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ORIGINAL ARTICLE

The Role of Executive Cognitive Functions in Changing Substance Use: What We Know and What We Need to Know

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Abstract
Background Executive cognitive functions (ECF) have been linked to skills such as planning, organizing, problem solving, decision-making, initiating and self-regulating behavior, working memory, and motivation; critical activities needed to monitor and change substance use behavior.
Purpose The purpose of this study is to investigate how ECF may impact important variables associated with changing substance use behavior.
Methods This study is a critical review of the extant literature about how ECF may influence substance abuse treatment outcomes and behavior change.
Results A review of the literature found evidence that poorer ECF likely hinders substance use behavior change and is often associated with behavior labeled as denial. However, the relationship between ECF and substance abuse appears to be highly complex.
Conclusions Traditional methods of substance abuse assessment, interpretation of behavior, and intervention may need to be reconsidered in light of new research about executive cognitive dysfunction. Implications for future research are discussed.

Keywords Executive cognitive functions · Substance abuse · Alcohol abuse

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Introduction

Executive cognitive functions (ECF) have been associated with the ability to monitor and change behavior. Executive cognitive functions facilitate people to engage in thoughtful goal-driven activities and include important behaviors such as planning, organizing, problem solving, decision-making, initiating and self-regulating behavior, working memory, and motivation and have been linked to complex cortical circuits that involve the frontal lobes and other areas of the brain [1]. In addition, there is evidence that ECF are associated with emotion regulation processes [2, 3]. Planning, organizing, problem solving, behavioral and emotional self-control, online memory, and motivation are necessary to change substance use.

Adults diagnosed with alcohol dependence have been found to have measurable executive cognitive deficits when compared with normal controls [4–6]. Severity of opiate dependence has significantly predicted greater task shifting disabilities associated with executive cognitive dysfunction [7]. Polysubstance abuse has also been linked to ECF deficits such as disinhibition, task shifting disabilities, and problems with decision making and processing of new information [8]. A study that investigated people with alcohol dependence found a significant relationship between ECF function and emotional discomfort, suggesting a link of ECF with emotion dysregulation [9]. Other researchers have found evidence that emotional processes associated with ECF and identification of risk may be compromised among people with substance abuse [10]. Some people with substance dependence have decision-making problems, perhaps contributing to an inability to predict negative outcomes from seeking immediate gratification [11, 12].

Researchers also have linked ECF deficiencies with substance abuse among adolescents and young adults.

Problems with self-regulation have been identified as a risk factor for problem drinking among youth [13]. Attention problems predicted by greater substance abuse over an 8-year period may have represented a barrier to learning skills necessary to cope effectively after treatment [14, 15]. Evidence of executive cognitive dysfunction also was found among heavy-drinking college students [16, 17].

Young adult drinkers, including college students [18], tend to progressively mature out of heavy and risky binge drinking as they age into their early to middle 20s. The maturing-out phenomenon has been linked to assuming greater responsibilities, such as partnering and marriage, having children, and beginning a career [19]. Interestingly, the maturing-out process seems to occur at the same time as critical brain functions associated with ECF maturation. A meta-analysis of studies investigating ECF across adolescence and early adulthood found evidence that planning skills continue to improve into adulthood [20]. Cognitive functions related to behavioral control when completing specific tasks mature into the mid-20s [21]. Adolescents have been found to use ECF processes less frequently when making risky decisions under experimental conditions than adults, suggesting that risk-assessment abilities may continue to mature into adulthood [22]. Additionally, prospective memory, or remembering to act or respond appropriately when a particular situation arises, has been associated with ECF maturity that continues into adulthood [23]. It seems to be more than coincidences that young adults are maturing out of alcohol abuse at the same time the ECF are reaching maturation. On the other hand, societal expectations related to assuming adult roles and responsibilities seem to be at least partially associated with maturing-out behavior [18, 19].

When executive cognitive deficits are identified among people abusing substances, it is generally difficult to sort out whether they represent the consequences of substance abuse or a pre-existing vulnerability for developing substance abuse. For example, prenatal exposure to alcohol has been found to predict executive cognitive deficits among young children that adversely affect interpersonal and coping skill development [24], and researchers have found that executive cognitive dysfunction persists into adulthood among people exposed prenatally to alcohol [25]. In a large study of adolescents investigating a number of suspected risk factors for subsequent development of substance use disorders, an ECF variable related to self-regulation of behavior, poor response inhibition, was found to significantly predict (along with family history of alcohol abuse and conduct disorder) substance abuse among adolescent participants [26]. It has been suggested that problems with self-regulation of behavior may be associated with the loss of control common to addictive behaviors [27]. Among young adult drinkers, binge patterns have been associated with difficulties with pattern recognition and spatial working memory [28]. Greater experience of aversive drinking-related consequences [29] and greater reports of drinking intentionally to intoxication [30] among young adults have been linked to poor ECF.

Another study found a significant relationship between ECF and cognitive biases toward alcohol word cues on a go/no-go experimental task among participants with poly-substance abuse including alcohol [31]. Similar findings have been published concerning participants who abused cocaine in a go/no-go task that involved cocaine-related cues [32]. Research suggests that intact ECF may be important for behavioral self-control during exposure to substance related cues in the environment.

Interventions for Change and ECF

Patients often enter treatment with cognitive deficits that may interfere with acquisition of new information needed to reduce or abstain from substance use. Some cognitive problems will improve naturally after cessation, but there is evidence that problem-solving disabilities persist after clients abstain from alcohol [33, 34], and although some recovery may be possible, it tends to be relatively slight at least during the first 6 weeks [35]. At 6 months of abstinence from alcohol, ECF can remain impaired, especially among older adults [36]. Interestingly, opioid-dependent clients on methadone had fewer perseverations, indicating better ECF than clients recently tapered from methadone [7], suggesting that acute withdrawal also may adversely ECF.

Unfortunately, treatment professionals have been poor at identifying patients with cognitive impairment [37]. In addition, treatment services rarely provide services to address cognitive impairment, including executive cognitive dysfunction. Even empirically supported treatment models have been slow to recognize and address potential executive cognitive dysfunction as a matter of normal practice. The following sections review research examining ECF and their relationship to commonly practiced and empirically supported therapies for substance abuse.

Twelve-Step Therapy

Very little is known about ECF and its relationship to outcomes in traditional Minnesota Model treatment facilities or even with regard to participation in traditional 12-step groups. Twelve-step facilitation therapy is an empirically supported intervention used in Project MATCH [38]. Twelve-step facilitation therapy includes a standardized treatment manual; however, the manual is not being commonly used by treatment centers across the country in

the delivery of services. Twelve-step facilitation therapy incorporates steps 1–3 of Alcoholics Anonymous into the core of the program, which focus on teaching acceptance of powerlessness over alcohol, how alcohol has made one's life unmanageable, and how trust in a higher power can restore balance and health; active participation in support groups, and other social interactions promoting sobriety; and psycho-education about the family disease model. These processes may have the effect of improving awareness and promoting self-regulation of behavior. The therapy has been associated with modest gains in ECF recovery 15 months post-treatment leading to speculation that peer and family support as well as a style of the therapy that uses learning through repetition and problem solving techniques such as breaking down larger goals into smaller negotiable steps may be helpful to promote abstinence and ECF recovery [39].

Cognitive-Behavioral Therapy for Substance Abuse

Cognitive-behavioral therapy (CBT) often includes behavioral monitoring and skills training that are meant to improve awareness, attention and concentration, planning, organizing, problem solving, and self-regulation of behavior [40]. However, little research has been conducted to determine if improvements in these ECF occur among patients engaged in CBT. Concern has been expressed that cognitive therapy techniques, in particular, may not be effective with patients who have cognitive deficits [41], implying that behavior therapy may be preferred under the circumstances. However, ECF outcomes among CBT patients have not been sufficiently investigated to understand what may be effective. Interestingly, a reexamination of Project MATCH data suggests participants with low self-efficacy (see ECF and self-efficacy below) may have benefited from CBT [42].

Relapse prevention, an evidence-based CBT [43, 44] to maintain substance use changes over time, includes impulse control, problem solving, decision-making, and emotion regulation strategies [45]. Addressing critical executive functions among patients with cognitive impairment may promote better outcomes, but the relationship of ECF and relapse prevention have not been examined empirically. Relapse prevention also includes meditation techniques (see following), which may be potentially helpful to patients with executive cognitive dysfunction.

Meditation

Meditation has been used effectively to reduce substance abuse among social drinkers [46] and to reduce recidivism and substance abuse among people who are incarcerated [47]. Meditation is a key component to relapse prevention therapy [48, 49]. Meditation teaches mindfulness skills that may improve awareness and attention–concentration and promote behavioral self-regulation. Meditation practices appear to aid patients in honing distress tolerance, emotion regulation, and attention skills and offer a spiritual alternative to 12-step approaches. Research findings have linked meditation practice to ECF. A comprehensive review of the literature examining brain function by means of EEG, fMRI, and ERP studies found evidence that frontal and prefrontal cortical areas of the brain were activated while engaged in meditation and that meditation was associated with increased attentional processes [50]. People who had engaged in meditation regularly had greater thickness in cortical brain matter in areas associated with attention than case-matched controls who did not meditate [51]. Meditation may be efficacious in treating addictive behaviors because of its ability to enhance ECF processes such as self-regulating behavior and emotion and improving attention and concentration.

Other Treatment Findings

In addition to the findings concerning specific-treatment modalities, other study findings have found that people with executive cognitive dysfunctions may have better outcomes in inpatient rather than outpatient care [52] or when placed in therapy that focuses on the "here and now" such as a Yalom-type interaction group [53]. Interestingly, executive cognitive dysfunction may not necessarily lead to poor treatment outcomes regardless of the treatment modality being utilized [54].

Cognitive Rehabilitation Strategies

Cognitive rehabilitation strategies have been used with some success among people being treated for substance abuse. The most common method uses mental exercises to restore cognitive function. Roehrich and Goldman [55] used this style of cognitive rehabilitation by means of a self-guided workbook as part of a relapse prevention program and found that clients in the program had better cognitive improvements than those in control conditions during 28-day inpatient treatment. Fals-Stewart and Lucente [56] used a computerize self-administered cognitive rehabilitation program and found that patients in rehabilitation had significantly cognitive recovery earlier than control or comparison conditions, but other groups tended to catch up in terms of cognitive recovery 5 months into the study. The authors suggested that cognitive recovery may be a useful adjunct to relapse prevention. Interesting, therapists rated patients in the cognitive rehabilitation condition as doing better in therapy than other participants at all time points in the study, suggesting

a treatment advantage to earlier cognitive recovery through rehabilitation; but it is unclear how effective such strategies are for improving ECF over the long-term.

Functional rehabilitation, a model for treating the behavioral disabilities created by traumatic brain injury, uses strategies that utilize intact cognitive function and promotes structured routines constructed around contextual cues to prompt appropriate behavioral responses to average daily living skills [57]. Bates and colleagues [57] suggest the functional rehabilitation model may be useful for traumatically brain injured patients, but research concerning the efficacy of this model for people diagnosed with substance use disorders is lacking.

Predictors of Substance use Change and ECF

Evidence exists that better ECF may improve chances to change substance use. For example, better attention and concentration abilities modestly predicted drinking reductions over a 3-month period among participants not seeking treatment [58]. However, the relationship of ECF to other predictors of substance use, such as expectancies, motivation to change, self-efficacy, and use of coping skills is not well understood. What is known is reviewed below.

Outcome Expectancies

Outcome expectancies, or expectations about the perceived effects of using substances, have been associated with changes in substance use behavior (e.g., [59, 60]). Reduction of substance use may be associated with decreased positive and increased negative substance-related expectancies [61–65]. Executive cognitive functions may be associated with substance use outcome expectancies [30, 66], and they also seem to be associated with attentional biases toward alcohol-related cues among heavy college-student drinkers [67].

Motivation to Change

Motivation to change has been identified as a key variable predicting substance use behavior change [68, 69]. In addition, better performance on ECF measures has predicted greater motivation to change substance use among people with severe co-occurring mental disorders [70] and college students [16]. A dissertation study by Blanchard [71] found evidence that ECF may moderate the relationship of motivation with successful outcomes after treatment completion.

Increased motivation to change substance use has been associated with increased awareness of the desirability to change [69, 72]. Lack of awareness has been traditionally referred to as denial about substance related problems by some clinicians. Interestingly, one study examined the relationship of treatment behavior labeled as evidence of denial and neuropsychological function including ECF. The investigators found that significantly lower neuropsychological function including lower ECF performance was associated with greater evidence of denial [73]. The study findings suggest that denial may be, in part, lack of awareness associated with executive cognitive dysfunction. Some researchers have suggested that the lack of awareness identified as denial may be associated with the phenomenon of anosognosia (lack of self-awareness of cognitive deficits) [41] linked with executive cognitive dysfunction.

Self-Efficacy

Greater self-efficacy has been found to be another potent predictor of successful substance use behavior change [74, 75], and enhancing self-efficacy has been identified as a critical element in treating substance abuse [45, 72]. Executive cognitive function deficits have been associated with lower self-efficacy for negotiating high-risk drinking situations among people in treatment [76]. Indeed, an analysis of cognitive function including ECF from the large Project MATCH study found that greater cognitive problems predicted lower self-efficacy and lesser participation in therapy [77]. Researchers found that ECF moderated the relationship of self-efficacy to predict substance use frequency after treatment [76], which was replicated in a later analysis that found self-efficacy moderated and mediated substance use [77].

Coping Skills

Coping skills training is an important component of empirically supported therapies to treat substance abuse [45, 78, 79]. Evidence suggests that ECF are associated with the ability to learn new skills. One study evaluated the role of ECF and learning among people who were diagnosed with alcohol dependence and found a positive relationship between ECF performance and ability to learn perceptually. When compared to normal controls on the same learning tasks, the investigators concluded that the process of learning by the alcohol-dependent participants was less efficient and potentially more cognitively taxing than processes used by control participants [80]. Fishbein and colleagues [81] found that poorer decision-making, capacity to delay gratification and control impulses, as well as lacking awareness for personal consequences and emotions experienced by others, predicted poorer acquisition of drug prevention skills among adolescents.

New Analyses

A new analysis of previously unpublished data from a previously conducted study [58] was conducted to test

relationships of neuropsychological test scores associated with ECF to positive expectancies, motivation to change, self-efficacy, and coping skills. Whereas earlier analyses principally examined memory and alcohol use behavior, the new analyses include a variety of measures of ECF. Participants included 91 young adults aged 18–30 (M=22.27; SD=3.17) who were drinking within the last month and had concerns about drinking. A majority were male (N=55; 60.40%), white (N=67; 73.60%), college students (N=65; 71.40%), and "single" (N=73; 80.20%). Most participants met criteria for alcohol dependence (N=58; 63.70%) with the remainder alcohol abuse.

The sample was recruited by means of written advertisement in a university neighborhood. After providing informed consent, the participants completed several neuropsychological tests associated with memory and ECF, as well as measures of alcohol use behavior. A previously published manuscript from this study provides a more complete description of methods employed in the original study [58].

Measures

In this reexamination, several neuropsychological tests that have been associated with assessing ECF were used. The first was the Wechsler Memory Scale-Revised [82], a standardized test assessing memory and attention–concentration. The attention–concentration index was used a predictor variable in subsequent analyses.

The Wisconsin Card Sorting Test (WCST) [83, 84] was also used. The WCST is a standardized test that measures mental flexibility and complex problem-solving abilities amidst a set-shifting context. Perseverative errors standardized scores (repeated same response mistakes in matching the cards after being told of the incorrect response) [84] were used as predictor variables.

The Ruff Figural Fluency Test (RFFT) [85] was used as another assessment of ECF. The RFFT is a standardized test that measures problem solving, fluency of nonverbal generativity by the creation of unique designs, and cognitive flexibility. The unique designs standardized scores from the RFFT were used as predictors in subsequent analyses.

Lastly, two-timed maze tests were used that had been developed as part of a battery of mazes used to assess online problem solving abilities among people with a major mental disorder [86, 87]. The original battery included 13 mazes to be solved with a penciled line under timed conditions, with the complexity and size of the mazes gradually increasing from the first to the last. For the purposes of this study, maze 1 (simplest) and maze 13 (most complex) were used to provide maximum contrast, with time in seconds representing performance scores in subsequent analyses. The aforementioned scores were standardized to z-scores for all data analyses. The z-scores for the maze performances were not derived from standardized scores but rather from the sample results since norms have not been established.

The constructs of interest included positive expectancies, motivation to change, self-efficacy, and coping skills. The Alcohol Expectancy Questionnaire [88] is a reliable and valid instrument measuring positive expectations (PE), or expectancies, associated with alcohol. One of its subscales, positive alcohol expectancies, was used in subsequent analyses and found to have adequate internal consistency for the study (α=.788).

Motivation to change was assessed by means of the Brief Readiness to Change Questionnaire (BRTC), a self-report instrument based upon the Transtheoretical Stages of Change Model [89]. The BRTC, which has good reliability and validity [90], has three subscale stage scores based upon the Transtheoretical Model: precontemplation (P; unawareness for the need to change), contemplation (C; considering change), and action (A; actively changing behavior). The BRTC yielded a total motivation to change score determined by the adding contemplation and actions and subtracting precontemplation scores [(C + A) – P] that was used in subsequent analyses. The BRTC was found to have adequate internal consistency in this study (α=.761).

To assess self-efficacy to resist heavy drinking in high-risk situations, the Situational Confidence Questionnaire-42 (SCQ-42) was used [61]. The SCQ-42 yields a total score concerning self-efficacy for coping with 42 high-risk situations without heavy alcohol consumption, measuring confidence to avoid heavy drinking in each situation on a probability scale ranging from 0 to 100 in intervals of 20. The SCQ-42 was found to have adequate internal consistency in this study (α=.964).

The Situational Competency Test (SCT) is a brief structured interview designed to measure the quality of coping skills for imaginal high risk drinking situations [78]. The SCT asks the respondent to identify how they would react in 16 different hypothetical high-risk drinking situations. The response latency score (time to begin to verbally problem solve), the most robust predictor of drinking rates after treatment [78], was used in analyses.

Results

Zero-order correlation analyses were conducted to test the relationships of the predictor variables of the study. Three significant correlations were found. Maze 1 was significantly and positively correlated with maze 13 (r=.355; p=.001) and significantly and negatively correlated with RFFT unique designs standardized scores (r=−.221; p=.035), whereas RFFT unique designs standardized

Table 1 Forced entry linear regression model predicting total motivation to change (N=91)

Predictor variable(s)	Betas	t	95% C. I.
WCST Pers Error Standard z	−.185	−1.786	−3.000, 0.160
RFFT Uniq Design Standard z	−.020	−0.180	1.882, 1.568
Maze 1 z-scores	.284	2.587*	−0.603, 4.611
Maze 13 z-scores	−.080	−0.735	−2.898, 1.333
WMS-R Attn/Conc Index	.151	1.425	−0.483, 2.928

R^2 =.133; F(5,85)=2.619; p=.030 for the full model. Betas, t values, and 95% confidence intervals listed are for the full model

Pers Error Standard Z WCST perseverative error standardized z scores, *Uniq Design Standard Z*, RFFT Unique Designs z scores, *Attn/Conc* attention concentration index z scores

*p<.05

scores were significantly and positively correlated with WMS-R attention/concentration index scores (r=.256; p=.014). No other correlation coefficients of independent variables were found to be significant.

Multiple linear regression analyses were used to test relationships between the z-score ECF variables from the WMS-R, RFFT, WCST, and the mazes with PE, BRTC, SCQ, and SCT scores. In the first analysis, the model of WCST perseverative errors standardized, RFFT unique designs standardized, maze 1, maze 13, and WMS-R attention/concentration index z-scores accounted for approximately 6% of the observed variance in PE scores, but the model failed to reach statistical significance at the p<.05 level (R^2=.060; F(5,79)=1.014; p=.415). In addition, no variables significantly predicted expectancies in the model. In Table 1, the model of WCST perseverative errors standardized, RFFT unique designs standardized, maze 1, maze 13, and WMS-R attention/concentration index z-scores accounted for approximately 13% of the observed variance in total motivation to change scores from the BRTC (R^2=.133; F(5,85)=2.619; p=.030). Within the model, greater time scores on maze 1 significantly predicted greater readiness to change scores on the BRTC. In Table 2, the model of WCST perseverative errors standardized, RFFT unique designs standardized, maze 1, maze 13, and WMS-R attention/concentration index z-scores accounted for approximately 10% of the observed variance in total SCQ scores, but the model failed to reach statistical significance at the p<.05 level (R^2=.099; F(5,85)=1.869; p=.108). However, as seen in Table 2, greater RFFT unique design-standardized scores significantly predicted greater total SCQ scores. Lastly, in the final regression analysis, the model of WCST perseverative errors standardized, RFFT unique designs standardized, maze 1, maze 13, and WMS-R attention/concentration index z-scores accounted for approximately 2% of the observed variance in mean total latency time scores from the SCT, but the model failed to reach statistical significance at the p<.05 level (R^2=.024; F(5,83)=0.411; p=.840), and no predictors were found to be significant.

Discussion

The significant correlations indicate shared variance by some of the predictors as would be suspected but were not found to be highly correlated. The results of the regression analyses suggest that poorer ECF as assessed by maze 1, a relatively simple task of online problem solving skill, was associated with greater motivation to change among younger adults. At first glance, this finding seems contrary to previous research that found higher ECF associated with greater motivation to change [16, 70]. Perhaps awareness [69, 72] of disability to solve relatively simple problems enhances motivation among young adults in a way that more difficult tasks do not, conceivably because such a disability would be difficult to deny or dismiss, but this is highly speculative. Results should be interpreted with caution with the cross-sectional design and very modest amounts of variance accounted for by the significant predictor.

Table 2 Forced entry linear regression model predicting total SCQ scores (N=91)

Predictor variable(s)	Betas	t	95% C. I.
WCST Pers Error Standard z	.015	0.137	−131.003, 150.453
RFFT Uniq Design Standard z	.277	2.467*	36.955, 344.266
Maze 1 z-scores	−.022	−0.195	−195.962, 160.948
Maze 13 z-scores	−.085	−0.766	−261.000, 115.773
WMS-R Attn/Conc Index	−.143	−1.322	−252.835, 50.921

R^2 =.099; F(5,85)=1.869; p was not significant for the full model. Betas, t values, and 95% confidence intervals listed are for the full model

Pers Error Standard z WCST perseverative error standardized Z scores, *Uniq Design Standard z* RFFT Unique Designs z scores, *Attn/Conc* attention concentration index z scores

*p<.05

Conclusions

Substantial evidence exists that substance abuse is linked with problems with ECF. Treatment providers should assess clients for ECF deficits, which can be difficult to detect by observation alone, and adjust treatment plans accordingly. Cognitive rehabilitation strategies should be incorporated into treatment under the assumption that most patients would benefit from earlier recovery of cognitive functions. However, more research is needed in order to understand what types of rehabilitation strategies are most effective and whether there are ways to promote continued improvement in ECF over the long term. For example, investigating long-term cognitive rehabilitation as a way to promote continued ECF recovery seems warranted.

Executive cognitive dysfunction should be considered as an important client variable when individualizing therapy and treatment. Those with severe ECF impairment are likely to be relapse prone and, therefore, more likely in need of abstinence goal. If patients are unwilling to commit to long-term abstinence, then trial abstinence should be encouraged to promote some recovery of ECF in the early stages of therapy. Behavioral strategies may be more helpful than cognitive for patients with executive cognitive dysfunction, but this assumption needs to be tested. In addition, use of meditation may be useful to encourage self-regulation of behavior.

Given the links between executive cognitive dysfunction and emotion dysregulation and distress, therapy and treatment strategies emphasizing emotional self-control would likely be helpful for patients with disabled ECF. Relapse prevention and meditation [49] include skills to regulate emotions. Dialectical Behavior Therapy, an empirically supported therapy to treat Borderline Personality Disorder and highly self-destructive behavior [91], includes emotion regulation skills as a key component of the therapy [92]. Use of the emotion regulation skills component in conjunction with substance abuse therapy could be useful for clients.

Researchers and practitioners should also consider how ECF of patients impacts important predictors of behavior change, such as outcome expectancies, motivation to change, self-efficacy, and coping skills. Studying the relationship of ECF and outcome expectancies may provide clues on how to better challenge expectancies and to promote behavioral self-control in the presence of positive expectancies. Understanding these processes could potentially improve substance use interventions targeting adolescents and young adults and be incorporated into existing best practices. Better understanding how ECF may influence the awareness of problematic substance use could translate into better understanding about how to motivate behavior change. Researchers may wish to investigate the role of anosognosia among people with low motivation to change substance use, as well as how ECF impacts how people, especially adolescents and young adults, interpret risk and make decisions from cost–benefit analyses of substance use.

Further investigation is warranted on how ECF impacts self-efficacy and coping skills acquisition. Low self-efficacy and poor treatment progress and outcomes in clients should alert clinicians to the potential for executive cognitive dysfunction. We need to know more about how to improve skills acquisition and develop confidence to use the skills masterfully in high-risk situations for people with co-occurring substance abuse and executive cognitive dysfunction. In addition, it would be helpful to know more about how to prepare clients with ECF difficulties to successfully solve problems in situations with varying levels of stress and complexity.

Progress has been made to understand the role of ECF in the development of substance use disorders. However, there is much work to be done to understand how to compensate for immature ECF that contributes to risky substance use behavior among adolescents or young adults or to compensate for problems with ECF that contribute to poor therapy outcomes among people desiring to change. Collaborative efforts among experimental, cognitive, and clinical scientists are required to increase knowledge about how to improve prevention and therapy strategies with a consideration of the impact of ECF on outcomes.

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