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Is Emotional Lability (EL) distinct from 'Angry/Irritable Mood', 'Negative Affect' or other subdimensions of oppositional defiant disorder (ODD) in children with ADHD?

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ABSTRACT

Background: Emotional Lability (EL) and oppositional defiant disorder (ODD) frequently co-occur with attention-deficit/hyperactivity disorder (ADHD). This study evaluates whether EL merely represents the negative 'mood/affect' component of ODD, or forms a distinct dimension.

Method: EL and ODD data from 1,317 ADHD participants were analyzed using exploratory and confirmatory factor analyses for binary data.

Results: Within ADHD, 39.4% children had ODD and 42.6% had EL; 16.6% had ODD-only, 19.7% had EL-only and 22.9% expressed both. In both exploratory and confirmatory factor analyses, EL forms a separate dimension from ODD items and the 'mood/affect' subdimensions (whether classified by DSM-5 or Burke et al. models or the *de novo* ODD subdimensions derived from our data). This factorial structure remains invariant across gender.

Conclusion: EL is distinct from ODD and its 'mood/affect' subdimensions. In line with emerging evidence, our findings provide further evidence of factorial validity for EL as a separate construct from ODD.

Keywords: ADHD, emotional lability, ODD, factor analyses

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder characterized by developmentally inappropriate levels of inattention, hyperactivity and impulsivity. ADHD frequently co-occurs with severe Emotional Lability (EL) (such as frustration intolerance, mood swings, temper outbursts and emotional fragility) and Oppositional Defiant Disorder (ODD) (such as negative mood/affect, conflicts and oppositional behaviours). Amongst ADHD, the prevalence of EL is about 30% (Sobanski et al., 2010), whilst ODD is around 30-80% (Yüce, Zoroglu, Ceylan, Kandemir, & Karabekiroglu, 2013). Given that a significant correlation exists between ODD and EL symptoms amongst ADHD (Sobanski et al., 2010), their co-concurrence could arise from their construct overlaps; for example, some ODD items[1] also describe emotional dysregulation behaviours, suggestive of item similarity on face validity. However, it remains unclear whether ODD is a conglomeration of distinct subprocesses which give rise separately to

[1] ODD consists of eight items, which include 'loses temper', 'angry', 'touchy', 'argues', 'defies', 'blames others', 'deliberately annoys others' 'spiteful or vindictive'.

emotional dysregulation and behavioural dysfunctions, or whether ODD captures a unifying substrate underlying global dysregulation difficulties (Burke, Hipwell, & Loeber, 2010). There is a possibility that severe EL merely represents the negative 'mood/affect' component of ODD, if the latter could be accurately cleaved from its behavioral components.

The multidimensionality of the ODD construct has been demonstrated by recent research, showing factorial validity, concurrent validity and predictive validity of separate and distinct subdimensions (Burke et al., 2010; Stringaris & Goodman, 2009). Indeed, DSM-5 classifies ODD items under three distinct categories: *Angry/Irritable Mood*, *Argumentative/Defiant Behavior* and *Vindictiveness* (APA, 2013). Since the publication of the DSM-5, further evidence has been provided on the factorial validity of the DSM-5 grouping (Krieger et al., 2013). Furthermore, a recent study has confirmed the concurrent validity of these three distinct categories demonstrating that *Angry/Irritable Mood* was associated with Emotional Problems, *Argumentative/Defiant Behavior* with ADHD symptoms and *Vindictiveness* with Conduct Problems (Mandy, Roughan, & Skuse, 2014). However, the precise methods of cleaving ODD items into subdimensions are still subjected to debate. Subdimensions of ODD items are defined differently by two key methods. Stringaris & Goodman (2009) propose a grouping, which is the same as that adapted by the DSM-5. In this first method, 'loses temper', 'angry'

and ‘touchy’ items are grouped as *Irritable* (equal to *Angry/Irritable Mood* in DSM-5); ‘argues’, ‘defies’, ‘blames’ and ‘annoys’ items are grouped as *Headstrong* (equal to *Argumentative/Defiant Behavior* in DSM-5); while ‘spiteful’ and ‘vindictive’ items are grouped as *Hurtful* (equal to *Vindictiveness* in DSM-5). These reported subdimensions were classified based on predictive validity: the *Irritable* dimension was found to predict later emotional disorders (depression and anxiety), while *Headstrong* predicts ADHD and *Headstrong* and *Hurtful* together predict conduct disorder (Stringaris & Goodman, 2009). In contrast, in the second method proposed by Burke et al. (2010), ‘touchy’, ‘angry’ and ‘spiteful’ items are grouped as *Negative Affect*; ‘loses temper’, ‘argues’ and ‘defies’ items as *Oppositional Behavior*; while ‘annoys’ and ‘blames’ items as *Antagonistic Behavior*. These subdimensions were first extracted by exploratory factor analysis, and then validated by their prediction of differential outcomes, with *Negative Affect* predicting depression while *Oppositional* and *Antagonistic* behaviours predicting Conduct Disorder.

Some research findings however suggest that EL and ODD, despite their co-occurrence, are not identical. Furthermore, EL has been suggested to represent an additional core dimension of ADHD (Remiherr et al., 2010; Skirrow & Asherson, 2013). Amongst ADHD, ODD is present in 46% of those with low EL, 65% of those with moderate EL, and in 79% of those with high EL (Sobanski et al., 2010). In other words,

substantial proportions of the sample express only one of these two conditions, despite their significant correlation. Whether EL represents a separate dimension distinct from ODD in the context of ADHD, to our knowledge, has not been formally evaluated by factor analysis in the literature.

Another important consideration in investigating the issue of construct duplication is the emerging importance occupied by emotional dysregulation in ADHD research, where mood- and emotion-related terms such as emotional dysregulation, emotional impulsivity, affective lability and mood instability have been used interchangeably (Sobanski et al., 2010). Barkley & Fischer (2010) highlighted that emotionally impulsive symptoms are the most impairing aspects of ADHD that persisted into adulthood, contributing to impairments in family and peer relationships as well as financial and driving ability, and consequently proposed emotional dyscontrol as the third dimension of ADHD phenotype. Seymour et al. (2014) demonstrated emotion regulation and its impairment mediate the relationship between baseline ADHD and subsequent depression in a community sample of children aged between 9-12 years old. Childhood ADHD increased the risk of recurring depression 12-fold (Chronis-Tuscano et al., 2010), while youths with comorbid ADHD and mood disorders are three times more likely to complete suicide (James, Lai, & Dahl, 2004). These recent findings

underscore the clinical importance and relevance of emotional dysregulation in ADHD research.

Moreover, on the etiological level, familial and additive genetic substrates accounting for a phenotypic association between ADHD and emotional dyscontrol have also been identified. Surman et al. (2011) identified familiality in ‘emotional dysregulation-ADHD’ phenotype as a ‘breeding true’ familial subtype. Furthermore, Merwood et al. (2014) using a twin study design, decomposed the genetic architecture of ‘EL’ within the context of ADHD symptoms, and identified common genetic substrates between EL and ADHD phenotypes. EL was found to share common genetic etiology with core ADHD dimensions, while showing a stronger link between EL and hyperactive/impulsive symptoms, however the potential construct overlap between EL and ODD could not be ruled out.

Given that EL has been found to be a predictor of depression and poor prognosis and ‘mood/affect’ subdimensions of ODD may also be a predictor of later depression, these two dimensions could be closely linked. The present study sought to examine the precise nature of the relationship between EL and ODD subdimensions within the context of ADHD. This study utilized a clinical sample of Chinese Han (i.e. the ethnic majority group in China, in order to minimize sample heterogeneity) and set out to answer a series of research questions.

First, what is the pattern of co-occurrence between EL and ODD amongst participants with ADHD? Second, is EL distinguishable from the *Angry/Irritable Mood* subdimension, as classified by the DSM-5 method, or is EL distinguishable from the *Negative Affect* subdimension, as classified by the Burke et al. method? Third, if not, how is EL distinct from other groupings of ODD items?

Methods and Materials

Participants

The clinical sample consisted of 1,338 children and adolescents with ADHD recruited from Peking University Institute of Mental Health. ADHD caseness was classified using the Clinical Diagnostic Interview Scale (CDIS; Barkley, 1998) based on the DSM-IV criteria. The inclusion criteria were: (1) 6 to 16 years old; (2) full-scale estimated intelligence quotient (IQ) estimated using Chinese Wechsler Intelligence Scale for Children (C-WISC, Gong & Cai, 1993)>70; (3) medication-naïve; (4) Chinese Han descent. The exclusion criteria included major neurological disorders, a diagnosis of schizophrenia, pervasive developmental disorder, epilepsy, mental retardation or other brain disorders. In addition, children with emotion-related disorders diagnosed using CDIS were also excluded such as special phobia, social phobia, separation anxiety disorder, generalized anxiety disorder, dysthymia, depression, and bipolar disorder.

The current study was approved by the Ethics Committee of Peking

University Institute of Mental Health. Written informed consent was obtained from parents of all participants.

Diagnoses and Assessment

(1) ADHD caseness

Clinical Diagnostic Interview Scale (CDIS): The Mandarin-Chinese version of CDIS was developed by Peking University Institute of Mental Health (Yang, Wang, Qian, Biederman, & Faraone, 2004). The semi-structured interview was conducted with ADHD probands and their parents by trained psychiatrists, yielding three diagnostic categories: inattentive type (ADHD-I), hyperactive-impulsive type (ADHD-HI) and combined type (ADHD-C). The parent who acted as the main carer and with the best knowledge of the child was used as the primary informant. Comorbidities including oppositional defiant disorder (ODD), tic disorder (TD) and learning problems were also evaluated.

(2) Emotional Lability

The EL construct was captured by the items derived from the 'Emotional Lability' subscale of *Conners' Parent Rating Scale* (Goyette, Conners, & Ulrich, 1978; Xu, 1999). The items were rated directly on a 4-point Likert scale (0=never, 1=sometimes, 2=often and 3=always) by the same parent who was interviewed. The items included were: (i) 'Mood changes quickly and drastically' (*Mood Swings*); (ii) 'demands must be met immediately – easily frustrated in effort' (*Frustration*); (iii) 'cries often

and easily' (*Cry*) and (iv) 'temper outbursts, explosive and unpredictable behaviour' (*Explosive*). An EL score was calculated by summing across the four items.

For the categorical comparison of co-occurrence between EL and ODD status amongst ADHD participants, a cut-off threshold of EL score 6 or more was used to yield EL caseness. As there is no published threshold for clinically significant EL in the Chinese population, the 'EL' threshold was empirically derived from a community sample, capturing the top 2% in EL scores. A total of 745 typically developed controls (TDC) were recruited from elementary schools in Beijing. All participants were of Chinese Han descent. Children with more than three ADHD symptoms evaluated by the ADHD Rating Scale-IV (ADHD RS-IV, Su et al., 2006) were excluded because of the potential presence of an ADHD diagnosis. Exclusion criteria included mania, bipolar disorder, other major psychiatric disorders, family history of psychosis, severe physical diseases and substance abuse (for more details see Guan et al., 2009). There was no significant difference in age between the TDC and our ADHD sample [(116 ± 20) versus (118 ± 29), Z=-0.74, p=0.462]; but there was a higher percentage of males in the ADHD sample [85.6% versus 53.4%; χ^2= 255.37; p<0.001]. Setting the cut-off threshold at 6 (i.e. a score of 6 or above) captured the top 2% of individuals, representing a clinically meaningful threshold of severe EL, i.e. 2 SDs above the mean.

(3) Oppositional Defiant Disorder

The eight DSM-IV ODD symptoms were derived from parents' report of the child's symptoms; and were captured using the CDIS by interviewers who recorded the same parent's description of ODD items, as 'present' or 'absent'. Eight items were evaluated by the same parent about the presence of each ODD symptoms over the course of at least 6 months, and rated as '0=No (absent)' and '1=Yes (present)'. If four or more symptoms were rated as present and lead to significant functional impairments, ODD diagnosis was made.

The ODD items were first grouped into subdimensions by the DSM-5 method, and then grouped by the 'Burke et al.' method.

In the DSM-5 method (APA, 2013), 'loses temper', 'angry' and 'touchy' items are grouped as an *Angry/Irritable Mood* subdimension; 'argues', 'defies', 'blames' and 'annoys' items as an *Argumentative/Defiant Behavior* subdimension; while the 'spiteful' item reflected a *Vindictiveness* subdimension.

In the Burke et al. (2010) method, 'touchy', 'angry' and 'spiteful' items are grouped as *Negative Affect*; 'loses temper', 'argues' and 'defies' items as *Oppositional Behavior*; while 'annoys' and 'blames' items as *Antagonistic Behavior*.

Statistics

Comparison of demographic and clinical characteristics between

excluded and included participants were conducted using either Pearson's chi-square test or independent samples' *t* test as appropriate. Co-occurrence of ODD and EL in ADHD participants was computed by cross-tabulation and Chi-square statistics.

For *de novo* exploratory and confirmatory factor analyses, the initial sample was randomly divided into two equal split-half subsamples: the first 'learning' sample for Exploratory Factor Analysis (EFA) and the second 'testing' sample for Confirmatory Factor Analysis (CFA). The dataset was split into 'learning' and 'testing' samples by a random number generator, providing equal distribution of potential measured and unmeasured covariates.

Examining the 'learning' sample using EFA allows an empirically derived factor structure to emerge. Examining the 'testing' sample using CFA allows validation of that derived factor model. CFA further permits comparison of the emerged model with other existing competing models already reported in the literature (Reis & Judd, 2000). For our present study, EFA for categorical data, via the weighted least squares estimator (WLSMV; Muthén, du Toit, & Spisic, 1997; Brown, 2006) was applied in all 12 items (EL and ODD) using the 'learning' sample. The second 'testing' dataset was used to test potential factor structures, including the one emerging from EFA and the other existing competing models already reported in the literature via CFA. In addition, we also test the modified

models in which EL items were grouped with the 'mood/affect' subdimensions of ODD while keeping all other initial features unchanged (details of these models are described with the results).

Both measures of absolute and relative fit were assessed (Hoelter, 1983). Though Mplus modelling can handle variables of mixed type (i.e. binary and ordinal), we took caution to dichotomize EL items into a binary variable (0/1=0; 2/3=1) in order to minimize the scalar effects (i.e. 4-level measure of EL items and 2-level measure of ODD items) influencing the final EFA and CFA models. All parameters in the model were estimated unless constrained for a priori reasons. Factor analysis for categorical data was implemented (also known as Item Factor Analysis (IFA) or Multidimensional IRT) in Mplus, which reports on the goodness of fit of both EFA and CFA models tested. We also re-ran the models using the original 4-level EL items to cross-check the robustness of the binary results. Due to the sensibility of the chi-square to the sample size, the relative chi-square (χ^2/df) (Hoelter, 1983) of each model is reported along with the Root Mean Square Error of Approximation (RMSEA; Browne & Cudeck, 1993), the Taylor-Lewis Index (TLI; Bentler & Bonett, 1980) and the Comparative Fit Index (CFI; Bentler, 1990). Should a novel factor structure have emerged a test for gender invariance would be applied. We conducted multiple group CFAs for gender invariance in novel factorial structures. All data analyses were conducted

using the SPSS (Version17.0; SPSS Inc., Chicago, IL, USA) and Mplus (Muthén & Muthén, 1988-2011) statistical packages.

Results

Characteristics of the sample

Of 1,338 participants, 21 were excluded due to missing data. The analyzed sample consisted of 1,317 participants; there were no significant differences between the excluded and analyzed samples in age (t=1.42; p=0.155), gender (χ^2=0.00, p=>0.999) or ADHD subtypes (χ^2=3.59, p=0.141).

Of 1,317 ADHD participants analyzed, 1125 (85.6%) were male. The mean age was 9.79 years (SD=2.42). Six hundred and sixty-eight (50.7%) children were classified as having the Combined subtype of ADHD; 59 (4.5%) having the Hyperactive-Impulsive subtype; 590 (44.8%) having the Inattentive subtype.

What is the pattern of co-occurrence between EL and ODD amongst participants with ADHD?

Within the 1,317 participants with ADHD, 39.4% (519) had ODD and 42.6% (561) had EL (dichotomized using the threshold of 6). A sizeable proportion expressed only either ODD or EL: 16.6% had ODD-only; 19.7% had EL-only; 22.9% expressed both; and 40.9% had neither (χ^2=83.1, p<0.001).

Is EL distinguishable from the 'Angry/Irritable Mood' subdimension, as classified by the DSM-5 method, or is EL distinguishable from the 'Negative Affect' subdimension, as classified by the Burke et al. method? If not, how is EL distinct from other groupings of ODD items?

To address these questions both EFA and CFA were conducted using all 12 binary items (4 EL and 8 ODD). The initial sample of 1,317 participants was randomly split into two halves: 656 in the 'learning' sample for EFA, and 661 in the 'testing' sample for CFA.

For the EFA solution the Geomin oblique rotation was used (Yates, 1987; Browne, 2001). The one factor model did not provide adequate fit (relative χ^2= 6.56, CFI= 0.92, TLI= 0.90, RMSEA= 0.099). The fit of the two factor solution was improved (relative χ^2= 3.5, CFI= 0.97, TLI= 0.95, RMSEA= 0.062), but it was the three factor solution which was indicated by the scree plot (Figure 1A) and provided adequate fit (χ^2= 1.92, CFI= 0.99, TLI= 0.98, RMSEA= 0.037). The rotated factor loadings are presented in Table 1. Under the three factor solution, the EL items form a distinct dimension from the ODD items. The latter form two more factors, replicating Burke's structure of negative and oppositional behaviour.

- INSERT TABLE 1 HERE -

- INSERT FIGURE 1 HERE -

- INSERT TABLE 2 HERE –

The next step in our analysis was to verify the 3-factor solution, suggested by the EFA, using the second half of the data. For completeness, several other models were tested and the goodness of fit indices are presented in Table 2. In particular, Model 1 corresponds to the one factor model, in which all 12 binary items load on a single factor. Model 2 consists of two dimensions, one for the ODD items and one for the EL items. Models 3 and 4 correspond to the DSM-5 method; in the former, the EL items belong to a fourth dimension, and in the latter, the EL items have been grouped with the *Angry/Irritable* dimension while keeping all other initial features unchanged. In the DSM-5 model, there was only one indicator (i.e. 'spiteful' item) representing the *Vindictiveness* dimension and therefore *Vindictiveness* was represented as an observed variable rather than as a latent factor. Model 5 corresponds to the Burke et al. method augmented by a fourth dimension for the EL items, while in Model 6 the EL items have been grouped with the *Negative Affect* dimension of the Burke et al. model. Finally Model 7 is derived from the EFA best fitted model and Model 8 is a modification of Model 7 where the 'spiteful' item is assigned to the *Oppositional/Provocative* (O/P) rather than *Negativity* (N) dimension. Model 8 was tested as "spiteful" cross-loaded on the O/P dimension as

suggested by the modification indices in MPLUS.

As presented in Table 2, the goodness of fit indices deteriorated when EL was merged with the respective putative 'mood/affect' components in both the DSM-5 (Model 3 vs. Model 4) and Burke et al. model (Model 5 vs. Model 6), mirroring the magnitude of change between Model 2 vs. Model 1. That is, the fit was not adequate when the EL items were grouped along with ODD items (Models 1, 4, 6); the fit improved substantially when the EL items were allowed to form a separate dimension.

The best fitted model was Model 8, which supported EL as a separate construct, distinct from *Negativity* (N) and *Oppositional/Provocative* (O/P) dimensions. Since Model 8 was the best fitting one, we proceeded with multiple group CFA (Muthén & Christoffersson, 1981) with respect to gender. Analysis indicated measurement invariance in thresholds and loadings for boys and girls (chi-square of nested comparison= 7.398, df= 6, p= 0.286). Therefore, the EL and ODD items form separate dimensions for both girls and boys in a similar manner. The corresponding loadings and intercorrelations between the three factors are reported in the path diagram (Figure 1B). The two ODD dimensions correlated strongly (r= 0.82); in contrast, EL showed lower correlations with ODD dimensions (0.55 - 0.62). The factor loadings derived from CFA were broadly consistent with those from the

respective EFA, which allowed for factor cross-loadings.

The analysis was repeated by using the EL items in a 4-point Likert scale. The model that was suggested by EFA was in fact identical to Model 8. Regarding the CFA results, the fit indices of all models were almost identical to the ones derived when using the binary items (complete results available upon request). These results indicate that Model 8 best describes the factor structure of the 12 items, regardless of the type of data (binary or ordinal) used for the EL items.

Discussion

There are four key findings of this study. First, EL and ODD are common comorbidities in children with ADHD: 39.4% had ODD and 42.6% had EL. Yet sizeable proportions of participants with ADHD only express either the ODD or EL phenotype alone, and only a quarter express both. Second, EL is a separate construct from ODD; and is distinct from the 'mood/affect' subdimensions of ODD whether classified by the DSM-5 (i.e. *Angry/Irritable Mood*), the Burke et al. models (i.e. *Negative Affect*) or by the model derived from our data (i.e. *Negativity*). Third, a novel factorial structure of ODD is identified when juxtaposed against EL items. In our data, ODD is best represented by two dimensions which are designated as *Negativity* (i.e. 'Angry' and 'Touchy' items) and *Oppositional/Provocative* (i.e. the remaining six items); and this grouping is similar to that of the Burke et al. model. Fourth, the detected 3-factor

structure (i.e. EL, *Negativity*, *Oppositional/Provocative*) was invariant across gender.

As far as the authors are aware, this is the first study which provides factorial validity of EL as a distinct and separate construct from ODD and its subdimensions.

The construct of 'Emotional Lability' examined here is derived from a subscale within the well validated Conners' Rating Scale (Conners, 1973; Parker, Sitarenios, & Conners, 1996). It refers to a subset of symptoms denoting emotional instability, frustration intolerance, rapid and drastic changes in mood, emotional fragility of crying easily as well as unpredictable and explosive temper outbursts. Its distinct factorial validity has previously been demonstrated in different samples only in relation to ADHD symptoms (Conners, 1973; Margalit, 1983; Furlong & Fortman, 1984; Epstein, Cullinan, & Gadow, 1986; Parker et al., 1996; Merwood et al., 2014).

Apart from the factorial validity of the EL construct, there are other findings, indicative of the genetic, concurrent and predictive validity of this construct.

For genetic validity, a family study provides evidence for co-segregation of emotionally dysregulated ADHD phenotype as a distinctive familial subtype (Surman et al., 2011). A quantitative genetic analysis isolates substantial genetic heritability for EL in the context of an

ADHD phenotype (Merwood et al., 2014).

For concurrent validity, a recent functional neuroimaging study identified two independent circuitries for executive attentional deficits and EL in participants with ADHD (Posner et al., 2013). Another study focused specifically on EL symptoms and identified abnormal amygdala-cortical functional connectivity in children with ADHD associated with high EL, and the association between EL and the neurocircuitry signature remains unchanged while accounting for ODD status (Hulvershorn et al., 2014). More specifically, high levels of EL were associated with increased positive functional connectivity between bilateral amygdala and medial prefrontal regions and less positive functional connectivity between amygdala and bilateral insula and superior temporal gyrus. The authors suggest that this pattern may represent a specific disruption in emotional control networks in a subset of children with ADHD and high EL, a process independent of ODD symptoms. For functional correlates, the risks of emotional dysregulation are highlighted in that *Emotional Impulsiveness* symptoms are the most impairing aspects of ADHD, contributing to family, peer relationships, financial and driving impairments in adult outcomes (Barkley & Fischer, 2010). Their findings are broadly replicated using an analogous construct – *Deficient Emotional Self-regulation* (DESR) – characterized by low frustration tolerance, temper outbursts, emotional impulsivity, and mood lability (Surman et al.,

2013).

For predictive validity, childhood DESR adversely impacted the quality of life in ADHD adults and was associated with significant functional impairments, reduced marital status, higher risk for traffic accidents and arrests. In a longitudinal study, baseline DESR was found to predict both DESR and persistence of ADHD at 4 year follow-up; and participants with ADHD+DESR had increased risks of ODD, social problems and psychiatric comorbidities (Biederman et al., 2012). Our findings showing EL as a distinctive dimension are therefore in line with the emerging evidence, which implicates emotional lability symptoms embodying a dimension with specific concurrent and predictive validity.

From our data, a novel factorial structure of ODD was identified when ODD items were juxtaposed against EL items: ODD is best represented by two dimensions which were designated as *Negativity* (i.e. ‘Angry’ and ‘Touchy’ items) and *Oppositional/Provocative* (i.e. the remaining six items). This grouping is largely similar to that of the Burke et al. model. However, the detected difference may arise from our sample consisting of ADHD participants while the study sample from Burke et al. consists of female community participants. The current study aimed to test for the independence of EL and ODD items and it is worth noting that EL remains a separate construct from ODD items regardless of whether these items were grouped according to the DSM-5, Burke et al. or our *de*

novo models. Our findings can therefore stimulate further research and replication studies on EL.

Our results should be interpreted in the light of several limitations. First, our clinical ADHD sample may not be generalized to children without ADHD. Second, the effect of anxiety, depression and autism spectrum disorder symptoms in modifying the expression of EL was not evaluated, as these measures were not available for analyses. Our sample also excluded childhood bipolar disorder and was not phenotyped for Severe Mood Dysregulation (SMD). Indeed, an overlap between EL in 10 item Conners (also known as APQ) and *Prepubertal and Early Adolescent Bipolar Disorder* phenotyped by WASH-U-KSADS was reported (Tillman & Geller, 2005). The extent to which these comorbidities may influence our findings remains untested and therefore unknown. Future studies with samples enriched and phenotyped for these conditions could test for the invariance and generalizability of our findings. Third, our measures of EL and ODD were also derived from the same source, based on parental report, however, they were recorded differently. EL items were rated directly by parents on a paper instrument. ODD items were reported by parents but recorded by interviewers in CDIS. It is unlikely that the detected independence of EL is entirely attributable to the effects of direct and indirect recording of the same source information based on parental reports. However, a replication

study using items derived from the same instrument by the same rater could overcome this limitation. Fourth, only one single indicator (i.e. ‘spiteful’ item) was available to represent the *Vindictive* dimension. Finally, there is no normative data on EL distribution in the Chinese population stratified by age and gender; we therefore relied on the cut-off threshold derived from the TDC sample as a single group. The TDC consists of children with few symptoms, which may potentially yield a lower cut-off threshold, thereby inflating the co-occurrence between EL and ODD. This could potentially bias our findings towards the null hypothesis leading to an inflated overlap between EL and ODD as well as less children with ‘neither’ (i.e. more children classified as expressing severe ‘EL’ by a lower threshold). Yet our finding was the contrary. This effect, if it exists, would potentially strengthen rather than weaken our finding. The detected dose-response trend of ADHD subtypes on EL in relation to impulsivity is consistent with findings from Caucasian samples (Sobanski et al., 2010; Overgaard et al., 2015), indicating that our sample is not atypical or ungeneralizable due to ethnicity or scaling atypicality. Replication studies with European or American population samples using standardized EL T-scores and cut-off threshold will overcome this limitation. Our CFA analyses model all measures as indicators without assigning arbitrary cut-off thresholds; the results likewise do not support EL merging with the *Angry/Irritable Mood* subdimension or the *Negative*

Affect subdimension.

In conclusion, our findings provide preliminary evidence that EL is distinct from ODD and the 'mood/affect' subdimensions of ODD, i.e. *Angry/Irritable Mood* or *Negative Affect*. In both EFA and CFA, EL formed a separate dimension from ODD items and this remained invariant across gender. In line with other emerging evidence suggestive of EL as an independent construct with specific concurrent correlates and predictive validity, our findings provide further factorial validity evidence for EL as a separate construct from ODD. We therefore recommend more research focusing on EL, as it may represent a separate clinical entity with important diagnostic and management implications.

Declaration of Conflicting Interests

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Tables

Table 1. EFA 3-factor solution (first half of the data)

		factor loadings		
		1	**2**	**3**
EL	Cry	**0.47**	-0.25	0.03
	Explosive	**0.54**	0.04	0.13
	Mood swings	**0.95**	0.00	-0.12
	Frustration	**0.56**	-0.20	0.01
ODD	Loses temper	0.09	**0.66**	0.22
	Argues	-0.02	**0.93**	-0.01
	Defies	-0.01	**0.88**	-0.02
	Annoys	-0.11	**0.76**	0.08
	Blames	0.07	**0.30**	0.26
	Spiteful	0.03	**0.25**	**0.46**
	Touchy	0.00	-0.21	**0.92**
	Angry	-0.18	0.01	**1.06**
EFA via weighted least squares with Geomin rotation				

Note: EFA= Exploratory factor analysis; EL=emotional lability, EL symptoms are derived from Conners' Parent Rating Scale; ODD= Oppositional Defiance Disorder, ODD symptoms are evaluated from the the interviewed parents' report of the child's symptoms. Factor loadings in bold indicate comparatively higher value (s).

Table 2. Comparison of Factorial Structures of tested models with Goodness of fit indices according to CFA (second half of the data)

	Fitted model							
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
	1 Factor Model	**2 Factor Model**	**Initial Stringaris & Goodman (DSM-5) 4 Factor Model**	**Modified Stringaris & Goodman (DSM-5) EL=A/I 3 Factor Model**	**Initial Burke et al. 4 Factor Model**	**Modified Burke et al. EL=NA 3 Factor**	**Model indicated by EFA from Beijing Data**	**Best fitted Model: CFA from Beijing Data (Gender Invariant, 3 Factor Model)**
Spiteful	GF	ODD	V	V	NA	NA	N	O/P
Angry	GF	ODD	A/I	A/I	NA	NA	N	N
Touchy	GF	ODD	A/I	A/I	NA	NA	N	N
Loses Temper	GF	ODD	A/I	A/I	O	O	O/P	O/P
Argues	GF	ODD	A/D	A/D	O	O	O/P	O/P
Defies	GF	ODD	A/D	A/D	O	O	O/P	O/P
Annoys	GF	ODD	A/D	A/D	A	A	O/P	O/P
Blames	GF	ODD	A/D	A/D	A	A	O/P	O/P
Cry	GF	EL	EL	A/I	EL	NA	EL	EL
Explosive	GF	EL	EL	A/I	EL	NA	EL	EL
Mood swings	GF	EL	EL	A/I	EL	NA	EL	EL
Frustration	GF	EL	EL	A/I	EL	NA	EL	EL
Goodness of fit								
Relative $\chi 2$	5.45	3.12	2.99	5.09	2.98	4.89	2.84	2.76
CFI	0.92	0.96	0.97	0.93	0.97	0.93	0.97	0.97
TLI	0.90	0.95	0.96	0.91	0.96	0.92	0.96	0.96
RMSEA	0.082	0.057	0.055	0.079	0.055	0.077	0.053	0.052

Note: CFA= confirmatory factor analysis; EL=Emotional Lability; GF=Global factor; A/D= Argumentative/Defiant Behavior; A/I= Angry/Irritable Mood; V= Vindictiveness; NA= Negative Affect; O= Oppositional Behavior; A= Antagonistic Behavior; N= Negativity; O/P= Oppositional/Provocative; CFI= Comparative Fit Index; TLI= Taylor-Lewis Index; RMSEA= Root Mean Square Error of Approximation.

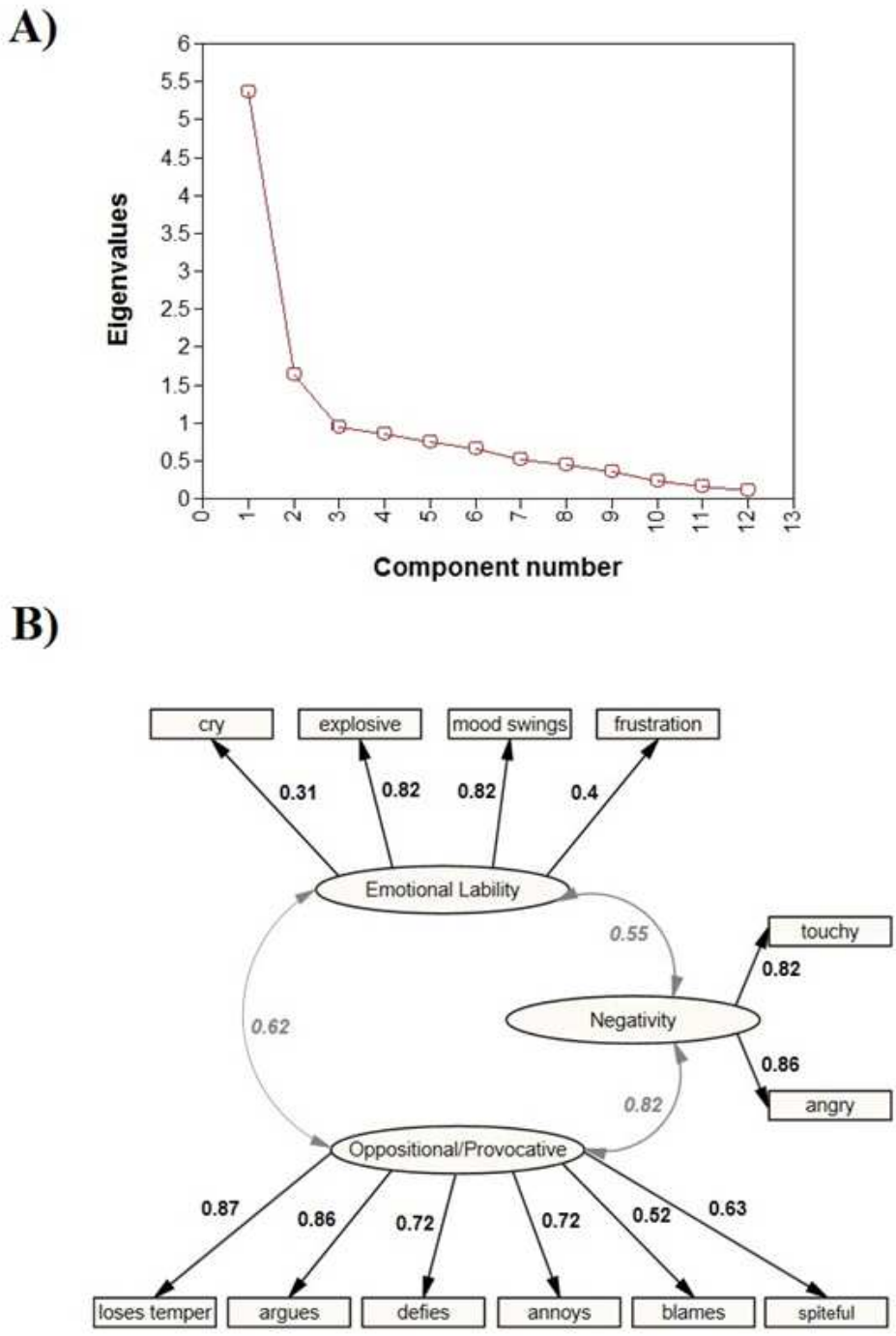

Figure 1(A) Screeplot of Exploratory Factor Analysis on the first split half 'learning' sample. (B) Path diagram of the CFA 3-factor Model (Model 8) derived from the second split-half 'testing' sample. Rectangles represent observed items and ellipses represent the latent variables (factors). The parameters printed by the black straight arrows represent the standardized loadings and the coefficients on the curved grey arrows represent the correlations between factors (p<0.05 in all cases).