Article

Temporal and Reciprocal Relations Between ADHD symptoms and Emotional Problems in School-Age Children

Gloria T. Han[1,2], Yi-Lung Chen[2] iD, Fang-Ju Tsai[2,3], and Susan Shur-Fen Gau[2] iD

Abstract

Objective: The study aimed to investigate the reciprocal and temporal relations between ADHD symptoms and emotional problems in school-age children. **Method:** This 1-year longitudinal study with a four-wave design included 1,253 children and adolescents (254 third graders, 281 fifth graders, and 718 eighth graders; 50.9% boys). ADHD symptoms and emotional problems were measured using parent report of the Swanson, Nolan, and Pelham, Version IV Scale and Strengths and Difficulties Questionnaire. **Results:** Cross-lagged panel analyses indicated that both inattention and hyperactivity/impulsivity symptoms were associated with emotional problems over the 1-year period. However, only inattention symptoms demonstrated a transactional relationship with emotional problems, such that inattention predicted future emotional problems, which in turn led to increases in inattention symptoms. **Conclusion:** Our findings highlight the transactional and dynamic interplay between inattention symptoms and emotional problems and support the mechanistic role of inattention symptoms in the development and persistence of emotional problems in school-age children. *(J. of Att. Dis. XXXX; XX(X) XX-XX)*

Introduction

ADHD is a common neurodevelopmental disorder characterized by developmentally inappropriate symptoms of inattention, hyperactivity, and impulsivity. ADHD affects around 3% to 10% of school-age children worldwide (Faraone, Sergeant, Gillberg, & Biederman, 2003; Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007) and 7% to 9% in Taiwan (Chen, Shen, & Gau, 2017; Gau, Chong, Chen, & Cheng, 2005). Symptoms related to ADHD seldom occur alone and are often accompanied by problems in other areas of psychological functioning, including emotional problems (Barkley & Fischer, 2010; Biederman et al., 2012; Bunford, Evans, & Langberg, 2018; Wehmeier, Schacht, & Barkley, 2010). Notably, literature documents high rates of emotional impairment ranging from 25% to 49% in children with ADHD (Anastopoulos et al., 2011; Becker et al., 2006; Sobanski et al., 2010; Spencer et al., 2011; Strine et al., 2006; Stringaris & Goodman, 2009). Investigating the association between ADHD and emotional problems is salient because concurrent emotional problems may negatively affect adaptive functioning, academic achievement, and long-term quality of life (Schei, Jozefiak, Nøvik, Lydersen, & Indredavik, 2016; Wehmeier et al., 2010). Hence, further understanding the co-occurrence and development of emotional problems, given

the existence of ADHD symptoms, may help to explain the onset of common psychiatric conditions that are comorbid with ADHD (e.g., conduct disorder, anxiety, depression; Pan & Yeh, 2017; Reale et al., 2017; Seymour et al., 2012) and inform targets for intervention to facilitate optimal outcomes for this vulnerable population.

Though the co-occurrence of emotional problems and ADHD symptoms is well documented in the current literature, relatively little is known about the unique predictive effects of inattention versus hyperactivity/impulsivity on children's emotional development. Furthermore, a dearth of longitudinal studies limits our understanding of the temporal effects of ADHD symptoms, as well as the transactional and dynamic relations between ADHD symptoms and emotional problems over time. Longitudinal studies suggest that impairment due to ADHD is persistent throughout adolescence and

---

[1]Vanderbilt University, Nashville, TN, USA
[2]National Taiwan University Hospital, Taipei, Taiwan
[3]En Chu Kong Hospital, Taipei, Taiwan

Corresponding Author:
Susan Shur-Fen Gau, Department of Psychiatry, National Taiwan University Hospital, No. 7, Chung-Shan South Road, Taipei 10002, Taiwan.
Email: gaushufe@ntu.edu.tw

into adulthood. Research also indicates that even if adolescents no longer meet criteria for ADHD, they may still be affected by lowered self-esteem and quality of social interactions and are at a heightened risk for anxiety and depression (Jarrett, Wolff, Davis, Cowart, & Ollendick, 2016; Meinzer, Pettit, & Viswesvaran, 2014; Wehmeier et al., 2010). These findings emphasize the persistent nature of impairment associated with ADHD and underscore the need for longitudinal studies to clarify trajectories of emotional well-being and negative effects of ADHD symptoms over time. Finally, previous work in this area is also limited in sociocultural context, as most research has examined Western samples. As a greater initiative in our understanding of developmental psychopathology, researchers must consider behavioral manifestations and symptoms of mental disorders across varied social and cultural contexts. To address these important gaps in the literature, the present study implemented a longitudinal framework to examine the temporal and reciprocal relations between ADHD symptom domains (i.e., inattention and hyperactivity/impulsivity) and emotional problems in a large Taiwanese sample of school-age children.

Co-Occurrence of ADHD Symptoms and Emotional Problems

Emotional problems in ADHD consist of a broad array of deficits in emotional functioning, including poor emotion regulation, excessive emotional expression, low frustration tolerance, reduced arousal to emotional stimuli, and anomalous allocation of attention to emotional stimuli (Bunford, Evans, & Wymbs, 2015; Serrano, Owens, & Hallowell, 2018). Such emotional symptoms are common in children with ADHD; in the United States, approximately one third of children with ADHD were reported to have co-occurring emotional and behavioral difficulties and impairments in daily functioning (Strine et al., 2006). In Europe, studies have shown that children and adolescents with ADHD symptoms exhibit increased emotional problems (i.e., excessive worry, depressed mood, heightened nervousness in new situations, increased fears, and/or somatic symptoms) compared with children without ADHD (Becker et al., 2006; Coghill et al., 2006). Previous reports have also highlighted the association between increased emotional lability (i.e., rapid, exaggerated changes in mood) and ADHD symptom severity, particularly in children and adolescents with more hyperactivity/impulsivity symptoms and comorbid psychopathology (Sobanski et al., 2010). As an important aside, this brief review of the literature documenting the co-occurrence of ADHD symptoms and emotional problems highlights the fact that "emotional problems" is a broad descriptor referring to impairments in emotional processing and emotion regulation. Critically, researchers have suggested that these component parts of the higher order construct of emotional problems may not be dissociable behaviorally, though they may be separable at the neural level (Goldsmith & Davidson, 2004). Thus, in the current study, the term "emotional problems" refers to the observed *behavioral manifestations* of affective disturbance that suggest putative deficits in underlying emotional processing (e.g., emotion identification, attentional processes regarding perception of emotion) and/or emotional regulation (e.g., emotion lability, excessive expression of negative emotions) common in children and adolescents with ADHD (Cole, Martin, & Dennis, 2004; Eisenberg & Spinrad, 2004).

Several explanations for the relations between ADHD symptoms and emotional problems have been proposed. First, previous work has suggested that though ADHD and emotion dysregulation are distinct constructs, the two constructs have shared variance that is accounted for by deficits in emotional processing and executive dysfunctioning in ADHD (Sjöwall, Roth, Lindqvist, & Thorell, 2013). Second, the presence of emotional problems and ADHD symptoms may be explained neurobiologically in overlapping anomalous neural circuitries involving the frontostriatal, fronto-cerebellar, and fronto-amygdala neural loops that are responsible for processing the emotional significance of one's environment (Castellanos & Proal, 2012; Hinshaw, 2003; Miller & Hinshaw, 2010; Nigg & Casey, 2005). Third, researchers have begun to consider whether the relation between emotional problems and ADHD is better understood when considering unique core symptom domains of ADHD (i.e., inattention and hyperactivity/impulsivity) compared with ADHD symptoms as a whole. Specifically, our previous work suggests that researchers could consider investigating the roles of inattention and hyperactivity symptoms separately on neuropsychological functioning (Chiang, Huang, Gau, & Shang, 2013; Gau & Chiang, 2013) and the onset of other comorbid psychiatric conditions (Gau et al., 2010). For example, inattention symptoms may be specifically related to low effortful control (i.e., difficulty inhibiting a dominant response to perform a subdominant response; (Lin, Chen, & Gau, 2014; Rothbart, Sheese, & Posner, 2007), while hyperactive/impulsive symptoms may be more related to negative emotionality, irritability, low frustration tolerance, and conduct problems (Lin & Gau, 2017; Martel & Nigg, 2006; Sobanski et al., 2010). In the context of subsequent psychopathology, increased inattention symptoms may confer increased risk for internalizing disorders (e.g., anxiety and depression) while hyperactivity/impulsivity symptoms may confer higher risks for externalizing disorders (Martel et al., 2011; Seymour et al., 2012; Seymour, Chronis-Tuscano, Iwamoto, Kurdziel, & MacPherson, 2014; Sobanski et al., 2010). Of note, the association between ADHD symptoms and deficits in emotional competence and subsequent implications for comorbid conditions underscores the need to clarify the transactional nature of the ADHD symptoms and emotional problems as the first step to inform prevention of future psychopathologies.

Longitudinal Relations Between ADHD and Emotional Problems

Current perspectives regarding the prospective and reciprocal relations between ADHD symptoms and emotional problems have been few with mixed findings. Preliminary longitudinal studies have suggested that early ADHD symptoms predict future emotional symptoms among children with ADHD (Meinzer et al., 2017; Smith et al., 2017; Thorell, Sjöwall, Diamatopoulou, Rydell, & Bohlin, 2017). However, other researchers have proposed that the reciprocal relation is also present where emotional problems may persist and exacerbate or lead to ADHD symptoms. For example, previous work indicates that deficits in emotion recognition and emotional awareness significantly predicts externalizing and hyperactive behaviors, and mediates the development of ADHD symptoms among boys (Factor, Rosen, & Reyes, 2016). Also, results from a longitudinal study by Stringaris, Maughan, and Goodman (2010) suggest temperamental emotionality at age 3 predicts comorbid ADHD at age 7. Furthermore, early individual differences in emotion regulation during preschool have been shown to predict ADHD symptoms across time and into adolescence (Brocki, Forslund, Frick, & Bohlin, 2017). Specifically, poor preschool emotion regulation has been associated with higher levels of inattention symptoms over time.

Cross-Cultural Perspective of Emotional Problems and ADHD

Previous studies examining the extent to which ADHD symptoms influence emotional problems in non-Western cultures are notably limited. In contrast to Western cultures that are characterized by heightened individualistic expression, Taiwanese society, which is greatly influenced by the relationship-oriented Chinese culture, focuses more on cooperation, maintenance of group harmony, and compliance with group norms (Butler, Lee, & Gross, 2007; Chen & French, 2008). In Chinese culture, children may be more expected to meet others' (e.g., peers, teachers, parents) expectations and are socialized to restrain their preferences to accommodate social norms. Thus, children with higher levels of hyperactivity or impulsivity who exhibit more disruptive behaviors during classroom or group activities may be disproportionately reprimanded for violating social norms, face peer rejection, have fewer friendships, and develop a more negative view of oneself (Kawabata, Tseng, & Gau, 2012; C. Y. Liu, Huang, Kao, & Gau, 2017). Similarly, children with inattention symptoms may also be vulnerable to declined academic performance or difficulty following instructions, resulting in lower social status, peer rejection, and bullying due to a violation of classroom and parental expectations (Gau et al., 2010). Importantly, research investigating cross-cultural perspectives of emotional impairment and co-occurring ADHD symptoms is scarce compared with the larger body of Western literature, thus warranting more studies from non-Western (e.g., Chinese) cultures.

Overall, though a notable body of literature documents increased emotional problems in children with ADHD diagnosis or symptoms, there is a substantial lack of literature examining the reciprocal and temporal relations between ADHD and emotional symptoms. Moreover, minimal longitudinal work has been conducted to elucidate the trajectories of specific subtypes of ADHD and occurrence of emotional problems. These sentiments are even more reinforced when considering our knowledge of this topic, or lack thereof, from a cross-cultural perspective. Understanding the co-occurrence and temporal dynamics of ADHD symptomatology and emotional symptoms is salient to facilitate continued efforts to explain the development of ADHD symptoms from childhood, through adolescence, and into adulthood. In regard to clinical implication, a closer examination of these processes is also warranted because the additional presence of emotional symptoms can significantly affect quality of life, academic performance, adult sociofunctional outcomes, and lifetime psychiatric comorbidities (Seymour et al., 2012; Wehmeier et al., 2010).

The Current Study

The current study attempts to examine the temporal and reciprocal relations between ADHD symptoms, specifically inattention and hyperactivity-impulsivity, and emotional problems in Taiwanese children and adolescents with ADHD symptoms in a four-wave, school-based, 1-year longitudinal prospective study. Analytically, a cross-lagged statistical model was implemented to facilitate the exploration of the directionality and longitudinal associations between ADHD and emotional symptoms. Importantly, this structural equation modeling approach is well suited for the investigation of psychological development because of its ability to simultaneously estimate direct and indirect associations in longitudinal data (Hays, Marshall, Wang, & Sherbourne, 1994). To our knowledge, the current study marks the first implementation of this approach to understand the temporal dynamics of emotional problems and ADHD symptoms.

We hypothesized that ADHD symptoms and emotional problems would be relatively stable in the 1-year period of data collection. We also hypothesized that there would be a bidirectional relationship between ADHD symptoms and emotional problems over time. However, given the mixed results and a dearth of longitudinal studies addressing this topic in previous work, we did not have specific predictions regarding the pattern of relations between ADHD inattention symptoms and hyperactivity/impulsivity symptoms with emotional problems.

Method

Description of the Study

The present study is part of a longitudinal, school-based epidemiological study that aims to investigate the psychosocial and emotional development of children and adolescents. Part of this work on a different topic has been published elsewhere (Chen & Gau, 2016).

Participants

This prospective longitudinal questionnaire-based study was conducted using a sample of 1,128 parents of children and adolescents in Grades 3, 5, and 8 from seven schools in Northern Taiwan from March 1, 2013, to January 31, 2014. The number of parent participants for the four time points was 1,128, 1,005 (89.1%), 941 (83.4%), and 849 (75.3%), respectively. The parent sample from the current study was comprised of parents of children who were enrolled in the same 1-year longitudinal study. Student characteristics from this study have been reported in detail elsewhere (Tsai et al., 2017). Briefly, all students enrolled in standard curriculum classes rather than special education classes were eligible and recruited for the study. Students with mental disorders in regular classes were not excluded from the study. At Time 1 (T1), the age range for the participants was 8 to 12 years ($M \pm SD = 8.6 \pm 0.3$ years), 10 to 12 years ($M \pm SD = 10.6 \pm 0.3$ years), and 13 to 16 years ($M \pm SD = 13.6 \pm 0.3$ years) for Grades 3, 5, and 8, respectively. There were 638 boys and 615 girls at T1 ($n = 1,253$); follow-up rates were 93.1% ($n = 1,166$ with 593 boys and 573 girls), 89.6% ($n = 1,123$ with 563 boys, and 560 girls), and 84.1% ($n = 1,054$ with 519 boys and 535 girls) at Times 2 (T2), 3 (T3), and 4 (T4), respectively.

Measures

The Chinese version of the Swanson, Nolan, and Pelham–IV (SNAP-IV). Parents reported on their child's ADHD symptoms using the Chinese version of the SNAP-IV. The SNAP-IV is a 26-item scale that includes the core *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association, 1994)-derived ADHD subscales of inattention and hyperactive-impulsive (Swanson et al., 2001). Each item is rated on a 4-point Likert-type scale (0 = *not at all*, 1 = *just a little*, 2 = *quite a bit*, and 3 = *very much*). Gau et al. (2008) have established norms and psychometric properties of the Chinese version of the SNAP-IV, which demonstrates good test–retest reliability, high internal consistency, and discriminant validity (Gau, Tseng, Tseng, Wu, & Lo, 2015). Though the SNAP-IV also assesses oppositional defiant disorder symptoms, they were not included in the analysis because this study was only interested in examining the two ADHD core symptom domains: inattention and hyperactivity/impulsivity symptoms. Given that data were collected as part of a school-based epidemiological study, we were primarily interested in examining impairment due to inattention and hyperactivity/impulsivity symptoms dimensionally. However, we also conducted complementary analyses with ADHD diagnosis as a binary variable (non-ADHD vs. ADHD) to allow for increased interpretability in the context of ADHD, as opposed to other etiologies. Using the SNAP-IV in accordance with *DSM-IV* criteria, participants were classified as having ADHD inattentive type and ADHD hyperactive/impulsive type if parents endorsed at least six of the nine inattention or hyperactive/impulsivity items, respectively.

The Chinese version of the Strengths and Difficulties Questionnaire (SDQ). The SDQ is a 25-item behavioral screening questionnaire that is designed to assess the broader psychological problems experienced by children and adolescents (Goodman & Scott, 1999). Each subscale consists of five items, and the total difficulties score is generated by summing the scores on four subscales: emotional symptoms, conduct problems, hyperactivity, and peer problems (range = 0-40). The Chinese version of the SDQ has shown good test–retest reliability and moderate to high internal consistency, ICC = .40 to .72; Cronbach's α = .84, in Taiwan (Liu et al., 2013). In the present study, we only used the emotional problems subscale. This subscale consists of the following five items: (a) often complains of headaches, stomachaches, or sickness; (b) many worries or often seems worried; (c) often unhappy, depressed, or tearful; (d) nervous in new situations, easily loses confidence; and (e) many fears, easily scared. Internal consistency for the emotional problems subscale was good (Cronbach's α = .72).

Procedure

This study was approved by the Research Ethics Committee of National Taiwan University Hospital (institutional review board [IRB] number: 201212010RINC). Informed consent was obtained from all individual participants included in the study and their parents. The data were collected from a convenience sample of primary and junior high students attending schools in Taipei, Taiwan. Schools were determined based on cooperation from school principals in response to invitations from the Taiwanese Ministry of Education. Parents were invited to attend a speech given by the corresponding author (SSG), who introduced the purpose and procedure of the study. Parents received informed consent documents in paper format from their children. Parents who agreed to participate were asked to complete the questionnaires at home and return the documents in a sealed envelope within 1 week. Seventy-five percent (75%) of parent informants were mothers. Responses

were collected quarterly within the same calendar year. Parents reported on the Chinese versions of the SNAP-IV and SDQ for all four time points of data collection.

Data Analytic Plan

Missing data. To address missing data, we conducted the Expected-Maximization algorithm in the SAS software (Version 9.4 of the SAS System for Windows. Copyright © 2013 SAS Institute Inc., Cary, NC, USA) to impute missing variables based on values from the participant's other available time points. At each time point, the proportion of participants with missing data on the SNAP-IV and SDQ was T1 = 3.5% and 3.2%, T2 = 14.1% and 14.0%, T3 = 19.1% and 19.0%, and T4 = 27.3% and 27.2%.

Confirmatory factor analysis (CFA). We conducted a CFA using Mplus (Version 7.0, Muthén and Muthén) to confirm the hypothesized existence of a single factor structure for our measure of emotional symptoms and a two-factor structure yielded by the SNAP-IV (i.e., inattention, Items 1-9, and hyperactivity/impulsivity, Items 10-18) for the ADHD symptoms at the first wave. As previously mentioned, the current study was primarily interested in the core ADHD symptoms domains of inattention and hyperactivity/impulsivity. Model fit was assessed with multiple criteria: Chi-Square Test (χ^2), comparative fit index (CFI), Tucker–Lewis index (TLI), and root mean square error of approximation (RMSEA).

Item parceling. Item parceling is a recommended procedure for combining individual items to create efficient, reliable, and valid indicators of latent constructs (Little, Rhemtulla, Gibson, & Schoemann, 2013). The SNAP-IV contains 18 items of ADHD symptoms. Item parceling was used to represent each factor (i.e., inattention and hyperactivity/impulsivity). Consistent with the terminology presented in Little et al. (2013), the nine indicators for each factor were divided into three parcels based on Items 1 to 3, 4 to 6, and 7 to 9 for inattention, and Items 10 to 12, 13 to 15, and 16 to 18 for hyperactivity/impulsivity. The averages of the three sets of indicators were used to create three parcel-level indicators. Next, the geometric midpoint of the triangle created by the three parcel-level indicators was used to estimate the centroid of each factor, thus providing a more parsimonious measure of the inattention and hyperactivity/impulsivity factors.

Cross-lagged models. To assess both the temporal and reciprocal relations between ADHD symptoms and emotional problems across four time points, we implemented a cross-lagged panel analysis using Mplus (Version 7.0, Muthén and Muthén). Cross-lagged panel analysis is widely used to infer the causal associations in a longitudinal study and is optimal for the current investigation because this method
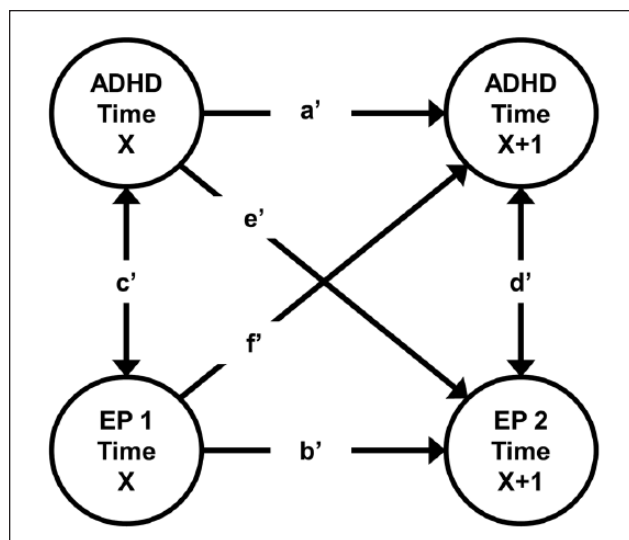

Figure 1. Generic depiction of a cross-lagged panel model.
Note. Paths a' and b' denote autoregressive path weights that represent the stability of each measure across time. Paths c' and d' are the contemporaneous paths that represent co-occurring correlations between the factors in the model. Paths e' and f' represent cross-lagged paths indicating the presence of reciprocal, bidirectional associations between the factors in the model. EP = emotional problems.

simultaneously estimates direct and indirect associations of ADHD symptoms and emotional problems over time (Hays et al., 1994). In cross-lagged modeling, there are three sets of paths that are of primary interest: the stability paths, contemporaneous paths, and cross-lagged paths. To illustrate these paths, a generic cross-lagged model is displayed in Figure 1. The stability paths are denoted by autoregressive path weights that represent the stability of each measure across each subsequent time point (i.e., Paths a' and b' in Figure 1). Contemporaneous paths represent co-occurring correlations between the factors in the model (i.e., Paths c' and d' in Figure 1). Finally, cross-lagged paths represent the presence of reciprocal, bidirectional associations between the factors in the model (i.e., Paths e' and f' in Figure 1). In all models, the parceled inattention and hyperactivity factors were used to create the latent variables for inattention and hyperactivity symptoms of ADHD. Furthermore, the five items of SDQ emotional problems subscale in each wave were used to create latent variables for the emotional problems construct. Finally, the homogeneity of variance assumption was assumed and constrained in our analysis.

We report the standardized regression coefficients (*B*) and standard errors (*SE*). The degree of model fit was assessed using the chi-square goodness-of-fit statistics, and the RMSEA (Browne & Cudeck, 1992). MacCallum, Browne, and Sugawara (1996) characterize a model with an RMSEA of 0.08 or less as an adequate fit; Hu and Bentler (1999) characterize a model with an RMSEA of 0.05 or less as a good fit, and .10 or more as a poor fit.
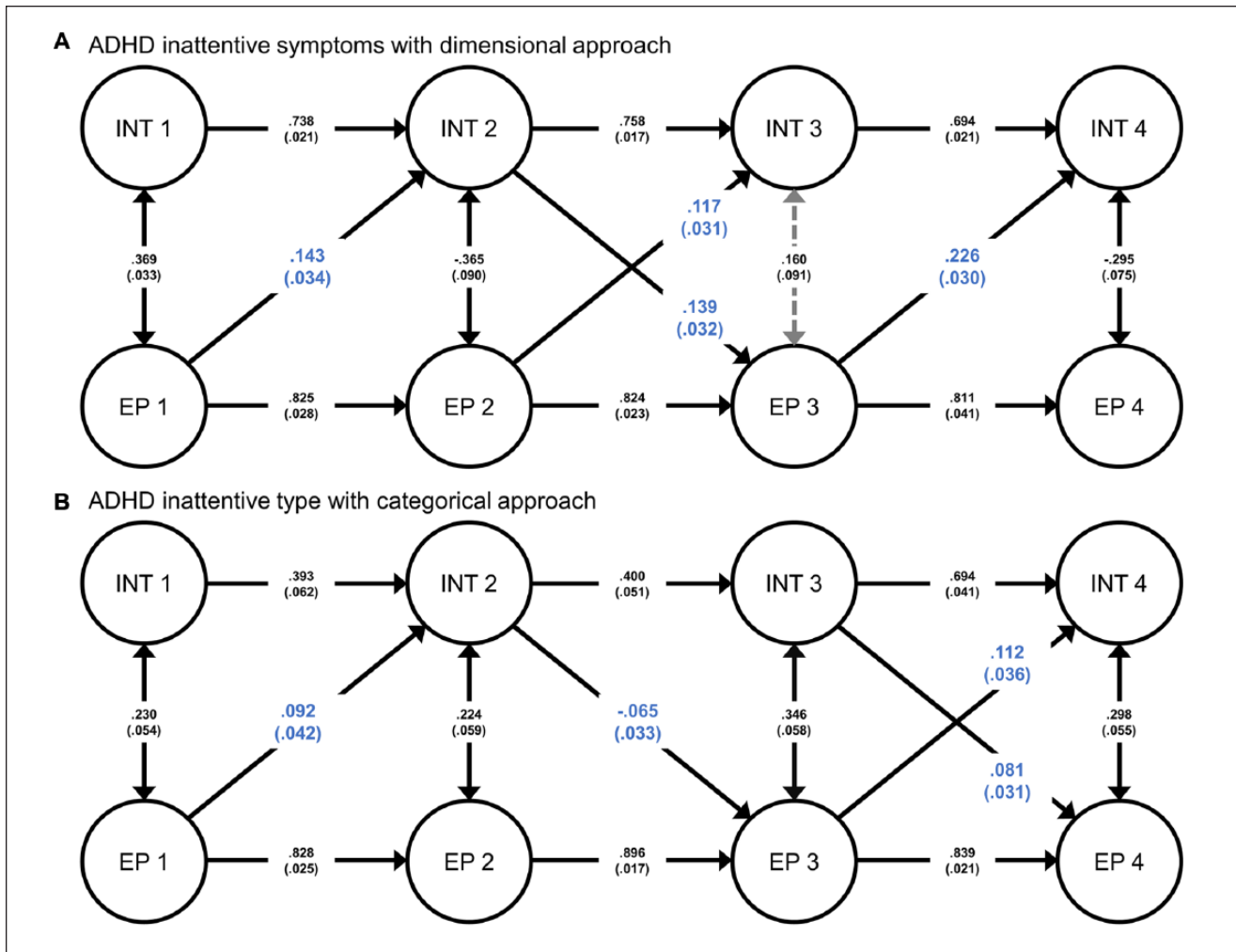
Figure 2. Cross-lagged model with inattention symptoms and emotional problems as the two factors of interest.
Note. Part (a) illustrates the cross-lagged model using inattention symptoms as a continuous, dimensional measure and Part (b) illustrates the model using ADHD-inattentive type as a diagnostic category. Standardized path coefficients and standard errors (in parentheses) are presented to depict the strength of each path. INT = inattention in 2a and ADHD inattentive type in 2b; EP = emotional problems.

To comprehensively test the possible relations between inattention symptoms, hyperactive-impulsive symptoms, and emotional problems, we tested two cross-lagged models. The first cross-lagged model consisted of a two-factor model where we tested the relations between inattention and emotional symptoms (Figure 2). This two-factor model consisted of (a) cross-lagged paths between inattention and emotional symptoms, (b) stability paths for inattention and emotional problems over time, and (c) contemporaneous paths representing the covariance of the residuals of inattention with emotional problems over time. The second cross-lagged model had the same structure as the first, except the two factors of interest were hyperactivity/impulsivity symptoms and emotional problems (Figure 3). For all models, emotional problems were treated as a continuous variable. We used both a dimensional and categorical approach to examine the relationship between emotional problems and core ADHD symptoms or diagnosis. The maximum likelihood method was used in the dimensional approach and the Satorra–Bentler correction (Satorra & Bentler, 1988) was used in the categorical approach to account for nonnormality.

Results

Table 1 provides demographic characteristics, means, and standard deviations of the symptom subscales yielded by the Chinese versions of the SNAP-IV and SDQ at each of the four time points. To better characterize the sample, we also calculated the percentage of students who met criteria for ADHD inattentive and hyperactive/impulsive type based on the SNAP-IV. Students with ADHD inattentive type and hyperactive/impulsive type ranged from 4.4% to 8.0% and
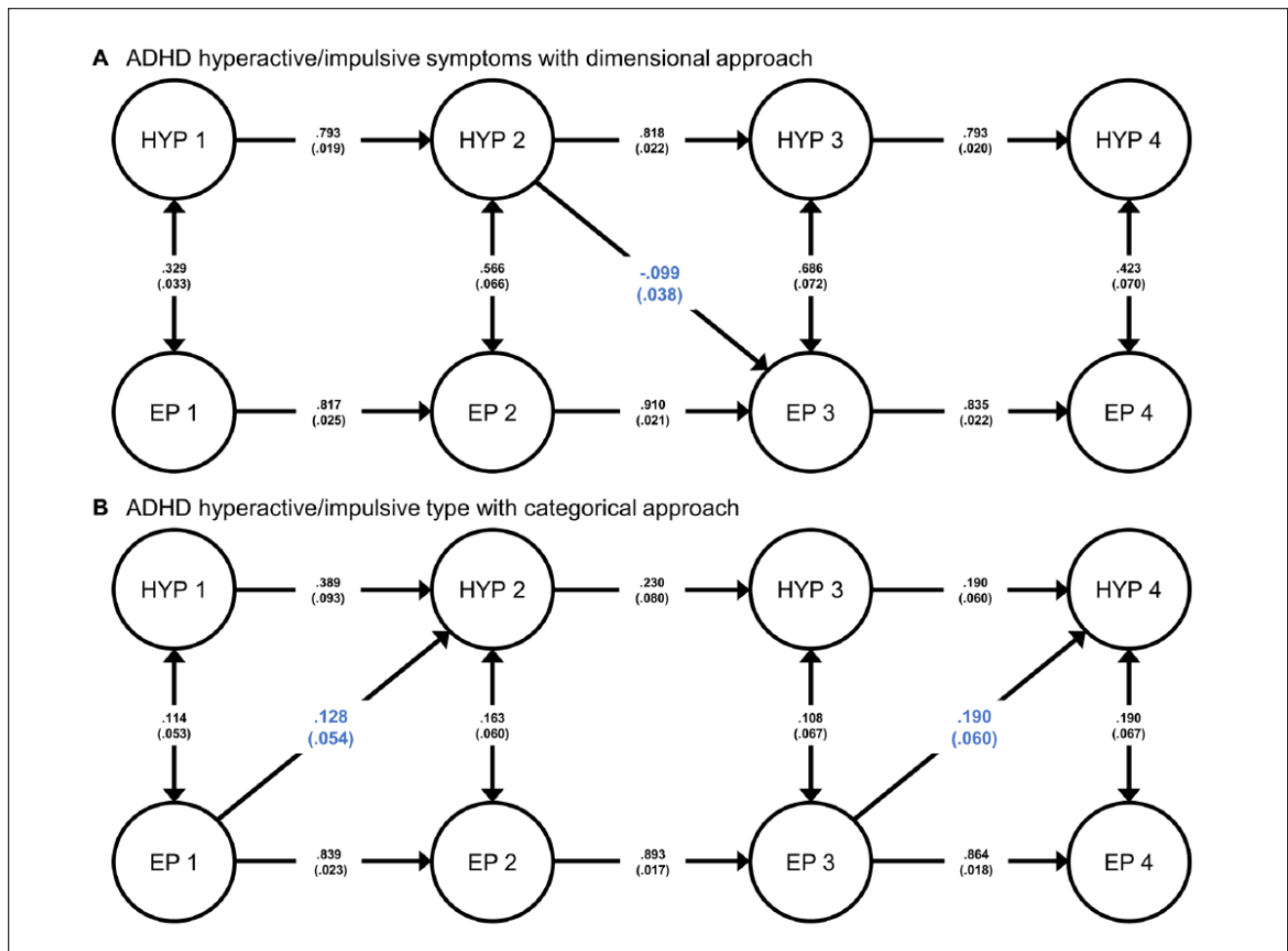
Figure 3. Cross-lagged model between hyperactivity-impulsivity symptoms and emotional problems.
Note. Part (a) illustrates the model using hyperactive/impulsive symptoms as a continuous, dimensional measure and Part (b) illustrates the model using ADHD hyperactive/impulsive type as a diagnostic category. Standardized path coefficients and standard errors (in parentheses) are presented to depict the strength of each path. HYP = hyperactivity/impulsivity in 3a and ADHD hyperactive/impulsive type in 3b; EP = emotional problems; B = standardized regression coefficients; *SE* = standard errors.

1.0% to 2.3%, respectively, from T1 to T4. At T1, 20.2% of the students were in Grade 3, 22.4% were in Grade 5, and 57.3% were in Grade 8. From T1 to T4, retention of the sample stratified by grade was as follows: 254, 219 (86.2%), 207 (81.5%), and 212 (83.5%) students for Grade 3; 281, 273 (97.2%), 270 (96.1%), and 249 (88.6%) students for Grade 5; and 718, 674 (93.9%), 646 (90.0%), and 593 (82.6%) students for Grade 8, respectively. No significant differences among participating students were found between the respondents and the nonrespondents based on gender at T2; however, by treating the participants at T1 as a reference group, the dropouts were significantly fewer in girls than boys at T3 ($\chi^2 = 13.78$, $p < .001$) and T4 ($\chi^2 = 13.33$, $p < .001$). Regarding school grade, the dropouts were significantly fewer in Grade 5 compared with Grades 3 and 8 at T2 and T3 ($ps < .001$), but not at T4 ($\chi^2 = 4.17$, $p = .125$) compared with T1. There were no significant

differences in parents' education level and occupation between dropouts and nondropouts ($p > .05$). Due to the significant differences in dropouts based on grade and sex across time points, we included grade and sex as covariates in all further analyses.

CFA

The CFA for the SNAP-IV and emotional symptoms of SDQ at T1 were satisfactory (SNAP-IV: $\chi^2 = 257.9$, $df = 8$, $p < .05$, CFI = 0.965, TLI = 0.947, and RMSEA = 0.036; SDQ: $\chi^2 = 59.9$, $df = 5$, $p < .05$, CFI = 0.931, TLI = 0.862, and RMSEA = 0.039). All factor loadings were significant at $p < .001$. These findings suggest that the constructs of emotional problems and the two ADHD symptom domains were distinct from each other in our sample of Taiwanese children and adolescents.

Table 1. Sample Characteristic of Students and Self-Report Data for ADHD and Emotional Symptoms.

Variables/student report	Time 1 (n = 1,253)	Time 2 (n = 1,166)	Time 3 (n = 1,123)	Time 4 (n = 1,054)
Gender *n* (%)				
Male	638 (50.9)	589 (50.5)	549 (48.9)	509 (48.3)
Female	615 (49.1)	577 (49.5)	573 (51)	545 (51.7)
Grade *n* (%)				
Grade 3	254 (20.3)	219 (18.8)	207 (18.4)	212 (20.1)
Grade 5	281 (22.4)	273 (23.4)	270 (24)	249 (23.6)
Grade 8	718 (57.3)	674 (57.8)	646 (57.5)	593 (56.3)
SDQ (*M* ± *SD*)				
Emotional symptoms	2.0 (1.9)	1.9 (1.9)	1.8 (1.7)	1.8 (1.8)
SNAP-IV (*M* ± *SD*)				
Inattention	6.9 (4.8)	6.4 (4.4)	6.1 (4.2)	6.2 (4.2)
Hyperactive-impulsive	3.6 (4.0)	3.4 (3.6)	3.1 (3.3)	3.2 (3.5)
ADHD inattentive type, *n* (%)	92 (8.0)	69 (6.0)	50 (4.4)	54 (4.7)
ADHD hyp/imp type, *n* (%)	26 (2.3)	22 (1.9)	11 (1.0)	20 (1.7)

Note. SDQ = Strengths and Difficulties Questionnaire; SNAP-IV = Swanson, Nolan, and Pelham–IV.

Reciprocal Relations Between Inattention and Emotional Problems

The first cross-lagged model is a two-factor model examining the temporal and reciprocal relations between inattention and emotional problems (Figure 2a). We examined the autoregressive, contemporaneous, and cross-lagged path coefficients to interpret the size of the relations for these paths. Path coefficients with $p < .05$ were considered statistically significant. When examining inattention symptoms dimensionally, results indicate longitudinal stability of inattention symptoms and emotional problems across the four time points: ADHD inattention symptoms with Standardized B (*SE*) = 0.738 (.021) from T1 to T2, 0.758 (.017) from T2 to T3, and 0.694 (.021) from T3 to T4; emotional problems with Standardized B (*SE*) = 0.825 (.028) from T1 to T2, 0.824 (.023) from T2 to T3, 0.811 (.041) from T3 to T4. As Figure 2a shows, contemporaneous paths at T1, T2, and T4 reached statistical significance; at T3, the path was marginally significant. When examining cross-lagged paths, emotional problems positively predicted inattention symptoms at the next time point, B (*SE*) = 0.143 (.034) from T1 to T2, .117 (.031) from T2 to T3, and .226 (.030) from T3 to T4. A similar pattern of temporal and reciprocal effects emerged when we used ADHD inattentive type as a binary variable (Figure 2b). However, the prediction of emotional problems at T2 to ADHD inattentive type at T3 was no longer significant, while ADHD inattentive type at T3 significantly predicted emotional problems at T4.

Reciprocal Relations Between Hyperactivity and Emotional Problems

The second cross-lagged model tested the temporal and reciprocal relations between hyperactivity symptoms and emotional problems. In the dimensional model (Figure 3a), all stability and contemporaneous paths were significant. Looking at cross-lagged paths, hyperactivity symptoms at T2 significantly negatively predicted emotional problems at T3, B (*SE*) = −0.099 (.038), while hyperactivity symptoms at T3 positively predicted emotional problems at T4 with marginal significance, B (*SE*) = 0.070 (.036), $p = .054$. Model fit indices for this model were as follows: $\chi^2 = 4{,}798.884$, $df = 502$, $p < .05$; CFI = .758; TLI = 0.730; RMSEA = 0.086, indicating adequate model fit. By contrast, when ADHD hyperactive/impulsive type was treated categorically (Figure 3b), an opposite prediction pattern was found, such that ADHD hyperactive/impulsive type did not significantly predict emotional problems from T1 to T4, while emotional problems at T1 and T3 positively predicted ADHD hyperactive/impulsive type at T2 and T4, respectively.

Discussion

The primary goal of this study was to better understand the temporal and reciprocal associations between ADHD inattention and hyperactivity/impulsivity symptoms with emotional problems in children and adolescents over time in a Chinese cultural context. Previous studies have documented the *association* between emotional problems and ADHD symptomatology, but the directionality of effects over time remains understudied. To our knowledge, this is the first study to investigate the reciprocal relations between ADHD inattention symptoms, hyperactivity/impulsivity symptoms, and emotional problems over time.

Due to the paucity of previous literature examining the directionality of effects between emotional problems and ADHD symptoms, this study examined two cross-lagged panel models to represent possible relations between

impairment due to ADHD symptoms and emotional problems using a four-wave prospective longitudinal design. Our primary findings are as follows: (a) ADHD symptoms and emotional symptoms were stable across time, (b) ADHD symptoms (both inattention and hyperactivity/impulsivity) and emotional symptoms were associated with each other across time, and (c) inattention symptoms demonstrated reciprocal relations with emotional problems, whereas hyperactivity/impulsivity symptoms did not.

Distinct Pattern of Effect for Inattention Compared With Hyperactivity/Impulsivity on Emotional Problems

The first cross-lagged model examining reciprocal relations between inattention and emotional problems suggested the presence of a bidirectional relationship between inattention and emotional problems over the 1-year period. When inattention symptoms were considered both dimensionally and in the context of a categorical diagnosis of ADHD inattentive type, results suggested a transactional relation between inattention and emotional problems such that emotional problems at T1 positively predicted inattention at T2, which predicted emotional problems at T3, followed by a prediction of inattention at T4. In contrast, this temporally reciprocal pattern was not found when assessing hyperactivity/impulsivity symptoms and emotional problems in the same model. In fact, the only significant cross-lagged path indicated that hyperactivity/impulsivity symptoms at T2 negatively predicted emotional problems at T3. When we conducted a secondary and complementary analysis treating ADHD hyperactive/impulsive type as a categorical predictor, emotion problems at T1 and T3 predicted subsequent diagnosis at T2 and T4, but diagnosis did not predict future emotion problems. Overall, our findings are consistent with previous longitudinal studies (Meinzer et al., 2017; Smith et al., 2017), indicating that, in general, childhood ADHD symptoms significantly predict emotional and behavioral maladjustment during middle school. For specific subtypes of ADHD, previous studies have posited that both inattention and hyperactivity/impulsivity symptoms play a role in the onset of emotional problems. Specifically, inattention has been hypothesized to be more linked to low effortful control and difficulties with emotion regulation, while hyperactivity/impulsivity may be more related to low frustration tolerance and sudden shifts toward negative emotions (Martel, 2009; Martel & Nigg, 2006; Nigg & Casey, 2005).

Undoubtedly, the emotional consequences of both ADHD symptom domains are difficult to parse as they are associated with related and overlapping constructs in emotional development. Interestingly, however, results from the current study indicate that the pattern of *transactional* relations between emotional problems and inattention is distinct compared with that of hyperactivity/impulsivity symptoms. These findings are consistent with a population-based study by Sørensen, Hugdahl, and Lundervold (2008), who showed that when inattention is considered dimensionally, children characterized as inattentive are at high risk for exhibiting emotional problems, as defined by the SDQ emotional problems subscale. Furthermore, both inattention and emotional problems have been shown to predict measures of cognitive control—a core deficit for children with ADHD—in primary school-aged children (Sørensen, Plessen, & Lundervold, 2012). Of note, our categorical model using ADHD hyperactive/impulsive *diagnosis* and emotional problems as primary variables revealed that heightened emotional problems predicted higher likelihood of diagnosis (at least six out of nine hyperactive/impulsive symptom items on the SNAP-IV) at future time points. This finding suggests that high levels of physical (e.g., headaches, stomachaches) and internalizing (e.g., unhappy, worries often, nervous) symptoms associated with emotional distress are present before students exceed a diagnostic threshold of more readily observed hyperactive/impulsive symptoms (e.g., fidgeting, blurting out, restlessness). This finding is consistent with previous studies suggesting that emotional symptoms that include irritability, lower frustration or distress tolerance, and intense sadness/dysphoria are particularly associated with the hyperactive/impulsive symptoms associated with ADHD (Sobanski et al., 2010).

Whereas the link between emotional problems and hyperactivity/impulsivity symptoms and emotional problems is more visibly apparent in children in the form of externalizing behaviors, our findings suggest that the connection with inattention is more mechanistic, such that difficulties in the allocation of one's attentional resources hinder the development of internalized rules for emotion regulation, social adjustment, and socialization in childhood (Eisenberg, Hofer, & Vaughan, 2007; Eisenberg, Spinrad, & Smith, 2004). Furthermore, our findings are also consistent with previous work attributing the emergence of emotion dysregulation to deficits in the ability to orient toward, recognize, and adaptively allocate attention to emotional stimuli (Shaw, Stringaris, Nigg, & Leibenluft, 2014). Individuals with such attentional and processing deficits of emotional information have also been shown to demonstrate attentional biases toward negative versus positive stimuli and perform more poorly on the emotional Stroop task, where they are asked to deflect attention from emotional features of a face and attend to nonemotional features, compared with unaffected controls (Passarotti, Sweeney, & Pavuluri, 2010). Thus, in line with our findings, increased inattention symptoms in children may reflect underlying cognitive vulnerabilities that interfere with one's ability to seek, develop, and maintain emotional competence and peer relationships. In turn, these children experience the transactional and continued exacerbation of *both* emotional problems and attentional impairment over time.

Furthermore, our results also warrant discussion within the context of our study sample. The finding that only inattention (not hyperactivity/impulsivity) predicted future

emotional problems suggests that attention problems may have more robust long-term effects on the emotional well-being of children in middle childhood and early adolescence. From a clinical perspective, studies have shown that, overall, ADHD symptoms tend to remit over time, with hyperactivity/impulsivity symptoms declining at a higher rate compared with inattention symptoms (Biederman, Mick, & Faraone, 2000). The differential symptomatic decline pattern highlights the role of attentional problems: Even as the severity of overall ADHD ameliorates over time, affected individuals may still experience persistent emotional impairment due to unremitting attention problems. Moreover, our findings may have also been influenced by the fact that our sample was a community—not a clinical—sample. Previous studies using both Western and Chinese community samples have similarly showed that inattention symptoms are associated with interpersonal problems and decreased number and quality of friendships (Scholtens, Diamantopoulou, Tillman, & Rydell, 2012; Tseng et al., 2014), which are both relevant to emotional well-being. Thus, clinical samples of ADHD could potentially show stronger associations between hyperactivity/impulsivity and social and emotional problems because of more representation of these symptoms. This idea is consistent with clinical samples in Taiwan where parents are more likely to seek help for children exhibiting severe hyperactivity/impulsivity symptoms due to overt difficulties with peers and noncompliance in the school setting (Gau et al., 2010). Our findings highlighting the role of inattention may have also been influenced by high expectations in the school setting, including organization, compliance, and preservation of group harmony that are emphasized in Chinese culture. As such, Taiwanese students may also be more emotionally vulnerable to attentional demands in elementary and middle school years. It is also possible that parents may have underreported about children's hyperactivity/impulsivity symptoms due to cultural stigma against having a child with disruptive and noncompliant behaviors. Though we cannot formally conduct a cross-cultural comparison in the current study due to a lack of a Western comparison group, our findings are consistent with previous work outlined above that support the mechanistic role of attention in the development of adaptive emotional processes.

Limitations and Future Directions

The primary strength of this study is that it is the first to address reciprocal and temporal relations between ADHD symptoms and emotional problems. In addition, these relations were examined using both dimensional impairment due to ADHD-related symptoms and categorical diagnostic status. However, this study is not without limitations. A primary limitation is that the study period only took place over a 1-year period. Previous literature indicates that emotional problems may occur at increased rates in adolescence. Our

sample consisted of children and adolescents aged between 8 and 17 years. Therefore, our sample characteristics and the relatively short, 1-year period may not be sufficient to capture meaningful points of symptom development and change. Considering that data were collected as part of a school-based survey study, our diagnostic classification of individuals based on the SNAP-IV should be interpreted with caution and results of the categorical cross-lagged models may have limited generalizability to a clinical sample.

Moreover, the current study employed a relatively broad measure of emotional problems and is thus unable to comment on underlying mechanisms that may explain the underpinnings of the reciprocal relations between emotional problems and inattention symptoms. Furthermore, previous work has hypothesized the role of parental skill, academic achievement, maternal adjustment, and other environmental factors to explain the emergence of emotional problems in ADHD (Wehmeier et al., 2010). In the current study, we were unable to comment on these relations due to our limited set of measures. Despite these limitations, a notable strength is that the prospective longitudinal design and use of cross-lagged models allowed for a novel examination of transactional relations between ADHD symptoms and emotional problems over time. Importantly, future studies are warranted to clarify and replicate the directionality of effects between core ADHD symptom domains and emotional problems. Future work may examine these relations over a longer duration of time to gain a deeper understanding of the interplay between ADHD and emotional problems throughout development. In addition, we recommend replication of this study in a Western sample or inclusion of a Western comparison sample in future studies to adequately elucidate the presence of cross-cultural similarities and differences in the role of inattention and hyperactivity/impulsivity symptoms on emotional well-being over time.

Conclusion

The current study supports a bidirectional and complex model of the development of ADHD symptoms and emotional problems in childhood and adolescence. When only inattention and emotional problems are considered, there appears to be a reciprocal relationship between the two factors over time where emotional problems and inattention symptoms mutually and positively predict each other. This pattern of effects was not found when only hyperactivity/impulsivity symptoms and emotional problems were considered. Our preliminary results suggest that increased inattention symptoms may play a more prominent role in the bidirectionality and persistence of emotional problems in school-age children. In addition to addressing the reciprocal relations between ADHD symptoms and emotional problems, this work also informs ongoing research questions regarding the etiology, typology, and treatment of ADHD as

it relates to co-occurring deficits in emotion regulation and social competence. Our study continues to highlight the clinically informative and longitudinal overlap between these domains to stimulate novel therapeutic approaches that acknowledge how ADHD and emotional problems may work in concert to affect functional impairment and quality of life.

Authors' Note

Gloria T. Han and Yi-Lung Chen contributed equally to this work as the first author.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

ORCID iDs

Yi-Lung Chen https://orcid.org/0000-0003-2934-5814
Susan Shur-Fen Gau https://orcid.org/0000-0002-8372-5685

References

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Anastopoulos, A. D., Smith, T. F., Garrett, M. E., Morrissey-Kane, E., Schatz, N. K., Sommer, J. L., . . . Ashley-Koch, A. (2011). Self-regulation of emotion, functional impairment, and comorbidity among children with AD/HD. *Journal of Attention Disorders*, *15*, 583-592.

Barkley, R. A., & Fischer, M. (2010). The unique contribution of emotional impulsiveness to impairment in major life activities in hyperactive children as adults. *Journal of the American Academy of Child & Adolescent Psychiatry*, *49*, 503-513.

Becker, A., Steinhausen, H. C., Baldursson, G., Dalsgaard, S., Lorenzo, M. J., & Ralston, S. J. . . . ADORE Study Group. (2006). Psychopathological screening of children with ADHD: Strengths and Difficulties Questionnaire in a pan-European study. *European Child & Adolescent Psychiatry*, *15*(1), i56-i62.

Biederman, J., Mick, E., & Faraone, S. V. (2000). Age-dependent decline of symptoms of attention deficit hyperactivity disorder: Impact of remission definition and symptom type. *American Journal of Psychiatry*, *157*, 816-818.

Biederman, J., Petty, C. R., Woodworth, K. Y., Lomedico, A., Hyder, L. L., & Faraone, S. V. (2012). Adult outcome of attention-deficit/hyperactivity disorder: A controlled 16-year follow-up study. *The Journal of Clinical Psychiatry*, *73*, 941-950.

Brocki, K. C., Forslund, T., Frick, M., & Bohlin, G. (2017). Do individual differences in early affective and cognitive self-regulation predict developmental change in ADHD symptoms from preschool to adolescence? *Journal of Attention Disorders*. Advance online publication. doi:10.1177/1087054717693372

Browne, M. W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research*, *21*, 230-258.

Bunford, N., Evans, S. W., & Langberg, J. M. (2018). Emotion dysregulation is associated with social impairment among young adolescents with ADHD. *Journal of Attention Disorders*, *22*, 66-82.

Bunford, N., Evans, S. W., & Wymbs, F. (2015). ADHD and emotion dysregulation among children and adolescents. *Clinical Child and Family Psychology Review*, *18*, 185-217.

Butler, E. A., Lee, T. L., & Gross, J. J. (2007). Emotion regulation and culture: Are the social consequences of emotion suppression culture-specific? *Emotion*, *7*(1), 30-48.

Castellanos, F. X., & Proal, E. (2012). Large-scale brain systems in ADHD: Beyond the prefrontal–striatal model. *Trends in Cognitive Sciences*, *16*(1), 17-26.

Chen, X., & French, D. C. (2008). Children's social competence in cultural context. *Annual Review of Psychology*, *59*, 591-616.

Chen, Y. I., & Gau, S. S. F. (2016). Sleep problems and internet addiction among children and adolescents: A longitudinal study. *Journal of Sleep Research*, *25*, 458-465.

Chen, Y. L., Shen, L. J., & Gau, S. S. F. (2017). The Mandarin version of the Kiddie-Schedule for Affective Disorders and Schizophrenia-Epidemiological version for DSM–5–A psychometric study. *Journal of the Formosan Medical Association*, *116*, 671-678.

Chiang, H. L., Huang, L. W., Gau, S. S. F., & Shang, C. Y. (2013). Associations of symptoms and subtypes of attention-deficit hyperactivity disorder with visuospatial planning ability in youth. *Research in Developmental Disabilities*, *34*, 2986-2995.

Coghill, D., Spiel, G., Baldursson, G., Döpfner, M., Lorenzo, M. J., Ralston, S. J. . . . ADORE Study Group. (2006). Which factors impact on clinician-rated impairment in children with ADHD? *European Child & Adolescent Psychiatry*, *15*(1), i30-i37.

Cole, P. M., Martin, S. E., & Dennis, T. A. (2004). Emotion regulation as a scientific construct: Methodological challenges and directions for child development research. *Child Development*, *75*, 317-333.

Eisenberg, N., Hofer, C., & Vaughan, J. (2007). Effortful control and its socioemotional consequences. In James. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 287-288). New York, NY, US: Guilford Press.

Eisenberg, N., & Spinrad, T. L. (2004). Emotion-related regulation: Sharpening the definition. *Child Development*, *75*, 334-339.

Eisenberg, N., Spinrad, T. L., & Smith, C. L. (2004). Emotion-related regulation: Its conceptualization, relations to social functioning, and socialization. In James. J. Gross (Ed.),*The regulation of emotion* (pp. 277-306). New York, NY, US: Guilford Press.

Factor, P. I., Rosen, P. J., & Reyes, R. A. (2016). The relation of poor emotional awareness and externalizing behavior among children with ADHD. *Journal of Attention Disorders*, *20*, 168-177.

Faraone, S. V., Sergeant, J., Gillberg, C., & Biederman, J. (2003). The worldwide prevalence of ADHD: Is it an American condition? *World Psychiatry*, *2*, 104-113.

Gau, S. S. F., & Chiang, H. L. (2013). Association between early attention-deficit/hyperactivity symptoms and current verbal and visuo-spatial short-term memory. *Research in Developmental Disabilities*, *34*, 710-720.

Gau, S. S. F., Chong, M. Y., Chen, T. H., & Cheng, A. T. (2005). A 3-year panel study of mental disorders among adolescents in Taiwan. *American Journal of Psychiatry*, *162*, 1344-1350.

Gau, S. S. F., Ni, H. C., Shang, C. Y., Soong, W. T., Wu, Y. Y., Lin, L. Y., & Chiu, Y. N. (2010). Psychiatric comorbidity among children and adolescents with and without persistent attention-deficit hyperactivity disorder. *Australian & New Zealand Journal of Psychiatry*, *44*, 135-143.

Gau, S. S. F., Shang, C. Y., Liu, S. K., Lin, C. H., Swanson, J. M., Liu, Y. C., & Tu, C. L. (2008). Psychometric properties of the Chinese version of the Swanson, Nolan, and Pelham, Version IV Scale–Parent Form. *International Journal of Methods in Psychiatric Research*, *17*(1), 35-44.

Gau, S. S. F., Tseng, W. L., Tseng, W. Y., Wu, Y. H., & Lo, Y. C. (2015). Association between microstructural integrity of frontostriatal tracts and school functioning: ADHD symptoms and executive function as mediators. *Psychological Medicine*, *45*, 529-543.

Goldsmith, H. H., & Davidson, R. J. (2004). Disambiguating the components of emotion regulation. *Child Development*, *75*, 361-365.

Goodman, R., & Scott, S. (1999). Comparing the Strengths and Difficulties Questionnaire and the Child Behavior Checklist: Is small beautiful? *Journal of Abnormal Child Psychology*, *27*, 17-24.

Hays, R. D., Marshall, G. N., Wang, E. Y. I., & Sherbourne, C. D. (1994). Four-year cross-lagged associations between physical and mental health in the Medical Outcomes Study. *Journal of Consulting and Clinical Psychology*, *62*, 441-449.

Hinshaw, S. P. (2003). Impulsivity, emotion regulation, and developmental psychopathology: Specificity versus generality of linkages. *The ANNALS of the New York Academy of Sciences*, *1008*, 149-159.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1-55.

Jarrett, M. A., Wolff, J. C., Davis, T. E., III., Cowart, M. J., & Ollendick, T. H. (2016). Characteristics of children with ADHD and comorbid anxiety. *Journal of Attention Disorders*, *20*, 636-644.

Kawabata, Y., Tseng, W. L., & Gau, S. S. F. (2012). Symptoms of attention-deficit/hyperactivity disorder and social and school adjustment: The moderating roles of age and parenting. *Journal of Abnormal Child Psychology*, *40*, 177-188.

Lin, Y. J., & Gau, S. S. (2017). Differential neuropsychological functioning between adolescents with attention-deficit/hyperactivity disorder with and without conduct disorder. *Journal of the Formosan Medical Association*, *116*, 946-955.

Lin, Y. J., Chen, W. J., & Gau, S. S. (2014). Neuropsychological functions among adolescents with persistent, subsyndromal and remitted attention deficit hyperactivity disorder. *Psychological Medicine*, *44*, 1765-1777.

Little, T. D., Rhemtulla, M., Gibson, K., & Schoemann, A. M. (2013). Why the items versus parcels controversy needn't be one. *Psychological Methods*, *18*, 285-300.

Liu, C. Y., Huang, W. L., Kao, W. C., & Gau, S. S. F. (2017). Influence of disruptive behavior disorders on academic performance and school functions of youths with attention-deficit/hyperactivity disorder. *Child Psychiatry & Human Development*, *48*, 870-880.

Liu, S. K., Chien, Y. L., Shang, C. Y., Lin, C. H., Liu, Y. C., & Gau, S. S. F. (2013). Psychometric properties of the Chinese version of Strength and Difficulties Questionnaire. *Comprehensive Psychiatry*, *54*, 720-730.

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods*, *1*, 130-149.

Martel, M. M. (2009). Research review: A new perspective on attention-deficit/hyperactivity disorder: Emotion dysregulation and trait models. *Journal of Child Psychology and Psychiatry*, *50*, 1042-1051.

Martel, M. M., & Nigg, J. T. (2006). Child ADHD and personality/temperament traits of reactive and effortful control, resiliency, and emotionality. *Journal of Child Psychology and Psychiatry*, *47*, 1175-1183.

Martel, M. M., Roberts, B., Gremillion, M., Von Eye, A., & Nigg, J. T. (2011). External validation of bifactor model of ADHD: Explaining heterogeneity in psychiatric comorbidity, cognitive control, and personality trait profiles within DSM-IV ADHD. *Journal of abnormal child psychology*, *39*, 1111-1123.

Meinzer, M. C., & Chronis-Tuscano, A. (2017). ADHD and the development of depression: Commentary on the prevalence, proposed mechanisms, and promising interventions. *Current Developmental Disorders Reports*, *4*, 1-4.

Meinzer, M. C., Pettit, J. W., & Viswesvaran, C. (2014). The co-occurrence of attention-deficit/hyperactivity disorder and unipolar depression in children and adolescents: A meta-analytic review. *Clinical Psychology Review*, *34*, 595-607.

Miller, M., & Hinshaw, S. P. (2010). Does childhood executive function predict adolescent functional outcomes in girls with ADHD? *Journal of Abnormal Child Psychology*, *38*, 315-326.

Nigg, J. T., & Casey, B. J. (2005). An integrative theory of attention-deficit/hyperactivity disorder based on the cognitive and affective neurosciences. *Development and Psychopathology*, *17*, 785-806.

Pan, P. Y., & Yeh, C. B. (2017). Impact of depressive/anxiety symptoms on the quality of life of adolescents with ADHD: A community-based 1-year prospective follow-up study. *European Child & Adolescent Psychiatry*, *26*, 659-667.

Passarotti, A. M., Sweeney, J. A., & Pavuluri, M. N. (2010). Differential engagement of cognitive and affective neural systems in pediatric bipolar disorder and attention deficit hyperactivity disorder. *Journal of the International Neuropsychological Society*, *16*, 106-117.

Polanczyk, G., De Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The worldwide prevalence of ADHD: A systematic review and metaregression analysis. *American Journal of Psychiatry*, *164*, 942-948.

Reale, L., Bartoli, B., Cartabia, M., Zanetti, M., Costantino, M. A., Canevini, M. P., . . . Lombardy ADHD Group. (2017). Comorbidity prevalence and treatment outcome in children and adolescents with ADHD. *European Child & Adolescent Psychiatry*, *26*, 1443-1457.

Rothbart, M. K., Sheese, B. E., & Posner, M. I. (2007). Executive attention and effortful control: Linking temperament, brain networks, and genes. *Child Development Perspectives*, *1*, 2-7.

Satorra, A., & Bentler, P. (1988). Scaling Corrections for Statistics in Covariance Structure Analysis. *UCLA: Department of Statistics, UCLA*. Retrieved from https://escholarship.org/uc/item/3141h70c

Schei, J., Jozefiak, T., Nøvik, T. S., Lydersen, S., & Indredavik, M. S. (2016). The impact of coexisting emotional and conduct problems on family functioning and quality of life among adolescents with ADHD. *Journal of Attention Disorders*, *20*, 424-433.

Scholtens, S., Diamantopoulou, S., Tillman, C. M., & Rydell, A. M. (2012). Effects of symptoms of ADHD, ODD, and cognitive functioning on social acceptance and the positive illusory bias in children. *Journal of Attention Disorders*, *16*, 685-696.

Serrano, V. J., Owens, J. S., & Hallowell, B. (2018). Where children with ADHD direct visual attention during emotion knowledge tasks: Relationships to accuracy, response time, and ADHD symptoms. *Journal of Attention Disorders*, *22*, 752-763.

Seymour, K. E., Chronis-Tuscano, A., Halldorsdottir, T., Stupica, B., Owens, K., & Sacks, T. (2012). Emotion regulation mediates the relationship between ADHD and depressive symptoms in youth. *Journal of Abnormal Child Psychology*, *40*, 595-606.

Seymour, K. E., Chronis-Tuscano, A., Iwamoto, D. K., Kurdziel, G., & MacPherson, L. (2014). Emotion regulation mediates the association between ADHD and depressive symptoms in a community sample of youth. *Journal of Abnormal Child Psychology*, *42*, 611-621.

Shaw, P., Stringaris, A., Nigg, J., & Leibenluft, E. (2014). Emotion dysregulation in attention deficit hyperactivity disorder. *American Journal of Psychiatry*, *171*, 276-293.

Sjöwall, D., Roth, L., Lindqvist, S., & Thorell, L. B. (2013). Multiple deficits in ADHD: Executive dysfunction, delay aversion, reaction time variability, and emotional deficits. *Journal of Child Psychology and Psychiatry*, *54*, 619-627.

Smith, E., Meyer, B. J., Koerting, J., Laver-Bradbury, C., Lee, L., Jefferson, H., . . . Sonuga-Barke, E. J. (2017). Preschool hyperactivity specifically elevates long-term mental health risks more strongly in males than females: A prospective longitudinal study through to young adulthood. *European Child & Adolescent Psychiatry*, *26*, 123-136.

Sobanski, E., Banaschewski, T., Asherson, P., Buitelaar, J., Chen, W., Franke, B., . . . Stringaris, A. (2010). Emotional lability in children and adolescents with attention deficit/hyperactivity disorder (ADHD): Clinical correlates and familial prevalence. *Journal of Child Psychology and Psychiatry*, *51*, 915-923.

Sørensen, L., Hugdahl, K., & Lundervold, A. J. (2008). Emotional symptoms in inattentive primary school children: A population-based study. *Journal of Attention Disorders*, *11*, 580-587.

Sørensen, L., Plessen, K. J., & Lundervold, A. J. (2012). The impact of inattention and emotional problems on cognitive control in primary school children. *Journal of Attention Disorders*, *16*, 589-599.

Spencer, T. J., Faraone, S. V., Surman, C. B., Petty, C., Clarke, A., Batchelder, H., . . . Biederman, J. (2011). Toward defining deficient emotional self-regulation in children with attention-deficit/hyperactivity disorder using the Child Behavior Checklist: A controlled study. *Postgraduate Medicine*, *123*(5), 50-59.

Strine, T. W., Lesesne, C. A., Okoro, C. A., McGuire, L. C., Chapman, D. P., Balluz, L. S., & Mokdad, A. H. (2006). Emotional and behavioral difficulties and impairments in everyday functioning among children with a history of attention-deficit/hyperactivity disorder. *Preventing Chronic Disease*, *3*(2), Article A52.

Stringaris, A., & Goodman, R. (2009). Longitudinal outcome of youth oppositionality: Irritable, headstrong, and hurtful behaviors have distinctive predictions. *Journal of the American Academy of Child & Adolescent Psychiatry*, *48*, 404-412.

Stringaris, A., Maughan, B., & Goodman, R. (2010). What's in a disruptive disorder? Temperamental antecedents of oppositional defiant disorder: Findings from the Avon longitudinal study. *Journal of the American Academy of Child & Adolescent Psychiatry*, *49*, 474-483.

Swanson, J. M., Kraemer, H. C., Hinshaw, S. P., Arnold, L. E., Conners, C. K., Abikoff, H. B., . . . Hechtman, L. (2001). Clinical relevance of the primary findings of the MTA: Success rates based on severity of ADHD and ODD symptoms at the end of treatment. *Journal of the American Academy of Child & Adolescent Psychiatry*, *40*, 168-179.

Thorell, L. B., Sjöwall, D., Diamatopoulou, S., Rydell, A. M., & Bohlin, G. (2017). Emotional functioning, ADHD symptoms, and peer problems: A longitudinal investigation of children age 6-9.5 years. *Infant and Child Development*, *26*(4), e2008.

Tsai, C. J., Chen, Y. L., Lin, H. Y., & Gau, S. S. F. (2017). One-year trajectory analysis for ADHD symptoms and its associated factors in community-based children and adolescents in Taiwan. *Child and adolescent psychiatry and mental health*, *11*(1), 28.

Tseng, W. L., Kawabata, Y., Gau, S. S. F., & Crick, N. R. (2014). Symptoms of attention-deficit/hyperactivity disorder and peer functioning: A transactional model of development. *Journal of Abnormal Child Psychology*, *42*, 1353-1365.

Wehmeier, P. M., Schacht, A., & Barkley, R. A. (2010). Social and emotional impairment in children and adolescents with ADHD and the impact on quality of life. *Journal of Adolescent Health*, *46*, 209-217.

Author Biographies

Gloria Han is a doctoral candidate in the Department of Psychology at Vanderbilt University.

Yi-Lung Chen is a doctoral student in the Graduate Institute of Epidemiology and Preventive Medicine, College of Public Health, at National Taiwan University.

Fang-Ju Tsai is a child and adolescent psychiatrist in the Department of Psychiatry at National Taiwan University Hospital and College of Medicine.

Susan Shur-Fen Gau is a professor in the Department of Psychiatry at National Taiwan University Hospital and College of Medicine.