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Association between the brief inventory of neurocognitive impairment (BINI) and objective cognitive testing among persons with opioid use disorders in drug treatment

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ABSTRACT

The current study examined the association between subjective cognitive dysfunction and objective test performance in persons enrolled in drug treatment and stabilized on methadone maintenance therapy (MMT). A total of 177 participants completed the self-reported brief inventory of neurocognitive impairment (BINI) and NIH Toolbox test battery. In participants with neurocognitive dysfunction, scores on all BINI subscales were negatively associated with objective performance on the NIH Toolbox (BINI Global r = −0.26, $p = 0.01$; BINI Subscales ranging −0.22 to −0.32, all p's < 0.03). Using cutoff scores, results showed participants who scored above the cutoff on the BINI Learning subscale demonstrated significant evidence of objective neurocognitive dysfunction on the NIH Toolbox (65% vs. 35%; $\chi^2 = 6.57$, $p = 0.02$), suggesting possible clinical utility. Future studies are needed to determine the feasibility of using the BINI to inform the accommodation of patients with specific neurocognitive profiles to optimize treatment outcomes.

KEYWORDS

Neurocognitive dysfunction; cognitive impairment; opioid-dependence; drug treatment; methadone maintenance therapy; HIV

Introduction

Neurocognitive dysfunction is common in persons with opioid use disorders (OUD), particularly on tasks of executive function, attention, working memory, and episodic memory.[1–5] Opioid-related cognitive deficits are further exacerbated by misuse of substances such as cocaine, methamphetamine, and alcohol.[1,6–13]

There is growing evidence that cognitive dysfunction in persons with OUD is associated with poorer treatment outcomes. Neurocognitive dysfunction can directly and fundamentally impact treatment outcomes, including linkage/retention in care and medication adherence.[14,15] It can also impede key contributors to treatment success, such as motivation, adherence, and strategies to reduce risky behaviors.[1,16–20] For these reasons, it is important to improve our detection of cognitive dysfunction and develop new ways to accommodate it when developing treatment approaches that target people who use drugs (PWUD).[21]

As comprehensive neuropsychological assessment is not necessary or feasible for all patients seeking treatment for OUD, alternative approaches are needed. One option is the use of brief cognitive screening tests. For example, the Montreal Cognitive Assessment (MoCA)[22] shows good discriminability[23] and good sensitivity to cognitive dysfunction in persons with substance use disorder.[24–27] Research also shows, however, that these types of paper-and-pencil measures are not routinely administered in many clinical settings due to several practical barriers.[28,29]

Another possible method for the identification of cognitive impairment in persons with OUD involves the use of self-report measures. Instruments such as the Cognitive Failures

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Questionnaire,[30] Cognitive Difficulties Scale,[31] and Prospective and Retrospective Memory Questionnaire[32] are commonly used in other patient populations to quantify an individual's experience of cognitive difficulties and/or decline.[33] Reports of subjective cognitive decline on such measures are linked to abnormalities on neuroimaging and risk of progression to dementia.[34–36] However, findings for an association between the subjective report of cognitive impairment and cognitive impairment are often mixed, with some studies showing subjective impairment is more closely associated with depressive symptoms than objective test performance.[37,38] Additionally, the relatively young age and possible anosognosia in most persons seeking treatment for OUD[39] raise concerns regarding the suitability of traditional instruments.

Members of our group recently developed a brief self-report measure of cognitive dysfunction specific to persons with OUD – the Brief Inventory of Neuro-cognitive Impairment (BINI).[40] In addition to providing a global score, the detailed factor structure of the BINI may ultimately help inform treatment decisions by targeting those behaviors most likely to be impacted by specific deficits (e.g., tailoring a reminder system for a patient with memory problems). The purpose of the current study was to examine the association between responses on the BINI and objective performance on the NIH Toolbox computerized cognitive test battery.[41] It was hypothesized that greater reported impairment on BINI would be associated with poorer performance on the NIH Toolbox, particularly in persons meeting criteria for mild cognitive impairment (MCI).

Methods

Participants

We recruited 234 participants from a larger HIV prevention study between July 2018 and October 2019. Individuals were eligible if they were: i) 18 years or older; ii) HIV-uninfected or status unknown (self-reported); iii) reported drug-related (i.e., sharing of injection equipment) risk behavior (past 6 months); iv) met DSM-5 criteria for OUD; and v) able to understand, speak, and read English. All patients were stabilized on methadone to treat their opioid dependence.

Procedure

Participants were recruited from a large addiction treatment program, the APT Foundation, Inc. (Connecticut, USA), using clinic-based advertisements and flyers, word-of-mouth, and direct referral from counselors. The program currently has over 7,000 patients on medication-assisted treatment (MAT) for OUD at five clinics. All screening, enrollment, and interview activities were conducted in a private room by trained research assistants. Individuals who met inclusion criteria and expressed interest in participating completed an informed consent process with a research assistant. Participants first completed a survey on a laptop that included socio-demographic characteristics, depressive symptoms, and BINI using an audio computer-assisted self-interview (ACASI), followed by administration of the NIH toolbox via iPad. All participants were reimbursed for the time and effort needed to participate in the survey. The study protocol was approved by the Institutional Review Board at the University of Connecticut and received board approval from the APT Foundation, Inc.

Instrumentation

Brief inventory of neurocognitive impairment (BINI)

The BINI is a 57-item self-report measure designed to assess neurocognitive dysfunction among high-risk drug users enrolled in treatment.[40] There was no time limit, but the scale took five minutes on average to complete. The nine-factor measure includes a diverse set of factors with excellent to good reliability (i.e., F_1 $\alpha = 0.97$ to F_9 $\alpha = 0.73$) ranging from generalized neurocognitive symptoms (Global Impairment) to more specific forms of impairment (Learning-related; Language-related; Memory-related; Psychomotor/Physical; Psychomotor/Perceptual; Anger-related; Pain-associated; Traumatic Head Injury-related). Given its ease of administration, sound psychometric properties, and straightforward interpretation, the BINI is designed to serve as an abbreviated instrument to screen for

neurocognitive dysfunction among patients entering or enrolled in addiction treatment and for monitoring symptoms of dysfunction over time.[40]

NIH toolbox

The NIH Toolbox for the Assessment of Neurological and Behavioral Function – Cognition was developed to assess cognitive performance across the lifespan.[41] For the current study, memory was assessed using Picture Sequence Memory Test Forms A-B, executive function/attention tasks included Flanker Inhibitory Control and Attention Test, List Sorting Working Memory Test, Dimensional Change Card Sort Test, processing speed tasks included Pattern Comparison Processing Speed Test, and language tasks included Picture Vocabulary Test and Oral Reading Recognition Test. NIH Toolbox Composite Cognition (i.e., composite t-score reflecting performance on all subtests) and individual subtests fully corrected t-scores (i.e., controlling for age, education, mother's education, handedness, age, and gender) were used as primary outcomes. This battery took approximately 60 minutes to complete. In order to examine the potential predictive value of the BINI for evidence of cognitive dysfunction, Jak criteria[42] were used to identify participants with objective cognitive dysfunction (i.e., two or more NIH Toolbox subtest FCS t-scores $\leq$ 40 in one domain).

Depressive symptoms

Depressive symptoms were assessed using the 20-item Center for Epidemiological Studies Depression Scale (CES-D), with $\geq$16 indicative of moderate to severe depression.[43] The overall internal consistency (Cronbach's alpha) for the scale was 0.90.

Data analysis

A series of analyses were conducted to better understand the possible relationship between the subjective report of neurocognitive dysfunction on the BINI and objective test performance on the NIH Toolbox. Given its known association in past work,[44,45] Pearson correlation was used to first determine the association between reported depressive symptomatology (CES-D) and BINI total and subscale scores.

Analyses were focused on those participants with objective cognitive impairment, as they would be expected to show poorer treatment outcomes and have the greatest need for treatment accommodations. Objective neurocognitive dysfunction was defined using established criteria (i.e., two or more NIH Toolbox subtest t-scores < 40).[42] Similar criteria have been used in past work to identify objective neurocognitive dysfunction in persons with substance misuse.[25,46] Pearson correlations were then used to quantify the relationship between self-reported responses on the BINI and objective performance on the NIH Toolbox. In order to clarify this relationship, independent samples t-tests compared potential differences in the BINI global and subscale scores between persons with and without neurocognitive dysfunction. BINI subscale cut off values were created using impairment group mean scores. Chi-square analyses were used to compare the percentage of participants with neurocognitive dysfunction reporting above or below the BINI cut off values (i.e., Learning subscale = 18, Language subscale = 10).

Results

Sample characteristics

Of the 234 participants enrolled for the current study, 34 were excluded due to missing BINI global data scores, and 22 were excluded due to missing NIH Toolbox Composite scores. One hundred seventy-seven (177) participants with complete data were retained for analyses (M_{age} = 42.2, SD = 10.2; 52% male; 66% White; 72% $\geq$ high school; Table 1). Within the sample, 76% met the criteria for depression on the CES-D and 54% for neurocognitive dysfunction on the NIH Toolbox.

BINI scores and depression

Pearson correlation analyses showed that CES-D total scores were significantly associated with the BINI global subscale score ($r = 0.56$, $p < 0.01$) as well as with all other BINI subscale scores (r ranging from 0.27 to 0.50, all p's < 0.01). Thus,

Table 1. Sample characteristics (n = 177).

	Mean/%	SD
Demographics		
Age	42.2	10.6
Education	70.1%	–
Sex (Male)	52.0%	–
Ethnicity		
White	65.5%	–
African American/Black	18.6%	–
Hispanic/Latino	13.6%	–
Other	2.3%	–
CESD	26.3	13.0
NIH Toolbox Scores		
Picture Sequence A	45.4	8.45
Picture Sequence B	46.9	10.1
Picture Sequence C	45.6	11.3
Flanker	36.9	11.3
List Sorting	42.1	10.6
Card Sorting	44.6	14.0
Pattern	42.8	15.7
Picture Vocab.	46.4	9.43
Oral Reading	55.5	12.1
Total Composite	43.56	11.9

Note: CESD = Center for Epidemiologic Studies Depression Scale; Picture Sequence = Picture Sequence Memory Test; Flanker = Flanker Inhibitory Control and Attention Test; List Sorting = List Sorting Working Memory Test; Card Sorting = Dimensional Change Card Sort Test; Pattern = Pattern Comparison Processing Speed Test; Picture Vocab. = Picture Vocabulary Test; Oral Reading = Oral Reading Recognition Test. Total Composite = Total Composite Cognition Score. Education reflects percent of persons with high school degree or greater.

Table 2. Pearson correlation between NIH toolbox and BINI scales in the full sample and persons meeting criteria for MCI.

	Full Sample	MCI-only
Global	−0.09	−0.27**
Learning	−0.21**	−0.32**
Language	−0.17*	−0.25*
Memory	−0.12	−0.26*
Physical	−0.12	−0.25*
Perception	−0.19*	−0.26*
Anger	−0.04	−0.25*
Pain	−0.15	−0.28**
Head Injury	−0.08	−0.22*

Note:
*Denotes $p < 0.05$.
**Denotes $p < 0.01$.

persons with greater self-reported depressive symptoms on the CES-D also endorsed greater subjective symptoms of neurocognitive dysfunction on all BINI subscales.

BINI scores and NIH toolbox performance

Pearson correlation analyses indicated no association between BINI global scores and NIH Toolbox Total Composite score in the overall sample [r = −0.09, $p = 0.22$] (See Table 2). Follow-up analyses, however, showed that the NIH Toolbox Total Composite score was significantly associated with BINI subscale scores of Learning (r = −0.21, $p < 0.01$), Perception (r = −0.19, $p = 0.01$), and Language (r = −0.17, $p = 0.03$), such that persons with higher self-reported ratings of cognitive complaints in these domains of the BINI also demonstrated poorer global neuropsychological test performance on the NIH Toolbox.

Table 3. Independent samples t-tests examining subjective cognitive impairment between intact (n = 82) and impaired (n = 95) participants.

	Intact (M/SD)	Impaired (M/SD)	t	df	p
BINI					
Global	54.90(18.3)	58.93(20.8)	−1.36	175	0.18
Learning	15.33(6.54)	18.63(8.50)	−2.86	175	0.01**
Language	8.67(3.69)	10.34(5.11)	−2.45	175	0.02*
Memory	9.78(4.54)	10.71(4.82)	−1.32	175	0.19
Physical	9.05(4.58)	9.53(4.66)	−0.69	175	0.49
Perception	6.93(2.99)	7.55(3.33)	−1.30	175	0.20
Anger	6.50(3.13)	6.03(3.09)	1.00	175	0.32
Pain	8.28(3.12)	8.24(3.70)	0.07	175	0.94
Head Injury	4.17(2.55)	4.80(2.98)	−1.50	175	0.14

Note:
*$p < 0.05$.
**$p < 0.01$.

Importantly, when focusing our analyses on just the subgroup of individuals classified as having neurocognitive dysfunction via the NIH Toolbox, the Composite NIH Toolbox scores were significantly associated with all BINI indices (Global r = −0.26, $p = 0.01$; Subscales ranging −0.22 to −0.32, all p's < 0.03). Thus, worse cognitive performance on the NIH Toolbox was associated with increased self-reported cognitive difficulties based on the overall BINI score as well as scores on all BINI subscales among our target group of individuals with neurocognitive dysfunction.

Objective neurocognitive dysfunction within BINI subscales

Next, we sought to examine whether the report of impairment on any of the BINI subscale scores would be specific to objective neurocognitive dysfunction. T-tests revealed that participants in the neurocognitive dysfunction subgroup reported significantly greater subjective complaints on the BINI subscales of Learning (M = 18.5, SD = 8.45, t= −2.77, df = 176, $p<.01$) and Language (M = 10.2, SD = 5.12, t = −0.22, $p = 0.26$; Table 3). To promote clinical utility, cut off values were then created for the BINI subscales of Learning (i.e., 18) and Language (i.e., 10) using mean values from the neurocognitive dysfunction

Table 4. Chi square analyses examining respective rates of high or low BINI scores by cognitive status.

	Cognitive Status	
BINI Groups	Intact	Impaired
Learning		
High	24	47
Low	58	48
χ^2 (1) = 7.48, $p = 0.009$		
Language		
High	25	40
Low	57	55
χ^2 (1) = 2.56, $p = 0.120$		

Note: High ≥ BINI cutoff values, Low < BINI cutoff values.

subgroup. Participants were then categorized into "high" or "low" based on the Learning and Language subscales. Chi-square analyses indicated that a greater number of participants with scores above the cutoff on the Learning subscale (indicating higher reported dysfunction) were more likely to exhibit objective neurocognitive dysfunction on the NIH Toolbox (65% vs. 35%; χ^2=6.57, $p = 0.02$) while that pattern did not reach significance when examining scores on the Language subscale ($p > 0.05$; Table 4).

Discussion

The current study found a greater report of subjective cognitive difficulties on the BINI in individuals with OUD exhibiting objective impairment on the NIH toolbox computerized testing. Further, the findings indicated that the BINI Learning subscale scores could reliably distinguish persons with and without objective impairment. Such findings provide initial support for the feasibility of using a brief self-report inventory to help identify cognitive dysfunction in persons seeking treatment for OUD. Several aspects of the current findings warrant a brief discussion.

The current results emerged in a sample that is largely representative of other MMT populations, including high levels of clinical impairment (i.e., 54% meeting established criteria for MCI) and depressive symptoms (i.e., 75% were above the cutoff). Each of these conditions increases the challenge in utilizing self-report to identify objective cognitive dysfunction, whether due to underreporting of impairment due to reduced awareness or over-reporting due to distress and symptom overlap in affective disturbance.[47,48] Additional refinement of the BINI may lead to even more accurate identification of persons with cognitive dysfunction, such as asking about other independent risk factors for impairment in persons with OUD that may be less vulnerable to contamination, such as the history of head injuries, the number of opioid overdoses, and other comorbidities.[49,50] After refinement, a detailed examination of the psychometric properties of the BINI, including sensitivity and specificity, is needed to provide insight into its potential role in a clinical setting. For example, it may be possible to utilize the BINI as an initial screening measure at treatment entry and then ask persons with suspected cognitive dysfunction to complete an objective screening measure like the MoCA to more precisely inform treatment planning. Past work has also suggested that accuracy of self-reported cognitive dysfunction may improve with serial assessment,[51] which may be particularly beneficial in persons with OUD given the known impact of methadone on cognitive function.[52–56]

The findings from this study should be considered in light of some limitations. First, due to missing data and relatively modest sample size, we had only moderate statistical power, and replication in larger samples and from other geographical regions is needed. We also note that, as in prior studies,[49,50] there was a strong association between self-reported responses on the BINI and our measure of depression (CES-D), indicating potential overlap of these constructs. Thus, it will be important to ensure that future measures of subjective cognitive impairment can be adequately distinguished from depressive symptoms. Similarly, the observed correlations between the BINI and performance on NIH Toolbox were modest in participants with objective cognitive dysfunction, and future studies are needed to more fully characterize convergent and divergent validity of the BINI across a wide range of patient settings. Finally, this study was necessarily limited by the use of self-reported data from the BINI and the CES-D. Each of these measures is subject to potential biases associated with the tendency toward providing socially desirable responses, which may impact the observed findings. Studies utilizing instruments sensitive to these response tendencies (e.g.,

MMPI-2-RF) could help clarify the current findings.

Conclusions

Cognitive impairment is common in persons with OUD, and these deficits are associated with poorer treatment outcomes.[1–5,14,15] The current study raises the possibility that the self-reported BINI may help identify cognitive impairment in persons with OUD. Should this finding be replicated, it may ultimately be possible to screen patients at entry into treatment and modify their treatment/intervention approach to better accommodate the weaknesses of their specific cognitive profile.[14,15,57,58] The individualized approach may help to increase engagement and retention in care as well as adherence to medications, thus reducing overdose, addiction severity, and risk behavior while improving public health.

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No potential conflict of interest was reported by the author(s).

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