The Expression of Adult ADHD Symptoms in Daily Life: An Application of Experience Sampling Methodology

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Abstract:
Objective: To use experience sampling method (ESM) to examine the impact of inattentive and hyperactive-impulsive ADHD symptoms on emotional well-being, activities and distress, cognitive impairment, and social functioning assessed in the daily lives of young adults. The impact of subjective appraisals on their experiences is also examined.
Method: Participants *(n = 206)* complete up to 56 in-the-moment assessments of mood and current activities using Personal Digital Assistants for I week.
Results: Multilevel modeling techniques reveal that ADHD inattentive and hyperactive-impulsive symptoms differentially relate to daily experiences. Higher inattentive symptoms are associated with indices of general distress, including less positive and more negative mood as well as more concentration problems. Higher hyperactive-impulsive symptoms are associated with reduced sensitivity to contextual factors in perceptions of situations.
Conclusion: These findings demonstrate predictive validity for adult self-report of ADHD symptoms in a general population sample and suggest future research directions using ESM.
Keywords: ADHD; adults; experience sampling methodology; daily activities; behavioral assessment

Article:
A DHD first appears during childhood, but the symptoms and related impairment can continue into adulthood (Barkley, Fischer, Smallish, & Fletcher, 2002; Weiss & Hechtman, 1993). Although the experience and impact of inattentive and hyperactive-impulsive symptoms in children has been widely examined, the impairment associated with these symptoms in adulthood has received less attention (Barkley, 2006). The present study employed the experience sampling method (ESM) to examine the expression of ADHD symptoms in the daily life of a nonclinical sample of young adults. ESM, a powerful research method, repeatedly prompts people to complete assessments of their current experiences. Specifically, the study examined the relationship of ADHD with the experience of social contact, affect, and cognition in daily life.

ADHD and Daily Functioning
In comparison to clinical lore about adult ADHD, empirical evidence about the expression of the disorder and the impairment it creates is relatively sparse. A few longitudinal studies following children with ADHD into adulthood have documented impairment in scholastic, occupational, relationship, and daily life functioning (e.g., Barkley, Fischer, Smallish, & Fletcher, in press; Manuzza, Gittelman-Klein, Bessler, Malloy, & LaPadula, 1993; Weiss & Hechtman, 1993). In addition, psychiatric comorbidity is often higher in these adults than in non-ADHD community controls (Fischer, Barkley, Smallish, & Fletcher, 2002). Adults diagnosed as hyperactive as children report increased levels of anti-social behavior, substance use, school failure, employment problems, lack of success in college, and relationship problems compared to their nonhyperactive peers (Barkley, Fischer, Smallish, & Fletcher, in press; Manuzza et al., 1993; Weiss & Hechtman, 1993).

Outcomes from studies of adults diagnosed with ADHD in childhood and followed to adulthood differ somewhat from findings with samples of clinic-referred adults (Barkley, 2006)—however, clinic-referred adults also report greater functional impairment than controls. Although studies of clinic-referred adults with ADHD indicate increased psychiatric comorbidity (Biederman et al., 1993), clinic-referred adults may report even higher rates of internalizing symptoms than adults followed from childhood (Young, Toone, & Tyson, 2003). Additionally, clinic-referred adults with ADHD and adults reporting a prior ADHD diagnosis have more relationship and employment problems than controls (Barkley, Murphy, & Kwasnik, 1996; Biederman et al., 2006) and describe themselves as less socially competent (Friedman et al., 2003). Adults with ADHD, regardless of referral source, are impaired academically compared to those without the disorder, and fewer of them attempt or complete college (Barkley et al., in press; Biederman et al., 1993; Biederman et al., 2006). On the whole, a person with higher levels of ADHD symptoms might be expected to experience greater stress and negative life events as well as diminished positive affect. In addition, self-report of inattentive symptoms might be associated with cognitive difficulties in daily life.

Limited evidence also suggests that subjective appraisals may vary with respect to ADHD symptoms. Children with ADHD overestimate their competence in a variety of domains, despite performing worse than their non-ADHD peers (Hoza et al., 2004). Knouse, Bagwell, Barkley, and Murphy (2005) also found that adults with ADHD were more likely to overestimate their driving competence despite using fewer safe behaviors and reporting more citations and accidents. Other studies suggest that problems with low self-esteem are common among those high in ADHD symptoms (Slomkowski, Klein, & Manuzza, 1995). Therefore, the relationship between ADHD symptoms and subjective appraisals of the self is unclear. Importantly, few studies examine the impact of contextual factors on self-appraisals with respect to these symptoms.

Challenges in Research on Adult ADHD and Functioning

Clinical research on the impact of ADHD on adult functioning involves a number of challenges, including the need to rely on retrospective reports that may not correspond to daily behavior and the difficulty of independently assessing the impact of inattentive versus hyperactive-impulsive symptoms. First, data obtained in prior studies of functional impairment using retrospective reports may not correspond to life experiences reported as they occur. People experiencing ADHD symptoms—especially inattentive symptoms—may be especially susceptible to biases or distortions in memory of functioning in daily life. Thus, self-report methods that tap target behaviors in natural settings may provide a more accurate and ecologically valid assessment of functioning than self-reports that are typically administered in laboratory settings (Barkley, 1991). Second, prior clinical studies have focused on the effects of an overall ADHD diagnosis and often have not distinguished between the impact of inattentive versus hyperactive-impulsive symptoms on adult functioning.

Factor analyses of ADHD symptom items indicate two factors: inattention and hyperactivity-impulsivity (Lahey et al., 1988). The *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text revision; *DSM-IV-TR*; American Psychiatric Association, 2000) diagnosis of ADHD is categorical in nature, but the symptoms of inattention and hyperactivity-impulsivity are expressed dimensionally as the extreme end of a continuum of ADHD behaviors (Levy, Hay, McStephen, Wood, & Waldman, 1997). Even subclinical levels of adolescent ADHD are associated with impairment in multiple domains (Whalen, Jamner, Henker, Delfino, & Lozano, 2002). Although measures of these dimensions are highly correlated (e.g., $r = .72$ in Mitchell & Nelson-Gray, 2006), the different symptom domains are associated with distinct patterns of functioning and impairment (Lahey et al., 1994; Milich, Balentine, & Lynam, 2001). For example, extra-version is associated with hyperactive-impulsive symptoms, but not inattentive symptoms, in a dimensional analysis (Parker, Majeski, & Collin, 2004). Because extraversion includes a sociability component (Costa & McCrae, 1992), a differential relationship should emerge between inattentive and hyperactive-impulsive symptoms with social functioning in daily life.

ESM and Context in Daily Life

Researchers have recently begun using ESM to explore the expression of ADHD symptoms in daily life. ESM is a widely used, within-day self-assessment technique in which participants are prompted at random intervals

to complete a brief questionnaire. ESM has been used in clinical and social psychology research, and it offers several powerful advantages relative to traditional data collection procedures (e.g., Csikszentmihalyi & Larson, 1987; deVries, 1992; Reis & Gable, 2000). Specifically, ESM (a) repeatedly assesses participants in their normal daily environment, thereby enhancing eco-logical validity; (b) assesses the participants' experiences at the time of the signal, thereby minimizing retrospective bias; (c) allows for an examination of the context of participants' experiences; and (d) allows for the use of powerful multilevel statistics. These statistical procedures are required to analyze the nested data provided by ESM. Furthermore, they enable the researcher to examine the aforementioned context effects.

Whalen et al. (2002) employed ESM with an adolescent community sample. They found that self-reports of higher ADHD symptoms were associated with increased negative affect and decreased positive affect, lower alertness, less engagement in achievement-oriented activities, more time spent with friends and less with family, and more tobacco and alcohol use. The sample was classified into upper, middle, and lower tertiles by total ADHD symptoms to allow for a quasi-dimensional view of ADHD. However, the authors did not differentiate between inattentive and hyperactive-impulsive symptoms.

Goals and Hypotheses

The present study used ESM to examine the effect of inattention and hyperactivity-impulsivity symptoms on emotional well-being, daily activities and distress, cognitive impairment, and social functioning assessed in daily life in a nonclinical sample of young adults. Because it represents the first application of ESM to the study of adult symptoms of ADHD, this study was designed to address the challenges of assessing adult functional impairment. In place of retrospective self-report of functioning, we collected repeated in-the-moment ratings of activities and subjective appraisals.

Finally, we examined the relationship of inattentive and hyperactive-impulsive symptoms with daily experience across a range of symptom levels in a nonclinical population. This dimensional approach provides more information and statistical power than dichotomizing samples based on symptom counts (Milich, Hartung, Martin, & Haigler, 1994). We hypothesized that inattentive and hyperactive-impulsive symptoms would be associated with diminished positive and increased negative affect, greater distress in daily activities, and cognitive impairment (e.g., difficulty concentrating). Given their relationship with extraversion, hyperactive-impulsive symptoms were predicted to be positively associated with involvement in social activities, whereas this was not predicted for inattentive symptoms. We also considered the impact of people's subjective appraisals of situations on their experiences and ADHD symptoms.

Method

Participants

Usable data were collected for 206 students enrolled in general psychology courses at the University of North Carolina at Greensboro (UNCG) during the 2004-2005 academic year. Participants volunteered for the study through the department's Web-based research participation system and received course credit for participation. The sample was 75% female and 25% male. The ethnicity of the sample was 72% Caucasian, 25% African American, 1% Hispanic, 1% Asian, and 1% unspecified. The gender and ethnicity of the sample were consistent with the student demographics at UNCG. The mean age of the sample was 19.4 years ($SD = 1.9$). Age and sex were not associated with ratings of inattention and hyperactivity-impulsivity.

Materials and Procedures

Paper-and-pencil measures. Participants completed a brief demographic questionnaire and the Attention-Deficit/Hyperactivity Rating Scale (AD/HD-RS; DuPaul, Power, Anastopoulos, & Reid, 1998), along with other measures not used in this study, as part of departmental mass screening sessions that lasted 1.5 to 2 hr. Students received course credit for their participation. The AD/HD-RS lists the *DSM-IV* inattentive and hyperactive-impulsive criteria for the disorder and asks participants to rate the frequency of each behavior based on a 4-point Likert-type scale ($0 = never or rarely$, $1 = sometimes$, $2 = often$, $3 = very often$). Ratings of current

symptoms (last 6 months) were used in this study. Internal consistency (coefficient alpha) was .83 for the nine-item Inattention subscale and .74 for the nine-item Hyperactive-Impulsive subscale in the present sample.

ESM information session. At the start of the ESM study, participants attended a 1-hr information session. During this session, experimenters obtained informed consent and pro-vided Personal Digital Assistants (PDAs; Palm Pilot Zire model). The PDAs used iESP software (Intel Corporation, 2004), a modification of the widely used ESP software (Feldman-Barrett & Barrett, 2004). After learning how to use the PDA in an instructional session, participants completed a practice questionnaire to ensure familiarity with study procedures. Before participants finished the session, they received a written summary of the study instructions and contact information in the event that they experienced problems with the procedures.

ESM procedures. PDAs signaled the participants, administered the questionnaires, and time stamped and recorded the participants' responses. Participants were signaled to complete the ESM questionnaire eight times daily between noon and midnight for 7 days. One signal occurred randomly during each of the eight 90-min blocks that fell within the 12-hr window. Participants responded by tapping the appropriate answer on the PDA screen with a stylus. Participants had up to 5 min to initiate their responses following the signal and up to 3 min to complete each question. After these time intervals (or the completion of a questionnaire), the PDA turned off and would not reactivate until the next signal, which ensured that participants could not skip questionnaire administrations and complete them later. The ESM questionnaires required about 2 min to complete.

Participants were also asked to return to the lab on Days 2 and 4 of the study to allow investigators to download their data. These visits were scheduled to decrease the likelihood of data loss resulting from lost or defective PDAs and to increase the likelihood of participants regularly completing the protocols. Participants received research credit for taking part in the PDA portion of the study; people who completed at least 70% of the PDA questionnaires were entered into a drawing for one of two $100 gift cards awarded each semester.

The ESM questionnaire included 32 questions that inquired about cognitions, affect, activities, and social contact that the participant was experiencing at the time of the signal. Most of the items were rated on a 7-point scale from 1 (*not at all*) to 7 (*very much*). The ESM questionnaire included a four-item positive affect index (including items such as "I feel happy right now"), a five-item negative affect index (including items such as "I feel sad right now"), a four-item activity impairment index (including items such as "It takes a lot of effort to do this activity"), a two-item cognitive impairment index (including items such as "I have trouble concentrating right now"), a five-item social impairment index (including items such as "Right now my time with this person [these people] is important to me"), and a three-item social isolation index (including items such as "Right now I enjoy being alone"). An index of perceived competence was computed by subtracting the score (1 to 7) of the item "Right now it takes a lot of effort to do this activity" from the score (1 to 7) of the item "Right now I have the ability to do this activity." Positive and negative affect were conceptualized as separate dimensions. The ratings of each dimension were made on unipolar scales indicating the degree to which the mood was pre-sent, not on a bipolar scale that ranged from negative to positive valence (see Watson, 2000). The positive and negative affect indices correlated –.43, consistent with the notion that they assess related but separate constructs. Coefficient alpha was .90 for positive affect, .91 for negative affect, .69 for activity impairment, .83 for cognitive impairment, .90 for social impairment, and .80 for social isolation.

Statistical methods. ESM data have a hierarchical structure in which ESM ratings made in daily life (Level 1 data) are nested within participants (Level 2 data). Multilevel modeling provides a more appropriate method than conventional regression analyses for analyzing nested data (Affleck, Zautra, Tennen, & Armeli, 1999; Schwartz & Stone, 1998). Multilevel modeling techniques are an extension of the more commonly used multiple regression analyses (Hox, 2002; Luke, 2004), and they are standard for the analysis of ESM data (see Nezlek, 2001; Reis & Gable, 2000).

The multilevel analyses in the present study examined two types of relationships between the ADHD ratings and experiences rated in daily life. The first was the intercept of the Level 1 criterion, which assessed the

independent effects of the Level 2 predictors (e.g., inattention and hyperactivity-impulsivity) on Level 1 dependent measures (e.g., ESM ratings of thought impairment in daily life). The intercept, β_0, was computed using the formula, $\beta_0 = \gamma_{00} + \gamma_{01}(sex) + \gamma_{02}(inattention) + \gamma_{03}(hyperactivity\text{-}impulsivity) + \mu_0$ (in which γ_{00} is the mean value of the Level 1 dependent measure, $0j$ are the effects of the Level 2 predictors, and μ_0 is the error term). The γ_{0j} coefficient provides information that is comparable to the unstandardized regression weight of each Level 2 predictor with the Level 1 measures.

The second analyses examined the cross-level interactions of the relationships of the Level 1 ESM variables (e.g., stress of an activity and thought impairment) with the Level 2 ratings of ADHD symptoms and sex. Cross-level interactions (or slopes-as-outcomes effects, as they are sometimes called; see Kreft & de Leeuw, 1998) test whether Level 1 relationships vary as a function of Level 2 variables. For example, the relationship between thought impairment and perceived competence (both Level 1, within-person variables) may vary as a function of the level of hyperactivity-impulsivity but not inattention (both Level 2, between-person variables). A cross-level interaction is evaluated by estimating the effect of the Level 2 predictor on the Level 1 slopes, using the equation $\beta_1 = \gamma_{10} + \gamma_{11}(sex) + \gamma_{12}(inattention) + \gamma_{13}(hyperactivity\text{-}impulsivity) + \mu_1$ (in which γ_{10} is the mean value of the Level 1 slope, γ_{1j} is the effects of the Level 2 predictors, and μ_1 is the error term). If a Level 2 predictor is significant, then it explains variability in the within-person slopes. The γ_{10} coefficient evaluates the strength of the relationship of the Level 1 predictor and criterion, independent of the Level 2 variables. These values are reported, although they are not necessarily directly related to hypotheses regarding inattention and hyperactivity-impulsivity.

In all of these analyses, we simultaneously assessed the effects of the Level 2 variables inattention and hyper-activity-impulsivity on the Level 1 intercepts and slopes to examine the independent effect of each variable. The multilevel data were analyzed with Hierarchical Linear Modeling 6 (Raudenbush, Bryk, & Congdon, 2001). Consistent with the recommendations of Cohen, Cohen, West, and Aiken (2003) and Luke (2004), the Level 1 and Level 2 predictors were grand mean centered. The data departed from normality, so we calculated parameter estimates using robust standard errors, following the recommendations of Hox (2002).

Results
The mean symptom severity score on the nine-item Inattention subscale was 7.3 ($SD = 5.3$, range = 0 to 27). The mean symptom severity score on the nine-item Hyperactivity-Impulsivity subscale was 7.7 ($SD = 4.5$, range = 0 to 27). Male and female participants did not differ on either subscale. Participants averaged completing 41.6 usable questionnaires ($SD = 11.0$). There were modest, albeit significant, Pearson correlations between the number of usable records and scores on inattention ($r = -.18$, $p < .05$) and hyperactivity-impulsivity ($r = -.20$, $p < .01$). As in past research, the inattentive and hyperactive-impulsive dimensions were highly correlated ($r = .70$, $p < .05$).

Multilevel analyses assessed the expression of inattention and hyperactivity-impulsivity in daily life in four domains of functioning: mood, current activities, social functioning, and cognition. We computed the effect of each ADHD symptom rating on the Level 1 intercepts and slopes after partialing out the variance associated with sex and the other ADHD symptom rating. All analyses had 203 degrees of freedom.

Relationship of ADHD Symptoms With Ratings of Mood in Daily Life
Our first set of analyses tested whether inattention and hyperactivity-impulsivity were associated with self-reported affect in daily life, whether affect was associated with social contact, and whether the relationship of affect and social contact was moderated by ADHD symptoms. Inattention had a significant inverse relation-ship with positive affect in daily life ($\gamma = -.28$, $SE = .07$, $t = -3.78$, $p < .001$), whereas hyperactivity-impulsivity was not related to positive affect ($\gamma = .12$, $SE = .07$, $t = 1.56$). Consistent with Fleeson, Malanos, and Achille (2002) and Watson (2000), participants reported more positive affect when they were with others than when they were alone ($\gamma = .23$, $SE = .03$, $t = 8.56$, $p < .001$). Furthermore, the cross-level interactions of this relation-ship were significant for inattention ($\gamma = -.10$, $SE = .04$, $t = -2.63$, $p < .01$) and hyperactivity-impulsivity ($\gamma = .10$, $SE = .04$, $t = -2.57$, $p < .05$), indicating that both inattention and hyperactivity-impulsivity moderated the relationship of

social contact and positive affect— although, notably, in opposite directions. As displayed in Figure 1a, high levels of inattention are associated with decreased reports of positive affect in daily life. However, the relationship of social contact and positive affect tends to reverse at high levels of inattentiveness, indicating that inattentive participants surprisingly reported more positive affect when they were alone than when they were with others. As seen in Figure 1b, hyperactivity-impulsivity was unrelated to positive affect when participants were alone but positively associated when with others. Note that a numerical scale is not presented on the abscissa because centering makes the scores no longer correspond to the original scale anchor points. However, participants endorsed the entire range of scores on every variable, so the abscissa represents the full range of the variable.

Consistent with the findings for positive affect, participants who were high in inattentiveness reported more negative affect in daily life ($\gamma = .30$, $SE = .09$, $t = 3.48$, $p < .01$), whereas hyperactivity-impulsivity was unrelated to negative affect ($\gamma = -.02$, $SE = .09$, $t = -.26$). Overall, participants reported more negative affect when they were alone than when they were with others ($\gamma = -.24$, $SE = .02$, $t = 11.86$, $p < .001$). In contrast to the findings for positive affect, however, neither of the cross-level interactions with inattention ($\gamma = -.04$, $SE = .03$, $t = -1.33$) or with hyperactivity-impulsivity ($\gamma = -.02$, $SE = .03$, $t = -.66$) was significant, indicating that relationship of social contact and negative affect did not change across levels of ADHD symptoms.

Figure 1a
Relationship of Inattention and Positive Affect When Alone and With Others
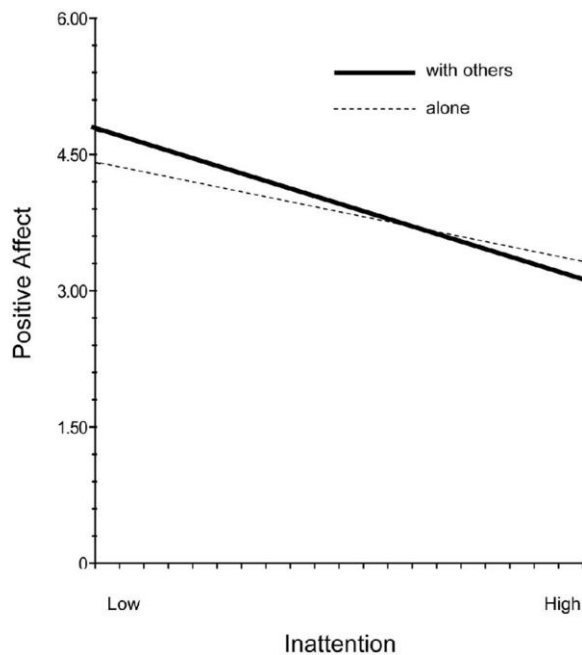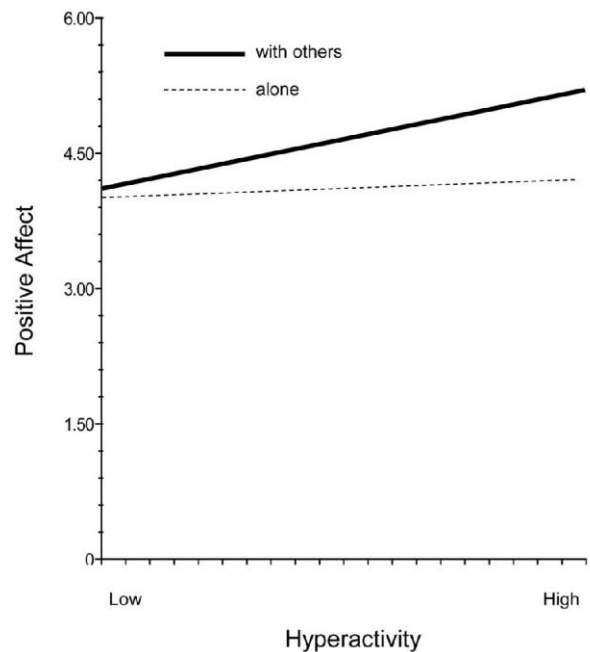
Figure 1b
Relationship of Hyperactivity-Impulsivity and Positive Affect When Alone and With Others

We next examined the relationship between self-reported mastery of competence in one's current activity and ratings of affect in daily life. Competence was associated with higher levels of positive affect ($\gamma = .10$, $SE = .01$, $t = 11.71$, $p < .001$). However, the cross-level inter-actions for inattention ($\gamma = -.02$, $SE = .01$, $t = -1.35$) and hyperactivity-impulsivity ($\gamma = .01$, $SE = .01$, $t = .35$) were not significant, indicating that ADHD symptoms did not moderate the relationship of self-perceived competence and positive affect and that the inverse relationship of inattention and positive affect reported above was not influenced by perceived competence.

Similar to the results for positive affect, participants reported more negative affect when they felt less competent at the task in which they were engaged ($\gamma = -.08$, $SE = .01$, $t = -11.98$, $p < .001$). However, the cross-level interactions for inattention ($\gamma = -.01$, $SE = .01$, $t = -.54$) and hyperactivity-impulsivity ($\gamma = -.01$, $SE = .01$, $t = .45$) were not significant, indicating that ADHD symptoms did not moderate the relationship of competence

and negative affect and that the relationship of inattention and negative affect was not influenced by perceived competence.

Figure 2a
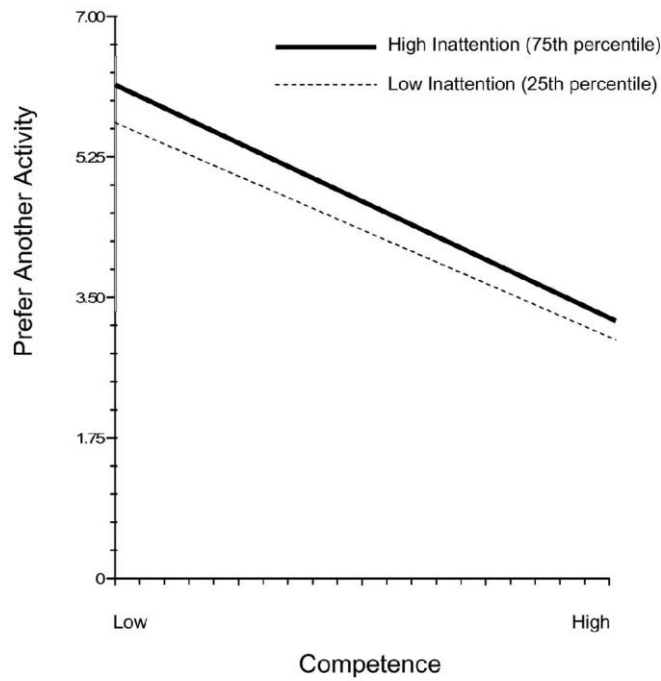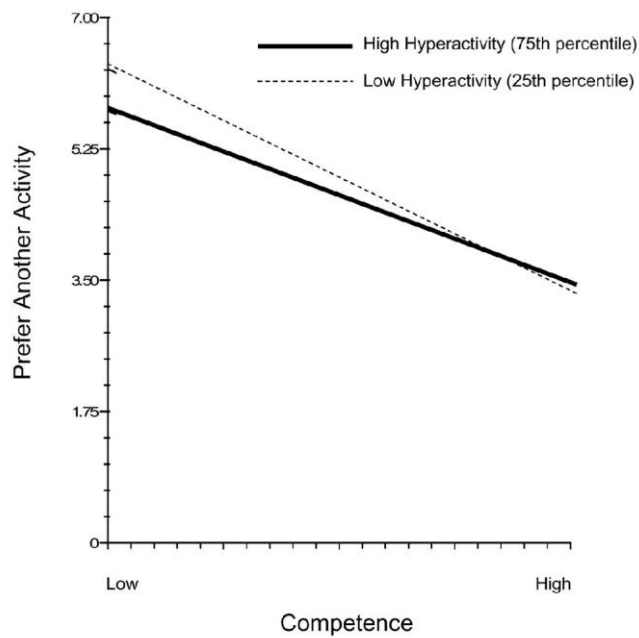**Relationship of Competence and Preference for Another Activity Across Levels of Inattention**

Figure 2b
Relationship of Competence and Preference for Another Activity Across Levels of Hyperactivity-Impulsivity

Relationship of ADHD Symptoms With Experience of Daily Activities

In the second set of analyses, we examined if inattention and hyperactivity-impulsivity were associated with competence, stress, and enjoyment reported during daily activities. Neither inattention ($\gamma = -.01$, $SE = .17$, $t = -.06$) nor hyperactivity-impulsivity ($\gamma = -.18$, $SE = .15$, $t = -1.17$) was associated with the ESM index of competence in the current activity. Note that ratings of competence were unrelated to social contact ($\gamma = .12$, $SE = .07$, $t = 1.59$), and neither the cross-level interaction for inattention ($\gamma = -.07$, $SE = .13$, $t = -.53$) nor for hyperactivity-impulsivity ($\gamma = .12$, $SE = .12$, $t = 1.02$) was significant for this relationship.

Neither ratings of inattention ($\gamma = .09$, $SE = .06$, $t = 1.40$) nor hyperactivity-impulsivity ($\gamma = -.01$, $SE = .06$, $t = .12$) was associated with the ESM index of activity stress. Inattention was inversely related to the degree to which the participants liked the activity at the time of the beep ($\gamma = -.19$, $SE = .07$, $t = -2.54$, $p < .01$), although hyperactivity-impulsivity was unrelated ($\gamma = .10$, $SE = .08$, $t = 1.32$). There was a significant Level 1 relationship between competence in the current activity and liking the current activity ($\gamma = .19$, $SE = .01$, $t = 13.37$, $p < .001$), indicating that people reported more enjoyment from activities at which they felt competent. The cross-level interaction for inattention was not significant ($\gamma = -.01$, $SE = .01$, $t = -.67$), indicating that the relationship of competence and liking the activity was not moderated by inattention. However, the cross-level interaction for hyperactivity-impulsivity ($\gamma = .02$, $SE = .01$, $t = 1.97$, $p < .05$) was significant, indicating that the impact of self-perceived competence on liking an activity was less pronounced at high levels of hyperactivity-impulsivity than at low levels. In other words, the enjoyment that hyperactive-impulsive participants felt during activities was less affected by a lack of mastery.

Similarly, inattention was marginally related to the preference for another activity at the time of the beep ($\gamma = .16$, $SE = .08$, $t = 1.90$, $p < .10$), although hyperactivity-impulsivity was not ($\gamma = -.04$, $SE = .09$, $t = .54$). There was a significant inverse Level 1 relationship between competence and preference for a different activity ($\gamma = -.21$, $SE = .01$, $t = -22.99$, $p < .001$), indicating that decreased self-reported competence was associated with greater preference for another activity. The cross-level interaction for inattention was not significant ($\gamma = .01$, $SE = .01$, $t = .87$) (see Figure 2a). As seen in Figure 2b, however, the cross-level interaction for hyperactivity-impulsivity ($\gamma = .04$, $SE = .01$, $t = 3.34$, $p < .01$) was significant, indicating that a lack of mastery or competence did not influence preference for another activity as much for people high on hyperactivity-impulsivity than for people low on hyperactivity-impulsivity.

Relationship of ADHD Symptoms With Ratings of Cognitive Impairment

The next analyses examined the expression of ADHD symptoms on cognitive functioning in daily life. Not surprising, but importantly, inattention was associated with self-reported cognitive impairment in daily life ($\gamma = .34$, $SE = .09$, $t = 3.73$, $p < .001$). However, ratings of hyperactivity-impulsivity were not associated with thought problems ($\gamma = .07$, $SE = .09$, $t = .75$). In general, participants reported more thought impairment during stressful activities ($\gamma = .28$, $SE = .02$, $t = 15.11$, $p < .001$). The cross-level interaction of this relationship was significant for hyper-activity-impulsivity ($\gamma = -.06$, $SE = .03$, $t = -2.18$, $p < .05$) but not for inattention ($\gamma = .02$, $SE = .03$, $t = .62$). These results indicate that the main effect of inattention on cognitive impairment was not moderated by the stressfulness of the activity (see Figure 3a). As seen in Figure 3b, stress from the current activity had a greater impact on cognition in people low in hyperactivity-impulsivity than in people high in hyperactivity-impulsivity.

There was a significant Level 1 relationship between ratings of competence in the current activity and thought impairment ($\gamma = -.11$, $SE = .01$, $t = 12.54$, $p < .001$), indicating that participants reported more thought impairment during tasks in which they felt less competent. The cross-level interaction of this relationship was significant for hyperactivity-impulsivity ($\gamma = .02$, $SE = .01$, $t = 2.39$, $p < .05$) but not for inattention ($\gamma = -.01$, $SE = .01$, $t = .39$) (see Figures 4a and 4b). Thus, the main effect of inattention on cognitive impairment in daily life was not affected by self-perceived competence (Figure 4a). However, changes in competence did not influence cognition in high hyperactive-impulsive participants to the extent that it did for low hyperactive-impulsive participants. Participants also reported less cognitive impairment when they were with others than when they were alone ($\gamma = -.09$, $SE = .04$, $t = -2.25$, $p < .05$); however, the cross-level interactions of this relationship were

not moderated by either inattention ($\gamma = .0\ 1$, $SE = .05$, $t = .25$) or hyperactivity-impulsivity ($\gamma = -.02$, $SE = .05$, $t = -.43$).

Figure 3a
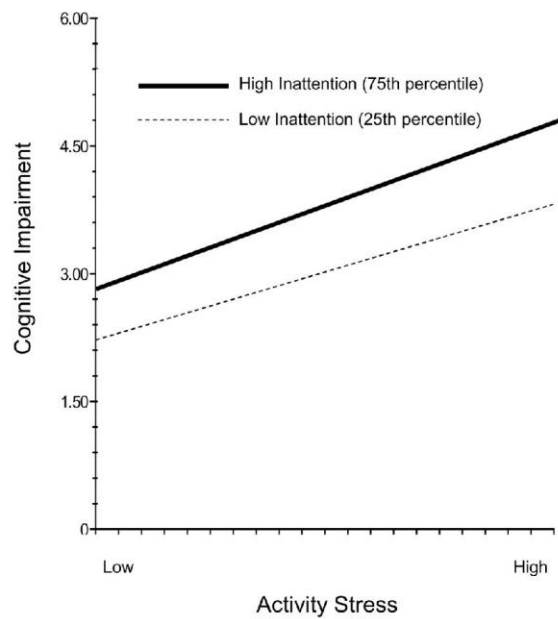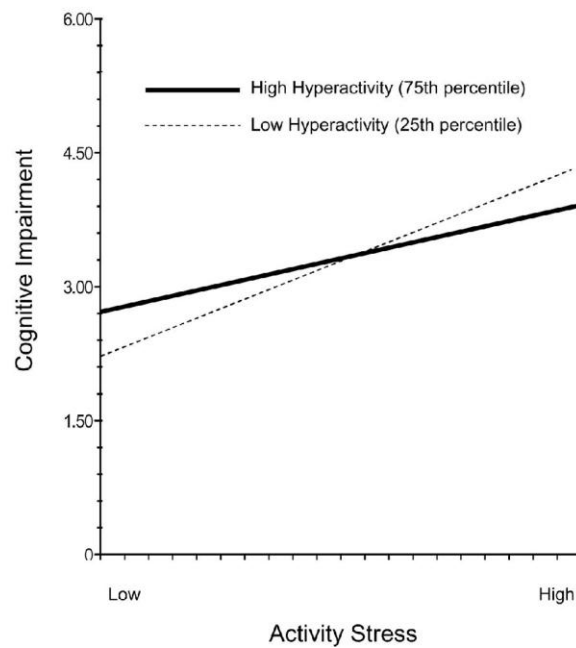**Relationship of Activity Stress and Cognitive Impairment Across Levels of Inattention**

Figure 3b
Relationship of Activity Stress and Cognitive Impairment Across Levels of Hyperactivity-Impulsivity

Relationship of ADHD Symptoms With Ratings of Social Functioning in Daily Life

The final set of analyses examined the relationship of ADHD symptoms with social functioning in daily life. Inattention was significantly related to ratings of impairment in social functioning ($\gamma = .\ 18$, $SE = .07$, $t = 2.56$, $p < .05$), whereas hyperactivity-impulsivity was not ($\gamma = -.08$, $SE = .07$, $t = -1.\ 10$). Neither inattention ($\gamma = .03$,

$SE = .10$, $t = .29$) nor hyperactivity-impulsivity ($\gamma = -.12$, $SE = .10$, $t = -1.18$) was associated with scores on the social isolation index. Likewise, neither inattention ($\gamma = -.03$, $SE = .02$, $t = -1.41$) nor hyperactivity-impulsivity ($\gamma = .02$, $SE = .02$, $t = .86$) was associated with the proportion of time that participants reported being with others.

Figure 4a
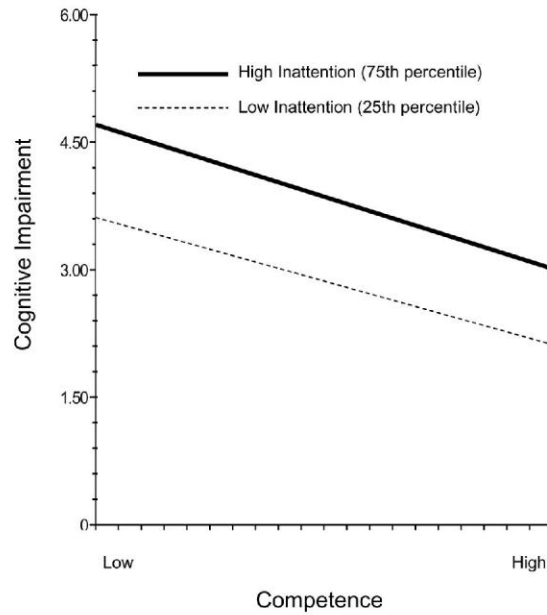**Relationship of Competence and Cognitive Impairment Across Levels of Inattention**
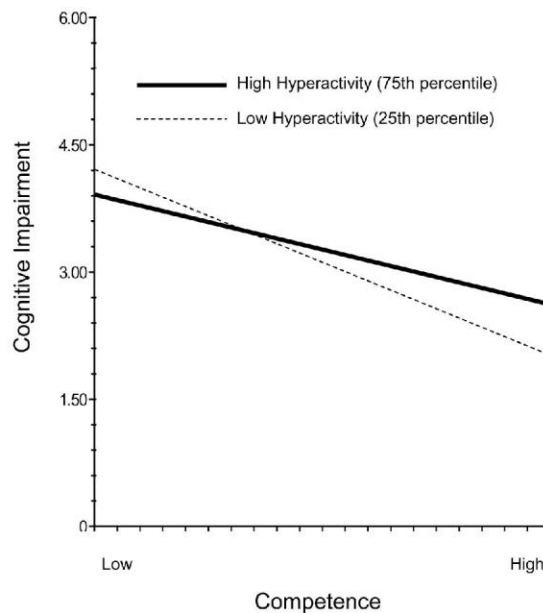

Figure 4b
Relationship of Competence and Cognitive Impairment Across Levels of Hyperactivity-Impulsivity

Discussion

The present study examined the impact of inattentive and hyperactive-impulsive symptoms on daily life experience across multiple domains and in relationship to appraisals and contextual variables. The ADHD symptom dimensions related differently to daily experiences. Increasing inattentive symptoms were related to indices of general distress, including decreased positive affect and increased negative affect, and these relationships were not moderated by social contact, satisfaction with current activities, concentration, or social context.

Hyperactive-impulsive symptoms were unrelated to overall affective states and self-reported concentration problems. Increasing levels of hyperactive-impulsive symptoms, however, were related to greater positive affect when people were with others but not when alone. In addition, increasing levels of these self-reported symptoms were associated with more persistent ratings of activity satisfaction and concentration problems regardless of perceived competence and stress. Whereas people with increased inattentive symptoms were likely to experience the world as consistently more distressing, people with increased hyperactivity-impulsivity were less likely to be influenced by their current context or their appraisals of their own competence.

These data, therefore, provide support for the predictive validity of ADHD symptoms along a continuum with respect to daily life functioning. Though the DSM-IV symptom lists were constructed with clinical populations in mind, these results suggest that there is meaningful variation in daily functioning associated with these symptom dimensions across a range of severity. This is especially apparent for inattentive symptoms, which are correlated with cognitive impairments and other categories of impairment. The predictive properties of hyperactive-impulsive symptoms are less straightforward. They appear to be associated with fewer self-reported problems in daily functioning but also less sensitivity to contextual factors. People high in hyperactivity-impulsivity may, therefore, be more likely to have a "bull in the china shop" approach—moving through daily life with less sensitivity to situational and intrapersonal variables.

Our findings also provide support for the use of ESM and multilevel modeling. Within this first adult study of inattention and hyperactivity-impulsivity using ESM, we found important effects when taking cross-level interactions into account. Specifically, the effects of hyperactivity-impulsivity symptoms were often absent when considering overall ratings. Cross-level interactions with respect to ratings, however, allowed us to examine the impact of context on ratings across a range of symptom severity. Importantly, when we considered the impact of other contextual and appraisal variables via these interactions (competence, stress), important effects emerged. These findings support the use of multilevel modeling in analyzing complex nested data where important interaction effects will not emerge when only bivariate analyses are conducted.

In addition to expanding knowledge of ADHD symptoms in adults, these findings also raise several important questions. The first concerns the frequently found high correlation between inattentive and hyperactive-impulsive symptoms. We controlled for this correlation by partialing out the effects for each symptom dimension and found that, to some extent, high levels of inattentive versus hyperactive-impulsive symptoms were associated with different profiles of daily life experience. Thus, although highly correlated, each dimension accounted for significant independent variance. Given this finding, the oft-cited high correlations between these symptom dimensions in studies of adult self-reports may disguise the unique attributes of each symptom list. Though shared method variance may account for some of the tendency for these symptoms to correlate highly in adult samples, a recent study found that high correlations remained whether symptom items were presented together or intermixed with other types of items (Mitchell, Knouse, Nelson-Gray, & Kwapil, 2006). Thus, these symptom dimensions may truly co-occur in nature as outlined in theoretical models of the disorder (e.g., Barkley, 1997). The current study goes further by demonstrating the importance of considering the independent variation in each dimension and its associations with various important activities in daily life.

Our findings also raise questions regarding other traits or dimensions that may be associated with inattentive and hyperactive-impulsive symptoms. As mentioned in the introduction, hyperactivity-impulsivity has been associated with extraversion in prior research (Parker et al., 2004). Parker et al. (2004) also found that

inattention is associated with neuroticism—a result consistent with our findings of association between inattention and general distress. These dimensions, however, are also associated with other disorders that can co-occur or mimic ADHD symptoms (e.g., depression, anxiety). Subsequent studies using multilevel modeling will enable us to examine the independent contributions of ADHD symptoms to daily life experience apart from those of other disorders.

Our findings raise questions about the measurement of ADHD symptoms in adults. In comparison to the adult literature, there are far more data concerning the expression of inattentive and hyperactive-impulsive symptoms in children. The DSM-IV criteria generally used in research on adult ADHD were developed to assess children specifically and many researchers have questioned their developmental appropriateness for measuring ADHD in adults (Faraone, Biederman, & Mick, 2006). The hyperactive-impulsive symptoms seem especially developmentally inappropriate and have been criticized as not capturing "adult" forms of this dimension (e.g., subjective feelings of restlessness, excessive talking; Barkley, 2006). If the inattentive symptom list is more sensitive to the disorder in adults than is the hyperactive-impulsive symptom list—perhaps because of the former's reliance on subjective experience—this may explain why we found inattentive symptoms to be associated with greater impairment. More developmentally appropriate measures of hyperactivity-impulsivity may be associated with greater impairments in daily life.

Future studies should consider alternative items that may enhance the ability to detect ADHD in adults while also evaluating their relationship to functioning in major life activities.

Though our results do not have direct clinical relevance because of the use of a general population sample, they raise intriguing questions that could be addressed in future clinical studies. The study provides preliminary evidence that self-reports of ADHD symptoms have predictive validity for functioning measured in the moment. In terms of clinical presentation, future studies could examine whether more client distress is associated with inattentive symptoms than with hyperactive-impulsive symptoms. Clinical knowledge about the associated features of ADHD (e.g., substance use, academic problems, and relationship problems) suggests additional areas that can be measured using future ESM data collection. Finally and most important, our study provides "proof of concept" that ESM can be feasibly and profitably applied to research examining ADHD in adults.

Our findings should be considered in light of their limitations. As mentioned above, we used a nonclinical sample, thus limiting the direct clinical relevance of our findings. Second, our sample was predominantly female, whereas the gender proportion in self-referred clinical samples is more balanced (Biederman, Faraone, Monuteaux, Bober, & Cadogen, 2004).

This study presents the first evidence of the impact of ADHD symptoms on self-reported in-the-moment daily functioning in a sample of adults. Our results suggest that this relationship depends on which symptom dimensions are being considered. Future studies must elucidate the high correlation between these dimensions, their overlap with other trait dimensions, and the measurement issues associated with adult ADHD symptoms.

References
Affleck, G., Zautra, A., Tennen, H., & Armeli, S. (1999). Multilevel daily process designs for consulting and clinical psychology: A preface for the perplexed. Journal of Consulting and Clinical Psychology, 67, 746-754.
American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders (4th ed., text rev.). Washington, DC: Author.
Barkley, R. A. (1991). The ecological validity of laboratory and analogue assessments of ADHD symptoms. Journal of Abnormal Child Psychology, 19, 149-178.
Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. Psychological Bulletin, 121, 65-94.
Barkley, R. A. (Ed.). (2006). Attention-Deficit Hyperactivity Disorder: A handbook for diagnosis and treatment (3rd ed.). New York: Guilford.

Barkley, R. A., Fischer, M., Smallish, L., & Fletcher, K. (2002). The persistence of attention-deficit/hyperactivity disorder into young adulthood as a function of reporting source and definition of disorder. Journal of Abnormal Psychology, 111, 279-289.

Barkley, R. A., Fischer, M., Smallish, L., & Fletcher, K. (in press). Young adult outcome of hyperactive children: Adaptive functioning in major life activities. Journal of the American Academy of Child and Adolescent Psychiatry.

Barkley, R. A., Murphy, K. R., & Kwasnik, D. (1996). Psychological adjustment and adaptive impairments in young adults with ADHD. Journal of Attention Disorders, 1, 41–54.

Biederman, J., Faraone, S. V., Monuteaux, M. C., Bober, M., & Cadogen, E. (2004). Gender effects on Attention-Deficit/Hyperactivity Disorder in adults, revisited. Biological Psychiatry, 55, 692-700.

Biederman, J., Faraone, S. V., Spencer, T. J., Mick, E., Monuteaux, M. C., & Aleardi, M. (2006). Functional impairments in adults with self-reports of diagnosed ADHD: A controlled study of 100 1 adults in the community. Journal of Clinical Psychiatry, 67,524-540.

Biederman, J., Faraone, S. V., Spencer, T., Wilens, T., Norman, D., Lapley, K. A., et al. (1993). Patterns of psychiatric comorbidity, cognition, and psychosocial functioning in adults with Attention Deficit Hyperactivity Disorder. American Journal of Psychiatry, 150,1792-1798.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). Applied multiple regression/correlation analysis for the behavioral sciences (3rd ed.). Mahwah, NJ: Lawrence Erlbaum.

Costa, P. T., & McCrae, R. R. (1992). NEO PI-R: Professional manual. Odessa, FL: Psychological Assessment Resources.

Csikszentmihalyi, M., & Larson, R. (1987). Validity and reliability of the experience-sampling method. Journal of Nervous and Mental Disease, 175, 526-536.

deVries, M. (1992). The experience of psychopathology: Investigating mental disorders in their natural settings. Cambridge, UK: Cambridge University Press.

DuPaul, G. J., Power, T. J., Anastopoulos, A. D., & Reid, R. (1998). ADHD Rating Scale-IV: Checklists, norms, and clinical interpretation. New York: Guilford.

Faraone, S. V., Biederman, J., & Mick, E. (2006). The age-dependent decline of attention deficit hyperactivity disorder: A meta-analysis of follow-up studies. Psychological Medicine, 36, 159-165.

Feldman-Barrett, L., & Barrett, D. J. (2004). The Experience Sampling Program (v. 2.0) [Computer software]. Retrieved August 5, 2004, from http://www2.bc.edu/~barretli/esp/

Fischer, M., Barkley, R. A., Smallish, L., & Fletcher, K. (2002). Young adult follow-up of hyperactive children: Self-reported psychiatric disorders, comorbidity, and the role of childhood conduct problems. Journal of Abnormal Child Psychology, 30, 463-475.

Fleeson, W., Malanos, A. B., & Achille, N. M. (2002). An intraindividual process approach to the relationship between extraversion and positive affect: Is acting extraverted as "good" as being extraverted? Journal of Personality and Social Psychology, 83, 1409-1422.

Friedman, S. R., Rapport, L. J., Lumley, M., Tzelepis, A., Van Voorhis, A., Stettner, L., & Kakaati, L. (2003). Aspects of social and emotional competence in adult attention- deficit/hyperactivity disorder. Neuropsychology, 17, 50-58.

Hox, J. (2002). Multilevel analysis: Techniques and applications. Mahwah, NJ: Lawrence Erlbaum.

Hoza, B., Gerdes, A. C., Hinshaw, S. P., Arnold, L. E., Pelham, W. E., Molina, B., et al. (2004). Self-perceptions of competence in children with ADHD and comparison children. Journal of Consulting and Clinical Psychology, 72, 382-391.

Intel Corporation. (2004). iESP [computer software]. Retrieved from http://seattleweb.intel-research.net/projects/ESM/iESP.html

Knouse, L. E., Bagwell, C. L., Barkley, R. A., & Murphy, K. R. (2005). Accuracy of self-evaluation in adults with Attention-Deficit Hyperactivity Disorder: Evidence from a driving study. Journal of Attention Disorders, 8, 221-234.

Kreft, I., & de Leeuw, J. (1998). Introducing multilevel modeling. London: Sage.

Lahey, B. B., Applegate, B., McBurnett, K., Biederman, J., Greenhill, L., Hynd, G. W., et al. (1994). DSM-IV field trials for attention deficit/hyperactivity disorder in children and adolescents. American Journal of Psychiatry, 151, 1673–1685.

Lahey, B. B., Pelham, W. E., Schaughency, E. A., Atkins, M. S., Murphy, H. A., Hynd, G. W., et al. (1988). Dimensions and types of attention deficit disorder. Journal of the American Academy of Child and Adolescent Psychiatry, 27, 330-335.

Levy, F., Hay, D. A., McStephen, M., Wood, C., & Waldman, I. (1997). Attention-deficit hyperactivity disorder: A category or a continuum? Genetic analysis of a large-scale twin study. Journal of the American Academy of Child and Adolescent Psychiatry, 36, 737-744.

Luke, D. A. (2004). Multilevel modeling. Thousand Oaks, CA: Sage.

Mannuzza, S., Gittelman-Klein, R., Bessler, A., Malloy, P., & LaPadula, M. (1993). Adult outcome of hyperactive boys: Educational achievement, occupational rank, and psychiatric status. Archives of General Psychiatry, 50, 565–576.

Milich, R., Balentine, A. C., & Lynam, D. R. (2001). ADHD combined type and ADHD predominantly inattentive type are distinct and unrelated disorders. Clinical Psychology: Science and Practice, 8, 463-488.

Milich, R., Hartung, C. M., Martin, C. A., & Haigler, E. D. (1994). Behavioral disinhibition and underlying processes in adolescents with disruptive behavior disorders. In D. K. Routh (Ed.), Disruptive behavior disorders in childhood (pp. 109-138). New York: Plenum.

Mitchell, J. T., Knouse, L. E., Nelson-Gray, R. O., & Kwapil, T. (2006). Self-report measurement of adult AD/HD symptoms: Does context matter? Manuscript submitted for publication.

Mitchell, J. T., & Nelson-Gray, R. O. (2006). Attention-Deficit/Hyperactivity Disorder symptoms in adults: Relationship to Gray's behavioral approach system. Personality and Individual Differences, 40,749-760.

Nezlek, J. B. (2001). Multilevel random coefficient analyses of event-and interval-contingent data in social and personality psychology research. Personality and Social Psychology Bulletin, 27,771–785.

Parker, J. D. A., Majeski, S. A., & Collin, V. T. (2004). ADHD symptoms and personality: Relationship with the five-factor model. Personality and Individual Differences, 36, 977-987.

Raudenbush, S., Bryk, A., & Congdon, R. (2001). HLM for Windows (v. 5.05) [computer software]. Lincolnwood, IL: Scientific Software International.

Reis, H. T., & Gable, S. L. (2000). Event-sampling and other methods for studying everyday experience. In H. T. Reis & C. M. Judd (Eds.), Handbook of research methods in social and personality psychology (pp. 190-221). Cambridge, UK: Cambridge University Press.

Schwartz, J. E., & Stone, A. A. (1998). Strategies for analyzing ecological momentary assessment data. Health Psychology, 17, 6-16.

Slomkowski, C., Klein, R. G., & Manuzza, S. (1995). Is self-esteem an important outcome in hyperactive children? Journal of Abnormal Child Psychology, 23, 303-315.

Watson, D. (2000). Mood and temperament. New York: Guilford. Weiss, G., & Hechtman, L. (1993). Hyperactive children grow up. New York: Guilford.

Whalen, C. K., Jamner, L. D., Henker, B., Delfino, R. J., & Lozano, J. M. (2002). The ADHD spectrum and everyday life: Experience sampling of adolescent moods, activities, smoking, and drinking. Child Development, 73, 209-227.

Young, S., Toone, B., & Tyson, C. (2003). Comorbidity and psychosocial profile of adults with Attention-Deficit Hyperactivity Disorder. Personality and Individual Differences, 35, 743-755.