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Authors

Olbert, Charles M
Penn, David L
Kern, Robert S
et al.

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Adapting Social Neuroscience Measures for Schizophrenia Clinical Trials, Part 3: Fathoming External Validity

Charles M. Olbert*[,1], David L. Penn[2], Robert S. Kern[3,4], Junghee Lee[3], William P. Horan[3,4], Steven P. Reise[3], Kevin N. Ochsner[5], Stephen R. Marder[3,4], and Michael F. Green[3,4]

[1]Department of Psychology, Fordham University, Bronx, NY; [2]Department of Psychology, University of North Carolina-Chapel Hill, Chapel Hill, NC; [3]Department of Psychiatry and Biobehavioral Science, Semel Institute for Neuroscience and Human Behavior, University of California Los Angeles, Los Angeles, CA; [4]Department of Veterans Affairs VISN 22 Mental Illness Research, Education, and Clinical Center, Los Angeles, CA; [5]Department of Psychology, Columbia University, New York, NY

*To whom correspondence should be addressed; Department of Psychology, Fordham University, Dealy Hall 216A, 441 East Fordham Road, Bronx, NY 10458-9993, US; tel: 919-259-1793, fax: 718-817-3785, e-mail: colbert@fordham.edu

It is unknown whether measures adapted from social neuroscience linked to specific neural systems will demonstrate relationships to external variables. Four paradigms adapted from social neuroscience were administered to 173 clinically stable outpatients with schizophrenia to determine their relationships to functionally meaningful variables and to investigate their incremental validity beyond standard measures of social and nonsocial cognition. The 4 paradigms included 2 that assess perception of nonverbal social and action cues (basic biological motion and emotion in biological motion) and 2 that involve higher level inferences about self and others' mental states (self-referential memory and empathic accuracy). Overall, social neuroscience paradigms showed significant relationships to functional capacity but weak relationships to community functioning; the paradigms also showed weak correlations to clinical symptoms. Evidence for incremental validity beyond standard measures of social and nonsocial cognition was mixed with additional predictive power shown for functional capacity but not community functioning. Of the newly adapted paradigms, the empathic accuracy task had the broadest external validity. These results underscore the difficulty of translating developments from neuroscience into clinically useful tasks with functional significance.

Key words: schizophrenia/social cognition/social neuroscience/functional outcome

Introduction

Social cognitive processes are centrally linked to vocational achievement and daily and interpersonal functioning in schizophrenia.[1–3] Moreover, social cognition has been shown to mediate the relationship between nonsocial cognition and functionally meaningful outcomes.[4–7] Treatment research for social cognition in schizophrenia stands to benefit from measures adapted from social neuroscience, which may guide the development of targeted interventions by virtue of being linked to specific cognitive subprocesses and neural substrates. In line with the Cognitive Neuroscience Treatment Research to Improve Cognition in Schizophrenia (CNTRICS) initiative,[8] the Social Cognition and Functioning (SCAF) project selected social cognition tasks with good construct validity linked to specific neuroanatomical systems. SCAF goals and selection of neuroscience measures (which we refer to in this article as adapted social neuroscience measures) are described in a companion article.[9] SCAF paradigms were selected by virtue of their linkages to neural regions involving bottom-up (lower level) recognition of social/emotional stimuli and top-down (higher level) mental state inferences, 2 critical components of the social-emotional processing stream.[10] Because social cognitive interventions are intended to eventually improve complex functional outcomes, it is important to evaluate the external validity of newly adapted measures to gauge their utility for clinical trials.

It is an open question whether tasks that tap into narrowly circumscribed social cognitive processes purchase increased sensitivity and specificity at the cost of attenuated relationships with functioning. This is a valid concern given that specialized cognitive paradigms evaluated as part of the CNTRICS initiative correlated relatively weakly with functional measures compared with clinical neuropsychological tasks, possibly because specific subprocesses did not adequately capture the complexity inherent in multifaceted functional measures.[11] It is

possible that the paradigms adapted from social neuroscience in the SCAF project will likewise show attenuated relationships with functionally meaningful outcomes. Attenuated relationships may provide evidence that functional outcomes either depend on a more diffuse array of cognitive processes or do not centrally involve the components of the social-emotional processing stream targeted by SCAF paradigms. Alternatively, these adapted paradigms may improve the signal-to-noise ratio of social cognitive measurements if they tap into cognitive processes that are centrally involved in functional outcomes. Stronger relations to functional measures would arise in this scenario from an enhanced signal-to-noise ratio compared with less pure, more multifaceted measures of social cognition.[11]

Like nonsocial cognition,[12,13] social cognition has become a treatment target that is being actively investigated in schizophrenia research. The ultimate goal of clinical trials for these unmet treatment needs is to improve community integration for individuals with schizophrenia, such as return to work, improved family and social relationships, and higher levels of independent living. Community-based functional outcomes are, however, unlikely to change over the time frame of a typical clinical trial. Consequently, the US Food and Drug Administration has endorsed the inclusion of functionally meaningful coprimary measures in clinical trials of cognition-enhancing agents in schizophrenia.[14] Such coprimary measures include measures of functional capacity, which are simulation tasks that can be administered in the clinic, in which a participant demonstrates how they would perform a task.[12,13] For clinical trial endpoints, it is therefore important to establish relationships between the proposed social cognition tasks and functionally meaningful coprimary measures.

In the best-case scenario, these newly adapted measures would perform at least as well as existing measures of social cognition both in terms of correlations with external variables and in terms of their capacity to explain variance beyond standard measures used in schizophrenia research. The present article is the third in a series describing the adaptation of measures with known neural correlates from cognitive and social neuroscience for use in schizophrenia clinical trials. Companion articles describe the theoretical background of the SCAF project and adapted social neuroscience measures,[9] as well as the psychometric properties of those measures.[15] The goal of this article is to characterize the relationship between the 4 social neuroscience measures and clinically and functionally meaningful variables. We present data on the correlations between these newly adapted measures and functional capacity, community functioning, as well as nonsocial cognition, and clinical symptoms. The secondary goal is to determine whether the new measures explain additional variance in functional capacity and community functioning above and beyond (1) nonsocial cognitive ability and (2) a standard facial affect identification task.

Methods

Participants

Participant characteristics, recruitment, inclusion/exclusion criteria, and psychometric properties of the SCAF social neuroscience measures are described in a companion article.[15] Briefly, participants for this study comprised 173 individuals with schizophrenia drawn from 2 performance sites (University of California, Los Angeles and University of North Carolina [UNC] at Chapel Hill). Social neuroscience paradigms were administered twice (baseline and 4-week retest) with symptom severity assessed at both testing occasions. Administration of social neuroscience paradigms was counterbalanced across subjects to minimize confounds. Together, the 4 paradigms take approximately an hour and a half to complete and are generally well tolerated. Although social neuroscience measures were administered twice to the patient group to evaluate test-test reliability, data from the first assessment time were used in the current analyses. Data from healthy controls are not presented here. After providing a complete description of the study to prospective study participants, written informed consent was obtained prior to participation.

Social Cognition

Social Neuroscience Paradigms. The 4 social neuroscience paradigms and their theoretical background are fully described in a companion article.[15] In brief, SCAF paradigms were selected by virtue of their neural substrates relating to the constructs of either (1) bottom-up/low-level perception of social/emotional stimuli or (2) top-down/high-level mental state inferences.[10] Bottom-up (low-level) perception tasks comprised (1) basic biological motion, capturing the ability to visually discriminate characteristic human motion from random motion represented by point-light figures[16] and (2) emotion in biological motion, capturing the ability to determine the emotion displayed by walking point-light figures[17]; top-down (high-level) inferential processes comprised (3) self-referential memory, capturing memory biases in the encoding and retrieval of trait information about oneself vs others[18,19] and (4) empathic accuracy, capturing the ability to accurately track the emotions of others over time.[20,21]

For the current article, we selected 1 representative variable from each of the social neuroscience paradigms for further analysis. For the basic biological motion test, the 70% and 85% coherent motion variables each had better psychometric properties than 100% coherent motion. Given no sharp theoretical or psychometric rationale for preferring either 70% or 85%, we selected the 85% coherent motion variable by virtue of its frequency distribution being slightly less skewed than that of the 70% coherent

motion variable. Accuracy measured as percent correct was used for the emotion in biological motion test. The self-referential memory test measures delayed recognition sensitivity to adjectives describing either the participant (self), generally desirable traits (other), or upper vs lowercase text (physical). The "self" index of sensitivity variable was chosen to represent this construct based on its better discrimination of patients from controls.[15] As explained elsewhere,[15] participants received one of 2 versions of the empathic accuracy task: an older version developed at Columbia University by Zaki and colleagues[20] or a new version developed at UCLA. Both versions contained positive and negative valence video clips of individuals discussing autobiographical events. Clips with extreme variability were subsequently dropped. Both tasks were designed to assess the same construct, and preliminary analyses revealed no differences across versions. Hence, 9-clip versions of the Columbia and UCLA version of the empathic accuracy task were collapsed into a single measure for these analyses.

Facial Affect Identification. Because facial affect identification tasks are commonly used in schizophrenia research and have established relationships to functioning,[22,23] they provide a benchmark standard for evaluating the incremental validity of the SCAF paradigms. In this computerized version, participants were asked to identify facial expressions of emotion in still photographs from a standardized stimulus set developed by Ekman.[24] The test included digitized color photos of 8 different posers displaying facial expressions of 6 basic emotions (happy, sad, angry, afraid, surprised, and disgusted) as well as a neutral expression for a total of 56 images. For each trial, a photo and a list of the 7 possible expressions were simultaneously presented on the screen for 5 s. Participants stated their selected choice aloud. The dependent measure was percent accuracy.

Nonsocial Cognition

Nonsocial cognition was assessed using the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) Consensus Cognitive Battery (MCCB).[25] Although the neurocognitive composite score from the MCCB normally includes one measure of social cognition, this test was excluded from our composite score, so that the neurocognitive composite score reflects only nonsocial cognition and includes the domains of speed of processing, verbal memory, visual memory, working memory, reasoning and problem solving, and attention/vigilance.

Symptoms

Presence and severity of psychiatric symptoms was assessed using the expanded Brief Psychiatric Rating Scale (BPRS)[26]; scores for the Positive, Negative, and Depressive subscales are reported.[27] Negative symptoms were assessed using the Scale for the Assessment of Negative Symptoms (SANS), which covers 5 domains: affective flattening, alogia, avolition-apathy, anhedonia-asociality, and attention.[28] A composite SANS score was computed as the sum of these domains with attention excluded. Training of symptom scale raters is described in the previous article on psychometric properties.[15]

Functional Measures

Functional Capacity. Functional capacity was assessed using 2 measures. The University of California at San Diego Performance-Based Skills Assessment (UPSA)[29] is a role-play simulation task designed to measure participants' ability to negotiate real-world tasks such as counting correct change, understanding a utility bill, reading a bus schedule, and making a grocery list. The UPSA yield a summary score spanning measures of 5 functional skill areas: general organization, finance, social/communicati ons, transportation, and household chores.

The Maryland Assessment of Social Competence (MASC)[30] is a measure of social skills comprising 4 short role-play scenarios designed to measure participants' ability to solve common interpersonal problems. Each conversation is 2 min long. Scripted confederate prompts and responses are minimal and open-ended, designed to enjoin participants to take primary responsibility for moving the conversation forward. The 4 scenarios consist of one involving initiating conversation with a new neighbor, 2 involving negotiation and compromise (eg, asking an employer for a second chance), and one involving standing up for one's rights (ie, confronting a landlord about fixing a leaky roof). The procedure is videotaped for later scoring. Each scenario was coded by specially trained raters using three 5-point Likert scales: verbal skill (a measure of speech content), nonverbal skill (a measure of paralinguistic style, including eye contact and body language), and overall effectiveness (a composite measure of focus and goal achievement). The 2 domains sum to a total score. MASC raters received training from the developers of this task or individuals the developers had certified and achieved intraclass correlation coefficients exceeding 0.85 for all the MASC variables on a set of 10 videos that were derived from a separate sample.

Community Functioning. Community functioning was assessed via a total score summing the 4 subscales of the Role Functioning Scale (RFS)[31]: work functioning, independent living, family network, and social functioning. Ratings were based on a semistructured interview that used standardized probe questions. Higher UPSA, MASC, and RFS scores indicate better functioning.

Statistical Analysis

We first examined the interrelationships among the social neuroscience tasks with Pearson correlation coefficients. To examine the relationships between the social neuroscience tasks and other variables, we computed Pearson

correlations between them and facial affect identification, symptoms, nonsocial cognition, functional capacity, and community functioning.

The external and incremental validity of the social neuroscience tasks was examined via hierarchical linear regressions with UPSA, MASC, and RFS total scores as individual dependent variables. Preliminary analysis were conducted to investigate possible differences across sites. The MCCB and functional outcome variables were used as independent measures in hierarchical regression analyses with the 4 social neuroscience variables entered in block 1 and a dummy variable (0,1) representing site along with an interaction term (social neuroscience variables x site) in block 2. An analogous set of regression analyses was used to evaluate possible effects associated with the 2 versions of the empathic accuracy task. These analyses showed no consistent site or version effects. Thus, site and version were not included as potential confounds in subsequent analyses.

Three sets of regression analyses were performed with the 4 social neuroscience task variables entered in a single block in each analysis. In the first set of analyses, we assessed the variance in functional measures accounted for by social neuroscience tasks considered alone with the 4 representative variables in a single block. Second, we assessed additional variance explained beyond nonsocial cognition by entering MCCB composite scores in block 1 and the social neuroscience variables in block 2. Third, we assessed additional variance explained beyond a standard measure of facial affect recognition by entering facial affect identification scores in block 1 and the social neuroscience variables in block 2. Because nonsocial cognition and facial affect recognition were expected to correlate well with the social neuroscience measures, we viewed this as a stringent test of incremental validity.

Results

Correlational Analyses

Intercorrelations among the social neuroscience and facial affect identification tasks are shown in table 1. In general, these measures tended to be modestly and significantly intercorrelated with correlations ranging from .17 to .53 and a mean correlation among the 4 social neuroscience tasks of .34.

Several of the social neuroscience tasks showed small but significant relationships with positive symptoms (table 2). Patients with greater positive symptoms performed worse on basic biological motion, self-referential memory, and empathic accuracy tasks. By contrast, there was only one significant association between the social neuroscience tasks and negative or depressive symptoms (SANS Total, BPRS Negative and Depressive subscales): more accurate perception of biological motion was associated with lower depressive symptoms.

The relationships among social neuroscience variables, facial affect identification, nonsocial cognition, and functional outcome measures are shown in table 3. There were consistent positive relationships between the social neuroscience variables and the neurocognitive composite score, with correlations ranging from .27 to .45. Likewise, greater functional capacity as measured by the UPSA was associated with higher ability in each social neuroscience domain, with correlations ranging from .24 to .39. Thus, better perception of biological motion and emotion in

Table 1. Intercorrelations Between Social Neuroscience Paradigms and Facial Affect Identification

	1	2	3	4
1. Basic biological motion				
2. Emotion in biological motion	.39**			
3. Self-referential memory	.23**	.34**		
4. Empathic accuracy	.17*	.33**	.23**	
5. Facial affect identification	.37**	.53**	.42**	.37**

*$P < .05$, **$P < .01$.

Table 2. Correlations Between Social Neuroscience Paradigms and Facial Affect Identification With Symptom Measures

	BPRS Positive	BPRS Depression	BPRS Negative	SANS Total
Basic biological motion	−.23**	−.16*	−.02	−.05
Emotion in biological motion	−.10	.03	−.03	−.09
Self-referential memory	−.21**	−.14	−.02	−.10
Empathic accuracy	−.23**	.05	.01	−.11
Facial affect identification	−.14	−.01	.01	−.13

Note: BPRS, Brief Psychiatric Rating Scale; SANS, Scale for the Assessment of Negative Symptoms.
*$P < .05$, **$P < .01$.

Table 3. Correlations With External Variables

	MCCB Composite	UPSA Total	MASC Total	RFS Total
Mean (SD)	30.8 (12.3)	.74 (0.13)	3.54 (0.48)	4.49 (1.13)
SCAF paradigms				
Basic biological motion	.38**	.24**	.07	.10
Emotion in biological motion	.43**	.39**	.23**	.13
Self-referential memory	.45**	.39**	.01	.12
Empathic accuracy	.27**	.30**	.27**	.17*
Standard measures				
Facial affect identification	.52**	.45**	.19*	.23**
MCCB composite	n/a	.69**	.30**	.28**

Note: MCCB, Measurement and Treatment Research to Improve Cognition in Schizophrenia Consensus Cognitive Battery; UPSA, University of California at San Diego Performance-Based Skills Assessment; MASC, Maryland Assessment of Social Competence; RFS, Role Functioning Scale; SCAF, Social Cognition and Functioning; n/a, not applicable.
*$P < .05$, **$P < .01$.

biological motion, better self-referential memory, and higher empathic accuracy were each associated with greater nonsocial cognitive ability and UPSA functional capacity.

Relationships between social neuroscience tasks and MASC social skills were mixed. Better perception of emotion in biological motion and higher empathic accuracy were associated with greater social skill. Perception of biological motion and self-referential memory were not significantly associated with MASC scores. The mean correlation with the MASC was .14. Relationships between social neuroscience tasks and community functioning were also mixed. Higher empathic accuracy was associated with better community functioning as measured by the RFS, but the other 3 tasks were not associated with community functioning. Overall, among the social neuroscience tasks, empathic accuracy showed the most consistent relations to MASC and RFS scores.

Multiple Regression Analyses

Social Neuroscience Measures Alone. Before examining incremental validity, the explanatory power of social neuroscience variables was assessed. As shown in table 4, the social neuroscience tasks significantly predicted 27% of the variance in functional capacity as measured by the UPSA ($R^2 = .27$, $F(4,153) = 13.9$, $P < .001$) and 11% of the variance in MASC social skills ($R^2 = .11$, $F(4,150) = 4.43$, $P = .002$) but did not significantly predict community functioning as measured by the RFS ($R^2 = .052$, $F(4,154) = 2.10$, $P = .084$).

Incremental Validity. Results from incremental validity multiple regression analyses are summarized in table 5. The social neuroscience tasks significantly predicted 8% of the variance in MASC social skills beyond nonsocial cognition ($\Delta R^2 = .076$, $\Delta F(4,149) = 3.38$, $P = .011$). Greater functional capacity was associated in this model with worse self-referential memory ($\beta = -.20$, $t(5,149) = -2.28$, $P = .024$) and higher empathic accuracy ($\beta = .20$, $t(5,149) = 2.42$, $P = .017$). The unexpected negative regression weight for self-referential memory reflected a subtle suppression effect; although self-referential memory was individually uncorrelated with MASC scores (see table 3), once all the other neurocognitive and social neuroscience variables were taken into account, the correlation became weakly negative. Social neuroscience variables did not significantly predict additional variance beyond nonsocial cognitive ability in functional capacity as measured by the UPSA or in community functioning.

Social neuroscience tasks significantly predicted 9% of the variance in functional capacity as measured by the UPSA ($\Delta R^2 = .090$, $\Delta F(4,152) = 4.85$, $P = .001$) and 8% of MASC social skills ($\Delta R^2 = .075$, $\Delta F(4,149) = 3.13$, $P = .017$) beyond facial affect identification. Better self-referential memory predicted greater UPSA functional capacity ($\beta = .22$, $t(5,152) = 2.92$, $P = .004$), and higher empathic accuracy predicted better MASC social skills ($\beta = .22$, $t(5,149) = 2.55$, $P = .012$). None of the social cognitive tasks—including facial affect identification—significantly predicted variance in community functioning in this analysis.

Discussion

The purpose of this study was to examine the relationship between social cognitive paradigms adapted from social neuroscience and functionally meaningful outcomes. Overall, the relationships were modest. Correlations between the adapted social neuroscience measures and functional capacity measured by the UPSA, while uniformly significant, were only slightly lower than previously observed correlations between the UPSA and social cognition measures.[3] Correlations between the social neuroscience measures and both functional capacity measured by the MASC and community functioning, however, generally fell below the range of mean correlations reported by Fett and colleagues[1]

Table 4. Final Regression Models Predicting Overall Contribution of New Measures to Outcome

	R^2	Adjusted R^2	F	P	β	t	P
UPSA total	.27	.25	13.9	<.001			
Basic biological motion					.07	0.89	.374
Emotion in biological motion					.23	2.87	.005
Self-referential memory					.27	3.55	.001
Empathic accuracy					.15	2.00	.049
MASC total	.11	.08	4.43	.002			
Basic biological motion					−.004	−0.05	.964
Emotion in biological motion					.20	2.19	.030
Self-referential memory					−.11	−1.30	.197
Empathic accuracy					.23	2.73	.007
RFS total	.05	.03	2.10	.084			
Basic biological motion					.09	1.04	.298
Emotion in biological motion					.07	0.80	.427
Self-referential memory					.02	0.27	.786
Empathic accuracy					.14	1.60	.112

Note: Abbreviations are explained in the first footnote to table 3.

Table 5. Final Regression Models Predicting Additional Variance in Dependent Measures (UPSA, MASC, and RFS) Beyond (1) Nonsocial Cognition and (2) FAI

	Block 1			Block 2							
	Predictor β			Predictor β							
	MCCB	FAI	R^2	MCCB	FAI	BBM	EBM	SRM	EA	R^2	ΔR^2
Nonsocial cognition											
UPSA	.69**		.47**	.60**		−.05	.09	.09	.10	.50**	.03
MASC	.30**		.09**	.30**		−.08	.14	−.20*	.20*	.17**	.08*
RFS	.28**		.08**	.26**		.04	.02	−.05	.11	.09**	.02
FAI											
UPSA		.45**	.20**		.21*	.03	.16	.22**	.11	.29**	.09**
MASC		.18*	.03*		.05	−.01	.18	−.12	.22*	.11**	.08*
RFS		.21*	.04**		.12	.07	.03	−.002	.11	.06	.02

Note: Abbreviations are explained in the first footnote to table 3. FAI, facial affect identification; BBM, basic biological motion; SRM, self-referential memory; EA, empathic accuracy; EBM, emotion in biological motion.
*P < .05, **P < .01.

(.22–.48) in a meta-analysis of the relationship between existing social cognitive and functional measures in schizophrenia. It is also notable that social neuroscience measures showed generally weak correlations with symptoms, given that some studies have reported that social cognitive task performance correlates with negative symptoms.[32]

Regression analyses, which combined the 4 social neuroscience tasks into a single block of predictors, provided modest evidence for external and incremental validity. The 4 social neuroscience paradigms were significant predictors of functional capacity (UPSA and MASC) but not community functioning. Evidence for incremental validity over traditional predictors in schizophrenia (nonsocial cognitive ability and facial affect identification) was also mixed. The social neuroscience paradigms demonstrated significant incremental validity beyond facial affect identification for functional capacity (UPSA and MASC; though the proportion of explained variance was small) but not community functioning. The paradigms showed incremental validity beyond nonsocial cognition for MASC social skills but not for functional capacity or community functioning. Note that we expected the 4 social neuroscience paradigms to correlate with both nonsocial cognition and facial affect identification, which they did. Hence, the analyses are a stringent test of incremental validity.

Overall, associations between the social neuroscience paradigms and external variables were disappointingly low, especially for community functioning. It is possible that relationships to external variables were impacted to some extent by differences across sites, a pattern that

has been observed in other multisite psychometric studies.[12,13] Although our regression analyses uncovered no systematic site effects, post hoc analyses showed higher relations between social neuroscience paradigms and functional capacity at UNC but higher relations to community functioning at UCLA. Notably, 2 of 4 paradigms showed significant relationships to community functioning at the UCLA site but not at UNC. Thus, combining data across sites may obscure relationships that existed within site, possibly due to restricted range in outcome at a given site.

A few other factors should be considered when interpreting these findings. First, our measure of community functioning was based solely on patient self-reports without information from collateral informants, which could limit the validity of these ratings.[33] Second, cross-sectional correlations might not be the best predictors of functional improvement, so further investigation of these measures should examine these relationships longitudinally.[34] Third, the modest relationships to functionally meaningful outcomes may be due to the increased specificity of neuroscience paradigms, which tap into 2 of the 5 core constructs with identified neural substrates that comprise the social-emotional processing stream.[10] The attenuated relationships in this study are consistent with results from the application of measures developed in the CNTRICS initiative, which also showed lower than hoped for associations to outcome measures.[11]

It is perhaps not surprising to find more specific measures that tap into narrowly circumscribed neural regions of interest to be more modestly related to complex, multifaceted social tasks than more general measures capturing variance across multiple constructs.[11] Consequently, these results may be taken to show that the functional capacity measures and community functioning measures in this study (UPSA, MASC, and RFS) encompass a broad spectrum of social-emotional processing capacities and do not depend heavily on the core neuroscience constructs that the SCAF paradigms captured. It is, however, somewhat difficult to reconcile this explanation with our finding that some of the relationships between facial affect identification and functionally meaningful outcomes in our regression analyses were also lower than that would be expected based on some previous studies examining emotion perception in schizophrenia, particularly for community functioning.[1,22,35] Although it is intuitive that highly specific tasks would be less likely to capture variance in multidimensional outcome measures,[11] the facial affect identification task is itself not particularly multifaceted; such explanations must therefore reckon with relatively consistent relationships observed between emotion perception tasks and functionally meaningful outcomes.[1,2] Further research should attempt to fathom why the magnitude of links between facial emotion perception and functioning fluctuate across studies, which could reflect factors such as the particular test used, patient characteristics, or social conditions (eg, family environment, economic and social benefit conditions).

In sum, although the adapted social neuroscience measures have firm grounding in neural systems, several of the tasks had modest external validity. These results underscore the difficulty of translating insights from neuroscience into tasks that are practical and appropriate for use in clinical trials. Of the adapted social neuroscience paradigms, the basic biological motion paradigm performed most poorly in terms of both its relationships to external variables and its psychometric properties.[15] The emotion in biological motion and self-referential memory paradigms each had somewhat stronger relationships to external variables and better psychometric properties than basic biological motion. Given their strengths and weaknesses in terms of external validity and psychometrics,[15] these paradigms may benefit from further development. The empathic accuracy paradigm appears to have the broadest external validity with significant association to all 3 functional outcome measures. The empathic accuracy task also had the best psychometric properties of the 4 paradigms: empathic accuracy discriminated between patients and controls (Cohen's $d = 0.59$) and had adequate test-retest reliability ($r = .74$).[15] Thus, of the 4 tasks, the empathic accuracy task shows the greatest utility for clinical trials given its combination of known linkages to neural substrates, strong psychometric properties, and external validity. It is the most highly recommended measure from the SCAF project.

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