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KNOW THYSELF: REAL WORLD BEHAVIORAL CORRELATES OF SELF-APPRAISAL ACCURACY

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Abstract

Accurate appraisal of one's own abilities is one metacognitive skill considered to be an important factor affecting learning and behavior in childhood. The present study measured self-appraisal accuracy in children using tasks of executive function, and investigated relations between self-appraisal and informant ratings of real world behaviors measured by the BRIEF. We examined self-appraisal accuracy on fluency tasks in 91 children ages 10-17. More accurate self-appraisal was correlated with fewer informant ratings of real world behavior problems in inhibition and shifting, independent of actual performance. Findings suggest that self-appraisal represents cognitive processes that are at least partially independent of other functions putatively dependent on the frontal lobes, and these self-appraisal-specific processes have unique implications for optimal daily function.

Keywords

Self Assessment; Self Concept; Awareness; Child Behavior; Executive Function; Meta-cognition

INTRODUCTION

Socrates' guiding principle was to "Know Thyself". This simple phrase refers to a multitude of complex metacognitive processes, including accurate self-knowledge and self-perception. Metacognition is defined as "cognition about cognition" or "knowing about knowing" (Barell, 1992). It refers to the process by which we understand and alter our own thinking. Metacognitive abilities allow people to select and apply a strategy, monitor their performance, revise their strategy if necessary, and ultimately to evaluate their performance. Accurate appraisal of one's own abilities is one metacognitive skill that forms an important basis for choosing tasks in life, modifying our behavior over time, and for improving our performance on tasks at which we would like to excel. Accurate self-monitoring of

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performance helps us determine our strengths and weaknesses and may affect real world behaviors, including academic performance, job selection, and social functioning.

Socrates' advice is apparently easier said than done, because some people have a propensity to overestimate themselves when rating their performance (Kruger & Dunning, 1999). This tendency toward inflated self-appraisal has been demonstrated in numerous populations, including high school students who viewed themselves as better leaders and writers than their peers (College Board, 1976-1977), business managers who perceived themselves as more able than the typical manager (Larwood & Whittaker, 1977), and football players who believed they had more "football sense" than their teammates (Felson, 1981).

Kruger and Dunning (1999) conducted a comprehensive examination of adult's self-appraisal accuracy across various domains, including competence in rating humor, performance on a logical reasoning task, and knowledge of English grammar. After completing tests in each of these domains, participants were asked to compare their ability and test performance to their peers by providing a percentile ranking. Participants who scored in the bottom quartile grossly overestimated their test performance and ability on all tasks. Specifically, test scores placed them in the 12th percentile, but they estimated themselves to be in the 62nd percentile. Kruger and Dunning (1999) interpreted this discrepancy between perceived and actual performance as a deficit in metacognitive skill and argued that the overestimating participants not only performed poorly, but they lacked the metacognitive ability to realize it.

Metacognitive skills are considered to be an important factor affecting learning and behavior in childhood (Efklides, 2009; Semrud-Clikeman, Walkowiak, Wilkinson, & Butcher, 2010), and some commonly-used informant-based pediatric behavioral rating scales target metacognitive skills (Gioia, Isquith, Guy, & Kenworthy, 2000). Metacognitive abilities such as self-appraisal can also be measured directly with cognitive testing. While this has been done in several cognitive domains in adults, prior studies of self-appraisal in children have mostly been limited to memory functions, and the relationship between self-appraisal in a laboratory and behavior in the real world has not received much attention.

The limited number of studies that have examined self-appraisal in children explored judgments of learning on memory tasks only (Hanten et al., 2004; Koriat & Shitzer-Reichert, 2002; Roebers, von der Linden, Howie, & Schneider, 2007; Schneider, Vise, Lockl, & Nelson, 2000). In general, these studies found that children's self-monitoring abilities varied greatly depending on testing circumstances and conditions, including immediate versus delayed judgments of learning (Schneider et al., 2000), prospective versus retrospective judgments of recall (Hanten et al., 2004), the opportunity for practice and availability of cues (Koriat & Shitzer-Reichert, 2002), and whether questions were answerable or unanswerable (Roebers et al., 2007). A few studies testing metacognition within the language domain revealed that children with traumatic brain injury were impaired on detection of semantic anomalies (Dennis, Barnes, Donnelly, Wilkinson, & Humphreys, 1996; Hanten et al., 2004). Less is known about children's self-appraisal in domains other than memory and language, such as executive functioning.

A small amount of research has examined the relationship between self-appraisal bias and behavior. Children with ADHD overestimated their own competence relative to teacher's estimates more than children without ADHD (Evangelista, Owens, Golden, & Pelham, 2008). This disparity between self-report of competence and actual competence was associated with hyperactivity/impulsivity, but not inattention in children with ADHD (Owens & Hoza, 2003). These findings were generated by comparing students' versus others' ratings of their abilities, rather than direct measurement of self-appraisal in a laboratory or other testing situation. Given that laboratory or office-based testing is an important component of cognitive and functional assessment in both adults and children, it is useful to know whether self-appraisal accuracy in a laboratory setting relates to behavior and functioning in the real world.

The present study examined self-appraisal in typically developing children and a mixed clinical group comprised of children with very low birth weight (VLBW) and sickle-cell anemia. These medical disorders are believed to affect executive functioning (Anderson & Doyle, 2004; Berkelhammer et al, 2007); therefore, these particular subgroups were chosen to determine if medical conditions associated with deficits in EF are also associated with problems in metacognition. Executive dysfunction and self-appraisal are both related to the prefrontal cortex (Berkelhammer et al., 2007; Rosen et al., 2010). Impairments in EF in VLBW children may be influenced by disturbed connectivity between posterior brain regions and the prefrontal cortex (Skranes et al., 2009). Sickle-cell anemia has also been associated with alterations in the prefrontal cortex (Al-Kandari et al., 2007). Given that these clinical subgroups have EF deficits ostensibly related to neuroanatomical regions associated with self-appraisal, it is likely that they will also display difficulty with accurate self-appraisal.

The present study was designed to measure self-appraisal accuracy in children using tasks of executive function, and to investigate relations between self-appraisal and informant ratings of real world behaviors. We hypothesized that greater self-appraisal accuracy would be associated with fewer problems in informant ratings of real world behaviors, such as monitoring and inhibition. Based on Kruger and Dunning's (1999) results highlighting overestimating participants' deficits in metacognitive skill, we also hypothesized that the relationship between self-appraisal accuracy and informant ratings of real world behaviors would be more robust in overestimating children than underestimating children.

METHODS

Procedures

Participants were all recruited through a NIH funded multi-site study examining executive functioning. Sites that recruited children and collected data used in this study included the University of California San Francisco, University of Nebraska-Lincoln, Case Western Reserve University, and University of South Carolina. Recruitment strategies and participants varied by site. All children with neurological disorders were previously seen at centers for clinical or research purposes. Children with sickle-cell disease and associated cerebrovascular injury as documented on MRI were recruited from the Neuropsychology and Human Development Lab at the University of South Carolina. Children with very low birth weight (VLBW, <1000 g birth weight) were recruited from children who had been followed as part of a larger multi-center neonatal follow-up program (NIHCH Neonatal Network). All children in the VLBW sample were born at Rainbow Babies & Children's Hospital in Cleveland, OH and all locatable children from birth cohorts 1996 to 1998 were recruited. Children who, based on previous neonatal follow-up data, were known to be so severely disabled as to preclude testing were excluded. Typically developing children were recruited by all sites from schools through mass mailings and through siblings of children in the clinical cohort. A database was maintained in order to cull participants at the appropriate age. Children were then screened before they were brought in to ensure that they did not have a diagnosed condition that would affect performance.

Subjects

We studied 91 children (mean age 11.9 years, standard deviation = 1.7), including 47 typically developing children and 44 children with medical disorders believed to affect executive functioning, including very low birth weight (n=29) and sickle-cell anemia (n=15). Children under the age of 10 years were excluded from the study due to concerns about their ability to understand the self-appraisal task. See Table 1 for demographic, neurobehavioral, and neuropsychological information for all subjects and information by participant group.

This study was approved by the each site's committee on human research (University of California San Francisco, University of Nebraska-Lincoln, Case Western Reserve University, and University of South Carolina). The legal-guardian of every child provided informed consent to participate in the study. Assent was obtained from each child as well.

Measurement of Self-Appraisal

Three neuropsychological tasks, delivered as part of a larger executive function testing battery, were selected to measure self-appraisal accuracy. The tasks measured lexical fluency (f-word generation: number correctly generated in one minute), semantic fluency (animal generation: number correctly generated in one minute), and design fluency (total number of designs correctly generated in one minute, including designs created by connecting empty dots and designs created by switching between empty and filled dots; D-KEFS Design Fluency: Delis, Kaplan, & Kramer, 2001). The neuropsychological evaluation was always collected by a clinician trained in its administration. These particular tasks were chosen because they all had existing normative data that would permit subjects' estimates of their performance to be compared with their actual performance, accounting for demographic factors such as age and education. D-KEFS normative data was used, including data separated by letter and category made available by one of the D-KEFS authors. At the beginning of the testing, participants were informed that after performing each of these cognitive tasks, they would be asked to assess their performance on the task relative to a hypothetical sample of children of the same age, sex and education as them. They were shown a picture of a bell curve with corresponding percentile rankings at the bottom of the page (Figure 1). They were reminded that on a typical task, the majority of healthy age-matched peers would perform at the 50th percentile, with smaller numbers performing above or below average (corresponding locations were pointed to by the experimenter). Participants were told that, after completing each task, they would have to indicate how they thought they had performed by pointing to where they would be on the bell curve picture. This approach to self-assessment has been shown to correlate well with other types of estimates of performance (Williamson et al., 2010). After each of these cognitive tasks, the bell curve picture was produced and the subject was asked to assess how they had performed in terms of a percentile rank. The examiner was in the room throughout the self-appraisal process and was watching while the participant indicated where on the graph they felt they performed. This self-appraisal task was also used in a previous study examining neuroanatomical correlates of self-appraisal in a mixed group of patients with neurodegenerative disease (Rosen et al., 2010). Self-appraisal was only assessed after task completion (post-diction), because prior studies have shown that prediction of performance on neuropsychological tasks of this type is poor in normal adults, but that post-diction is relatively accurate (Eslinger et al., 2005).

Measure of Real World Behaviors

Real world behaviors were measured using the Behavior Rating Inventory of Executive Function - Parent form (BRIEF; Gioia et al., 2000). The BRIEF is an informant-based rating scale designed to assess behavioral functioning in children ages 5–18. It measures parental perceptions of regulatory behaviors that children express in their everyday environment, as observed by parents. Parents are asked to rate how often (“never”, “sometimes”, or “often”) their child engages in a specified behavior. The BRIEF contains 86 items and produces eight clinical subscales (Inhibition, Shifting, Emotional Control, Initiation, Working Memory, Planning/Organization, Organization of Materials, and Monitoring), two indexes, and a Global Executive Composite score. Internal consistency ranges from .80 to .98 for parent and teacher forms and clinical and normative samples (Gioia et al., 2000). Test-retest reliability correlation (*r*) across clinical scales for the Parent form in a normative subsample was .81 (range: .76-.85) (Gioia et al., 2000).

Creation of Variables

Self-appraisal accuracy scores—Raw scores on each of the cognitive tasks were converted into Z-scores using available norms for each task. Post-test performance percentile estimates were converted to Z-scores as well. Actual performance scores were subtracted from post-test performance estimates, and the absolute discrepancy served as a measure of self-appraisal accuracy (absolute self-appraisal accuracy = |self-appraisal – actual performance|). The three absolute discrepancy measures were averaged in order to calculate an overall measure of self-appraisal accuracy. Accuracy could be impaired in two ways, with children overestimating or underestimating their performance, and we hypothesized that these two types of miscalibration might have different etiologies and different behavioral implications. In order to take direction of miscalibration into account, we also created self-appraisal accuracy scores where the sign of the discrepancy value was kept (as opposed to absolute values) and these values were averaged to create an overall measure of relative self-appraisal accuracy, which was used in analyses examining overestimating and underestimating children separately (relative self-appraisal accuracy = self appraisal – actual performance). The terms absolute self-appraisal accuracy or relative self-appraisal accuracy are used throughout the paper to indicate which measure of self-appraisal accuracy was used for that analysis.

Performance score—Theoretically, if all subjects rated themselves at the same level, for instance rating themselves conservatively as performing at the level of an average person, those with the worst performance on cognitive testing would be expected to show the greatest error in self-appraisal just because they were most impaired. In order to ensure that analyses represented self-appraisal, rather than cognitive performance on the tasks we used, the Z-scores for performance on all cognitive tasks were averaged to create a variable representing overall cognitive performance, which was used as a covariate in all analyses examining self-appraisal accuracy independent of performance. While this approach may eliminate variance in EF that actually contributes to self-awareness, the approach is necessary to ensure that the variance in self-appraisal used for our analyses is truly attributable to self-appraisal ability and not just fluency. Table 1 displays each subgroup’s performance on fluency tasks and relative self-appraisal accuracy score.

Operationalizing overestimating and underestimating children—Children were separated into groups based on the direction of miscalibration of performance. Children were defined as accurate estimators of ability if their relative self-appraisal accuracy Z-score was between −0.5 and 0.5 (n= 37, Mean age=11.2(1.3), 13 patients and 24 controls). Overestimating children were defined as those children who had a self-appraisal accuracy Z-score greater than 0.5 (self-appraisal-actual performance> 0.5; n=41, Mean age=12.9(1.9), 25 patients and 16 controls). Underestimating children were defined as those children who had a self-appraisal accuracy Z-score less than −0.5 (self-appraisal-actual performance< −0.5; n=13, Mean age=11.3(0.9), 6 patients and 7 controls). The majority of typically developing children were accurate appraisers of their abilities whereas the majority of children in the clinical group overestimated their abilities. The ratio of patients to controls was higher in the overestimating group than the underestimating group ($p<.05$). Children in the overestimating group were older than children in the underestimating group ($p<.05$). Nevertheless, as age is related to the development of executive functioning, statistically holding its effect constant would remove an important source of variance; therefore, age was not included as a covariate in subsequent analyses. Table 3 displays performance on each fluency task and self-appraisal accuracy by cohort and age.

Statistical analysis

Statistical analyses were computed using SPSS software package (version 16.0 for Windows, SPSS Inc., Chicago, IL). Descriptive statistics were utilized to examine the discrepancy between children's self-appraisal and actual performance. The main goals for the analysis were to investigate relationships between self-appraisal accuracy and BRIEF scores and to examine whether these relationships differed for underestimators vs. overestimators. Thus, correlations were computed between the self-appraisal accuracy composite score and the eight clinical scales on the BRIEF measuring behaviors in the real world. Because we were interested in identifying variance specifically associated with self-appraisal, our primary analyses focused on partial correlations controlling for actual performance. A Dunn-Sidak correction (Sidak, 1967) was used to control for multiple comparisons (resulting in a p value of .0064 functioning as the new significance level).

Additional analyses were performed for the control group and clinical group separately to see if there was any evidence that the relationships differed across groups. We also present findings from analyses done without corrections for performance to illustrate the effect of covarying out this factor.

RESULTS

Self-Appraisal Accuracy

On average, children rated their ability to be at the 52^{nd} percentile, which exceeded their actual performance (38^{th} percentile), by 14 percentile points. Correlations with and without controlling for performance computed between the self-appraisal accuracy composite score, age, and gender were not significant ($p>.05$). This suggests there is not a significant effect of age or gender on self-appraisal accuracy. While fluency needed to be accounted for a-priori, other cognitive measures might also account for self-appraisal accuracy. Given that error-monitoring is usually considered a frontally mediated function (Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004) we examined partial correlations between self-appraisal accuracy, after accounting for fluency, and other measures of cognition, in particular measures of EF. General intellectual ability (using the WRAT reading score as a proxy for IQ; $r=.39$, $p=.002$) and other measures of executive functioning and processing speed (Trails B completion time: $r=.-.42$, $p=.001$; Stroop Interference number correct: $r=.39$, $p=.002$; Digit Symbol number correct: $r=.34$, $p=.01$) correlated with self-appraisal accuracy, but none of these correlations remained significant after covarying for performance on the fluency tasks ($p>.05$).

Real World Correlates of Self-Appraisal Accuracy

Absolute discrepancy

Overall relationships (regardless of diagnosis): Before controlling for performance, inhibition, shifting, emotional control, initiation, working memory, and monitoring behaviors correlated significantly with self-appraisal accuracy. After controlling for performance, shifting behavior correlated significantly with self-appraisal accuracy (r=.32, *p*=.006, Table 5).

Relationships within diagnostic groups: The relationship between self-appraisal accuracy and shifting remained significant when examining typically developing children alone (n=47), with (r=.40, *p*=.006) and without (r=.41, *p*=.006) controlling for performance. Although self-appraisal accuracy correlated significantly with inhibition (r=.52, *p*<.001) in the clinical group alone (n=44), this relationship was not significant when controlling for performance (*p*>.05).

Relative discrepancy

Overall relationships (regardless of diagnosis): Analyses were performed for overestimating children (n=41) and underestimating children (n=13) separately to determine whether the relationship between insight and real world behaviors differed depending on the direction of miscalibration of performance (see Tables 4 and 5). Before correcting for performance, overestimating children's relative self-appraisal accuracy scores correlated significantly with inhibition, shifting, emotional control, initiation, working memory and monitoring. After controlling for performance, self-appraisal accuracy correlated with inhibition (r=.54, *p*=.002) and shifting (r=.49, *p*=.006) on the BRIEF. Correlations were not significant in underestimating children with or without controlling for performance (*p*>.0064). These findings illustrate that overestimating children were driving the relationship between self-appraisal accuracy and informant ratings of real world behaviors.

Relationships within diagnostic groups: Correlations were evident between self-appraisal accuracy and the BRIEF when examining overestimating typically developing children alone without controlling for performance (n=16; emotional control r=.66, *p*=.006 and planning r=.66, *p*=.006), and some correlations were significant after controlling for performance (shifting r=.75, *p*=.003 and emotional control r=.79, *p*=.001). There was a correlation between self-appraisal accuracy and inhibition (n=25; r=.62, *p*=.001) when examining the overestimating clinical group alone, but this was not significant when controlling for performance (*p*>.0064). Correlations were also not significant when examining underestimating controls (n=7) and underestimating patients (n=6) separately (*p*>.05).

DISCUSSION

In a group of school aged children, self-appraisal accuracy correlated with informant ratings of real world behaviors including inhibition and shifting abilities. This relationship, which was identified using an objective, neuropsychologically-based assessment of self-appraisal, was independent of cognitive performance scores used to calculate self-appraisal ability (i.e. fluency tasks). Once fluency was accounted for, there was no evidence that other measures of executive function or general intelligence contributed to self-appraisal accuracy. Furthermore, the relationship between self-appraisal and behavioral ratings differed depending on the direction of miscalibration of performance. There was a significant relationship between self-appraisal accuracy and real world behavioral ratings in children who overestimated their cognitive performance, but not in those who underestimated, indicating that factors contributing to underestimation of performance and the consequences thereof may differ from those contributing to overestimation of performance. For example, low self-esteem may account in part for a tendency to underestimate one's performance, with this tendency obscuring associations between self-appraisal accuracy and test performance.

Our results are consistent with prior studies indicating that behavioral problems are affected by cognitive processes beyond those measured by traditional tests of executive function. For instance, parent ratings of regulatory behaviors among preschoolers (using the BRIEF-P) are sensitive to symptoms of ADHD, but do not correlate with performance-based measures of executive function, suggesting that this rating scale measures different elements of executive function than those tapped by performance-based measures (Mahone & Hoffman, 2007). Similarly, the BRIEF is correlated with ratings of behavioral disruption and impairment in children ages 6-15, but not with performance-based tasks of executive function (McAuley, Chen, Goos, Schachar, & Crosbie, 2010). In patients with traumatic brain injury, lack of social self-awareness predicts behavioral disturbance independent of cognitive and executive functioning (Bach & David, 2006). At the same time, other studies have demonstrated that metacognitive abilities are partially independent of the cognitive processes they are monitoring. This has been shown, for example, for memory performance (Kircher, Kosh, Stottmeister, & Durst, 2007) and executive function impairments (Pickup, 2008) in patients with schizophrenia. These findings support the idea that metacognition is an independent cognitive process with unique implications for behavioral control and the idea that specific assessments of separate behavioral and cognitive deficits, including metacognitive processes, are potentially useful in clinical practice (Godefroy, Jeannerod, Allain, & Le Gall, 2008).

In parallel with studies showing that metacognition is a psychologically specific construct, literature is also accumulating to show that it has specific anatomical substrates, in the frontal lobes and specifically the ventromedial prefrontal cortex (Gusnard, Akbudak, Shulman, Raichle, 2001; Kelley et al., 2002; Rosen et al., 2010; Schmitz & Johnson, 2007). Schnyer and colleagues (2004) tested the hypothesis that prefrontal cortex is implicated in accurate predictions of episodic memory performance using a feeling-of-knowing paradigm (a commonly used measure of metacognition). Lesion analysis of patients who displayed markedly impaired self-appraisal accuracy showed damage in the right ventromedial prefrontal cortex. Self-appraisal accuracy was also correlated with tissue content in the right ventromedial prefrontal cortex in a mixed group primarily comprised of patients with neurodegenerative disease, many suffering from anosognosia (Rosen et al., 2010). Future research should examine the neuroanatomical correlates of self-appraisal accuracy in children.

Given that metacognition is a specific psychological function with specific anatomical substrates, it follows that metacognition should be evaluated more regularly in standard assessments of cognition. Our findings showing that self-appraisal accuracy predicts informant ratings of real world function support this idea. Considering self-appraisal abilities in children may be useful in understanding the learning and behavioral needs of children, particularly those with medical conditions associated with executive dysfunction and frontal lobe alterations. Metacognition is an important aspect of childhood behavior and should be measured directly (Efklides, 2009; Reeve & Brown, 1985; Semrud-Clikeman et al., 2010); however, more research is needed to further define the role of metacognitive testing in clinical assessment. Future research should investigate whether self-appraisal accuracy measured in a laboratory relates to other aspects of real world functioning, such as academic success and social functioning.

We measured metacognitive monitoring (what people think about their abilities). A closely related concept is metacognitive control (how people adjust their behavior for circumstances), which itself is likely comprised of multiple components and is often assessed to some degree in standard tests of executive functions (e.g. Stroop effect, flanker effect, errors, rule violations). Measures of metacognitive control are related to real world behaviors as well, including inattention (Kim et al., 2005), goal-directed behavior and processing speed (Lawrence et al., 2004), and test performance (Dermitzaki, 2005; Krebs & Roebers, 2010). The anatomy of metacognitive awareness and control may overlap, as both are dependent on the frontal lobes (Fernandez-Duque, Baird, & Posner, 2000; Pannu & Kaszniak, 2005). Thus, further research will be required to examine whether metacognitive monitoring makes independent predictions, or predicts different types of real world deficits, compared with metacognitive control. This would be the best justification for including standardized assessments of metacognitive monitoring in traditional neurocognitive evaluations.

The majority of typically developing children accurately rated their abilities whereas the majority of children in the clinical group overestimated their abilities, as might be expected. Surprisingly, when the relationships between self-appraisal accuracy and real world behavioral ratings were examined separately in typically developing children and a group of children with medical conditions affecting cognition, the correlations were significant for the typically developing but not the clinical group. Given the cognitive impairments in the clinical group, the reverse finding might have been expected. The fact that the relationship was present even in the typically developing children, where other cognitive and social confounds are less likely to be present, helps to support the idea that self-appraisal represents cognitive processes that are at least partially independent of other functions putatively dependent on the frontal lobes, and these self-appraisal-specific processes, in turn, have unique implications for optimal daily function. Interpretation of the clinical group findings is more complicated, and concluding that metacognition does not contribute to their behavioral regulation seems premature. In these children, there are many more potential determinants of both their behavioral and metacognitive status, including cognitive, cultural, social, or educational variables. Variance in cognitive abilities within groups may have influenced the results because lower birth weight is associated with increased cognitive dysfunction, and the location (frontal lobe damage) and quantity (including silent strokes) of cerebrovascular injury results in varying cognitive manifestations. In addition, social psychology has explored how socio-economic status, ethnicity, and gender are related to people's self-perception and expectations of success (Cohen, Garcia, Apfel, & Master, 2006; Major & O'Brian, 2005; Miyake et al., 2010). Expectations of success are also related to test anxiety, which may be heightened if there is an examiner with whom the test-taker must interact (which was the case here). Given that this was a novel, complex task, children may have performed worse in this situation. Our method of self-appraisal of performance may also have contributed to social facilitation. The relationship between metacognition and behavior, even if present, might be more difficult to detect in a medical context where many more of these factors could be contributing.

Some study limitations are notable. The lack of teacher ratings and possible subjectivity of parent ratings limits the interpretability of the BRIEF to some degree. Furthermore, this study only examined self-appraisal accuracy on executive functioning measures, and only assessed retrospective self-appraisal (post-diction), whereas predictive approaches would be equally, or potentially even more interesting. Because these fluency measures were likely novel tasks for children, they lacked an inherent idea of how many words or figures the average person would generate, making it unlikely that they could accurately predict their performance. Indeed, adults are inaccurate at predicting their responses on these types of tasks, whereas they are more accurate at post-diction (Eslinger et al., 2005). It would be valuable to examine self-awareness using tasks that allow reasonable predictions (based on everyday cognitive experiences in life, e.g. Williamson et al., 2010). Nevertheless, the novelty of the tasks may also be viewed as a strength of the study because bias might be more pronounced when there is nothing concrete upon which to attach one's expectation. Of course, performance on the self-appraisal tasks may reflect personality characteristics or self-esteem. This is an issue in any study that examines self-appraisal.

Our use of the fluency measures to examine self-appraisal, while very convenient, also limited our ability to examine the cognitive underpinnings of self-appraisal. This ability is likely multifactorial, and could depend on many functions, including memory, frontally-based cognitive abilities and emotions (Shimamura, 2000). Although it was methodologically necessary to factor out fluency to ensure we were focusing on self-appraisal, this may have also removed some variance contributed by fluency, or cognitive abilities correlated with fluency, to self-appraisal. Studies using an assessment method for self-appraisal that is separate from the rest of the neuropsychological battery, although less efficient than our approach, would be better able to address the cognitive components of self-appraisal.

Finally, we only included children ages 10 to 17 years and failed to find an association between age and self-appraisal accuracy. Children between ages 3 and 5 years show rapid improvement on most laboratory measures of executive function (Ewing-Cobbs, Prasad, Landry, Kramer, & DeLeon, 2004; Luciana & Nelson, 1998), which may be associated with rapid growth of the prefrontal cortex during this time (Webb, Monk, & Nelson, 2001). Future studies should attempt to examine self-appraisal abilities in preschool aged children to learn more about developmental aspects and trajectories of metacognition.

Summary

In summary, self-appraisal accuracy correlated with informant ratings of real world behaviors, including inhibition and shifting abilities, independent of cognitive performance scores. Findings suggest that self-appraisal represents cognitive processes that are at least partially independent of other functions putatively dependent on the frontal lobes, and these self-appraisal-specific processes, in turn, have unique implications for optimal daily function.

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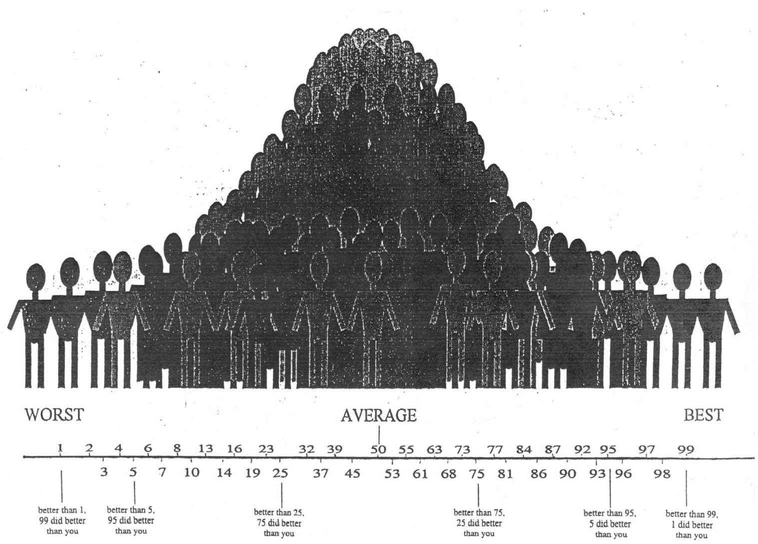

Figure 1. Bell curve picture used to help children estimate their performance

Illustration of the normal curve filled with people used to assess children's self-appraisal of performance on a percentile scale.

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Table 1

General demographic, neurobehavioral, and neuropsychological information of all subjects and by subgroup.

	All	Controls	Sickle cell	Very Low Birth Weight
Age (years)	11.9 (1.7)	10.8 (1.7)	13.1 (2.5)	12.1 (0.4)
Gender	45 M/ 46 F	22 M/ 25 F	7 M/ 8 F	16 M/ 13 F
WRAT Reading Standard Score	100.5 (14.4)	106.7 (14.2)	Not available	96.4 (15.0)
BRIEF Inhibition T-score	53.4 (11.6)	50.6 (10.4)	54.7 (12.1)	54.8 (12.3)
BRIEF Shifting T-score	52.1 (10.9)	50.4 (10.7)	54.7 (9.0)	52.9 (11.3)
BRIEF Emotional Control T-score	51.8 (10.4)	49.2 (9.7)	55.5 (10.3)	51.1 (10.3)
BRIEF Initiation T-score	54.5 (10.7)	52.0 (8.9)	53.4 (10.4)	57.9 (12.0)
BRIEF Working Memory T-score	55.6 (11.9)	52.4 (9.9)	57.6 (11.8)	60.3 (13.5)
BRIEF Planning T-score	52.5 (9.7)	50.3 (8.7)	52.6 (7.5)	55.0 (11.3)
BRIEF Org. of Materials T-score	45.5 (7.5)	44.9 (7.0)	44.0 (7.9)	47.2 (7.4)
BREIF Monitoring T-score	51.9 (10.0)	48.2 (8.2)	52.2 (9.3)	55.8 (11.6)
Lexical fluency Z-score (F-words)	−0.47 (0.8)	−0.4 (0.9)	−0.9 (0.8)	−0.4 (0.9)
Semantic fluency Z-score (Animals)	−0.14 (1.0)	0.9 (1.0)	−0.2 (1.2)	−0.3 (1.0)
Design Fluency Z-score	−0.49 (1.0)	−0.1 (0.9)	−1.1 (0.7)	−0.7 (1.0)
Self-appraisal accuracy Z-score	0.52 (1.1)	0.4 (0.9)	1.1 (1.1)	0.6 (1.2)

Table 2

Number (and percent) of participants in each self-appraisal bias category.

	Underestimator	Accurate estimator	Overestimator
All	13 (14%)	37 (41%)	41 (45%)
Control group	7 (15%)	24 (51%)	16 (34%)
Clinical group	6 (14%)	13 (29%)	25(57%)

Table 3

General neuropsychological information and self-appraisal accuracy by age and cohort (Z-scores).

	Control Group					Clinical Group				
Age	**N**	**Lexical**	**Semantic**	**Design**	**Self-appraisal**	**N**	**Lexical**	**Semantic**	**Design**	**Self-appraisal**
10	**34**	−.45(0.8)	.07(0.8)	.01(1.0)	.46(0.4)	**2**	−.48(1.0)	−.78(1.6)	−2.1(0.3)	.76(0.4)
11	**2**	−.11(1.7)	.04(2.1)	−.88(0.0)	.76(0.9)	**15**	−.06(1.0)	−.13(1.1)	−.46(1.1)	.95(1.1)
12	**5**	−.02(0.5)	−.21(0.9)	−.53(0.6)	1.0(0.4)	**17**	−.28(0.8)	−.10(1.1)	−.62(0.9)	1.1(0.9)
13	**0**	-	-	-	-	**5**	−.94(0.7)	.13(0.7)	−.63(0.6)	.91(0.7)
14	**2**	−.11(1.2)	−.86(0.2)	−.30(0.4)	1.1(0.8)	**4**	−.33(0.6)	−.31(0.6)	−.83(0.4)	1.0(0.6)
15	**3**	−.76(1.0)	.07(0.7)	−.48(0.7)	0.9(0.6)	0	-	-	-	-
16	**1**	−1.3(0.0)	−.58(0.0)	−1.8(0.0)	0.4(0.0)	**0**	-	-	-	-
17	**0**	-	-	-	-	**1**	−1.8(0.0)	−1.7(0.0)	−1.4(0.0)	1.2(0.0)

Table 4

Correlations between self-appraisal accuracy and BRIEF clinical scales for all patients, by cohort, and by self-appraisal category.

	Absolute Self-Appraisal Accuracy			Relative Self-Appraisal Accuracy					
				Overestimators			Underestimators		
	Overall	Control	Clinical	Overall	Control	Clinical	Overall	Control	Clinical
Inhibition	−.42*	−.24	−.51*	−.51*	−.34	−.62*	.71	.70	.87
Shifting	−.33*	−.40*	−.23	−.43*	−.56	−.32	.28	.08	.57
Emotional Control	−.32*	−.25	−.35	−.53*	−.66*	−.45	.11	.10	.07
Initiation	−.30*	−.26	−.28	−.45*	−.46	−.41	.13	.27	.11
Working Memory	−.41*	−.34	−.37	−.52*	−.51	−.50	.27	.51	.06
Planning	−.22	−.29	−.10	−.39	−.66*	−.10	.35	.34	.40
Org. of Materials	−.15	−.05	−.30	−.38	−.27	−.42	.08	.16	.59
Monitoring	−.36*	−.25	−.31	−.46*	−.63	−.36	.29	.19	.19

* *Note:* =p<.0064.

Table 5

Partial correlations between self-appraisal accuracy and BRIEF clinical scales controlling for performance for all patients, by cohort, and by self-appraisal category.

	Absolute Self-Appraisal Accuracy			Relative Self-Appraisal Accuracy					
				Overestimators			Underestimators		
	Overall	Control	Clinical	Overall	Control	Clinical	Overall	Control	Clinical
Inhibition	−.29	−.31	−.22	−.54*	.65	.41	.74	.77	.73
Shifting	−.32*	−.41*	−.16	−.49*	.75*	.25	.47	.26	.78
Emotional Control	−.13	−.19	−.02	−.46	.79*	.19	.38	.32	.34
Initiation	−.15	−.29	−.03	−.40	.71	.10	.40	.52	.23
Working Memory	−.23	−.32	−.10	−.37	.59	.11	.52	.78	.54
Planning	−.17	−.22	−.06	−.37	.68	.07	.64	.68	.70
Org. of Materials	−.07	−.07	−.03	−.23	.51	.10	.07	.10	.45
Monitoring	−.25	−.24	−.15	−.34	.61	.08	.72	.60	.77

**Note:* = $p < .0064$.