

The diagnostic validity of attention-deficit/hyperactivity disorder

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Abstract

Despite considerable research, the validity of attention-deficit/hyperactivity disorder (ADHD) remains controversial. This paper summarizes the results of a comprehensive review of the internal and external validity of ADHD as defined in the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). Results indicate that for most individuals DSM-IV ADHD is a valid disorder in the sense that it is associated with significant impairment in social, academic, and occupational functioning and increased risk of accidental injury across the life span. Additional research is needed, however, to clarify the diagnostic validity of the hyperactive-impulsive type and the discriminant validity of the combined and inattentive subtypes. Other areas in need of further study include potential modifications to the diagnostic conceptualization of the inattentive subtype, developmental trajectories of the subtypes, and methods to address cross-informant diagnostic inconsistencies. Such research is likely to benefit from an etiologically informed approach to examining heterogeneity both across and within subtypes.

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1. Introduction

Despite considerable research, there is continuing controversy regarding the nature and validity of the syndrome termed attention-deficit/hyperactivity disorder (ADHD) in the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; [1]). Although substantial evidence has accumulated to support the diagnostic validity of ADHD (e.g. [2–4]), some argue that ADHD symptoms may simply describe the exuberant behavior of normal children (e.g. [5]). Others accept that some children with ADHD have a valid disorder, but contend that weaknesses in the current diagnostic criteria cause some children to be diagnosed inappropriately (e.g. [6]).

Interpretation of studies of the validity of ADHD is further complicated by changes to the diagnostic criteria for ADHD in each successive edition of the DSM (see [4] for a summary of the implications of these changes). The diagnostic criteria for DSM-IV ADHD incorporated

separate lists of nine symptoms of inattention and nine symptoms of hyperactivity-impulsivity, and defined three diagnostic subtypes based on differential elevations on these symptom dimensions ([1,7]). The predominantly inattentive type describes individuals with maladaptive levels of inattention only, the predominantly hyperactive-impulsive type is characterized by maladaptive levels of hyperactivity-impulsivity alone, and the combined type describes individuals with maladaptive levels of both inattention and hyperactivity-impulsivity.

Due to the continuing controversy regarding the validity of ADHD, we recently completed a comprehensive meta-analysis of 114 published studies of DSM-IV ADHD to evaluate the internal and external validity of the DSM-IV ADHD symptom dimensions and subtypes [118]. Space constraints for this special issue preclude a comprehensive review of these studies. Therefore, in this paper, we first describe the criteria a disorder must meet to be considered valid, and then summarize the key findings from the meta-analysis in the text and in Figs. 1 and 2. In a final section, we examine the implications of these results for the DSM-IV model of ADHD and highlight several keys remaining questions regarding the validity and nosology of ADHD.

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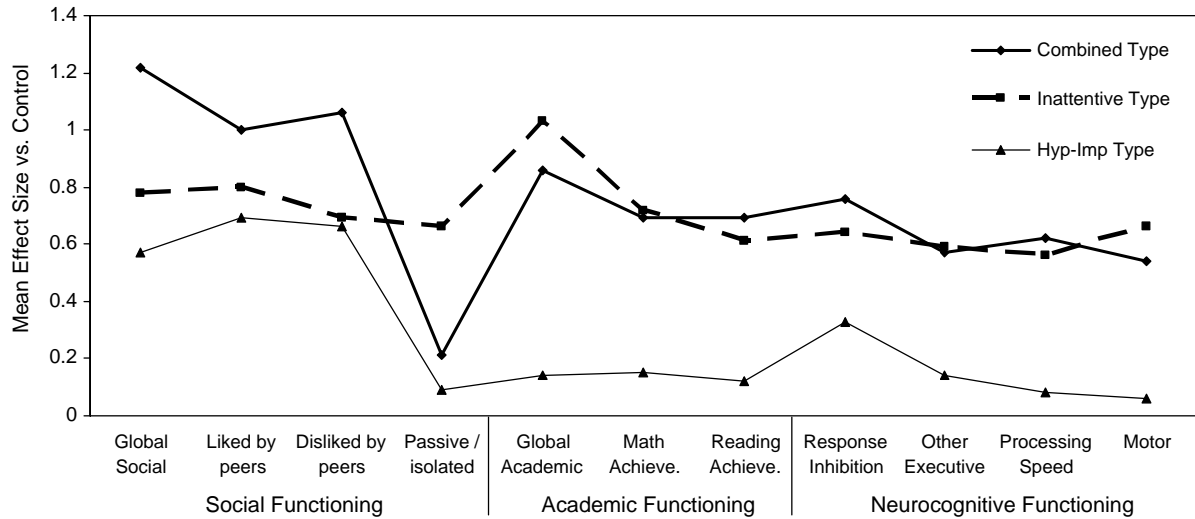


Fig. 1. Performance of groups with DSM-IV ADHD on measures of functional impairment and Neurocognitive functioning. Effect sizes are based on a meta-analysis of all published studies of DSM-IV ADHD [118]. An effect size was calculated for each measure in each study based on Cohen's *d*: (ADHD *M*—Comparison *M*)/pooled SD [113]. Effect sizes presented in the figure are the mean effect size across all studies weighted by the sample size in each study ([121]). All scores are scaled so that a positive effect size indicates greater impairment in the ADHD group regardless of the original scaling of the measure.

2. Validity of mental disorders

As described in more detail elsewhere in this special issue [8], the criteria, which must be met for a mental disorder to be considered valid, have been the focus of considerable discussion (e.g. [4,8–14]). These authors have considered an extensive range of important issues, including the role of theory in the development of diagnostic criteria (e.g. [10]), the utility of a dimensional versus categorical conceptualization of mental disorders (e.g. [14]), the extent to which the definition of a mental disorder is influenced by social values (e.g. [12]), and the potential usefulness of evolutionary theory to identify mental processes that have gone awry ([13]).

A comprehensive description of all facets of this debate is beyond the scope of the current paper. More focally, in this review we examine the evidence for what we have termed the *diagnostic validity* of ADHD. Diagnostic validity hinges on a straightforward question: do the symptoms of ADHD impair an individual's functioning sufficiently to warrant treatment? In addition, it must be demonstrated that the disorder can be measured reliably and distinguished consistently from other related disorders. After the diagnostic validity of a disorder has been established, it then becomes possible to examine more complex aspects of validity such as etiology, underlying pathophysiology, and the other complex issues described above. In the remainder of this introductory section, we

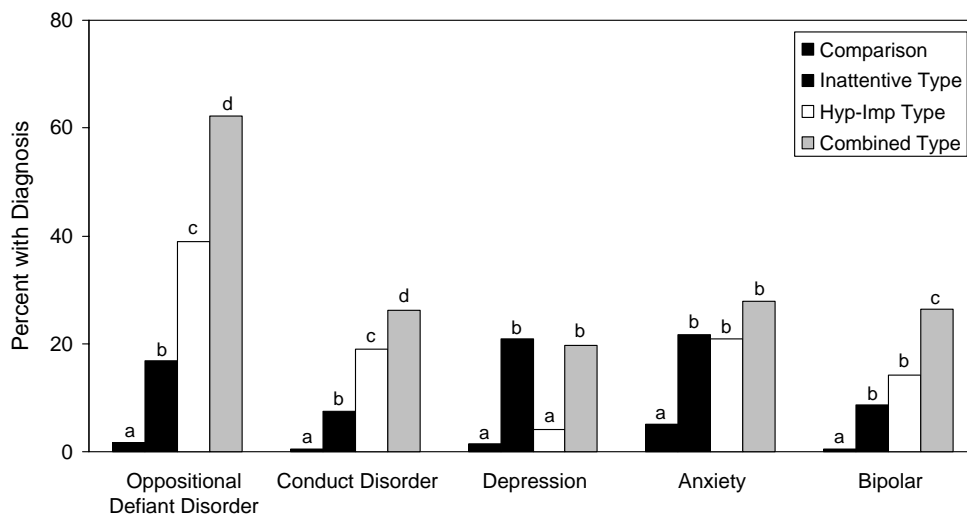


Fig. 2. Rates of comorbidity in children with the DSM-IV ADHD subtypes. Rates of comorbidity represent prevalence when samples are pooled across all published studies [118]. Different letters indicate significant differences between groups in the pooled sample ($P < .05$).

describe in more detail the three key facets of diagnostic validity that we review in this paper.

2.1. Internal validity

Studies of all aspects of a disorder are constrained by the reliability of the symptoms and diagnosis. Therefore, before testing the external validity of ADHD, the DSM-IV symptom dimensions and subtypes must be shown to be reliable and internally consistent. Studies have evaluated the internal validity of ADHD by using factor analysis to test statistically whether the DSM-IV model best describes symptoms of ADHD, and by examining the inter-rater and test–retest reliability of the symptom dimension and subtypes.

2.2. Criterion validity

Criterion validity refers to a significant relation between a construct and an independent external criterion (e.g. [9]). For a mental disorder, the relation between the symptoms of the disorder and consequent functional impairment is the most essential criterion to verify that the disorder is valid and warrants treatment. Criterion validity can be subdivided into concurrent and predictive validity. *Concurrent validity* refers to a significant association between symptoms of the disorder and functional impairment at a single point in time. *Predictive validity* is similar to concurrent validity except that symptoms of the disorder are used to predict future negative outcomes. One recent study reported short-term predictive validity for the DSM-IV symptom dimensions and subtypes over a period of 3 years in early childhood ([15]), but no studies have examined the long-term predictive validity of DSM-IV ADHD into adolescence and adulthood. Therefore, in this review we focus on the concurrent validity of DSM-IV ADHD.

2.2.1. Dimensional versus categorical analyses

Most studies of the concurrent validity of DSM-IV ADHD compared the means of groups with and without the DSM-IV ADHD subtypes on dimensional measures of functional impairment. Comparisons of group means are more statistically powerful than categorical comparisons of the proportion of individuals with significant impairment, but the implications of a significant mean difference between groups with and without ADHD must be interpreted with caution ([16]). For example, if a comparison of groups with and without ADHD reveals a significant mean difference with a moderate effect size, this could indicate a moderate difference between most individuals in the two groups. On the other hand, a moderate effect could reflect a large difference that is only present in a subset of the group with ADHD, with the remainder of the ADHD sample exhibiting no impairment in relation to the comparison group. Therefore, in addition to comparisons of group means on measures of functional impairment, to

assess fully the concurrent validity of ADHD it is also essential to test what proportion of individuals with each ADHD subtype are significantly impaired.

2.3. Discriminant validity

Finally, the discriminant validity of a disorder must be demonstrated by showing that it can be distinguished from other disorders by differential associations with important external variables. Two facets of discriminant validity are critical for DSM-IV ADHD. First, the symptom dimensions and subtypes must be shown to be distinguishable from other disorders. Second, the DSM-IV symptom dimensions and subtypes must also have discriminant validity from one another to justify their inclusion in the diagnostic criteria for ADHD. In the absence of clear evidence of discriminant validity between the DSM-IV symptom dimensions and subtypes, it would be more parsimonious to define ADHD based on a single symptom dimension without diagnostic subtypes.

3. Internal validity of DSM-IV ADHD

3.1. Factor analyses

Exploratory and confirmatory factor analyses of parent and teacher ratings in 16 independent samples of over 15,000 children and adolescents consistently support the DSM-IV model incorporating separate inattention and hyperactivity-impulsivity symptom dimensions (e.g. [17,18]; reviewed by [118]). All 18 DSM-IV ADHD symptoms loaded on their predicted factors in virtually all studies. Moreover, several studies found that the DSM-IV inattention and hyperactivity-impulsivity factors emerged even when symptoms of oppositional defiant disorder, conduct disorder, and several internalizing disorders were also included in the model, providing initial support for the discriminant validity of ADHD (e.g. [18,19]).

3.2. Reliability

3.2.1. Internal consistency and temporal stability

Parent and teacher ratings of ADHD symptoms have high internal consistency ($\alpha = .88-.94$) and moderate to high test–retest reliability over periods ranging from 2 weeks to 2 years (mean $r = .69$; e.g. [17,20–22]a, [23]). Similarly, the few studies that have been conducted support the test–retest reliability of the overall diagnosis of ADHD, such that children who meet criteria for DSM-IV ADHD at one time point tend to continue to meet criteria for ADHD at later assessments (e.g. [15]). In contrast to the results for the overall diagnosis, however, preliminary evidence suggests that the DSM-IV subtype classifications may be less stable. Although test–retest reliability is adequate for all subtypes in parent interviews conducted 1 week apart ([24–26]), early

results from one of the first longitudinal studies of the DSM-IV ADHD subtypes suggest that children often shift from one subtype to another over time ([27]). We return to this issue in more detail when we discuss the developmental trajectories of the DSM-IV subtypes in a later section.

3.2.2. *Inter-rater reliability*

Whereas test–retest reliability of the DSM-IV symptom dimensions is adequate when the symptoms are rated by a single individual, correlations between parent and teacher ratings are low to moderate (mean $r = .42$; e.g. [17,20,21,28–30]). Similarly, the rate of agreement between parents and teachers is moderate for the overall diagnosis of DSM-IV ADHD (47% across studies) and low for the specific DSM-IV subtypes (11.5–40% agreement; [20,30–32]). These modest levels of inter-rater agreement indicate that parent and teacher ratings identify partly independent samples of children and that even when parents and teachers agree that a child meets criteria for ADHD their ratings often place the child in different subtype groups. Some differences between parent and teacher ratings are undoubtedly due to measurement error, but these differences may also reflect meaningful differences in behavior across settings, differences in the threshold at which a behavior is identified as atypical, and other individual differences among raters (e.g. [2]).

3.3. *Conclusions regarding the internal validity of DSM-IV ADHD*

Factor analytic studies clearly support the two-dimension model of ADHD described in DSM-IV, and available data suggest that the DSM-IV ADHD symptom dimensions and subtypes have adequate short-term reliability when rated by a single adult. In contrast, additional research is sorely needed to evaluate the temporal stability of the DSM-IV subtypes and the implications of the modest agreement between ratings by different observers.

4. **Concurrent validity**

4.1. *DSM-IV symptom dimensions*

In the DSM-IV field trials for the disruptive behavior disorders ([33]), regression analyses were conducted to assess the associations between DSM-IV inattentive and hyperactive-impulsive symptoms and several indices of functional impairment, controlling for symptoms of oppositional defiant disorder (ODD), conduct disorder (CD), anxiety disorders, and depressive disorders. The number of inattentive behaviors was not related to ratings of global adaptive functioning completed by the child's parent or the interviewer, but was significantly associated with parent ratings of homework problems and teacher ratings of schoolwork problems. In contrast, the number of

hyperactivity-impulsivity symptoms was associated with lower ratings of global adaptive functioning, but was not significantly associated with ratings of academic difficulties. Subsequent community studies found that both symptoms of inattention and symptoms of hyperactivity-impulsivity were associated with significant academic impairment, but these studies confirmed that this relation was stronger for inattention than hyperactivity-impulsivity (e.g. [17,30,34,35]).

More extensive multiple regression analyses were conducted to examine the impairments associated with the DSM-IV symptom dimensions in a sample of 4–6 years old children with and without DSM-IV ADHD ([36]). In addition to controlling for symptoms of other types of psychopathology, these analyses controlled family income, intelligence, and ethnicity to determine if the association between ADHD symptoms and functional impairment was independent of these factors. Both ADHD dimensions were associated with lower teacher ratings of prosocial behavior and higher interviewer ratings of global impairment. Inattention symptoms were independently associated with parent ratings of global impairment, child self-report ratings of friendship difficulties, teacher ratings of shyness, withdrawal, and lack of cooperation, and lower scores on standardized tests of mathematics achievement. In contrast, hyperactivity-impulsivity symptoms were uniquely associated with accidental injuries, peer rejection, and poor self-control. These studies convincingly demonstrate that DSM-IV inattention and hyperactivity-impulsivity symptoms are associated with multiple aspects of functional impairment when potential confounding variables are controlled, providing support for the concurrent validity of the symptom dimensions.

4.2. *DSM-IV subtypes*

4.2.1. *Global functioning*

Children with each DSM-IV ADHD subtype received lower ratings than children without ADHD on measures of global adaptive functioning in studies that controlled a wide range of potential confounding variables (e.g. [33,36,37]), as well as several studies in which fewer of these variables were controlled (e.g. [38,39]). Similarly, categorical analyses revealed that most children with each subtype exhibited significant global impairment based on parent ratings (combined type = 98%; inattentive type = 89%; hyperactive-impulsive type = 71%; e.g. [37,39]).

4.2.2. *Accidental injuries*

Several studies using previous definitions of ADHD found that ADHD is associated with an increased frequency of accidental poisonings, other accidental injuries, and higher ratings of accident proneness by parents [40–43]. The only published study of unintentional injuries sustained by children with DSM-IV ADHD, found that preschool children with the combined and hyperactive-impulsive

types were significantly more likely than children without ADHD to sustain an injury requiring care from a physician [36]. Moreover, the difference in the frequency of accidents remained significant when symptoms of other disruptive disorders, intelligence, academic achievement, and other potentially confounding variables were controlled. Therefore, although comorbid conduct problems are also associated with increased risk for accidental injuries (e.g. [44,45]), these data suggest that the DSM-IV combined and hyperactive-impulsive types are associated independently with this key facet of functional impairment.

4.2.3. Social functioning

Peer relationships of children with the inattentive and combined types are clearly impaired in comparison to those of children without ADHD (Fig. 1; e.g. [33,36,46,47]; reviewed by [118]). In comparison to children who did not meet criteria for ADHD, mothers and teachers reported that children with the inattentive and combined types were less socially skilled, had fewer friends, and were less often liked and more often actively disliked by peers. Several studies demonstrated that these social difficulties are not explained by group differences in age, comorbid disruptive disorders, intelligence, or academic achievement ([36,37,46]). Categorical analyses revealed that the majority of children in each group exhibited significant social impairment (74% of the combined type and 61% of the inattentive type), although it is also important to note that a nontrivial subset of individuals in each group did not exhibit significant social difficulties based on ratings by parents or teachers ([48]a; [37,39]).

Studies of the social impairments associated with the hyperactive-impulsive type are less consistent. Some studies reported that in comparison to individuals without ADHD, individuals with the hyperactive-impulsive type scored lower on measures of global social functioning, were less likely to be liked by peers, and were more often actively disliked (Fig. 1; e.g. [48]a; [36]). In contrast, several other studies did not find a significant difference between the comparison and hyperactive-impulsive groups on measures of social functioning (e.g. [33,49]), and only 38% of the children in the hyperactive-impulsive group exhibited significant social impairment ([48]a; [39]). These inconsistencies suggest that additional research is needed to clarify the profile of social impairment associated with the hyperactive-impulsive type.

4.2.4. Academic functioning

In comparison to groups without ADHD, the combined type and inattentive type are associated with significant impairment on numerous measures of academic functioning (Fig. 1), and studies that controlled a variety of potential confounding variables suggest that these academic weaknesses are not explained by group differences in comorbid externalizing symptoms, intelligence, sex, age, or socioeconomic status (e.g. [36,37,46,50]b).

Moreover, categorical analyses indicate that 81% of children with the inattentive type and 79% of children with the combined type exhibit significant academic impairment (e.g. [19,37,39]).

In contrast to the results for the inattentive and combined types, the mean of the hyperactive-impulsive type was significantly different from the mean of a control group without ADHD on only one of 21 measures of academic functioning administered in previous studies (e.g. [32,33,36,38,51]a). The average effect size across studies was small and not significantly different from zero (mean $d=0.14$; Fig. 1), and less than 25% of the children with the hyperactive-impulsive type exhibited significant academic impairment (e.g. [19,39,52]).

4.2.5. Neurocognitive correlates

Although neurocognitive tasks do not assess functional impairment per se, weaknesses on these measures provide another important external criterion to test the concurrent validity of ADHD. Studies which controlled for group differences in intelligence, academic achievement, and comorbid mental disorders found that the combined and inattentive types exhibited significant weakness on measures of response inhibition and other executive functions, processing speed, and motor functioning even when all or most of these potential confounding variables are controlled (Fig. 1; e.g. [53–55]a; see reviews by [50,56,57]a). In contrast, similar to the results on measures of academic impairment, the hyperactive-impulsive type was associated with a significant group deficit on only one of 18 neurocognitive tasks, and the mean effect size across studies was small and nonsignificant (mean $d=.12$; Fig. 1).

4.3. Conclusions regarding the concurrent validity of DSM-IV ADHD

Existing data clearly support the concurrent validity of the DSM-IV ADHD symptom dimensions. Both symptom dimensions are associated with multiple aspects of global and social impairment. Inattention symptoms are also significantly correlated with a variety of academic and neurocognitive weaknesses, and hyperactive-impulsive symptoms are associated with higher rates of accidental injuries. Previous studies also support the concurrent validity of the DSM-IV combined and inattentive types. Both subtypes are associated with significant impairment in nearly all domains of functioning, and these impairments are not explained by comorbid mental disorders, low intelligence, or other potential confounding variables (e.g. [36]).

In contrast, the concurrent validity of the hyperactive-impulsive type is less clear. Very few studies reported significant academic or neurocognitive weaknesses in groups with the hyperactive-impulsive type, and less than half of the individuals in the hyperactive-impulsive group exhibited significant social impairment. These results indicate that additional research is needed to test more

definitively whether the DSM-IV hyperactive-impulsive type is a valid diagnosis.

5. Discriminant validity

5.1. Gender ratio

More boys than girls met symptom criteria for DSM-IV ADHD in all population-based samples (mean male: female ratio = 2.7: 1; [118]). In all but one of these studies, the male to female ratio was lower for the inattentive type than the combined type (and the hyperactive-impulsive type in some cases). Due to the relatively small samples in many of these studies, however, the difference in gender ratios was often not statistically significant. To obtain adequate statistical power to test more definitively for gender differences in the frequency of the subtypes, we pooled results from all population-based samples separately for parent and teacher ratings. Among all individuals who met symptom criteria for any subtype of ADHD, a significantly larger proportion of females than males met criteria for the inattentive type than one of the other two subtypes based on both parents ratings (53 versus 45%) and teacher ratings (61 versus 50%). In contrast, males with ADHD were more likely than females with ADHD to meet criteria for the combined type based on both parent (34 versus 26%) and teacher ratings (31 versus 26%). Similar gender differences are also apparent in clinic-referred samples; females with ADHD were more likely than males with ADHD to meet criteria for the inattentive type (39 versus 30%), whereas males with ADHD were more likely than females to meet criteria for the combined type (60 versus 53%).

These results suggest that a higher proportion of females with ADHD than males with ADHD meet criteria for the inattentive type. However, although this difference is significant in the large sample obtained by pooling across studies, the gender differences are relatively small in magnitude. Therefore, although these results provide tentative support for the discriminant validity of the DSM-IV ADHD subtypes, it is also important to note that the ratio of the subtypes is more similar than different in males and females with DSM-IV ADHD.

5.2. Developmental trajectory

5.2.1. Symptom dimensions

A potentially strong source of support for the discriminant validity of DSM-IV inattention and hyperactivity-impulsivity is provided by emerging evidence that the two symptom dimensions may follow somewhat different developmental trajectories. A first source of information about this topic is provided by studies that examined age-related changes in the mean number of symptoms of inattention and hyperactivity-impulsivity exhibited by youth in cross-sectional population-based samples. These

studies found no significant age differences in teacher ratings of DSM-IV inattention between preschool and 18 years of age, whereas the mean number of DSM-IV hyperactivity-impulsivity symptoms was significantly lower in adolescence than childhood [31,58]. Similarly, although parent ratings of both hyperactivity-impulsivity and inattention declined with increasing age, symptoms of hyperactivity-impulsivity declined more steeply than symptoms of inattention ([17,59], [28,60]).

A second aspect of developmental course is reflected in age-related changes in symptoms exhibited by youth who met criteria for ADHD during childhood. In a prospective longitudinal study of children first diagnosed with DSM-IV ADHD in preschool, [27] found that symptoms of hyperactivity-impulsivity declined significantly across the first 8 years of the study, whereas symptoms of inattention did not. This result is consistent with results of prospective longitudinal studies of DSM-III-R ADHD ([61,62]).

Although additional longitudinal data are needed that track children with DSM-IV ADHD into later adolescence and adulthood, available data suggest that the number of hyperactivity-impulsivity symptoms declines substantially from early childhood through adolescence, whereas inattention declines less with age. If future longitudinal studies confirm these differences in developmental course, this would support the distinction between inattention and hyperactivity-impulsivity in DSM-IV. In fact, such a result would mean that it would be impossible to describe the developmental course of ADHD without distinguishing between inattention and hyperactivity-impulsivity symptoms.

5.2.2. Subtypes

Because complete longitudinal datasets are not yet available from studies that have been initiated to study age-related changes in the DSM-IV subtypes (e.g. [36]), cross-sectional prevalence data can be examined to obtain preliminary information regarding the developmental trajectory of the subtypes. Studies of both clinic-referred and community samples suggest that the overall proportion of children meeting symptom criteria for any subtype of ADHD decreases with age, but that this decrease in prevalence differs by subtype (e.g. [17,63]). Consistent with the age-related changes in the symptom dimensions described previously, a higher proportion of children with DSM-IV ADHD in preschool met criteria for the combined or hyperactive-impulsive types than in samples ascertained during childhood or adolescence. In contrast, a higher proportion of adolescents met symptom criteria for the inattentive type.

At least two possible explanations could account for the pattern of results observed in cross-sectional studies of the prevalence of the DSM-IV ADHD subtypes. The first explanation would suggest that the developmental trajectories of the three subtypes are distinct, and that each

subtype has a different age of onset and prognosis. For example, the hyperactive-impulsive type could be a distinct subtype with an earlier onset and better long-term prognosis than the other subtypes, leading to a lower prevalence in samples of adolescents with ADHD. In contrast, the inattentive type might only begin to impair functioning significantly when children encounter more complex academic tasks that challenge their attentional capacity in late childhood or adolescence. If future studies reveal results consistent with these predictions, the discriminant validity of the DSM-IV model will be supported.

On the other hand, these findings may indicate that at least a subset of individuals shift from one subtype to another in a systematic way over time. For example, several authors have suggested that when the hyperactive-impulsive type is identified in preschool children it may be a developmental precursor to the combined type ([2,36]), and this hypothesis has received support from initial longitudinal analyses ([27]). Similarly, because DSM-IV inattention symptoms remain relatively stable across development whereas DSM-IV hyperactivity-impulsivity symptoms decline with age, many children who initially meet criteria for the combined type in childhood may come to meet criteria for the inattentive type as they get older and their symptoms of hyperactivity-impulsivity fall below the diagnostic threshold (e.g. [2,53,64,65]).

Developmental shifts such as these would not necessarily invalidate the distinction between the subtypes, but would necessitate a reconceptualization of the diagnostic criteria for the subtypes to take these developmental changes into account. If future longitudinal studies support the hypothesis that a subset of children shift predictably from the hyperactive-impulsive type to the combined type or from the combined type to the inattentive type, it will be essential for the field to address the developmental course of the disorder when criteria for ADHD and related disorders are developed for DSM-V.

5.3. Comorbid mental disorders

Thus far, we have primarily considered comorbid mental disorders as potential confounding variables that complicate interpretation of the relations between ADHD and important criterion variables such as measures of functional impairment. In addition to this important aspect of the discriminant validity of ADHD from other disorders, differential rates of comorbidity would provide important support for the discriminant validity between the DSM-IV symptom dimensions and subtypes.

5.3.1. Symptom dimensions

DSM-IV hyperactivity-impulsivity and inattention symptoms are each significantly associated with elevations of externalizing and internalizing symptoms (e.g. [4,17,21,22,28]b), but several of these studies found that hyperactivity-impulsivity was more strongly associated with

symptoms of externalizing psychopathology (mean $r = .61$ versus $.49$ for ODD and mean $r = .56$ versus $.41$ for CD; [118]). In contrast, most studies found that inattention was associated more strongly than hyperactivity-impulsivity with symptoms of depressive disorders (mean $r = .39$ versus $.24$) and anxiety disorders (mean $r = .47$ versus $.40$).

5.3.2. Subtypes

Fig. 2 summarizes results of studies that compared the prevalence of comorbid mental disorders among the DSM-IV ADHD subtypes [22,52,38]; reviewed by [118]). Individuals with the combined type were significantly more likely than individuals with the inattentive type to meet criteria for bipolar disorder, ODD, and CD. Although studies of the hyperactive-impulsive type are again qualified by small sample size, available data suggest that youth with the hyperactive-impulsive type are less likely than individuals with the combined type to meet criteria for ODD or CD, but are at higher risk for these disorders than individuals with the inattentive type. In contrast to the results for the externalizing disorders, studies of internalizing comorbidity suggest that children with the inattentive and combined types do not differ in rates of depression or anxiety, but both subtypes are associated with higher rates of depression than the hyperactive-impulsive type.

The differential strength of these associations provides tentative support for the discriminant validity of the symptom dimensions and subtypes. In contrast, inattention and hyperactivity-impulsivity symptoms are both significantly associated with most dimensions of psychopathology, and the inattentive and hyperactive-impulsive types are associated with elevations of most disorders that are frequently comorbid with the combined type, albeit to a lesser degree. Taken together, these results suggest that the symptom dimensions and subtypes are distinguished by their profile of comorbidity, but at least some profile differences among the subtypes appear to be a matter of degree rather than kind.

5.4. Functional impairment

5.4.1. Symptom dimensions

DSM-IV hyperactive-impulsive symptoms are associated more strongly than DSM-IV inattention symptoms with global impairment, accidental injuries, and peer rejection, whereas inattention symptoms are more strongly associated with shyness, self-reported friendship difficulties, and academic impairment (e.g. [32,34,36,119,120]). Moreover, two recent studies that included both symptom dimensions in a regression model predicting neurocognitive performance found that inattention was significantly associated with weaknesses on measures of executive functions and processing speed, whereas hyperactivity-impulsivity was not independently associated with performance on these

tasks after the influence of inattention was controlled ([53,66]).

5.4.2. Subtypes

Children with the combined type exhibit impairment equal to or greater than the impairment exhibited by groups with the inattentive type or hyperactive-impulsive type in nearly all domains of global and social functioning (Fig. 1; [118]). One important exception to this pattern is revealed in studies of passive social behaviors. These results indicate that in comparison to youth with the combined type or hyperactive-impulsive type, individuals with the inattentive type more often exhibit passive or shy behaviors in social situations ([46,47]).

Several authors suggested that differential academic or neurocognitive deficits could provide key evidence of discriminant validity between the DSM-IV inattentive and combined subtypes (e.g. [53,56,57,67]). However, subsequent studies have found few consistent differences on these measures (Fig. 1). In contrast, both the inattentive and combined groups consistently performed more poorly than groups with the hyperactive-impulsive type on measures of both academic and neurocognitive functioning (e.g. [32,51]).

5.5. Etiology

Family studies indicate that biological family members of probands with DSM-IV ADHD are 6–8 times more likely to also meet criteria for ADHD than family members of control probands (e.g. [69,115]), and twin studies suggest that this significant familiarity is primarily attributable to genetic influences (reviewed by [70]). However, recent results suggest that the etiology of ADHD may differ by ADHD subtype. Although results are mixed (e.g. [71]), several large family studies have found that the DSM-IV inattentive and combined types cluster in the same families, whereas the hyperactive-impulsive type is substantially less familial (e.g. [26,115]). Similarly, two large population-based twin studies suggest that the combined and inattentive types are highly heritable and due in part to common genetic risk factors, whereas the hyperactive-impulsive type was not significantly heritable in either study ([26,72,73]).

Two recent molecular genetic studies provide further support for the etiological distinction between the hyperactive-impulsive type and the other DSM-IV subtypes ([74, 75]). In a meta-analysis of the association between ADHD and a specific form of the dopamine D5 receptor gene, [74] found a significant association between this gene and the inattentive and combined types. In contrast, the hyperactive-impulsive subtype was not associated with the risk allele. Similarly, in a genome scan of a large sample of affected sibling pairs with DSM-IV ADHD, [75] found that evidence for linkage was consistently strongest when probands with the hyperactive-impulsive type were excluded from the analysis. Taken together, these results provide converging

evidence that the etiology of the hyperactive-impulsive type may be distinct from the etiology of the other two subtypes, at least in school-age children.

6. Implications for the validity of DSM-IV ADHD

6.1. DSM-IV symptom dimensions

Ratings of hyperactivity-impulsivity and inattention symptoms by both parents and teachers are reliable and internally consistent, and nearly all symptoms load primarily on their specified factor in most samples. Both symptom dimensions are associated with multiple aspects of global, academic, and social impairment in rigorously controlled analyses, providing support for the concurrent validity of each symptom dimension. Although inattention and hyperactivity-impulsivity symptoms are associated with many of the same external correlates, the discriminant validity of the symptom dimensions is supported by studies showing that they are associated with at least partially distinct aspects of functional impairment, neurocognitive functioning, comorbid psychopathology, and developmental course. Taken together, these results provide strong support for the validity of the DSM-IV ADHD symptom dimensions.

6.2. DSM-IV subtypes

Existing data also generally support the validity of the DSM-IV combined and inattentive types. Both groups exhibit significant impairment in nearly all domains of functioning, the average effect size is moderate to large in each of these areas, and these impairments are not explained by comorbid mental disorders, low intelligence, or other potential confounding variables. Therefore, although it will be some time until information is available regarding the long-term predictive validity of any of the DSM-IV subtypes (e.g. [36,27]), the current literature strongly supports the criterion validity of the DSM-IV inattentive and combined types.

The discriminant validity of the inattentive and combined types is less clear. The combined type is associated with greater social impairment in some domains, higher rates of externalizing comorbidity, and more frequent accidental injuries, whereas individuals with the inattentive type are more likely to be socially passive or isolated. On the other hand, the inattentive and combined types exhibit similar weaknesses on nearly all academic and neurocognitive measures, and etiologically informative studies suggest that these subtypes are due at least in part to common genetic influences (e.g. [26,72,74]). Overall, these results tentatively support the distinction between the inattentive and combined types, but suggest that additional research is needed to determine if these subtypes can be distinguished at cognitive or etiological levels of analysis.

In contrast to the inattentive and combined types, evidence of diagnostic validity is far weaker for the hyperactive-impulsive type. Very few studies reported significant academic impairment or neurocognitive deficits in groups with the hyperactive-impulsive type, and less than half of the individuals in the hyperactive-impulsive group exhibited significant social impairment. Although these results must be interpreted with caution due to the relatively small samples of individuals with the hyperactive-impulsive type, they indicate that additional research is sorely needed to test if the hyperactive-impulsive type is a valid diagnosis that should be retained in its current form in DSM-V.

7. Directions for future research

In this final section, we highlight several keys remaining questions regarding the validity of ADHD, and describe future research directions that may help to address these questions.

7.1. How is a predominantly inattentive disorder best conceptualized?

Contrary to the initial predictions of many researchers (e.g. [53,64,65]), evidence for the discriminant validity of the DSM-IV inattentive and combined types is somewhat weak, especially, in terms of differential neurocognitive profiles (e.g. [67]). In this section, we summarize methods that have been suggested to identify a predominantly inattentive subtype of ADHD (or a primarily inattentive disorder that is separate from ADHD) that can be distinguished consistently from the combined type. The first method proposes an adjustment to DSM-IV criteria to decrease the heterogeneity of the inattentive subtype, whereas the second approach suggests that the validity of the inattentive type and DSM-IV ADHD as a whole may be improved by developing positive diagnostic criteria for the predominantly inattentive subgroup.

One possible means to reduce heterogeneity and improve discriminant validity of the inattentive subtype would be to remove individuals who may be better conceptualized as subthreshold combined type from the inattentive group. The different developmental trajectories of DSM-IV inattention and hyperactivity-impulsivity symptoms and the limitations inherent in categorical diagnostic thresholds suggest one possible explanation for the relatively weak discriminant validity of the inattentive and combined types. Prevalence estimates from cross-sectional samples (e.g. [17,58]), retrospective ratings of adolescents with DSM-IV ADHD ([76]), and early results from the first longitudinal study of DSM-IV ADHD ([27]) all suggest that some children who meet criteria for the combined type in elementary school may begin to fall slightly below the diagnostic threshold on the hyperactivity-impulsivity dimension as they grow older. Similarly,

several studies have found that in groups with the inattentive type at any age, a subset of individuals often exhibit subclinical elevations of hyperactivity-impulsivity (e.g. four–five symptoms) that fall slightly below the DSM-IV diagnostic threshold (e.g. [53,64,65]). Normative data on DSM-IV rating scales indicate that a child or adolescent with five symptoms of hyperactivity-impulsivity would fall between the 85th and 96th percentile even if the rater endorsed all other hyperactivity-impulsivity symptoms at their lowest possible level (e.g. [17]).

Therefore, whereas in both of these examples the individual would be diagnosed with the inattentive type based on their current symptoms, their pattern of difficulties may be better conceptualized as a slightly less severe or later developmental manifestation of the combined type than as a disorder characterized by inattention in the absence of significant hyperactivity-impulsivity. If future research suggests that these individuals have a form of the combined type, the development of systematic criteria to remove them from the inattentive group may improve the internal and external validity of the inattentive type and the discriminant validity of the inattentive and combined types.

Alternatively, several researchers have suggested that the internal and external validity of the inattentive type might be improved by developing positive diagnostic criteria for this subgroup based on a cluster of inattentive behaviors that have been labeled *sluggish cognitive tempo* (SCT; e.g. [32, 65,67,77–81]a).

Several studies have tested the internal and external validity of potential SCT items. Three factor analytic studies found that SCT symptoms loaded on a third factor separate from DSM-IV inattention and hyperactivity-impulsivity symptoms ([79–81]), although [81] found that this was only true for males. Four studies found that the mean SCT score of the DSM-IV inattentive type was significantly higher than the mean of the combined or hyperactive-impulsive types ([78–80,82]). However, the mean of the combined type was also significantly higher than the mean of the comparison group in several of these analyses, suggesting that SCT may not be uniquely associated with the inattentive type.

To test the external validity of SCT symptoms, three studies compared groups with the inattentive type with and without significant elevations of SCT ([37,54,78]). [78] found that the group with the inattentive type with elevated SCT exhibited more internalizing symptoms and social impairment, and [37] found that the group with elevated SCT also performed more poorly on a subset of measures of neurocognitive functioning. In contrast, [54] did not find significant differences as a function of SCT in a study of the neurocognitive correlates of the DSM-IV inattentive and combined types in females.

Although these early results are mixed, they suggest that additional systematic research is warranted to clarify the potential utility of SCT symptoms for the nosology of

ADHD and related disorders. If initial results support the hypothesis that SCT symptoms identify individuals with a disorder that is distinct from ADHD, it will be essential to test whether these symptoms identify a new attentional syndrome or are simply a marker for another existing psychological disorder. For example, many aspects of SCT are similar to symptoms of internalizing disorders such as major depressive disorder (e.g. drowsiness and psychomotor retardation) and generalized anxiety disorder (e.g. mind going blank), and slow processing of cognitive stimuli is also a correlate of learning disabilities such as reading disorder [23,120]. Because a diagnosis of an attentional disorder may be more palatable to parents than a diagnosis of major depression (e.g. [83]), it is essential that the discriminant validity of SCT symptoms be carefully assessed to avoid precipitating inappropriate treatment for individuals with these other disorders (see [79] for a detailed discussion of these issues).

7.2. Gender, ethnic, and cross-national differences in ADHD

Girls are significantly less likely than boys to meet criteria for DSM-IV ADHD in both clinic-referred and community samples, and girls with ADHD are slightly more likely than boys with ADHD to meet criteria for the inattentive type. Recent research conclusively demonstrates that DSM-IV ADHD is associated with significant impairment in both males and females, suggesting that DSM-IV criteria are valid for both sexes [54,76,84,116]. However, further research is needed to identify the unknown etiology of the gender difference in prevalence.

The few available studies that have compared the prevalence of ADHD in different ethnic groups suggest that African American children may receive higher ratings of ADHD symptoms from parents and teachers than Caucasian and Hispanic children (e.g. [17,58,85]). In contrast, a recent study of treatment rates suggests that African American and Hispanic children are less likely than Caucasian children to receive treatment for ADHD ([86]). Once again, the reasons for these differences are unknown.

Prevalence differences in different demographic groups could reflect rater biases (e.g. [85]), social pressure to conform to gender norms ([84]), cultural differences in parenting style or definition of normative behavior ([87]), socioeconomic differences or other responses to environmental stressors (e.g. [88]), different thresholds at which symptoms begin to impair functioning (e.g. [89]), or etiological differences (e.g. [90]). Future studies that test these and other competing hypotheses will have critical implications for the validity of ADHD in these groups, and will help to facilitate the implementation of valid diagnostic procedures and effective interventions in all populations.

7.3. Validity of ADHD across the lifespan

7.3.1. Preschool

Whereas substantial evidence supports the validity of DSM-IV ADHD in school-age children, additional research is needed to evaluate the validity of ADHD in preschool children. Two recent studies suggest that DSM-IV ADHD is a valid diagnosis among 3–6 years old children ([36,91]). These studies await replication, however, particularly in population-based samples and prospective longitudinal studies that will be able to address the long-term predictive validity of ADHD when it is first diagnosed during the preschool years.

7.3.2. Adults

Prospective studies clearly indicate that the majority of children with DSM-III or DSM-III-R ADHD continue to exhibit elevations of ADHD symptoms and associated impairments in adulthood, and individuals diagnosed with DSM-III-R or DSM-IV ADHD in adulthood exhibit significant social, occupational, academic, and driving impairments that are not explained by comorbid ODD, CD, internalizing symptoms, or substance use (e.g. [92]; [93,94]; [68,95,96]a; [97–99]).

These studies suggest that DSM-IV ADHD is associated with many of the same external correlates in childhood, adolescence, and adulthood (e.g. [41,68]b; [100,110,112,117]), and leave little doubt that ADHD is a valid diagnosis in adulthood for many individuals with a history of childhood ADHD. Nonetheless, a number of issues remain regarding the validity of DSM-IV ADHD in adults. First, very few studies have evaluated the validity of the DSM-IV subtypes in adults; indeed, it is currently not clear how these subtypes are best defined in adult populations. A second issue regarding the assessment of ADHD in adulthood is the fact that most studies have relied on self-report measures. Although recent data provide preliminary support for the validity of retrospective self-report ratings [114], additional research is needed to determine the optimal methods to assess and diagnose ADHD in adulthood ([2]). Third, [101] raised the concern that adults without ADHD who are impaired because of other mental disorders may seek out a diagnosis of ADHD because they find it less stigmatizing than other diagnoses. If a careful diagnostic assessment is not conducted, improperly diagnosed individuals may not receive optimal treatment for their primary mental disorder. Finally, much remains to be learned about the response of adults with ADHD to psychopharmacologic and psychosocial treatments ([102]).

7.4. Optimal informants for the diagnosis of ADHD

Although previous studies support the validity of ADHD ratings by both parents and teachers, these ratings identify partially non-overlapping samples of children. Moreover, whereas many studies of the validity of DSM-IV ADHD have used ratings from parents or teachers alone,

symptom criteria for DSM-IV ADHD were derived based on the combination of parent and teacher ratings ([33]). The rule used in the DSM-IV field trials codes each symptom as present if it is endorsed by either the parent or the teacher, and therefore, identifies a larger number of children than parent or teacher ratings alone. In contrast, the more conservative criteria for hyperkinetic disorder in the tenth edition of the International Classification of Diseases (ICD-10; [103]) require that symptom criteria be met based on both parent and teacher ratings, and an even more conservative approach would code each individual symptom as positive only if the symptom was endorsed by both the parent and the teacher. Additional research is needed to compare the validity of these and other algorithms for combining ratings from multiple informants when functional impairment is used as the external criterion for a valid diagnosis.

7.5. Etiology and diagnostic heterogeneity

Existing data clearly suggest that multiple genetic and environmental risk factors increase susceptibility to ADHD. Each risk factor appears to lead to a small increase in susceptibility to ADHD, but none of these risk factors is necessary or sufficient to cause the development of ADHD by itself (e.g. [70,104]). Moreover, the combined effects of all risk factors that have been identified to date is not sufficient to fully explain the variance in ADHD symptoms, suggesting that future studies are likely to discover additional genetic and environmental risk factors. The complexity of these results is not unique to ADHD; a similar pattern is apparent in studies of the etiology of other complex phenotypes such as reading disability (e.g. [105]), schizophrenia (e.g. [106]), addictive behaviors (e.g. [107]), and bipolar disorder (e.g. [108]).

In light of the complex multifactorial etiology of ADHD, it is perhaps not surprising that groups with ADHD are quite heterogeneous. For example, population-based studies consistently show that a substantial subset of individuals with ADHD also meet criteria for one or more other mental disorders, whereas other individuals meet criteria for ADHD alone [109,119]. Similarly, neuropsychological studies suggest that subgroups of children with ADHD exhibit deficits on different clusters of neurocognitive tasks ([110]), and a subset of children with ADHD do not exhibit deficits on any of the neuropsychological measures administered in these studies ([16]).

Heterogeneity within groups with ADHD may be decreased to some extent by future refinements to behavioral diagnostic criteria. However, it is also plausible that a better understanding of the pathophysiological processes involved in ADHD will facilitate the development of diagnostic subtypes based on etiology (e.g. [16]). For example, the paper by McFadden et al. (2005) in this special issue presents evidence that prenatal exposure to androgens is predictive of the inattentive type but not the combined

[111] tested whether subgroups within the combined type were differentiated by the presence or absence of the putative risk allele of the dopamine D4 receptor gene (e.g. [104]). The group without the risk allele exhibited the expected pattern of neuropsychological impairment, whereas the group with the risk allele did not display significant neurocognitive abnormalities. This counter-intuitive result led the authors to speculate that the D4 receptor gene may be associated with extreme scores on a dimension of personality or temperament, whereas the group without the DRD4 risk allele may be composed of individuals with other genetic or non-genetic etiologies.

Whether or not these findings are replicated in future studies, the papers by [111] and McFadden et al. (2005) clearly demonstrate methods to identify potential etiologically informed subtypes of ADHD. If the external validity of such subtypes is then demonstrated by consistent differences in patterns of symptoms, impairment, or neurocognitive functioning, these methods could contribute considerably to refining diagnostic criteria and reducing diagnostic heterogeneity.

8. Summary and conclusions

Existing data provide strong converging evidence that for most individuals DSM-IV ADHD is a reliable diagnosis that is associated with important aspects of functional and neurocognitive impairment after controlling a wide range of variables that are often confounded with the diagnosis. Thus, similar to previous definitions of ADHD ([2]), these results suggest that DSM-IV ADHD is not a construct that inappropriately labels as abnormal a set of behaviors that are upsetting to parents and teachers but are not inherently maladaptive for the individual. Instead, ADHD is a valid disorder because it significantly impairs social, academic, occupational, and general adaptive functioning in both children and adults. Additional research is needed to test the validity of the hyperactive-impulsive type, to clarify the distinction between the combined and inattentive subtypes, and to test the relation between the ADHD subtypes and other aspects of inattention that are not captured in the DSM-IV criteria for ADHD.

Recent advances in molecular genetics and neuroscience provide new tools that will play an essential role in the next generation of studies of ADHD. By applying these techniques in samples with well-validated measures of the behavioral symptoms of ADHD, it will be possible to improve both the diagnostic nosology of ADHD and models of underlying pathophysiology. Studies that integrate these multiple levels of analysis will help to guide the field toward the ultimate goal of all psychopathology research: the development of effective prevention and intervention techniques to alleviate the symptoms of ADHD and associated functional impairment.

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