The human brain is hard-wired to acquire information and make it readily available for cross-modal, -domain, -hemispheric, -situational information processing, as is evidenced in the example of associative memory systems in language morphology (Carter and Werner 1978; Joanisse and Seidenberg 1999; Shuell 1986). Our ability to survive and evolve depends on the ability to generalize, internalize and apply information to various contexts, and therefore this "transferred learning" is rapid, efficient and automatic. However, in people with compromised brain function such as schizophrenia or autism, the learning disability encompasses a generalization deficiency, so acquired information is stagnant within a single task or domain (Bellack et al. 2001; Berger et al. 1993; Prior 1979). Therefore, generalization, which is an automatic process in healthy individuals, requires specific, targeted, interventions in individuals with schizophrenia.

When patients make task-specific cognitive gains from repeated drill and practice executive training trials in set shifting and sequencing, the intent is for the changes in frontal ability to translate to everyday or novel undertakings such as organizing bills or delineating the steps involved in applying for competitive employment. However, this level of generalization does not always occur (Fiszdon et al. 2006; Kurtz et al. 2008a). Therefore, many cognitive remediation programs supplement training tasks by conducting therapy sessions, separate or integrated into the remediation curriculum, that seemingly facilitate the transfer of cognitive gains toward more functional abilities. There are various names for the interventions used to facilitate generalization, including bridging, social information processing, generalization therapy, cognitive enhancement training and modeling training. All attempt to parlay training-specific improvements into a larger arena of functional domains using a wide spectrum of instructional techniques ranging from group dynamics to individual attention, peer feedback to therapist comments, immediate connection for learned exercises to delayed connection between task and behavior, and task specific recollection to entire session review. Certain remediation programs focus specifically on metacognitive or social skill strategies integrated into the training tasks themselves to promote generalization (Roder et al. 2006; Wykes et al. 2007a). Interestingly, although a number of studies that incorporate these generalization techniques into cognitive remediation programs have shown modest efficacy in improving functional outcomes (Bell et al. 2007b; Hodge et al. 2008, McGurk et al. 2007a; Medalia et al. 2001; Twamley et al. 2008), there is no empirical literature to date that validates the individual contribution of these generalization techniques as a means to promote functional gains from cognitive remediation. That is, at this point it is not known whether generalization techniques themselves are efficacious, drill and practice remediation training by itself is insufficient to change functional abilities, or remediation and generalization procedures mutually provide a synergic functional advantage. There is obvious face validity in incorporating generalization techniques and clinicians are generally receptive to implementing techniques or therapy sessions that link training tasks to more real-world application for their patients. However, this remains an undertaking in need of methodical evaluation in order to systematically dismantle the active components of cognitive remediation.

Conclusion

Cognitive remediation is an evidenced based practice for people with schizophrenia and psychotic disorders, which can be narrowly defined as consisting of a set of cognitive drills or compensatory interventions designed to enhance neuropsychological functioning. While it is a behavioral intervention that targets cognition, CR differs from other cognitive behavioral interventions in both focus and methodology. CR targets the neuropsychological processes that underpin thought, whereas other cognitive behavior therapies target the form and content of thought (e.g. attributional style, paranoid ideas). CR focuses on neuropsychological functioning with the intent of improving role functioning in daily life. The premise is that when attention, memory and executive functioning improve, a person will be better able to function in their role as student, worker, friend and roommate.

Given the ultimate goal of improving role functioning, CR can be more broadly defined as a psychiatric rehabilitation intervention. The field of psychiatric rehabilitation has a relevant knowledge base that can inform the conceptual and empirical developments in cognitive remediation (Medalia et al. 2009; Anthony 2008), and place it more squarely in the realm of a therapy as opposed to a series of exercises. Psychiatric rehabilitation ties interventions to functional goals; a technique has also been used in cognitive remediation, as when for example the exercises are linked to vocational goals. Psychiatric rehabilitation also emphasizes the importance of engagement, therapeutic relationship, environmental supports and self-determination, all factors which may be important for cognitive remediation outcomes.

Current approaches to cognitive remediation vary in the extent to which they reflect narrow or broader perspectives on the goal of treatment. There is also considerable heterogeneity of response to the treatment. The model of reciprocal interactions between baseline ability level, instructional techniques and motivation was offered to explain the heterogeneity of response to CR, and to provide a framework for designing even more effective cognitive remediation programs. While many questions remain about dosing, the relative merits of instructional techniques, the value of booster sessions and bridging groups, and the profiles of patients who respond best, there is convincing evidence that cognitive remediation can offer substantial and lasting benefits for the cognitive deficits seen in schizophrenia.

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