

Emotional Impulsivity in Children with ADHD Associated with Comorbid—Not ADHD—Symptomatology

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Abstract Children with ADHD often demonstrate sudden and intense shifts in both positive and negative affect. This study examined the role of diagnostic status on emotional impulsivity in children utilizing ecological momentary assessment (EMA). Parents of 64 8–12 year old children (15 ADHD-only; 27 ADHD-comorbid; 22 control) completed a diagnostic structured interview and then an EMA protocol, rating the child's affect thrice daily for 28 days. Analysis of covariance (ANCOVA) suggested that children with ADHD and a comorbid disorder demonstrated significantly more EMA-derived emotional impulsivity than children with ADHD only and control children. No difference was found between children with ADHD only and control children. This study suggested that children with ADHD demonstrate significantly higher levels of emotional impulsivity than control children only in the presence of a comorbid disorder.

Keywords ADHD · Internalizing · Externalizing · Comorbidities · Ecological momentary assessment · Emotion · Emotional impulsivity · Emotional lability

Impaired emotional functioning has been recognized as a central feature of ADHD in children (Barkley 2010). Studies have found higher rates of emotional instability (Skirrow et al. 2009), intense reactions to emotional stimuli (Jensen and Rosen 2004), and disinhibition of negative emotional

reactions (Crundwell 2005) in children with ADHD relative to healthy controls. A pattern of sudden, intense shifts in emotion has been identified in children with ADHD. Barkley (2010) and others have used the term “emotional impulsivity” to describe this phenomenon. Emotional impulsivity has been characterized by impatience, low frustration tolerance, quickness to anger, irritability, and emotional excitability (Barkley and Fischer 2010). Individuals with ADHD display quicker and more dramatic shifts when presented with an emotionally evocative stimulus, whether positive or negative (Musser et al. 2011; Barkley and Fischer 2010).

All children—regardless of ADHD status—are capable of demonstrating impulsive emotional reactions. However, a subset of children has been identified as frequently engaging in emotionally impulsive behaviors, and this subset is strongly associated with the presence of ADHD (Anastopoulos et al. 2011). Indeed, Anastopoulos and colleagues (2011) found that approximately 47 % of children with ADHD demonstrated this pattern, as compared to 15 % of non-ADHD children. Emotional impulsivity is more likely to occur in conjunction with the combined subtype of ADHD (Wheeler Maedgen and Carlson 2000; Martel 2009), and in children with more severe ADHD symptomatology (Banaschewski et al. 2012).

Barkley (2010) and others have speculated that this finding stems from executive functioning difficulties at the neurological level. Specifically, the inability to inhibit responses causes the difficulties with selective attention, hyperactivity, and impulsivity inherent in ADHD, as well as an impaired ability to inhibit strong emotional responses. Furthermore, children with ADHD display heterogeneous physiological responses to emotionally arousing stimuli, suggesting that there is variability within this population at the neurobiological level regarding emotional responses (Musser et al. 2013). Such physiological heterogeneity may explain the reasons why only a certain subset of children with ADHD displays significant problems with emotional impulsivity.

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Severe emotional impulsivity is associated with a number of negative outcomes in children with ADHD. Children with ADHD who demonstrate this pattern of emotional lability show higher levels of aggression (Skirrow et al. 2009) and internalizing and externalizing problems (Rosen and Factor 2012). Additionally, emotional impulsivity was found to partially mediate the relation between ADHD status and impairment in social and adaptive skills (Anastopoulos et al. 2011). This pattern of impairment associated with emotional impulsivity is unique to children with ADHD; emotional impulsivity was associated with internalizing and externalizing problems in children with ADHD but not in children without ADHD (Rosen et al. n.d.).

Emotional Impulsivity in ADHD and Comorbid Disorders

Emotional impulsivity is associated with comorbid diagnoses in children with ADHD. ADHD commonly occurs in conjunction with one or more comorbid internalizing (e.g. Major Depressive Disorder, Generalized Anxiety Disorder) and/or externalizing (e.g. Oppositional Defiant Disorder). It is estimated that approximately two-thirds of children with ADHD also meet diagnostic criteria for another comorbid disorder (Jensen et al. 2001). There is no inclusion of emotional symptoms in the current construction of ADHD in the Diagnostic and Statistical Manual despite the large and growing body of evidence to suggest that impairment in emotional functioning is significantly associated with ADHD. Rather, the current diagnostic criteria focus solely on inattention, hyperactivity, and impulsivity related to behavioral inhibition (American Psychiatric Association 2013). Consequently, the emotional impairments experienced by children with ADHD are often accounted for by symptoms of other diagnoses. This may in part explain the high rate of comorbid disorders diagnosed in children with ADHD.

Emotional Impulsivity in Comorbid Externalizing Disorders Impaired emotional functioning has been identified in children with ADHD and comorbid ODD. There is a high rate of comorbidity between ADHD and ODD, with some estimates as high as 84 % (Barkley 2005). It is thought that emotional lability could underlie one of the multiple pathways to ODD revealed by factor analysis of ODD symptoms (Sobanski et al. 2010; Drabick and Gadow 2012).

Some studies have found two factors, roughly separated into symptoms based on irritable reactivity and symptoms based on willful defiance (Burke et al. 2010); others have found three factors based on irritable reactivity, oppositionality, and vindictiveness (Stringaris and Goodman 2009b). The DSM-5 has utilized the three-category approach in classifying symptoms (American Psychiatric Association 2013). In previous iterations of the DSM, the irritable/reactive symptoms of ODD were included as part of the diagnoses (e.g. hyperkinetic disorder,

minimal brain dysfunction) that are considered precursors to ADHD (Barkley 2010; Carlson 1998). However, these symptoms were split off from the precursors to ADHD in the initial DSM-III formulation of ADD/ADHD and instead combined with symptoms of willful defiance to form ODD. It is thought that there are different affective pathways to these sets of ODD symptoms (Drabick and Gadow 2012). Both sets of symptoms are highly comorbid with ADHD (Pardini and Fite 2010), but each set presents a different affective profile.

The irritable/reactive symptoms are strongly associated with symptoms of ADHD (Barkley 2010), and impaired emotional functioning within ADHD has been associated with the irritable/reactive symptoms but not the defiant/vindictive symptoms of ODD (Factor et al. 2013). These symptoms are often displayed in response to emotional distress (Stringaris and Goodman 2009a). Children higher in the irritable/reactive symptoms demonstrate more problems with affect (Kolko and Pardini 2010), physiological reactivity in response to negative stimuli (Waschbusch et al. 2002), and problems with effective response planning in response to emotional arousal (Factor et al. 2013). Irritable traits in early childhood have been linked to depression and anxiety later on (Burke 2012). It is possible that children with ADHD experience frequent bursts of negative emotion in reaction to a stimulus and externalize this emotion, appearing irritable and oppositional (Factor et al. 2013). This may explain the overlap between the emotional impulsivity seen in ADHD and the irritable/reactive symptoms of ODD.

In contrast, a subset of children with ODD has been identified as having “callous/unemotional” traits, demonstrating the defiant/vindictive symptoms, low response to distressing stimuli, and behavioral disinhibition without the irritable/reactive symptoms (Frick et al. 2003). They are physiologically underaroused when anticipating emotionally evocative stimuli (Fung et al. 2005), suggesting an underreactivity to external stimuli that runs counter to the overarousal seen in children with the irritable/reactive presentation of ODD. Thus, the defiant/vindictive symptoms do not appear to be linked to emotional impulsivity or overarousal.

Emotional Impulsivity in Comorbid Internalizing Disorders ADHD also frequently occurs in conjunction with internalizing disorders. Estimates of comorbidity range from 13 to 50 % (Jensen et al. 1997). Children with ADHD demonstrate stronger negative emotion in reaction to adverse events (Jensen and Rosen 2004) and have more difficulty coping with these negative emotions than children without ADHD (Babb et al. 2009; Walcott and Landau 2004); thus, they are more likely to experience episodes of frustration in everyday situations (Scime and Norvilitis 2006). Additionally, comorbid anxiety can exacerbate working memory and inhibitory deficits, further complicating efforts to plan and execute an effective regulatory response to a negative stimulus (Schatz and Rostain 2006).

Children with ADHD often show impairments in their emotional functioning consistent with symptoms of internalizing disorders. They may display social impairment, aggression (Blackman et al. 2005), and problems with self-esteem (Barkley 2005). These behaviors are characteristic of depressive and anxiety disorders, and may partially explain the origins of the coexistence of internalizing disorders with ADHD.

Furthermore, emotional lability fully mediated the relation between ADHD and comorbid depression (Seymour et al. 2012) in one study and partially mediated the relation between ADHD and both depression and anxiety in another study (Anastopoulos et al. 2011). Internalizing problems may also inhibit the ability of children with ADHD to cope with and regulate negative emotion. Indeed, comorbid anxiety has an additive effect on disinhibition and working memory in children with ADHD that may further reduce the effectiveness of their already deficient ability to regulate negative emotion (Sorensen et al. 2011). Given the assertion by Barkley (2010) that impaired executive functioning in the form of disinhibition is one of the root causes of emotional impulsivity, children with ADHD who experience additional disinhibition are particularly susceptible to emotional lability, negative emotions and behavior, and negative consequences, all reminiscent of internalizing problems.

Co-occurrence of Internalizing and Externalizing Problems in Children with ADHD Many children with ADHD demonstrate co-occurring internalizing and externalizing problems. These comorbidities can interact with and affect each other. Peyre and colleagues (2012) found that children with ADHD who demonstrated elevated aggression and “anxious/depressed” symptoms were significantly more likely to have a comorbid internalizing disorder diagnosis and marginally significantly more likely to have a comorbid externalizing disorder diagnosis. Additionally, these children were rated as higher in emotionality. Furthermore, children with ODD and ADHD were more likely to be rated as higher in “anxious/depressed” symptoms than children with ODD without ADHD (Kim et al. 2010). Children with ADHD and a comorbid disorder showed more aggressive and anxious behavior relative to children with ADHD and no comorbidities, indicating an effect of comorbidities on both internalizing and externalizing problems (Tzang and Chang 2009). Emotional impulsivity in ADHD was related to both internalizing and externalizing problems in children (Rosen and Factor 2012), suggesting that the same underlying construct is associated with multiple symptoms, often in conjunction. Thus, the evidence suggests that the interplay between internalizing and externalizing comorbidities in children with ADHD affects their emotional and behavioral functioning.

Internalizing and externalizing problems not only frequently coexist in children; they are frequently interrelated. Fraire and Ollendick (2013) noted that deficits in emotion regulation

and information processing underlie both anxiety and ODD in children, and are related to poorer relations with both peers and parents as well as functional impairment. Many of the same risk factors (e.g. familial conflict, peer rejection, harsh discipline) have been identified as underlying both internalizing and externalizing disorders in children, indicating similar pathways that can result in either divergent or co-occurring disorders (Oland and Shaw 2005). Others have theorized that temperamental factors and other common features among the disorders can account for the relation between internalizing and externalizing disorders, or that the presence of one disorder can in turn result in impairment in another area characteristic of another disorder (Lilienfeld 2003). Furthermore, internalizing and externalizing disorders have been linked to similar outcomes, including impaired social (Greene et al. 2002; Rudolph et al. 1994) and academic functioning (Franco et al. 2007; Mychailyszyn et al. 2010).

Regardless of the underlying reasons, it is clear that internalizing and externalizing problems are not independent of each other. Therefore, when assessing comorbid pathology within ADHD, it must be understood that individuals with ADHD and a comorbid disorder form a heterogeneous group, and that children with ADHD and internalizing and/or emotionally-driven externalizing disorders (i.e., ODD with reactive/irritable symptoms) often display symptoms or are characterized by the same underlying constructs regardless of the actual comorbid diagnosis. Given the frequency of both comorbid emotional and behavioral problems and the evidence of a pattern of emotional variability and intensity in a subset of children with ADHD, it is likely that there is a link between emotional impulsivity and the emotional and behavioral difficulties that underlie comorbid internalizing and externalizing disorders. Thus, it is likely that the subset of children with ADHD who demonstrate this pattern of emotional impulsivity will be at increased risk for developing comorbid psychopathology.

Ecological Momentary Assessment of Emotional Impairment in Children with ADHD

Collection of data on emotion in children has typically been conducted through retrospective report or laboratory-based procedures (Porges et al. 1994; Shields and Cicchetti 1997). However, retrospective reports are often not ecologically valid, and laboratory-based procedures do not yield data regarding patterns of emotion over time in the child’s natural environment. In contrast, Ecological Momentary Assessment (EMA) methods allow for data on children’s emotional functioning to be collected by the primary caretaker in the child’s natural environment at the moment it occurs (Stone and Shiffman 1994). Additionally, EMA methods allow for the

collection of multiple ratings over a period of time. This allows for the analysis of patterns of data over time (Ebner-Priemer and Trull 2009).

EMA methodology is uniquely suited to assessing emotional impulsivity. EMA enables assessment of the frequency of emotional shifts, the valence of the emotion, the intensity of the emotion, the intensity of emotional fluctuations, and the individual’s baseline emotional state. Obtaining such data is crucial for the study of emotional impulsivity, and other data collection methods cannot provide such information. Previous research by the authors has demonstrated the feasibility of obtaining EMA data in children with and without ADHD (Rosen and Factor 2012). However, analysis of emotional impulsivity collected via EMA has not yet been conducted specifically investigating the role of comorbidities within ADHD.

Research Questions Given the links between emotional impulsivity and emotional and behavior problems in ADHD, and the increased likelihood of emotional lability in children with ADHD and a comorbid internalizing and/or externalizing disorder, we seek to examine the effects of diagnostic status on emotional impulsivity. Specifically, we seek to examine whether ADHD status alone is linked to higher levels of emotional impulsivity relative to control children, as indicated by more frequent and intense shifts in overall affect over the course of the day, or if it is only in the presence of a comorbid disorder that children with ADHD demonstrate significantly elevated emotional impulsivity. Based on the evidence in the extant literature, the following hypotheses are offered:

- Hypothesis 1 Children with ADHD will demonstrate more emotional impulsivity than control children.
- Hypothesis 2 Children with ADHD and a comorbid disorder will demonstrate more emotional impulsivity than children with ADHD only and control children.

Methods

Participants

A sample of 64 children (41 boys, 23 girls) ages 8 to 12 years ($M=9.83$, $SD=1.15$) and their families participated in the present study. Participants were recruited through advertisements distributed through elementary and middle schools in a mid-sized Midwestern metropolitan area. The demographic breakdown of the participants was 39 Caucasian, 20 African-American, 4 biracial, and 1 other. Forty-two of the children lived in a two-parent home, and 22 lived in a single-parent home. One parent or caretaker (59 mothers, 4 fathers, 1 custodial grandparent) was designated as the primary rater

for the duration of the EMA procedures to ensure internal validity of the EMA data, as discrepancies between raters’ perception of child behavior may increase the variability of ratings across the study period. A full demographic breakdown can be found in Table 1.

Diagnostic Status

Parents were administered the Diagnostic Interview Schedule for Children, Fourth Edition (*DISC-IV*; Shaffer et al. 2000) to determine the child’s diagnostic status. Children were included in the ADHD group if they met criteria for ADHD-Combined Type or ADHD-Predominantly Inattentive Type plus three or more symptoms of hyperactivity/impulsivity (no children met criteria for ADHD-Hyperactive/Impulsive Type), following Barkley’s (2010) theory that emotional impulsivity is present in children with either the combined subtype or a subthreshold level of hyperactivity/impulsivity rather than a “sluggish cognitive tempo” presentation of ADHD-Inattentive Type. Children were also assessed for Oppositional Defiant Disorder, Generalized Anxiety Disorder, Separation Anxiety Disorder, Social Phobia, Major Depressive Disorder, and Dysthymic Disorder. Children were included in the control group if they did not meet for any of these disorders. Twenty-two children were classified as controls, 15 as ADHD-only, and 27 as ADHD-comorbid. Among the children in the ADHD-comorbid group, four were diagnosed exclusively with a comorbid internalizing disorder, 11 with exclusively a comorbid externalizing disorder (ODD), and 12 with both ODD and an internalizing disorder. Children who met for the “sluggish cognitive tempo” presentation of ADHD-Inattentive Type or who met for an internalizing or externalizing disorder without a co-occurring diagnosis of ADHD were excluded from this analysis entirely. Children presenting a “callous/unemotional” presentation of ODD—that is, three or more of the defiant/vindictive symptoms without any of the irritable symptoms—were to be excluded from the analysis as well; however, none of the children met these criteria. Twenty-three children—seven in the ADHD-only group and 16 in the ADHD-comorbid group—were

Table 1 Demographics by diagnostic category

	Control (<i>n</i> =22)	ADHD-only (<i>n</i> =15)	ADHD-comorbid (<i>n</i> =27)
Mean age	10.23	9.73	9.56
% male	59.1	53.3	74.0
% Caucasian	68.2	46.7	63.0
% on psychotropic medication	0	46.7	59.3
% in two-parent household	77.3	66.6	55.5

receiving psychotropic medication during the study; medication doses remained constant throughout the study. One-way ANOVA did not indicate significant differences among the diagnostic groups on any of the demographic variables, aside from medication status (none of the control children were receiving pharmacological treatment).

Procedures

Parents of children provided informed consent and children provided assent at a baseline session prior to beginning the study procedures. Parents completed the *DISC* to assess the child's diagnostic status. Parents and children also completed questionnaires regarding the child's emotional and behavioral functioning at baseline. At the end of the baseline session, parents and children were trained by study personnel in the completion of the EMA procedures.

Parents and children completed EMA-based ratings three times a day for 28 days (84 time points). Participants completed ratings using Palm Tungsten E2 Personal Data Assistants (PDA) that were programmed with Purdue Momentary Assessment Tool (PMAT; Weiss et al. 2004). The PDA was programmed to alert participants to complete ratings at three specifically designated time points (morning, afternoon, and evening) requested by parents. These time points were selected by the parents to maximize the likelihood that the parent would be with the child at the time of the rating.

At each rating interval, parents indicated their identity (i.e. mother, father, other caretaker) to ensure that the designated parent was completing the ratings. Parents rated the child using a Positive and Negative Affect Scale-Parent Report (*PANAS-PR*; Phillips et al. 2002) to indicate their perception of the child's positive (PA) and negative (NA) affect at the time of the rating. Parents were compensated \$15 for completing measures at baseline, and up to \$10 per week depending on the percentage of EMA ratings they completed. Child report was not used, as previous studies have found that children were less likely to complete EMA ratings during intervals where their parents rated them as upset, thus rendering their ratings invalid (Rosen and Factor 2012; Rosen et al. 2013). Therefore, only parent ratings were utilized in this analysis. Only ratings by the primary rater were included in this analysis, as interrater discrepancies would artificially increase variability. All procedures were approved by the university's Institutional Review Board.

Measures

Parents were administered the *DISC* (Shaffer et al. 2000) at baseline to assess the child's diagnostic status. The *DISC* is a diagnostic structured interview that assesses whether children meet DSM-IV criteria for a number of psychological

disorders. The *DISC* has demonstrated validity and reliability in a number of settings (Shaffer et al. 2000).

The *PANAS-PR* (Phillips et al. 2002) is a 20-item scale which was administered to parents thrice daily to assess the child's positive, negative, and total affect as part of the EMA protocol. To minimize the inconvenience to participants and improve EMA adherence rate, a 10-item equivalent of the *PANAS*, first developed by Thompson (2007), was utilized. Parents rated the amount of each listed emotion that their child was showing at that moment on a five-point Likert-type scale from 1 ("not at all") to 5 ("extremely"). The *PANAS* has been utilized in previous EMA protocols, including a previous protocol examining parent-report of emotional impulsivity in children with ADHD (Rosen and Factor 2012; Shrier et al. 2005).

Use of PANAS-PR for Assessment of Emotional Impulsivity

The *PANAS-PR* was utilized to measure emotional impulsivity. First, each time point was examined to ensure that it was completed by the primary rater in the presence of the child; time points in which the rater indicated otherwise were removed from the data set. We created PA, NA, and TA (total affect) scores at each interval by summing the responses from each category. Mean NA, PA, and TA scores were created by averaging the scores from the *PANAS-PR* across each interval to represent the child's average total affect. Mean squared successive difference (MSSD) scores were created from the *PANAS-PR* to illustrate variability of the child's affect by taking the difference of each successive within-day rating point (i.e. morning-afternoon and afternoon-evening), squaring each difference score, and averaging these difference scores across the 28-day rating period; this process was recommended by Solhan and colleagues (2009) and has previously been utilized in assessing emotional impulsivity in children with and without ADHD (Rosen and Factor 2012). This procedure creates a single score to account for the frequency and intensity of within-day affective variability over the entire study period. Separate MSSD scores were created to assess the child's PA, NA, and TA. *PANAS* MSSD data has previously been used as an indicator of emotional impulsivity, as it is uniquely suited to track variable patterns of positive, negative, and overall emotions over time (e.g. Rosen and Factor 2012).

On average, participants completed the ratings at 75.5 % of the rating periods. A one-way ANOVA was conducted to determine diagnostic status group differences on EMA adherence. Results were not statistically significant, $F(2, 61) = 1.004, p = 0.37$.

Results

PANAS ratings were compiled across the rating periods to create overall means and MSSDs for TA, NA, and PA.

Analysis of covariance (ANCOVA) was calculated to determine the relation between diagnostic status and both the mean and MSSDs for each variable. Age, gender, and medication status were entered as covariates for all variables. For MSSDs, mean affect scores were entered as a covariate as well to analyze affective variability independent of the sheer amount of affect the child shows.

For PANAS-TA, no significant differences were found across the groups on mean or any of the covariates. Contrasts did not indicate significant differences between any two diagnostic groups. On PANAS-TA MSSD, there was a significant effect of diagnostic status on levels of MSSD, $F(2, 57) = 3.962, p = 0.024, \eta^2 = 0.122$. Planned contrasts revealed no significant difference between the control and ADHD-only groups, $p = 0.83$, but did reveal a significant difference between the ADHD-comorbid group and both the control, $p = 0.019$, and ADHD-only groups, $p = 0.022$. Results can be seen in Table 2 and Fig. 1.

For PANAS-NA, no significant differences were found in the covariates, but there was a significant effect of diagnostic status on mean NA, $F(2, 58) = 9.934, p < 0.001, \eta^2 = 0.255$. Planned contrasts indicated significant differences between the ADHD-comorbid group and both the control ($p < 0.001$) and ADHD-only ($p < 0.01$) groups, but no difference between the control and ADHD-only groups ($p = 0.19$). On PANAS-NA MSSD, the overall effect of diagnostic status approached significance, $F(2, 57) = 2.705, p = 0.075, \eta^2 = 0.087$. Planned contrasts indicated a significant difference between the ADHD-only and ADHD-comorbid groups, $p = 0.028$; none of the remaining contrasts was significant. Results can be seen in Table 3 and Fig. 2.

For PANAS-PA, no significant differences were found in the covariates, and there was no significant effect of diagnostic status on mean PA, $F(2, 58) = 1.406, p = 0.25$. Planned contrasts did not indicate any significant differences between the diagnostic status groups. There was no significant effect of diagnostic status on PANAS-PA MSSD, $F(2, 57) = 0.582, p = 0.56, \eta^2 = 0.02$. Planned contrasts did not indicate any

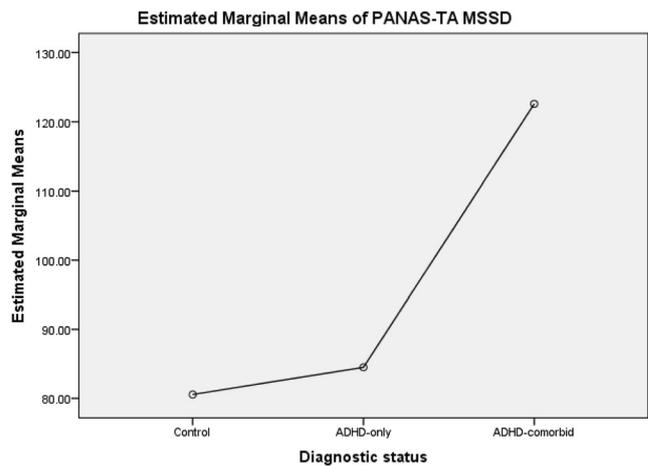


Fig. 1 Estimated marginal means of emotional impulsivity (PANAS-TA MSSD) per diagnostic group. ADHD-comorbid > ADHD only and control, $p < .05$

significant differences among any of the diagnostic categories. Results can be seen in Table 4 and Fig. 3.

Discussion

This study sought to examine the relation between ADHD, comorbidity status, and emotional impulsivity. Results indicated that it is only in the presence of a comorbid disorder that children with ADHD display significantly more emotional impulsivity than typically functioning children, lending support to Hypothesis 2 but not Hypothesis 1. Furthermore, this relationship is most evident in total and negative affect, as it is in these areas that children with ADHD and a comorbid disorder demonstrated significantly more variability than children in the other diagnostic categories.

Previous studies have examined the role of emotion in ADHD comorbidities (Anastopoulos et al. 2011; Okado et al. 2013; Tzang and Chang 2009). To our knowledge, this is the first study to utilize EMA ratings to assess emotional

Table 2 Estimated marginal means of PANAS-TA MSSD

	Control mean (SD)	ADHD-only mean (SD)	ADHD-comorbid mean (SD)	F	p	η^2
Step 1						
Gender (M=0, F=1)				0.192	0.663	0.003
Age				0.138	0.713	0.002
Med. status (N=0, Y=1)				0.004	0.948	0.000
Step 2						
PANAS-TA Mean	37.695 (6.19) (1.53)	37.410 (6.53) (1.63)	40.479 (5.73)	0.058	0.810	0.001
Step 3						
PANAS-TA MSSD*	81.173 (37.43) (11.78)	83.250 (54.48)	122.800 (48.99)	4.235	0.019	0.127

Covariates appearing in model are evaluated at the following values: gender=0.36, age=9.83, medication status=0.36, PANAS-TA Mean=38.80

* ADHD-comorbid > ADHD-only and control, $p < 0.05$

Table 3 Estimated marginal means of PANAS-NA MSSD

	Control mean (SD)	ADHD-only mean (SD)	ADHD-comorbid mean (SD)	<i>F</i>	<i>p</i>	η^2
Step 1						
Gender (M=0, F=1)				0.098	0.756	0.002
Age				0.259	0.614	0.005
Med. status (<i>N</i> =0, <i>Y</i> =1)				1.162	0.286	0.020
Step 2						
PANAS-NA Mean **	5.279 (0.268) (1.53)	5.553 (0.775)	6.130 (0.689)	54.03	<0.001	0.487
Step 3						
PANAS-NA MSSD [†]	2.234 (3.66) (0.685) (11.78)	2.30 (2.25)	6.800 (3.93)	2.705	0.075	0.087

Covariates appearing in model are evaluated at the following values: gender=0.36, age=9.83, medication status=0.36, PANAS-NA Mean=5.70

** ADHD-comorbid > ADHD-only and control, $p < 0.01$

† ADHD-comorbid > ADHD-only, $p < 0.05$

impulsivity across diagnostic status. EMA is uniquely suited to assess affect over time, in terms of its nature, valence, and variability. Thus, we believe these results present a significant development in the area of assessment of emotional impulsivity in children with ADHD and the way in which it affects diagnostic status with regard to comorbidities.

These results underscore the role that comorbid psychopathology plays in the emotional functioning of children with ADHD. The executive dysfunction inherent in ADHD hinders the ability of children with ADHD to inhibit negative emotional reactions. These emotional reactions are typically intense and can often result in negative and unpredictable emotionally-driven behaviors and subsequent negative consequences, which can ultimately develop into symptoms of externalizing and internalizing psychopathology over the long-term. Conversely, it is possible that co-existing psychopathology predisposes children to stronger and more frequent negative emotion, and the additive effects of ADHD-based

disinhibition lead to more emotional volatility. Though this study could not determine the directionality of the relationship between ADHD, comorbid psychopathology, and emotional impulsivity, it is clear that ADHD is not uniquely associated with emotional impulsivity; rather, it is in the presence of ADHD with comorbid symptoms that maladaptive and impairing emotional impulsivity is most often observed.

Interestingly, our results indicated that children with ADHD and a comorbid disorder demonstrate significantly more variable NA than children with ADHD only, but no more than control children, and no difference was found across any of the groups with regard to PA. Individually, these findings do not appear to directly follow the trends seen in the existing literature; however, when combined to form the TA variable, a robust and significant pattern emerges that does fit conceptually with the existing literature. We interpret these results as supporting a conceptualization of TA as a construct greater than merely the sum of its parts (PA and NA). Patterns of TA depend not only on patterns of PA and NA but also on the way in which PA and NA interact dynamically—how they covary, the intensity and frequency of each, and the extent to which a child demonstrates complex emotions that combine positive and negative affective states. Further study is needed to determine how PA and NA interact to form TA and the way in which TA is distinct from a mere sum of PA and NA.

Clinical Implications Such diagnostic heterogeneity presents significant challenges for clinicians. First, diagnostic evaluations must be very thorough in order to account for the high rates of comorbidity in children with ADHD. In particular, close attention should be paid to the child's typical patterns of emotion to determine if the child demonstrates significant emotional impulsivity, and, if so, how these impairments manifest as they relate to symptoms of internalizing and/or externalizing disorders. It is possible that EMA methodologies might be used as part of a thorough diagnostic assessment of

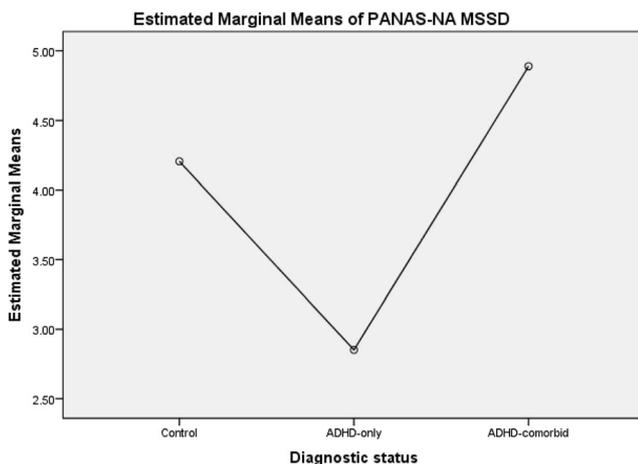


Fig. 2 Estimated marginal means of negative affect variability (PANAS-NA MSSD) per diagnostic group. ADHD-comorbid > ADHD only, $p < .05$

Table 4 Estimated marginal means of PANAS-PA MSSD

	Control mean (SD)	ADHD-only mean (SD)	ADHD-comorbid mean (SD)	F	p	η^2
Step 1						
Gender (M=0, F=1)				0.125	0.725	0.002
Age				0.085	0.773	0.001
Med. status (N=0, Y=1)				0.209	0.649	0.004
Step 2						
PANAS-PA Mean	15.347 (5.33)	13.328 (2.76)	14.112 (2.79)	25.31	<0.01	0.308
Step 3						
PANAS-PA MSSD	28.852 (26.75) (3.97) (11.78)	19.588 (14.86)	27.563 (11.38)	0.588	0.562	0.020

Covariates appearing in model are evaluated at the following values: gender=0.36, age=9.83, medication status=0.36, PANAS-PA Mean=14.29

children’s emotional and behavioral functioning. Further study would be needed to determine the utility of such an assessment.

Additionally, these findings present significant implications for the development and use of psychosocial interventions for children with ADHD and comorbid disorders. Typical psychosocial treatments for ADHD largely emphasize behavior management (e.g. Pelham et al. 1998). Though these treatments have demonstrated significant efficacy in treating the core symptoms of ADHD, behavior management treatments do not typically address the emotional functioning of children with ADHD, regardless of the presence of comorbid diagnoses (Graziano et al. 2011). Specifically, impaired emotional functioning and emotional impulsivity underlie many of the behavioral problems experienced by children with ADHD and a comorbid externalizing disorder (Factor et al. 2013). Additionally, a strictly behavioral approach would not address any of the symptoms related to mood or anxiety in children with ADHD and a comorbid internalizing disorder.

Thus, existing treatments must be modified and new treatments created to address the role of emotional impulsivity in children with ADHD. Interventions can utilize cognitive-

behavioral techniques for worry, anger, and frustration (Suveg et al. 2006), teach emotion recognition techniques and physiological relaxation exercises for anger and frustration (Kovacs et al. 2006), and utilize problem-solving to help children adjust when their expectations are not met (Kazdin et al. 1992). These are not mutually exclusive to traditional behavior management techniques for inattention, hyperactivity, and impulsivity; rather, these can and should complement traditional approaches based on the child’s emotional functioning and comorbid diagnoses.

Theoretical Implications These findings have significant implications for research related to patterns of emotion in ADHD and related disorders, as well as in formulating the diagnostic criteria for these disorders. Previously, research on emotional impulsivity has largely been concentrated on children with ADHD, and comparisons have been made between individuals with and without ADHD. To our knowledge, this study represents the first investigation of emotional impulsivity and comorbid disorders within ADHD in children. Based on our findings, it appears that ADHD is necessary but not sufficient for children to display significantly higher levels of emotional impulsivity than control children; it is only in the presence of a comorbid disorder that this pattern of elevated emotional impulsivity begins to emerge. It stands to reason that affective intensity and impulsivity are independent entities, each with their own associated pattern of negative sequelae. Children with ADHD who experience impairments in both of these areas are particularly susceptible to negative outcomes, both from these entities themselves and from their interaction. Specifically, these children experience strong emotions and lack the executive resources to inhibit their strong initial reactions. These children thus display more overt reactions to emotionally evocative stimuli and experience negative consequences from inappropriate display of and reactions to these emotions, leading them to demonstrate impairment consistent with an internalizing and/or externalizing disorder.

However, additional exploration is necessary to determine the origins and directionality of emotional impulsivity as it

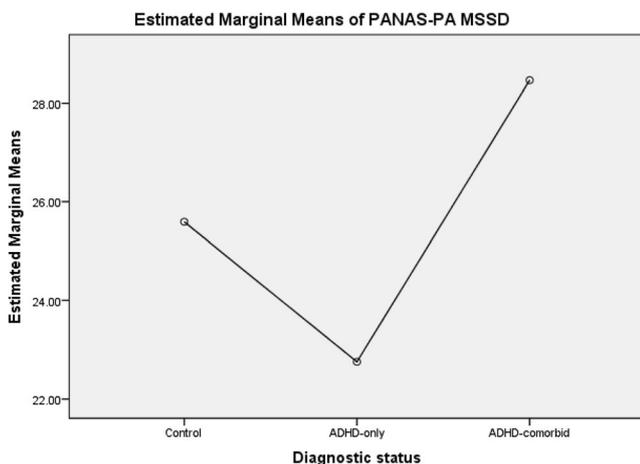


Fig. 3 Estimated marginal means of positive affect variability (PANAS-PA MSSD) per diagnostic group

relates to ADHD and comorbid psychopathology. Future studies should investigate the role of emotional impulsivity in non-ADHD psychopathology to determine if emotional impulsivity is associated with these disorders independent of ADHD or if the combination of ADHD and a comorbid disorder is uniquely associated with this phenomenon. Additionally, future research could explore the causal mechanisms that underlie both emotional impulsivity and comorbid psychopathology in children with ADHD. Such research could help answer the question of whether emotional impulsivity within ADHD leads to the development of comorbid psychopathology or whether factors underlying both ADHD and comorbid psychopathology (i.e. temperamental or biological factors) lead children to demonstrate impairing levels of emotional impulsivity.

Furthermore, these findings could have an impact on the way in which these disorders themselves are construed. Histories of ADHD have paid special attention to the role of emotional lability in the disorders considered to be precursors to ADHD; however, none of the current symptoms of ADHD are related to emotion despite a large and growing body of literature emphasizing the role of emotional lability within ADHD (Barkley 2010; Taylor 2011). Meanwhile, ODD was introduced to the DSM-III—at the same time as the modern description of ADHD—as a way to encapsulate patterns of disruptive emotions and behaviors of children. Some (e.g. Barkley 2010) suggest that this separated the emotional impairment inherent in ADHD away from other equally vital components of the disorder, and others (e.g. Stringaris and Goodman 2009b) have suggested that ODD itself is a heterogeneous disorder, with symptoms of irritability and noncompliance more strongly associated with ADHD than symptoms of willful defiance and hurtfulness/vindictiveness. Additionally, there are high rates of comorbidity and shared precursors between ODD and internalizing psychopathology (Tzang and Chang 2009). Taken together, these findings suggest that further exploration on the delineation between ADHD and comorbid disorders is warranted. Our findings, which suggest that a phenomenon previously thought to be associated with ADHD is in fact a product of ADHD *and* comorbid disorders, further underscore the importance of this area as an important topic for future exploration.

Limitations and Directions for Future Research Several limitations exist with regard to this study. First, our relatively small sample size may have decreased our statistical power, reducing our ability to uncover small but significant findings within our data. Second, there was only one single responder for both the diagnostic structured interview and the EMA ratings. Though child EMA report has previously been found to be unreliable (e.g. Rosen and Factor 2012), the utilization of ratings from additional sources (e.g. another parent, teacher, objective coding by researchers) would provide a more comprehensive assessment of patterns of the child's emotional and

behavioral functioning. Third, the irritable/reactive presentation of ODD is not the only presentation associated with ADHD; children with ADHD also demonstrate the callous-unemotional presentation of ODD. However none of the children in our sample met for an exclusively callous-unemotional presentation of ODD. It is likely that children with this presentation of ODD would not demonstrate the same pattern of emotional lability, as they are less strongly reactive to situational stimuli. Inclusion of a subset of children with this symptom profile would allow us to test this hypothesis. Fourth, though we utilized EMA to assess affective variability over time, the short data collection period did not allow for an assessment of the temporal and dynamic relation of diagnostic status and emotional impulsivity. Such an assessment would further clarify the diagnoses of the participants over time and how emotional impulsivity might affect the stability of such diagnoses. Additionally, the lack of EMA sampling at random intervals may have allowed parents to rate their children at convenient times in which the child was most likely to demonstrate positive or neutral affect and avoid times at which the child may have been more likely to display frustration or negative emotion (e.g. transitional times). Finally, parental psychopathology is often an overlooked factor in assessing the validity of parental perceptions of children's emotional and behavioral functioning. This study—and future studies utilizing similar methodology—would have benefitted from the inclusion of parental psychopathology as a covariate in analyzing ratings of child affect.

A number of directions for future research exist based on the findings from this current study. First, a study with a larger sample would achieve more statistical power and potentially enable the detection of more meaningful findings. The use of a longitudinal study would enable us to determine the reliability of the diagnoses assessed during the baseline diagnostic structured interview. As there is a considerable amount of overlap and shared variance between comorbid internalizing and externalizing disorders within ADHD, assessment of the test-retest reliability of these diagnostic labels would allow for comparison across multiple patterns of comorbidity (e.g. ADHD + internalizing, ADHD + mixed internalizing-externalizing). Additionally, a study of emotional impulsivity in children with internalizing and/or externalizing disorders without ADHD would shed additional light on whether EI is inherent in all internalizing and externalizing disorders, or if it is only in the presence of both ADHD and a comorbid disorder that this pattern emerges.

Conclusion

The concept of emotional impulsivity in individuals with ADHD is an emerging area of research. The current study

presents a significant development in this field, as it provides evidence that emotional impulsivity is uniquely associated with comorbid psychopathology within ADHD rather than ADHD itself. These findings will aid in our understanding of which children are likely to demonstrate emotional impulsivity, and suggest areas for future research in order to further hone our understanding of this concept. Additionally, these findings also invite discussion about the way in which symptoms of impaired emotional functioning are classified in our current constructions of ADHD and internalizing and externalizing disorders. By enhancing our understanding of the specific concept of emotional impulsivity and the broader area of diagnostic classification, we can improve our ability to study, diagnose, and treat individuals with ADHD and related psychopathology.

Conflict of Interest Perry I. Factor declares that there is no conflict of interest; Rachel A. Reyes declares that there is no conflict of interest; Paul J. Rosen declares that there is no conflict of interest.

Experiment Participants This project was approved by the Institutional Review Board at the University of Louisville. All parents provided written consent and all children provided written assent prior to beginning any study procedures.

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