Annual Research Review: Categories versus dimensions in the classification and conceptualisation of child and adolescent mental disorders: implications of recent empirical study

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The question of whether child and adolescent mental disorders are best classified using dimensional or categorical approaches is a contentious one that has equally profound implications for clinical practice and scientific enquiry. Here, we explore this issue in the context of the forth coming publication of the DSM-5 and ICD-11 approaches to classification and diagnosis and in the light of recent empirical studies. First, we provide an overview of current category-based systems and dimensional alternatives. Second, we distinguish the various strands of meaning and levels of analysis implied when we talk about categories and dimensions of mental disorder – distinguishing practical clinical necessity, formal diagnostic systems, meta-theoretical beliefs and empirical reality. Third, we introduce the different statistical techniques developed to identify disorder dimensions and categories in childhood populations and to test between categorical and dimensional models. Fourth, we summarise the empirical evidence from recent taxometric studies in favour of the 'taxonomic hypothesis' that mental disorder categories reflect discrete entities with putative specific causes. Finally, we explore the implications of these findings for clinical practice and science. **Keywords:** Assessment, classification, diagnosis, DSM, factor analysis, ICD, taxometrics.

Introduction

Few matters can polarise groups of clinicians and researchers in our field more than the question of whether mental disorder should be classified and conceptualised in categorical or dimensional terms. This debate is common to both those working with children and adolescents and our counterparts working with adults (Lawrie, Hall, Mcintosh, Owens, & Johnstone, 2010). On the one hand, those who propose a categorical approach regard mental disorders as qualitatively different from variation across the normal range of expression in the population, and as having their own pattern of rather distinct causes – *disorder differs from normality in both degree and kind.* On the other hand, those who regard disorder as an extreme expression of normal variation in the population emphasise continuity in underlying causes – *disorder and normality differ only in degree but not kind.* This tension between categorical and dimensional conceptualisations is reflected in the debate, energised recently by the revision of DSM-5 and the consequent renewed interest in nosology and diagnostics, over whether current category-based systems for the classification of child and adolescent mental disorders are fit for purpose or whether they should be superseded by dimensional alternatives: a debate which clearly has far reaching implications for both clinical practice and scientific enquiry.

Although at first sight this debate seems relatively simple to resolve by addressing some rather straight forward and apparently tractable questions – it is, in fact rather complex as it raises issues about the relationship between clinical and scientific reality, the role of values in science and clinical practice and the practical politics of mental disorder classification. Understanding these different levels of analysis depends on rather subtle differences in the use of the terms category and dimension in different contexts and for different purposes. This review sets out to (a) describe the nature of the category/dimension debate and its influence on current models of classification (b) understand the practical, political and philosophical origins of the current category-based

system and its implications for clinical practice and scientific enquiry (c) distinguish these philosophical and practical issues from the empirical question about the existence of categories of disorder as discrete causal entities (d) review the empirical data directly addressing these empirical questions and (e) explore the implications of these data for approaches to classification and diagnosis in the light of the upcoming DSM-5 and ICD-11 systems. Our analysis is founded on the notion that seemingly contradictory views are, in fact, often resolvable when different levels of analysis of the strengths and weaknesses and uses of the concepts of categories and dimensions are distinguished. Our approach is also based on the idea that systems based on these concepts can coexist with each other, serving a different but equally useful purpose, even within the context of a single disorder.

Section 1: Current category-based approaches and dimensional alternatives to classification of child and adolescent mental disorders

Historically, psychiatry emerged as a discipline when shared systems of diagnosis, based on informal rules of categorisation emerging out of everyday experience were developed not only to aid the drawing of appropriate distinctions between 'health' and 'illness' but also to better characterise different disorders in psychiatric settings (Mack, Forman, Breown, & Frances, 1994). Initial attempts at classification were, however, rather idiosyncratic and their use was inconsistent. This led to the first attempts to introduce more formal and universal diagnostic criteria, guided by attempts to promote clear communication, reliability (Spitzer & Fleiss, 1974), validity (Cloninger, 1989), and consistency of application across clinicians who often held very different views of the causes of disorder. Although version 6 of the WHO International Classification of Diseases (ICD-6) included a chapter on mental health, it was the publication in 1977 of ICD-9 (WHO, 1977), and of DSM-III in 1980 (APA, 1980) that really represented the start of the modern era of classification. This signalled an active attempt to shift away from a predominantly psychodynamic approach to mental health and illness, where boundaries between health and disorder were vague and poorly specified, towards a more scientific one, which shared a common frame of reference with mainstream medicine – a pronounced bio-medical focus (Spitzer & Endicott, 1978). The introduction of this category-based approach with its clear and explicit criteria for making a diagnosis meant that identifying the presence of a disorder changed, at least in theory, from something of an art-form linked to the nuanced interpretations of symptom meaning, to a more technical task involving the application of algorithms based on 'data' from systematic observation. Whilst here we focus on issues relating to childhood disorders it is

important to recognise that many of these changes were initiated from within the adult mental health arena. In that context, the categorical view was proposed partly to oppose the psychoanalytical views, as mentioned above but also to bring psychiatry back closer to other medical specialties, as governmental and private insurance had cut reimbursements to psychiatry due to the confusion and lack of reliability of mental disorder diagnoses (Wilson, 1993). Whilst its clinical utility (ease of use, ability to improve communication and inform treatment planning; Mullins-Sweatt & Widiger, 2009) and scientific approach (Kendler, 1990) are reasons why categorical approaches have been widely adopted, there are also political, economic, sociological and psychological reasons why these systems have come to hold such a strong position in the field.

1. *Practical clinical reality:* It is a clinician's job to make difficult practical decisions about *whether* an individual should or should not receive specialist health interventions and *which* interventions they should receive. It is, therefore, just as important to ensure that individuals for whom an intervention is unlikely to be beneficial are not exposed to unnecessary risk, as it is to ensure that those who may benefit from an intervention are accurately identified. By definition these are categorical decisions (see also below).

2. *Politics and economics:* Childhood disorders arouse strong, but very different, public and political reactions from different groups and individuals with different agendas. Despite these differences, it is important for both the advocates of the diagnosis and treatment of child and adolescent mental health problems and those who campaign against their existence to be able to point to the label and diagnostic criteria – even where the ultimate aim is to dismantle these same criteria. At the same time, it is universally the case that service provision for children and young people with mental health problems lags way behind those for children with physical illness or adults with mental health problems. As a consequence, it has become important for those lobbying for better services to be able to point to the 'validity' of disorders and their impact on quality of life. To do this, they will often rely on recognised diagnostic categories to make the argument for more financial resources. Similarly, it is the case that specialist healthcare services are almost always rationed, whether at the level of the state or by private insurance companies. It seems easier to justify the need for clinical care if one can associate this need with a discrete diagnostic entity.

   Following this economic imperative can result in clinical misunderstanding. This was highlighted recently by the case of severe mood dysregulation (SMD). In many healthcare systems, the lack of a formal diagnostic label for those with

SMD is a barrier to funding for treatment. The recognition that certain symptoms of SMD paralleled those of bipolar disorder (e.g. rapid fluctuating mood) led to the widening of the concept of *paediatric bipolar disorder* (PBD) as a clinical entity. This in turn eased problems with reimbursement. However, although well intentioned, the concept of PBD resulted in much confusion and led to claims and counterclaims about the validity of this new variant of an established disorder (See The DSM-5 Childhood and Adolescent Disorders and Mood Disorders Work Groups, 2010, for discussion of the current standing of the debate).

From a different perspective, the application of category-based diagnostics can be used to support the rationing of treatment that may have the potential for much broader beneficial application. An extreme, but interesting, example is the use of stimulant medication, currently restricted to those with ADHD, but which can be (and indeed in practice are; Mccabe, Teter, & Boyd, 2006; Mccabe, Brower, West, Nelson, & Wechsler, 2007) used as cognitive enhancers to boost performance in the general population (Sahakian & Morein-Zamir, 2007). If we were to eschew the use of categorical diagnoses but still wish to ration healthcare, where would one draw the line about who should and who should not receive reimbursement for such 'treatment?'

3. *Psychology:* Studies in experimental psychology show that human beings are natural categorisers. Children as young as few months can learn to distinguish between stimuli along categorical lines (Blewitt, 1994; Eimas & Costello, 1994; Younger, 1993), and people, when presented with a stimulus array with little or no formal structure, will group its component parts into categories (but see Dagostino & Beegle, 1996). This manifests as *categorical perception* when relating to physical stimuli and *group polarisation* when relating to social stimuli. It is, therefore, the case that the clinical tendency towards categorising 'cuts with the grain of human nature' (Schoeeman, Segerstrom, Griffin, & Greshham, 1993). It is also the case that the act of categorisation itself serves to reorganise the categorisers' perception of the category members (Harnad, 1987). In particular, there is an increase in the perceived separation between people in different groups and an increase in the perceived of similarity within groups (Mcgarty & Turner, 1992). This observation seems to hold just as well in the clinical situation as it does in the many group social psychology experiments in which it was first described (Sonuga-Barke, 1998).

Leaving these more general issues about the origins of the category-based systems to one side, it remains to be seen whether these systems have improved clinical practice. Certainly clinicians, who have received special training, achieve good levels of interrater and test–rest reliability (see Blashfield & Livesley, 1991). Evidence is lacking, however, for improvements in the day-to-day performance of untrained clinicians (Kirk & Kutchins, 1994). This may be because clinicians simply do not apply the classification rules properly or consistently. This in turn may be because of a mismatch between the decision rules of the system and the clinician's natural approach to categorising [i.e. clinicians appear to categorise patients by using typical exemplar or prototype based decision-making models (Blashfield, Sprock, Pinkston, & Hodgin, 1985)]. There are also issues associated with heterogeneity and comorbidity that may be especially undermining of the categorical approach to classification (Sonuga-Barke, 1998). Comorbidity is common in childhood mental disorder and the relationships between disorders is complex (Ford, Goodman, & Meltzer, 2003; Nottelmann & Jensen, 1995) and appears to work against the concept of disorders as discrete entities with clear boundaries (Clark, Watson, & Reynolds, 1995). Whilst heterogeneity has not been as well studied as comorbidity, the dual problems of within category heterogeneity (not everybody with a disorder has the same pattern of symptoms or even defining features) and mixed symptom patterns that fall between categories (or just below diagnostic thresholds) are also likely to impact heavily on the clinical utility of category-based diagnostic systems. The problem here is that if one seeks to reduce comorbidity by reducing categories, one is faced with increasing levels of heterogeneity and vice versa (Morgan, Hynd, Riccio, & Hall, 1996; Sonuga-Barke, 1998). The strict application of categorical diagnostic rules can also result in individuals with significant symptoms and impairments, but who fall just short of the diagnostic criteria, being denied support and treatment. Whilst many of the current criteria include definitions for subtypes, the true meaning of these groupings is often unclear and within a disorder the evidence for stability within these subgroups is poor, with individuals often moving between different subgroups over time (Lahey, Pelham, Loney, Lee, & Willcutt, 2005).

These criticisms have been accompanied by calls to abandon current category-based approaches. First, some call for the scrapping of the concept of mental disorder altogether, echoing the antipsychiatry movement of the 1960s following such figures as Foucault, Laing, Szasz and Basaglia (Foucault, Khalfa, & Murphy, 2006). The central thesis of this loosely constituted movement was that diagnostic criteria are too vague and arbitrary to meet scientific standards and that psychiatric treatments cause more harm than good to patients. They also focused on an inappropriate use of medical concepts and miscategorisation of normal reactions to extreme circumstances as psychiatric disorders, the stigmatising nature of psychiatric labelling and misuse of

power by doctors, and the state, against patients (Cooper, 1967; Whitaker, 2004). Although less prevalent now, there are still those within the child and adolescent mental health professions who actively question the existence of mental disorder and the use of labelling – a view perhaps most prominently expressed by the huge variation in the acceptance and treatment of ADHD even within relatively well defined regions (e.g. NHS Quality Improvement Scotland, 2008).

Second, there are those who work from a theoretically driven position and advocate the development of aetiology-based categories as is seen across much, but not all, of physical medicine (Andreasen & Carpenter, 1993). From this perspective, symptoms that share the same cause should be seen as indicating the same disorder. There are two contrasting, but related, problems with this approach. On the one hand, it has been noted, at several levels of analysis that causal factors do not map on a one-to-one basis with other indicators of disorder-integrity such as treatment response or prognosis (Coghill, Rhodes, & Matthews, 2007). One cause or set of causes can lead to different and apparently unrelated clinical manifestations, while the same manifestation can be linked to many different causes (Coghill, Nigg, Rothenberger, Sonuga-Barke, & Tannock, 2005). For example, deficits in working memory have been identified in conditions as diverse as schizophrenia (Park & Holzman, 1992), autism (Steele, Minshew, Luna, & Sweeney, 2007), ADHD (Rhodes, Coghill, & Matthews, 2005) and oppositional defiant disorder (Rhodes, Park, Seth, & Coghill, 2011a). At the same time a single disorder, ADHD is a good example, can be underpinned by different neuropsychological deficits in different individuals with the same clinical expression. Rhodes et al. (2005) described separable patterns of executive and nonexecutive functioning and Sonuga-Barke, Bitsakou, and Thompson (2010) reported discrete and dissociable patterns of deficient executive function, delay-related responding and temporal processing. Given this heterogeneity within clinical manifestations and causal overlap between aspects of functioning, any such aetiology-based system of classification is likely to be unworkable, given the many thousands of categories that would likely be needed to map identified causes onto clinical manifestation in a specific and sensitive way. Dimensional approaches that characterise disorders 'on a linear continuum of graded severity' offer a third alternative (Clark et al., 1995, p. 145). Advocates of dimensional approaches point out that they avoid the waste of potentially important information associated with categorical approaches. From a research perspective, dimensions have been found to some times have greater predictive validity than do their diagnostic counterparts (Fergusson & Horwood, 1995). Others have simply argued that dimensional approaches are preferable as they provide a better fit with the data than the categorical

ones. For example, Gjone, Stevenson, and Sundet (1996), investigated the heritability of attention problems in a general population sample of twins. They found evidence of substantial heritability and importantly that the degree of heritability was similar for those with low levels of attention problems as it was for those with moderate or even high levels of problems. This failure to find different estimates of heritability at either extreme of the continuum clearly supports a dimensional rather than a categorical model of ADHD.

We can distinguish between several different dimensional approaches. These propose either (a) the replacement of specific categorical disorders with equivalent dimensional concepts, (b) the wholesale replacement of the current categorical structure with an common set of empirically derived dimensions representing the major aspects of behaviour and cognition that can lead to impairment and distress or (c) a mixed approach whereby both dimensions and categories are used alongside each other. The first approach has been proposed for ADHD. Confirmatory factor analytical studies have suggested that a nonhierarchical bi-factor model for ADHD, with a general factor and specific factors of inattention and hyperactivity-impulsivity, fits the available data better than either simple one-, two-, and three-factor models, or a second-order factor model (See below; Martel, Von Eye, & Nigg, 2010). It has therefore been argued that the ADHD category could be replaced by these three dimensions and individuals described by their ratings on each, an overall rating for the ADHD g factor and separate ratings for inattention and hyperactivity/impulsivity. Typically such ratings would be made using symptom based measures such as the SNAP (Bussing et al., 2008) or the ADHD-IV rating scale (Du Paul, Power, Anastopoulos, & Reid, 1998), although truly dimensional measures that measures the continuum from good through average to poor attention have also been advocated (Swanson, Wigal, Lakes, & Volkow, 2011).

The second approach, the wholesale replacement of the current categorical structure with empirically derived dimensions, has been advocated by developmental psychopathologists such as Achenbach, who developed the Child Behaviour Checklist (CBCL; Achenbach, 1991). This instrument was designed to capture information across the broad range of behavioural and emotional difficulties in childhood. Indeed, the driving force that led Achenbach to develop the CBCL in the 1960s was the desire for a more differentiated picture of child and adolescent psychopathology than was provided by the prevailing version of DSM. Starting with a long list of descriptors of problematic childhood behaviours that were not necessarily the same as the symptoms of recognised disorders, Achenbach used multivariate statistical analyses of correlations and factor analytic techniques to derive subscales that measured behaviour across multiple continuous dimensions.

These data are used to (a) develop reports of skills and involvement in activities, social relations, school, and work (b) assess competencies and adaptive functioning and (c) construct profiles of scales and subscales on which to display individuals' scores in relation to norms for their age and gender.

Factor analytic analyses of CBCL data have generally supported the existence of two broad-based dimensions of disorder, that is, externalising and internalising (Achenbach, Conners, Quay, Verhulst, & Howell, 1989) and several other more specific dimensions represented by different subscales. Whilst several of these original empirically derived subscales bore similarities to recognised diagnostic categories (e.g. anxious/depressed, withdrawn/depressed and attention problems, rule-breaking behaviour, aggressive behaviours and somatic complaints), there were clear differences in both content and orientation and also other categories (e.g. thought problems and social problems) that do not readily map on to particular diagnostic categories. One distinct benefit of such scales is that symptom overlap among subscales is considered as clinically relevant information rather than nuisance and contamination across diagnostic categories (Cummings, Davies, & Campbell, 2000). Although not unique to these types of scales, such empirically derived data can be used much more flexible for examining diverse developmental trajectories compared to categorical systems. This is particularly relevant to developmental psychopathology where equifinality (multiple pathways ending with the same outcome) and multifinality (children with similar risks ending with different outcomes) are particularly common (Cicchetti & Rogosch, 1996). The CBCL has changed over time and in its current form also includes six DSM orientated scales. These represent a clear nod to the dominance of the categorical approach as they were not empirically derived but instead comprise items identified by experts as 'very consistent with DSM-IV categories' (affective problems, ADHD problems, anxiety problems, oppositional defiant problems, somatic problems, conduct problems). Perhaps a more interesting development has been the construction of subscales that reflect potentially important clinical groupings such as those with 'Sluggish Cognitive Tempo'.

The CBCL, like most other measures of psychopathology, truncates the range of aptitudes that can be rated by collapsing ratings of normal and supernormal characteristics under one rating of 'no problem' and distinguishing these from different levels of subnormal aptitudes (Swanson et al., 2001). When applied to a normal population this results in an extremely skewed data, with a J shaped or exponential distribution of scores in the population. Whilst such a scale can still be clinically useful in situations where the behaviours upper (superior) levels of function have no meaning or importance for clinical decision making, this psychometric flaw makes it difficult, if not impossible, to use such a scale to classify individuals in situations where behaviour across the full range of aptitudes is relevant to the decision-making process.

As a response to this problem, Swanson developed the Strengths and Weaknesses of ADHD-symptoms and Normal-behaviour (SWAN) rating scale. This re-conceptualised the DSM symptom domains of ADHD as a continuum that covers the full range of relevant aptitudes (from super- to subnormal), allowing the ADHD construct to have a truly dimensional characterisation. Several studies have provided empirical support for the advantageous distributional characteristics of the SWAN (e.g. Cornish et al., 2005; Hay, Bennett, Levy, Sergeant, & Swanson, 2007; Polderman et al., 2007), although Swanson et al., 2011 report that, whilst the SWAN produced normally distributed scores in a school wide sample, it did not do so in a clinical sample. This suggests that the value of this approach may be less apparent in clinical studies than it is in epidemiologic studies where the full range of behaviour is the primary interest.

The third approach, using a combination of categorical and dimensional systems, can be viewed from two different perspectives. In the first, both approaches are used together within the same class of behaviour. For example, the diagnostic category of ADHD as defined by one of the recognised diagnostic systems would be retained, but with individuals also described dimensionally with respect to their position on the ADHD g factor and the inattentiveness and hyperactivity/impulsivity dimensions. This seems attractive at first glance as it allows identification of those who are subthreshold for diagnosis and gives a clear picture of an individual's standing on each dimension. On closer inspection, however, one could ask what relevance the diagnostic category has if it can be trumped by the dimensional data. It is also the case that if such an approach was adopted into clinical practice, there would be many difficult choices to make for those cases that were at the borders either dimensionally and/or categorically. Whilst clinicians may see this as a problem as it exacerbates ethical dilemmas around treatment decisions, others may regard it a strength as it highlights both the uncertainty and the fact that the current solutions are rather arbitrary and provide a spurious sense of certainty. A second way of integrating categories and dimensions is to allow different classes of problem to be described differently. For example, for those disorders such as autism spectrum or endogenous depression, risk factors such as schizotypy and anxiety sensitivity and behavioural patterns such as antisocial behaviour where categorical entities have been demonstrated (see Section 4) a categorical approach could be retained. Whereas for those such as ADHD, PTSD, nonendogenous depression, psychopathy and attachment status, where a dimensional approach

seems more appropriate, the category would be dismissed and the condition described only in dimensional terms.

Whilst the dimensional approach to classification certainly seems to be 'correct' in certain situations and can avoid the waste of information that is inherent to the categorical approach, many clinicians express concern as to how they should best apply a dimensional approach within a clinical situation and, more specifically, when and how to use the dimensional data to enhance clinical decision making. It is, however, important to recognise that dichotomous decision making is not an inevitable consequence of adopting a categorical approach. For example, evidence-based medicine (EBM) approaches to assessment and diagnosis emphasise the use of clinical data to estimate the probability of the presence of a categorical diagnosis (Mash & Hunsley, 2005). Using this approach, where the basic clinical data suggest that the probability of a particular categorical disorder is low, the clinician will often decide that no further assessment is required and discharge the patient. If the probability is somewhat higher more detailed and expensive assessments may be required. Where it is still higher but still not in the range of strong probability, the clinician may give a provisional diagnosis and recommend less risky or expensive treatment approaches with minimal potential for adverse effects (e.g. parent training, CBT and/or educational accommodations in ADHD). If we are, at least in certain circumstances, to move towards a more dimensional approach within clinical practice it would seem that the initial use of a combined categorical and dimensional approach would allow for a smoother transition to a more dimensional approach, allowing clinicians to be familiarised to dimensional approaches while not deleting a categorical approach with which they are much more used to.

Section 2: The category/dimension debate: important distinctions between practical necessity, meta-theoretical convictions and empirical reality

As described above, both the categorical and dimensional approaches have strengths and weaknesses as well as advocates and detractors, with each group making apparently reasonable claims. The *category/dimension* debate can be confused and confusing. This is because it operates at a number of different levels of analysis, with the notions of category and dimension being employed in subtly different ways at different levels, with different implications for clinicians and scientists. Here, we draw a number of important distinctions between different levels of analysis and different usages.

First, as we have noted above, there is the practical level – it is self-evident that there are good practical reasons why clinicians must, to some degree, be categorisers. Effective management is premised on the ability to distinguish those that are in need of treatment from those that are not, and then to decide which treatment is most appropriate. In this sense, there is a boundary (irrespective of how arbitrary it is) between those who do and don't require particular treatments. 'I distinguish X from Y because X needs treatment A and Y doesn't'. Such decisions require clinicians and commissioners of health services to be categorisers in this practical sense, irrespective of their political, philosophical or theoretical bent and irrespective of the underlying structure of the disorder in question.

Second, this practical need to categorise must be distinguished from a second level whereby the distinctions drawn between those in need of treatment are considered to reflect (or not) a discrete causal entity. Whilst one group of clinicians may believe that 'my distinction between X and Y on practical grounds also reflects a more deep seated belief that X's disorder places him in a group of the population that is qualitatively distinct from the norm', others may make the same decisions without holding such a view. Where such a conviction is present it often reflects a more deep seated distinction between different clinical/philosophical 'world views' – grounded in what has come to be regarded as the bio-medical model of mental disorder (as opposed to the psychosocial model). Both Sonuga-Barke (1998) and Beauchaine (2003) highlighted the overlap between the biomedical and the psychosocial 'world views' and the opposing stances of 'essentialist' and 'nominalist' views of human behaviour (Flanagan & Blashfield, 2002). Essentialists argue that mental disorders reflect objective underlying causal realities that are independent of human values, whilst nominalists argue that psychiatric disorders reflect deviations from socially constructed prescriptions for behaviour, and that there are no objective means of demarcating normality from abnormality. The nominalists are, therefore, likely to interpret all behaviours, including those characterised by others as symptoms of a mental health problem, as falling along a continuum of social acceptability (they are likely to be dimensionisers), consider diagnostic cut-offs as arbitrary and are extremely wary of diagnosis altogether. However, it is important to recognise that the practical necessity of categorising and a philosophical conviction about what that practical category reflects, in terms of underlying reality, are independent and essentially orthogonal. This means that there is no inherent contradiction between holding a dimensional view of disorder and in making clinical decisions about clinical need. 'I am happy to make a practical distinction between X and Y but I do not believe that X is part of a discrete and qualitatively distinct group'.

Third, the relationship between the use of categorical approaches to diagnosis and classification such as those used in DSM and ICD and cate-

gorisation, both as a practical necessity and a philosophical conviction, need to be understood and clarified. As we have stated above, in one sense classification systems build on the practical clinical need to categorise. They were introduced as an attempt to provide clear and consistent way of making those clinical distinctions and so to increase the validity, reliability and consistency of diagnosis in everyday clinical practice, by providing clinicians with simple, explicit symptom and impairment-based rules, independently of the particular theory preferences of clinicians – they are practical aides. However, alongside their support of the practical value of diagnostic categories, there was also, at least in the beginning, a strong implicit adherence to the assumption that mental disorders are conceptually equivalent to medical diseases – a conviction held by Spitzer, who was the driving force behind the development of modern diagnostic approaches. In this sense, the DSM and ICD systems have promoted the view that the diagnostic categories are manifestations of underling discrete causal entities.

Fourth, and crucially for the purposes of the current review, we need to distinguish these practical (I need to distinguish X from Y so X get the right treatment) and meta-theoretical levels (the conviction that X differs in both degree and kind from Y) from the empirical question – 'Is X a member of a discrete category that is not only quantitatively but also qualitatively different from the category which Y inhabits?' When seen from the empirical point of view, this statement, which may represent a philosophical conviction on the part of the clinician or researcher, is turned in to a hypothesis that is scientifically testable. In recognition of the important work of Paul Meehl in this field this may be referred to as the 'taxonomic hypothesis' (Meehl, 1995). That the category to which X belongs is not an arbitrary division or merely a practical grouping, but actually describes a discrete causal entity that is *qualitatively* different from the normal range – *a taxon*. Sonuga-Barke (1998) argued that there was little available evidence at that time to test the 'taxonomic hypothesis' for childhood mental health problems in general and with respect to ADHD in particular. Additional evidence and alternative methodologies have become available since that time. These will be reviewed below.

Fifth, the category/dimensions debate is of as fundamental importance for clinical scientists too as it is for clinicians. Beauchaine (2003) clearly enunciated the various fundamental but elusive questions facing those who try to investigate the latent structure of mental health problems; do mental disorders reflect failures of biological systems to perform naturally selected functions (e.g. Wakenfield, 1992, 1993, 1997, 1999), or are they defined by somewhat arbitrary distinctions derived from social values (e.g. Lilienfeld & Marino, 1995, 1999)? Should a set of symptoms be considered a disorder when induced by a high risk environment, or is evidence of independent

internal mechanisms necessary (Wakefield, Pottick, & Kirk, 2002)? Can environmental risk and internal mechanisms even be considered as separate causal agents (e.g. Bremner & Vermetten, 2001)? Could all of the 365 categories in DSM-IV possibly be distinct (e.g. Houts, 2002; Kendell, 1989)? Does the *DSM-IV* framework pathologise normal behaviour (e.g. Richters & Cicchetti, 1993)? Again, the issues relating to category/dimension operate here at a number of levels to influence and constrain the scientific study of psychopathology. First, as we have seen with clinicians, it can be argued that there may be some practical benefits from categorising participants into those with a disorder and those without it. Assuming the presence of clear and clean boundaries between categories, may reduce the recruitment burden for studies. However, several researchers have shown that in some cases when categorical latent structure is identified, dimensional measurement approaches can still have superior psychometric properties and predictive validity (Peralta & Cuesta, 2003). A dimensional view would of course require sampling across a broader range of symptom expression. There will be a balance between the increased power associated with a wider range of scores and the requirement to recruit an adequate sample size to ensure sufficient power to adequately test hypotheses. For disorders where taxometric analyses have failed to identify taxa and a dimensional structure is assumed, adopting a categorical approach will seriously undermine the statistical power of a study. Second, science, like clinical practice, is performed by human beings and human beings have convictions and values about what they are studying which the philosophers of science suggest influence the science carried out (see Sonuga-Barke, 1998 for a discussion). There are epistemic values (i.e. values about what is a good explanation in science) and nonepistemic values in science (more general values about the phenomenon to be studied which are often derived from a broader world view). These second set of values can be seen in the sorts of assumptions that are made about the matter under investigation. The philosophers of science also tell us that such assumptions are inevitable (even in the 'hard sciences'). They are often seen as 'natural' and so often go unnoticed remaining implicit. In as much as they are inevitable, they are necessary for the practice and progress of science. This is because they provide a set of shared meanings and a common set of references that allow communication between scientists. Finally, in as much as they are necessary they are also constraining – they determine the questions that can be asked, the way they are addressed and therefore the sorts of answers that are found. In the field of mental disorders, if one assumes that mental disorders are discrete entities which have a specific set of causes (the assumption behind much categorical thinking), this promotes a particular model of cause that focuses on discrete core dysfunctions rather than continuous risk. The

assumptions inherent in categorical models of classification can have very real implications for scientific study (Sonuga-Barke, 2011).

Whilst some developmental psychopathologists have entered these philosophical debates about the value of categorisation and diagnosis, most have focused more on the methodological issues and practical constraints imposed by categorical systems. Mirowsky & Ross (1989) propose that the categorical approach (a)confounds interpretation with measurement by presenting attributes as entities (b) wastes information about meaningful differences both within classes and between classes by grouping together people who differ on potentially significant characteristics (c) and collapses causal structures and so wastes valuable information about the aetiological origins of disorder. Poland, Von Eckardt, & Spaulding (1994) suggest that the use of categorical systems promote neither acceptable nor productive research. They argue that by conducting research that is founded on 'protoscientifically conceived, polythetic and massively heterogeneous groups' such as those derived from the DSM manuals and then using these groups as independent variables within experimental research, we will confound the effects of symptoms and limit the likelihood that effects will be properly explored. However, as Sonuga-Barke (1998) points out, these claims are probably motivated as much by a rejection of the whole political and ideological basis of categorisation and labelling as they are by pure scientific reasoning.

Sixth, we need to understand how categories operate at the intercept between the clinic and the laboratory. Clearly, clinical science needs to be grounded in clinical concepts if it is to address relevant themes and issues and to be able to communicate its findings in a meaningful way to clinicians, and facilitate translation from the laboratory into the clinic (Poland et al., 1994). In this sense, there is a connection between the practical necessity of categorisation in clinical practice, the codification and reification of those categories in diagnostic manuals and the categorical assumption that underpins much of scientific investigation in the field. So long as categorical models persist in clinical practice, scientists have to (at least in part) base their work on clinical categories. For scientists to unilaterally reject categorical models and replace them with dimensional ones (even of those proved to be in fact more accurate), would break a crucial bridge of communication between the clinic and the lab that diagnostic categories provide and render the meaning of findings from science hard to implement in clinical practice. On the other hand, it is not yet clear whether a failure to find taxa for some or all mental disorders and an acceptance that some or all mental disorders are dimensions and not categories should result in a change in the way that these disorders are diagnosed in everyday practice, and/or the way that they are represented in the diagnostic manuals. On

the face of it, the answer seems obviously yes. However, the huge practical implications that such changes would have on clinical practice make this much less clear. We discuss this question further in Section 4.

Section 3: Statistical approaches to testing between categorical and dimensional models of disorder in childhood populations

Since the publication of DSM-IV and ICD-10 there have been several important developments in data analysis that have started to impact on our ability to describe more accurately the underlying structure of mental health problems. Some of these start with the assumption that disorder is dimensional and/or categorical, and are designed to identify the number and form of independent and dissociable dimensions or classes of mental disorders as they are expressed in a population of individuals (factor analysis, latent class analysis, etc.). Other techniques, more useful to our current purposes, make no prior assumptions and are specifically designed to identify patterns of discontinuity in underlying structure of observed data, and so can provide a test between categorical and dimensional models of data.

Starting with the assumption that a disorder is either dimensional or categorical and using categorical techniques to testing how many dimensions/classes there are

Factor analysis comprises a series of approaches that start by assuming that there is an underlying dimensional structure and aim to identify the latent (underlying) factor structure of an entity. When used in an exploratory way they are more suited to generating hypotheses, while confirmatory factor analysis (CFA) is designed to test a predefined model of underlying latent structure against data. CFA can therefore be used to: (a) establish the validity of a single model, (b) compare the ability of two different models to account for the same set of data, (c) test the significance of a specific factor loading or the relationship between two or more factor loadings, (d) test whether a set of factors are correlated or uncorrelated or (e) assess the convergent and discriminant validity of a set of measures. CFA has been used to address specific questions about the distinctions that can be drawn between subdimensions within broader categories. Studies have sought to investigate the relationship between anxiety and depression in children (e.g. Cole, Peeke, Martin, Truglio, & Seroczynski, 1998; Cole, Truglio, & Peeke, 1997; Murphy, Marelich, & Hoffman, 2000). In the autism field, Frazier, Youngstrom, Kubu, Sinclair, and Rezai (2008) investigated the factor structure of the Autism Diagnostic Interview-Revised (ADI-R) using EFA and CFA methods. Whilst the EFA indicated strong support for two-factor structure, with social communication and

stereotyped behaviour factors, the CFAs gave roughly equal support for this two-factor model and a three-factor model separating peer relationships and play from other social and communicative behaviours. Both the two and three-factor models showed good stability across age with only slight changes in factor relationships. In the ADHD field, CFA has supported bi-factor models (with dissociable factors for inattention and impulsiveness/hyperactivity; Amador-Campos, Forns-Santacana, Martorell-Balanzo, Guardia-Olmos, & Pero-Cebollero, 2005; Burns, Boe, Walsh, Sommers-Flanagan, & Teegarden, 2001; Wolraich et al., 2003). However, more recent work by Martel et al. (2010) and others (Dumenci, Erol, Achenbach, & Simsek, 2004; Toplak et al., 2009) used the CFA to support a nonhierarchical model that includes a 'g' factor as well as two specific factors of inattention and hyperactivity–impulsivity against other simple one, two or three-factor models or hierarchical bi-factor models (Martel et al., 2010). Whilst this finding could be seen as partially supporting the current DSM-IV model, it is important to remember that these statistical techniques cannot distinguish whether the different factors represent dimensions or categories.

In contrast to CFA, latent class analyses (LCA) assumes the presence of discrete classes or groupings rather than dimensions. LCA is a form of categorical data analysis which hypothesises that it is possible to account for the observed symptom profiles in terms of a small number of mutually exclusive respondent classes (M), each class with its own set of symptom probabilities. One benefit of this approach over say cluster analysis, is that it simultaneously defines the structure and estimates the probabilities of membership. The parameter estimates obtained from an LCA are (a) class membership probabilities and (b) symptom endorsement probabilities for each class. Using ADHD as an example one might anticipate, based on its DSM conceptualisation, that within a population-based sample at least four latent classes would be identified for this disorder, (a) an unaffected class with low probability of endorsement of all symptoms (b) a predominantly inattentive class with high probability of endorsement of attention problem items and low probability of hyperactive/impulsive items (c) a predominantly hyperactive/impulsive class with the opposite profile and (d) a combined class with a high probability of endorsement of all items. In one of the first studies to use LCA to investigate the structure of childhood mental disorders, Szatmari, Volkmar, and Walter (1995) compared the sensitivity and specificity of three competing diagnostic systems for autism: DSMIII, DSM-III-R, and ICD-10. They reported that, when the results of the LCA were used as a referent, the ICD-10 criteria for autism had better sensitivity and specificity than either of the DSM criteria. Wadsworth, Hudziak, Heath, and Achenbach (2001) conducted an LCA of the CBCL anxiety

and depression items. These analyses revealed three levels of problem presentation across two independent samples. Children in a nonreferred sample were classified as having no problems, mild problems, or moderate anxiety/depression problems, whilst children and adolescents in a referred sample were classified as having mild, moderate, or severe levels of problems. No pure anxiety or depression classes were found – only classes containing a mixture of both anxiety and depressive problems. These results suggest that the comorbid conditions of anxiety and depression may be best thought of as part of the same continuum of problems. Todd and colleagues conducted a series of LCA analyses on several ADHD samples (Hudziak et al., 1998; Neuman et al., 1999). They consistently identified three ADHD subtypes, primarily inattentive and hyperactive/impulsive types and a combined inattentive and hyperactive/impulsive type, even though the samples differed significantly from one another with respect to diagnostic criteria, sex, age, and method of ascertainment and data collection. Whilst these observed latent classes were somewhat similar to the three subtypes of ADHD defined in DSM-IV, they also included individuals who did not meet DSM-IV ADHD criteria. Conversely, the ADHD latent classes did not contain all of the cases that met DSM-IV criteria. In a later study, designed to take comorbidities into account, the same group used LCA to subdivide a population sample of adolescent female twins into mutually exclusive classes based upon their pattern of responses to a series of questions relating to symptoms of ADHD, ODD, separation anxiety, and depression (Neuman et al., 2001). Whilst the LCA again revealed three ADHD categories of clinical interest, these were different from the previous analyses: an inattentive subtype without comorbidity, a second inattentive subtype with increased number of ODD symptoms, and a combined inattentive/hyperactive-impulsive type with elevated levels of ODD, separation anxiety, and depressive symptoms. The LCA also distinguished an ODD class and a separation anxiety class, each without increased levels of other comorbid symptoms, a second ODD class co-occurring with increased separation anxiety and depression symptoms, and a pure depression class. This pattern of latent classes, along with associated genetic data, suggested that in the general female adolescent population there are three highly heritable ADHD subtypes, two of which are comorbid with other disorders. These classes were consistent with a genetic hypothesis for ADHD, with each class potentially reflecting a unique genetic subtype.

Testing between dimensional and categorical models

Whilst they begin to illuminate the latent structure of psychopathology neither CFA nor LCA can answer

the question; *is the underlying structure of a disorder dimensional or categorical?* Developing empirical approaches to addressing this question has been a challenge. This is partly because, even where discrete groups exist within a population, they are likely to overlap at the symptom level with each other because of measurement error and within group variability. As a consequence two groups with discrete and quite distinct underlying distributions can often appear to be unimodal at the level of symptom expression. The converse can also be seen where, as a consequence of unusual measurement properties associated with particular instruments, a bimodal score distribution is observed when the latent structure is dimensional (Waller & Meehl, 1998; and see Beauchaine, 2003 for a comprehensive discussion of these issues). It was in an attempt to address these problems that Paul Meehl developed the taxometric approach over 30 years ago (summarised in Meehl, 1995). Meehl recognised that whatever general concerns existed concerning the use of a categorical approach to classifying and conceptualising mental disorders, the answer to the question about whether a particular disorder represents a discreet causal entity (a real category) or simply one end of a continuum (a part of a dimension) is an empirical one that can be addressed mathematically.

At the core of Meehl's approach to this problem was the profound insight that one could distinguish between categories and dimensions by examining discontinuities in the underlying latent structure of multiple correlated manifest disorder-related variables across continua of symptom severity (Meehl, 1995). To take a general case, if one measured symptoms of a disorder, genetic risk (in some way) and levels of disorder-related cognitive impairment in a full population and plotted the pattern of associations between these three manifest variables as a function of the severity of the disorder symptoms, (perhaps by calculating correlations for separate multiple windows across the symptom severity distribution), then it would follow from Meehl's logic that where a taxon is present, there should be an abrupt change in the strength of these associations as one moves to towards the extreme. Such a pattern of results would be consistent with the notion of a categorical model of this hypothetical disorder. Where no such abrupt change occurs a dimensional model would be favoured.

Meehl was particularly interested in applying this logic to identifying the underlying genetic diathesis for schizophrenia, which he labelled schizotaxia, and the core set of observable phenotypic markers for this diathesis that he labelled schizotypy. In his quest to achieve this, he developed a series of mathematical algorithms that are able to distinguish between discrete types and continua. Together he referred to these techniques as coherent cut kinetics (CCKs). Commonly used CCK algorithms include the MAXSLOPE, MAXCOV, MAMBAC MAXEIG and

L-Mode procedures. Given space limitation it is not possible to describe these techniques in any detail here but detailed descriptions are available elsewhere (Beauchaine, 2003; Meehl, 1995). Meehl was able to identify four putative markers for the schizotaxic genotype, each representing a discrete entity with the broader population: *anhedonia, interpersonal aversiveness, ambivalence and cognitive slippage to which smooth pursuit and saccadic eye tracking abnormalities* have been subsequently added. Although a single gene locus for schizophrenia has never been identified, repeated taxometric studies have shown that these schizotypic traits do indeed mark a manifestation of a discrete taxon or latent category. In the context of the current discussion, there are obvious benefits of being able to identify whether a disorder represents a true taxon or not. Beauchaine (2003) described these potential benefits, which, with some additions, are summarised below.

1. *Supporting/refuting the validity of current category-based models:* Finding evidence of taxonicity would strongly support the validity of the current categorical approaches to classifying and diagnosing disorders. Failure to do so would cast doubt on the extent to which such categorical models accurately capture the underlying reality of the disorder and suggest that the use of these categories may distort both clinical practice and scientific enquiry.
2. *Refining diagnostic thresholds:* Where taxonic boundaries are identified it may help to specify more precisely the diagnostic thresholds of a disorder.
3. *Identifying disorder subtypes:* Taxometric analysis can be used to identify discrete subgroups of individuals within disorders. A wide range of biomarkers and clinical factors, such as symptom patterns, longitudinal course or treatment response, could potentially be used as indicators to identify such subgroups. Such analyses may help answer questions such as; does Asperger's disorder reflect a discrete behavioural syndrome as is assumed by DSM-IV or does it simply represent a particular point on a continuous autism spectrum as suggested in the draft DSM-5 proposals?
4. *Confirming the biological/environmental basis of a condition:* Where evidence to support the taxon comes from multiple levels of analysis (i.e. genetic, environmental anatomical, physiological, neuropsychological, observational), this may help to pinpoint the underlying causal basis for a disorder.
5. *Tailoring therapeutic approaches:* Therapeutic approaches may differ based on whether a person does or does not belong to a certain taxon group.
6. *Identifying moderators of treatment outcome:* Understanding which factors are associated with

taxon membership may help identify potential responders or nonresponders. For instance, around 30% of those with ADHD do not respond to methylphenidate and similar proportions of those with anxiety disorders or conduct problems fail to response to cognitive behavioural therapy or parent training, respectively. It has, however, proved extremely difficult to identify clinically relevant moderators of treatment outcome in child and adolescent mental health.

7. *Identifying at risk groups for early intervention:* For example, around 5% of children can be identified as having constellation of observable traits and symptoms that place them in the schizotypy taxon, which itself is associated with an increased genetic liability for schizophrenia spectrum disorders (Blanchard, Gangestad, Brown, & Horan, 2000; Golden & Meehl, 1979; Korfine & Lenzenweger, 1995; Lenzenweger, 1999; Lenzenweger & Korfine, 1992; Tyrka et al., 1995). This base rate is considerably higher than that for the prevalence of schizophrenia in the general population which is estimated at 1.1% (Regier et al., 1993), implying that the trait is not fully penetrant. High levels of expressed emotion have been consistently linked with the course and prognosis of schizophrenia (Falloon et al., 1985). It is, therefore, possible that measures to reduce expressed emotion, if targeted towards those with the high risk taxon, could reduce or postpone the risk of these individuals developing schizophrenia. It is possible that similar taxons can be identified for other disorders. This may allow the opportunity for primary prevention by targeting these individuals with early interventions.

8. *Locating bifurcation points in the development of discrete traits:* Where taxometric traits have been identified in adults, developmental taxometric studies could help answer questions about at what point during development do these discrete groups arise. For example, Harris, Rice, & Quinsey (1994) identified a taxon for psychopathy. Does this discrete group first appear during adulthood or adolescence, or is it present in the younger child, or even from birth? Identification of such developmental bifurcation points may go on to help to identify the optimal timing of various interventions.

9. *Elucidating mechanisms of equifinality and multifinality:* Similar to the identification of treatment moderators, taxometric studies have the potential to identify those factors that result in some individuals with apparently similar starting points following very different paths and reaching very different endpoints from each other (multifinality). Alternatively, they could also identify the common thread that results in individuals who start from seemingly different starting points but converge on a single outcome (equifinality).

Whilst the discussion here will concentrate on the taxometric approaches described above there are other, recently developed, latent variable modelling methods, such as factor mixture or latent class factor analysis models that are able to address the same questions. The empirically recommended approach is now to examine both factor and latent class models and then compare the fit of these models to plausible factor mixture models to determine whether data is best represented by a combination of categories and dimensions or whether only one or the other is needed (Muthen, Asparouhov, & Rebollo, 2006).

Section 4: What is the evidence for taxa in the child and adolescent disorders?

Coherent cut kinetic methods have only recently been applied to child and adolescent disorders and while the field remains in its infancy, with many of the above options remaining unstudied, there is sufficient evidence to start to draw some provisional conclusions about the taxonic status of different diagnoses. Due to the very technical nature of this work we have resisted the temptation to describe the detail of the analyses used in each study. Interested readers should consult the original papers which describe the precise methods in detail.

Schizophrenia

In the first application of taxometrics to the field of developmental psychopathology, Erlenmeyer-Kimling, Golden, and Cornblatt (1989) used various measures of cognitive and neuromotor performance in a sample comprised of children of schizophrenic, depressed or healthy parents. They were able to identify a taxon that chiefly comprised children of schizophrenic patients rather than those from the other two groups. The authors note that whilst the taxon rate for those with healthy parents (4%) was similar to the rate of schizotypy in the normal population, the proportion of subjects with schizophrenic parents (the high risk group) was higher than expected at 47%. Whilst this may indicate the presence of a dominant, single major locus genetic model for the taxon, the authors are rightly cautious about drawing any strong conclusions on causality on the basis of a single study. Interestingly, the taxon group also identified those individuals in the high risk group with the worst psychiatric outcomes by early adulthood, as measured by inpatient admission rates, although this association did not extend to history of outpatient treatment. Unfortunately, this work has not been followed up with further studies.

Insecure attachment classification

In another early study, Fraley and Spieker (2003) investigated whether individual differences in

attachment status, as measured by the strange situation test, are more consistent with a continuous or a categorical model. Using data on 1,139 fifteen month old children from the NICHD Study of Early Child Care, they were unable to identify the presence of any taxa and therefore concluded that variation is largely continuous rather than categorical. This is, of course, interesting as the longstanding and widely held view within the field, and based on traditional statistical methods of identifying groups, was that children's attachments could be organised into secure, avoidant and resistant groupings. On the basis of their CCK analyses, the authors proposed a two dimension model of attachment based on the observations of the Strange Situation; a *Proximity-Seeking Versus Avoidant Strategies* characterised by variability in the degree by which children's attachment systems are organised by the goal of proximity maintenance, and an *Angry and Resistant Strategies dimension that* refers to the variability in the amount of overt conflict and anger towards the caregiver when the attachment status is stressed during the strange situation. They hypothesised that variation in this factor may reflect a history of inconsistent caregiving and the insecurity that arises from such experiences.

Anxiety sensitivity

Bernstein, Zvolensky, Weems, Stickle, and Leen-Feldner (2005) and Bernstein, Zvolensky, Stewart, and Comeau (2007) conducted two taxometric studies of anxiety sensitivity. Anxiety sensitivity reflects relatively stable individual differences in the fear of anxiety and anxiety-related sensations (Mcnally, 2002). It is proposed that when individuals with high levels of anxiety sensitivity become anxious, they will have additional worries that an event will have negative consequences which will further increase the anxiety, and that may be a key factor in the development of panic attacks. Whilst some previous studies have suggested that the basic structure of anxiety sensitivity may be hierarchical with a higher order factor and a number of lower order factors (Zinbarg, Mohlman, & Hong, 1999), others have suggested that it is a dimensional construct that varies along a latent dimension. Whilst the first taxometric study of anxiety sensitivity in adults failed to find a taxonic structure (Taylor, Rabian, & Fedoroff, 1999), this study has been criticised as having several significant limitations. Two further studies in adults (Bernstein et al., 2006; Schmidt, Kotov, Lerew, Joiner, & Ialongo, 2005) suggested a taxonic structure. In the first of their investigations into the structure of anxiety sensitivity in youth, Bernstein et al. (2005) used two sets of indicators from the Childhood Anxiety Sensitivity Questionnaire (CASI); three composite indicators indexing disease concerns, unsteady concerns and mental health concerns and nine single item indicators representing each of these three facets of anxiety sensitivity. The

taxometric analyses indicated that the latent structure of anxiety sensitivity in this group of young people (*n* = 371) was taxonic, with a base rate of between 13.6% and 16.5% for the anxiety sensitivity taxon. These rates are similar to those found in adult populations (Bernstein et al., 2006; Schmidt et al., 2005). The second study, Bernstein et al. (2007) conducted using similar data from the CASI and a larger sample (*n* = 4,462) of North American youth, also supported a taxonic latent class structure, although with a slightly lower base rate of 9%. Subsequent confirmatory factor analysis supported a continuous multidimensional four-factor model of anxiety sensitivity among the nontaxonic 'normative form' of anxiety sensitivity, but not the taxonic 'high risk' form. Interestingly, and in contradiction to previous studies, the social concerns indicator did not contribute to the distinction between the taxonic latent classes, suggesting that these social concerns are similarly distributed between youth in both the normative and high risk groups. The authors speculate that this may indicate that the anxiety sensitivity taxon may confer vulnerability for some disorders such as panic and PTSD but not for social anxiety. On the other hand, the mental concerns factor was highly discriminating, leading the authors to suggest that future studies could focus on the potentially important role of fears of cognitive dyscontrol in the anxiety sensitivity taxon.

Depression

Studies in adults with depression have suggested that depression per se is best conceptualised as a dimensional, not categorical, construct (Prisciandaro & Roberts, 2005; Ruscio & Ruscio, 2000, 2002). Early taxometric studies of so called melancholia, or endogenous depression (depression with prominent physical or biological symptoms) have, however, supported melancholia being a discrete subtype with a taxonic structure (Grove et al., 1987; Haslam & Beck, 1994), although these studies have been criticised on methodological grounds (Ruscio & Ruscio, 2000). Several studies have investigated adolescent depression from a taxometric perspective. Hankin, Fraley, Lahey, and Waldman (2005) collected data using structured diagnostic interviews from a population-based sample of 845 children and young people aged 9–17 years. Using taxometric procedures and analyses that explicitly took into account the skewness of depressive symptoms, they found consistent evidence that adolescent depression is a dimensional not categorical construct. This dimensional structure held for all of the DSM-IV major depressive symptoms as well as for different domains of depression (emotional distress symptoms and vegetative, involuntary defeat symptoms) and also for both parent and youth reports, as well as for several subsamples (boys vs. girls, younger vs. older). They suggest that future depression research should be

based around dimensional rather categorical models of depression, and that a failure to do so will result in the loss of important information. Richey et al. (2009) utilised taxometric procedures to analyse self-report data derived from the Child Depression Inventory (CDI) from three independent samples using multiple nonredundant taxometric methods, and found consistent evidence to support taxonicity in childhood depression. They argued that the differences between their findings and those of Hankin et al. (2005) may be accounted for by methodological weakness within the Hankin study. From their results Richey et al. (2009) constructed a 9 item CDI taxon scale that despite containing fewer items than the original scale, had as good validity and predictive utility as the full scale and accurately identified taxon members. This represents a significant development as it will allow future researchers to taxon members without the logistic and computational burden of conducting taxometrics. Ambrosini, Bennett, Cleland, and Haslam (2002) utilised a taxometric approach to investigate adolescent melancholia using data from the KIDDIE-SADS interview and the Beck Depression Inventory in a sample of 378 referred adolescents. As with the adult samples they found consistent support for a taxon. The suggestion here is that these data imply that 'melancholic/ endogenous' depression may be a discrete category within those occupying the extreme end of the depression dimension. Schmidt et al. (2007) investigated whether mixed anxiety depression (MAD), which is a provisional diagnosis in DSM-IV and is proposed as a free-standing diagnosis in DSM-5, is a discrete category. To qualify for a diagnosis of MAD, the patient must have three or four of the symptoms of major depression (which must include depressed mood and/or anhedonia), accompanied by anxious distress (two or more of the following symptoms: irrational worry, preoccupation with unpleasant worries, having trouble relaxing, motor tension, fear that something awful may happen). They used taxometric procedures and mixture modelling to discern whether indicators derived from the Child Behaviour Checklist and the KIDDIE-SADS constitute a discrete taxon in a school-based population of 706 adolescents. Both the taxometric and modelling approaches identified a taxon with a prevalence of between 11% and 15%. Taxon membership was predictive of the development of mood and anxiety disorders over a 14 month prospective follow-up.

Posttraumatic stress disorder (PTSD)

Taxometric studies in predominantly adult samples have supported a dimensional model of PTSD (Broman-Fulks et al., 2006; Ruscio, Ruscio, & Keane, 2002). The only published study in adolescents investigated a national epidemiologic sample of 2,885 adolescents (Broman-Fulks et al., 2009) and the results were consistent with these adult studies

in supporting a dimensional model of posttraumatic stress reactions.

Aggression and psychopathy

Adult studies have suggested that the constructs of psychopathy (Edens, Marcus, Lilienfeld, & Poythress, 2006; Guay, Ruscio, Knight, & Hare, 2007; Marcus, John, & Edens, 2004; Walters, Duncan, & Mitchell-Perez, 2007b; Walters et al., 2007c) and antisocial personality disorder (Marcus, Lilienfeld, Edens, & Poythress, 2006; Walters, Diamond, Magaletta, Geyer, & Duncan, 2007a) are dimensional in nature. Several groups have investigated the taxometric structure of various aspects of aggression, antisocial behaviour and psychopathy in adolescence. Skilling, Quinsey, and Craig (2001) and Skilling, Harris, Rice, and Quinsey (2002) found consistent evidence for a taxon indexing antisocial behaviour across several samples using various different measures. Vasey, Kotov, Frick, and Loney (2005) specifically investigated the taxometric structure of psychopathy in youth, using data from the antisocial process screening device and a sample of referred, nonreferred adolescents enriched with a sample of adolescents from a juvenile justice diversion programme. Similar to the findings of Skilling et al., they identified an antisocial behaviour taxon but also found evidence for an overlapping, less common but more severe psychopathy taxon. Murrie et al. (2007) were unable to replicate these findings using similar procedures, but a broader set of indicators of psychopathy, among delinquent boys. Their investigations failed to identify a discrete taxon and supported a dimensional structure for psychopathy. A strength of the Murrie study was their use of a fairly homogenous sample of youth which reduced the risk of identifying pseudo-taxons. Walters, Ronen, and Rosenbaum (2010) investigated the broader concept of general, as opposed to pathological, aggression in a large sample of Israeli school children. Taxometric analysis of self and teacher-reported data gave consistent support for a dimensional latent structure with no evidence of a discrete taxon. These are consistent with findings in adults (e.g. Edens et al., 2006; Guay et al., 2007).

Attention deficit/hyperactivity disorder

There have been three taxometric investigations into the latent structure of ADHD. The first and largest of these analysed data on almost 3,000 children and adolescents drawn from an Australian epidemiological study (Haslam et al., 2006) and found no evidence for a discrete taxon. Marcus and Barry (2011) conducted similar analyses on data from another large community sample. Their data support a dimensional rather than categorical latent structure for ADHD as well as for the separate inattention and hyperactivity/impulsivity domains. They went on to investigate the strength of association between both

dimensional and dichotomous models of ADHD and various associated features (e.g. academic performance, externalising and internalising symptoms and social problems), and found that the dimensional model demonstrated stronger validity coefficients than the dichotomous models. Frazier, Youngstrom, and Naugle (2007) again found support for a dimensional model of ADHD after conducting a taxometric analysis of subjective report and neuropsychological data from a referred population. Unlike other types of research where the use of a clinical sample is associated with the possibility of Berkson's Bias, the inclusion of a sample with a relatively high base rate can be helpful in taxometric studies. Taken together, these analyses suggested that ADHD is best modelled as a continuum in both children and adolescents, thus supporting the genetic and other evidence that suggests a dimensional structure and multifactorial aetiology (Coghill et al., 2005).

Autism spectrum disorder

Several questions about autism and the proposed autism spectrum would appear to be obvious candidates for taxometric analysis. Frazier et al. (2010) investigated the taxonic structure of autism spectrum disorders (ASD) using data from an autism registry that recruits families with at least one child with an ASD. They included 6,621 families in total and data from 6,901 affected and 4,606 unaffected children using the Social Responsiveness Scale and the Social Communication Questionnaire. Taxometric and latent variable analyses strongly supported the presence of a taxon that is very closely aligned with existing DSM diagnostic criteria when all of the spectrum disorders (DSM-IV-TR autistic disorder, PDD NOS, and Asperger's disorder) are combined. This taxon is similar to the criteria for ASD proposed for DSM 5. Studies aimed at identifying the package of nonredundant measures that are associated with the highest pretest probabilities of ASD diagnosis are planned. Ingram, Takahashi, and Miles (2008) found evidence for a categorical structure for a social interaction/communication taxon that appeared to be related to an ASD/no-ASD distinction, a second taxon related to intelligence and a third essential/complex phenotype that identified individuals with genetic syndromes many of which have large head circumference and/or dysmorphology. No taxa were identified for adaptive functioning, insistence on sameness, repetitive sensory motor actions or language acquisition.

Section 5: Implications of taxometric evidence for clinical practice and science

While far from giving a complete picture of the taxometrics of child and adolescent mental disorder, these studies described above provide initial evidence about the underlying structure across a number of conditions. More specifically, they help us to start to answer the question of whether the diagnostic categories in current approaches reflect discrete classes within the wider population marked by nonarbitrary boundaries or whether they represent an extreme expression of normal variation with essentially arbitrary pragmatically defined thresholds. In this final section, we reflect on the implications of the results so far from taxometric analyses for current category-based models of classification and their relation to clinical practice and scientific enquiry. There are of course many caveats. Many disorders remain unstudied, many studies have been conducted on relatively small samples, almost all have only used symptom data and have not made use of data from other levels of analysis (e.g. physiological, neuroimaging, neuropsychological). It is also the case that the latent structure may differ by rater (parent-report vs. clinician report) and that this difference may arise as a consequence of rater biases rather than actual differences in the structure of the disorder. Studies have also not yet used measures, like the SWAN described above, that are able to capture the full range of behaviour or experience.

The most striking and perhaps important finding of the review of taxometric studies is that different disorders appear to 'behave' very differently when it comes to their categorical or dimensional underpinnings. Maybe the most important general contribution of these taxometric analyses is to emphasise the point that there is no single or simple resolution to the category versus dimension debate in relation to mental disorder per se. Taken together, they demonstrate that within the field of developmental psychopathology, there are likely to be situations where a categorical solution is appropriate and others where a dimensional approach is both more correct and more useful. Interestingly, for several of those conditions where discrete taxa have been identified, these taxa seem likely to represent high risk groups rather than the disorder per se, and in the case of depression the taxon is for a subgroup, melancholic/endogenous depression, rather than the broader category of major depressive disorder. In other cases, such as ADHD, the evidence seems to point strongly to a dimensional rather than categorical structure whereby those currently identified as *having* ADHD represent the extreme end of a continuum. Here, we distinguish the implications for those disorders where there is evidence for taxonicity and those where a dimensional model seems more appropriate.

Implications where evidence to date supports categories rather than dimensions

According to our survey of the extant literature, there are a number of disorder-domains where, despite the methodological limitations listed above, evidence for taxa are emerging. These include schizotypy, anxiety sensitivity, melancholic/endogenous depression,

mixed anxiety depression disorder, antisocial behaviour and ASD. For those disorders that map onto the current classification systems there is a degree of consistency between the taxon and the DSM structure of the disorder. This is most clear for melancholic/endogenous depression and mixed anxiety depression disorder. It is interesting to note that for autism the presence of a taxon representing the ASDs suggests that the 'spectrum' exists within the disorder and not merely as an extreme representation of normality. In other cases, the taxa appears to describe a broader group of individuals than are currently captured by the diagnostic manuals (e.g. schizotypy), or a grouping that does not really match up to any of the traditional diagnostic groups (e.g. anxiety sensitivity and antisocial behaviour). Here, the taxa may be describing a group at risk of mental health problems rather than those suffering from a disorder. The identification of taxa using empirical means should only be regarded as a starting point. As noted above, the identification of taxa can result in a broad range of benefits to both scientists and clinicians. From the science perspective, identification of such discrete taxa may be of benefit to those searching to understand the causes of a disorder. The identification of a taxon, whether it is for a high risk group or the disorder itself, suggests a unit of analysis that would be more likely to represent the outcome of a common causal pathway and can be used to refine study populations into more homogeneous groupings. Taxa can also be used to investigate the mechanisms of equifinality and multifinality within and across different groups. From a developmental perspective, it will be important to identify the point in development at which discrete taxa first appear. This could have significant clinical implications, for example, where it is possible to identify a discrete bifurcation point during development it may be possible to time interventions in such a way as to prevent individuals at risk from developing a full blown disorder. It should also be noted that just because a particular latent structure (either categorical or dimensional) has been demonstrated at the symptom level it does not necessarily follow that the same structure holds at other levels of analysis (e.g. genetic, brain structure and function, neuropsychological). Thus, the presence of a clearly identified categorical latent structure for a particular disorder does not imply a homogeneous causality. For example, a significant minority of those with autism have thought to be due to large, rare, clinically meaningful copy number variants (CNV; Glessner et al., 2009). However, very few of these cases share the same CNVs and many arise as de novo mutations (Sebat et al., 2007). The implicated CNVs do, however, tend to cluster in particular regions of the genome that contain genes known to be important for brain development and on-going neuroplasticity (Glessner et al., 2009). As a consequence, whilst knowing the latent structure at the symptom level may give hints as to underlying mechanism these relationships should not be overstated or over-interpreted.

From the clinical perspective the identification of a true taxon opens the door to the search for nonarbitrary diagnostic cut-offs and potentially aids identification of stable subtypes within a disorder. Whilst there is currently not enough data to describe reliable cut-offs for any of the child and adolescent disorders, this may become possible in the not too distant future. Where a taxon identifies a risk group rather than a disorder, this information can be used to identify the unique characteristics of those individuals that distinguish them from low risk individuals, distinctions that may help develop/facilitate early intervention strategies and treatments. Treatment outcomes will need to be compared for taxonic and nontaxonic groups and this data used to tailor therapeutic interventions and identify important moderators of treatment outcome.

Implications where the balance of evidence to date supports dimensions rather than categories

Where the evidence supports a dimensional rather than a categorical structure (e.g. ADHD, psychopathy, PTSD or nonmelancholic depression, attachment status and general aggression), the approach taken in response to these findings is likely to be rather different. We will explore this in the case of ADHD as an example where all three taxometric studies fail to confirm the existence of an ADHD taxon. Confidence in the initial findings is supported by their consistency with behavioural genetic studies that demonstrate similar patterns of heritability across the full range of symptom expression (Gjone et al., 1996). There are, however, a number of caveats to these findings. First, ADHD is a pathophysiologically heterogeneous condition with different patients being affected to different degrees by different types of underlying deficits (Rhodes, Riby, Matthews, & Coghill, 2011b; Rhodes et al., 2005; Sonuga-Barke, 2002, 2005; Sonuga-Barke & Halperin, 2010). It, therefore, remains possible that there may be subgroups, marked by specific causal factors that show a taxonic structure. Second, even though the studies already conducted include many thousands of individuals they probably still do not have sufficient power to identify taxa at the extreme right of the distribution. This is important as there is data to suggest that those with the most seven ADHD who meet criteria for ICD Hyperkinetic Disorder respond differently to ADHD treatments when compared to those with DSM defined combined type ADHD but not ICD hyperkinetic disorder (Santosh et al., 2005). It is still therefore possible that a discrete more restricted taxa for ADHD exists and further studies are required.

Leaving these caveats aside, we can ask what are the implications for the failure to find a general

ADHD taxon? At first sight this seems obvious – the current category-based diagnostic system should be replaced by a dimensional approach, perhaps of the types we described in Section 1. Such a system would have the obvious advantage of actually reflecting 'reality'. But would it have value as a system for classification and diagnosis of ADHD? This must be the overriding priority. In Section 2 of this review, we highlighted distinctions between clinical pragmatics, philosophical conviction and empirical reality in relation to the category/dimension debate. There, we made the case that clinicians have to make categorical decisions for clinical pragmatic reasons and that the tendency to create categories out of continua goes with the grain of human cognition. In this sense, it could be argued that dimensional systems, which potentially better reflect reality, may be difficult to implement and to use in everyday clinical practice. Our guiding question must therefore be – would dimensional systems help (or improve) clinical decision making? The case for this has yet to be made convincingly (see Section 1). Until such a case can be made *and* until a dimensional approach that both adds clinical value and is acceptable and workable for clinicians is developed, this mismatch between the dimensional structure of the disorder and the pragmatic benefits of diagnostic categories will continue to create a tension. Whilst clinicians will continue to treat ADHD as if it is a category they, at the same time, ought to acknowledge that this is in fact not so and that ADHD represents the extreme expression of normal variation with cut-offs and diagnostic thresholds that are to some degree arbitrary. The evidence may appear to cast doubt over the clinical validity of ADHD and other apparently dimensional disorders – *If there is no ADHD taxon does it really exist as mental disorder?* In response to this question, it is important to point out that, at least from a psychometric and pragmatic point of view, the evidence continues to support the clinical validity and utility of the ADHD disorder dimension with clustering of symptoms of inattention overactivity and impulsivity (e.g. Neuman et al., 1999). It is also clear that ADHD can be reliably distinguished from other disorder dimensions and categories (Neuman et al., 2001). High levels of this symptom cluster are associated with suffering and impairment and there are treatments that can alleviate these problems (Taylor et al., 2004). The possibility of dimensional mental disorders has certain precedents in physical medicine. For example, hypertension and obesity are rarely questioned as genuine health problems but neither are taxonic in nature and for both, the cut-offs between health and disease are somewhat arbitrary. Indeed, in both cases, the cut-offs have changed over time as understanding of the risk associated with each has been refined. In both cases it is their association with future risk that identifies them as important

health indicators. A similar logic can be applied to disorders such as nonmelancholic depression and ADHD, both of which are associated with increased risk of negative health and social outcomes. The decision to persist with category-based classification systems for putative dimensional disorders (such as ADHD) does, however, raise an interesting dilemma for scientists. On the one hand, maintaining a categorical system which does not reflect the underlying structure of the disorder and forces the dichotomising of continuous measures is a clearly suboptimal approach to design and measurement (see Section 2 for a discussion of these issues). In this case, correlational designs using truly dimensional measures (Swanson et al., 2001) with appropriate sampling techniques would be the scientifically preferred and statistically more powerful option. However, a unilateral break from the use of category-based systems would breach a crucial bridge of communication between the science of psychopathology and clinical practice which provides its ultimate purpose and end. Such a breach would potentially reduce the ability of scientists to ask clinically meaningful questions and provide answers to those questions that can translate basic science findings into therapeutic innovations. Thus, the finding that ADHD appears to be dimensional rather than categorical creates a dilemma for the clinical scientist about which way it should be characterised. One possible way forward is for studies to routinely include both categorical and dimensional conceptualisations and measurements of disorder. They should also explore the distinctive features and overlap between these different models so that over time, the meaning of dimensional concepts for category-based classifications can be built up within the scientific community. This would allow researchers and clinicians to eventually translate between one approach and the other. Such an approach may throw up some interesting and unexpected findings. For instance, studies of molecular genetics of ADHD have tended to show somewhat different patterns of association when ADHD is characterised categorically than when it is analysed as a continuous quantitative trait.

Conclusions

In this review, we have explored contemporary aspects to the category/dimension debate within the fields of child and adolescent mental health and developmental psychology. The application of modern analytic techniques, especially taxometric approaches, has made it clear that there is no simple or overall resolution to this debate from an empirical point of view. Both categorical and dimensional solutions appear to have a value and this varies from disorder to disorder. Whilst some disorders, such as melancholic/endogenous depression and mixed anxiety and depression disorder, appear to be

associated with discrete taxa others, such as ADHD, PTSD, nonmelancholic depression, and psychopathy, do not. In other cases such as schizotypy, the taxa appear to identify a high risk group rather than the disorder per se. These data, whilst interesting, only represent the start of the journey and there is still investigating need to investigate these taxa and dimensions in greater detail. There now needs to be further focus on the scientific underpinnings of identified taxa, and their clinical implications with respect to course outcome and treatment effects. Where a dimensional model appears more appropriate, scientists and clinicians need to work together, rather than against each other as has often been the case in the past, to address and better understand the tensions and relationships between these dimensional disorders and the traditional categorical models.

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