Title
The Differential Longitudinal Effect of Early Pubertal Timing on Two Domains of Externalizing Behaviors From Adolescence to Young Adulthood

Permalink
https://escholarship.org/uc/item/13f5q1p6

Author
Dimler, Laura M

Publication Date
2018

License
CC BY 4.0

Peer reviewed|Thesis/dissertation
The Differential Longitudinal Effect of Early Pubertal Timing on Two Domains of Externalizing Behaviors From Adolescence to Young Adulthood

A Dissertation submitted in partial satisfaction of the requirements for the degree of

Doctor of Philosophy

in

Psychology

by

Laura Marie Dimler

June 2018

Dissertation Committee:
   Dr. Misaki N. Natsuaki, Chairperson
   Dr. Chandra A. Reynolds
   Dr. Tuppett M. Yates
The Dissertation of Laura Marie Dimler is approved:

______________________________________________________________

______________________________________________________________

______________________________________________________________

Committee Chairperson

University of California, Riverside
ACKNOWLEDGMENTS

This accomplishment would not be possible without the support, encouragement, and love from multiple individuals. Thank you to everyone in my life who has given me unwavering support and advice over the last 5 years through all the ups and downs.

First and foremost, I need to thank and acknowledge my advisor, Dr. Misaki N. Natsuaki for all her support, feedback, reassurance, and advice – both professional and personal – throughout my five years of training at UC Riverside. She has pushed me to be a better critical thinker, writer, and researcher, shown me how to both widen and narrow my interests when applicable, and has always kept my professional interests and goals in mind when helping me craft a plan for my training. Her fierce dedication to all of her ‘academic children’ is apparent to all of us in the lab and I will always be grateful that she chose me to be a part of her academic family.

Additionally, I am grateful to Drs. Chandra Reynolds and Tuppett Yates for serving on all committees throughout my doctoral training – they have imparted more wisdom and knowledge on me than they realize. Their courses and my conversations with them outside of the classroom were helpful, exciting, and simply enjoyable. Dr. Reynolds always made time for me and other lab mates throughout the last five years to assist in statistical training and interpretation. She pushed me and helped me realize that I can do more with statistics than I ever thought was possible – thank you for helping me push out of that self-imposed boundary. Dr. Yates taught me the importance of speaking up for myself, to consider all possibilities of a child’s background when thinking as a developmental psychopathologist, and for always holding me to a high standard. I will never forget when she called me after my written qualifying exams and said, “You are better than this.” That has now become a
mantra of mine. I also want to thank my undergraduate faculty mentor, Dr. Jennifer Harriger at Pepperdine University, who was the first person to truly take an interest in my academic future and help me realize my full potential as a scholar and teacher. You are the one who instilled this career goal of mine. Without a doubt, I would not be obtaining a Ph.D. without your assistance during my undergraduate years. I will always hold you in high esteem and am grateful for your continued advice and friendship during my graduate years.

I am also indebted to individuals who journeyed through the doctoral program alongside me. Specifically, my Developmental Transitions Labmates, both past and present. I will always be grateful to (almost Dr.) Danielle Samuels and Sofia Stepanyan for their support, the wine and cheese nights, and the endless conversations that fostered support over my doctoral training. You two have become close friends and I am appreciative of the calming phone calls and being able to bounce ideas off of you two. I am also thankful to Agnes Varghese, Jing Yang, Dr. Carly Dierkhising, and Dr. Shelly McCoy for encouragement, feedback, and advice on multiple presentations and papers throughout the last 5 years. I am also grateful for Fanita Tyrell’s feedback and help on statistical analyses and decisions throughout this dissertation process. This dissertation would have been much more stressful without her advice.

To my supportive and loving husband, Nick, who has supported my career and training over the last 1.5 years. You have endured hours of listening and have only offered your steadfast support and understanding no matter if you are on the couch with me or 7,000 miles away on deployment. I am looking forward to our next chapter together more than you know. I am eternally grateful to my parents who instilled a passion for reading, learning, and education from the very beginning. You made many sacrifices to ensure I had the best
education possible, taught me to persevere through any obstacles I may face, and have let me know that I can achieve anything as long as I work hard and stay humble. Finally, none of these achievements or relationships would be remotely possible if it were not for my faith in Jesus Christ. Without Him, I would not have the understanding, strength, and self-discipline that I currently have in order to successfully complete my doctoral degree.
ABSTRACT OF THE DISSERTATION

The Differential Longitudinal Effect of Early Pubertal Timing on Two Domains of Externalizing Behaviors From Adolescence to Young Adulthood

by

Laura Marie Dimler

Doctor of Philosophy, Graduate Program in Psychology
University of California, Riverside, June 2018
Dr. Misaki N. Natsuaki, Chairperson

Early pubertal timing consistently shows to have a deleterious effect on adolescent problem behaviors, with mixed research regarding the duration of the effect (i.e., concurrent or longitudinal). Part of the reason for the mixed research may be that externalizing behaviors is too broad of a term to describe a wide range of behaviors, thus the purpose of this dissertation was to assess if and when the deleterious early maturation effect wanes in externalizing behaviors, specifically two domains of externalizing behaviors: nonviolent and violent behaviors. This study used the National Longitudinal Study of Adolescent to Adult Health (Add Health) dataset, a longitudinal, nationally representative dataset spanning 4 waves and 14 years ($M_{age,\text{Wave1}} = 14.6$ years; 52.8% female; $N = 4,255$).

One of the unique features of this study is that it incorporates age-appropriate items of violent and nonviolent behaviors in assessing externalizing behaviors from early adolescence (i.e., age 12) through young adulthood (i.e., age 30) via a parceling technique in a measurement invariance model. The measurement invariance analysis indicated partial strong factorial invariance, suggesting that nonviolent and violent behaviors had the same underlying structure over time, respectively, despite a change in measurement items to
accommodate the age of the participants. Next, results from longitudinal growth curve analyses suggested that early maturing adolescents reported significantly elevated overall externalizing, nonviolent, and male violent behaviors throughout adolescence but became indistinguishable from on-time and late-maturers after adolescence, thus supporting the attenuation hypothesis. Most interestingly, the main effect of pubertal timing was only significant for the trajectory of males’ violent behaviors, but not females’ violent behavior, such that early maturing males engaged in more violent behaviors at age 12, but these early maturers declined at a more rapid pace than on-time or late-maturing males. As the research for the effect of early pubertal timing on overall externalizing behaviors is more extensive and consistent for females than for males, this finding helps clarify the differential effect of early maturation for males and females on overall externalizing behaviors as well as nonviolent and violent behaviors. Results are discussed in terms of future research, theoretical, and applied implications.
# TABLE OF CONTENTS

**Chapter 1**  
Introduction and Theoretical Framework ............................................. 1

**Chapter 2**  
Methods .................................................................................................. 18

**Chapter 3**  
Results ................................................................................................... 30

**Chapter 4**  
Discussion ............................................................................................. 44

**References** .............................................................................................. 59

**Tables** ................................................................................................... 72

**Figures** .................................................................................................. 83

**Appendix A** ............................................................................................. 90
## LIST OF TABLES

Table 1: Common Items of Nonviolent and Violent Behaviors ................................. 72

Table 2: Unique Items of Nonviolent and Violent Behaviors .................................. 74

Table 3: Means and Standard Deviations for Age, Externalizing Behaviors, Subtypes by Sex and Wave ................................................................. 76

Table 4: Correlations for Study Variables .................................................................. 77

Table 5: Correlations for Study Variables by Sex ....................................................... 78

Table 6: Unstandardized Model Fit Indices and Factor Loadings for Factorial Invariance Models of Externalizing Behaviors for the Full Public Dataset of Add Health ....... 79

Table 7: Model Fit for Externalizing Behaviors by Sex with Unstandardized Parameter Coefficients .............................................................. 80

Table 8: Model Fit for Nonviolent Behaviors by Sex with Unstandardized Parameter Coefficients .............................................................. 81

Table 9: Model Fit for Violent Behaviors by Sex with Unstandardized Parameter Coefficients .............................................................. 82
LIST OF FIGURES

Figure 1: Partial Strong Factorial Invariance Model for Externalizing Behaviors with
Unstandardized Parameter Coefficients .........................................................83

Figure 2: Externalizing Behavior Trajectories by Age and Sex..........................84

Figure 3: Nonviolent Behavior Trajectories by Age and Sex.............................85

Figure 4: Violent Behavior Trajectories by Age and Sex..................................86

Figure 5: Externalizing Behavior Trajectories by Age, Sex, and Pubertal Timing....87

Figure 6: Nonviolent Behavior Trajectories by Age, Sex, and Pubertal Timing....88

Figure 7: Violent Behavior Trajectories by Age, Sex, and Pubertal Timing.........89
CHAPTER 1: INTRODUCTION AND THEORETICAL FRAMEWORK

Puberty is a normative, developmental process in which all typically developing individuals experience. It is a biological phenomenon with a multitude of behavioral repercussions that can be altered by different environment and contexts. Understanding the process of how puberty affects behaviors is important for psychological research because pubertal changes are related to a plethora of psychological outcomes, including externalizing problems, in adolescence and adulthood (Negriff & Susman, 2011; Graber, Brooks-Gunn, & Warren, 2006; Stattin, Kerr, & Skoog, 2011). The current study focuses on the potential negative effects harbored by entering into puberty earlier than peers on two domains of an adolescent’s externalizing behaviors and if this effect is constrained to adolescence or continues into adulthood.

Although excellent theoretical and empirical strides have been made in understanding the role that puberty, especially the effect of entering puberty earlier than other same-age, same-sex peers (known as pubertal timing), plays in externalizing problems (Negriff & Susman, 2011; Rudolph, 2014), there are still gaps in our understanding for how long this effect occurs and if specific types of externalizing behaviors are especially affected by early pubertal timing. While two recent meta-analyses have conferred that the magnitude of the effect of pubertal timing on externalizing behavior problems is small yet significant (Dimler & Natsuaki, 2015; Ullsperger & Nikolas, 2017), there is still a wide gap in understanding why some studies report early puberty having an effect on externalizing behavior problems which extend past adolescence (e.g., Graber, Seeley, Brooks-Gunn, & Lewinsohn, 2004), while others report that this effect seems to remain only in the confines of adolescence (e.g.,
Boden, Fergusson, & Horwood, 2011). Additionally, while it is not common practice to separate externalizing behaviors into distinct subtypes, there is burgeoning research which suggests that pubertal timing affects nonviolent behaviors (e.g., shoplifting) and violent behaviors (e.g., physical aggression) differentially (Cota-Robles, Neiss, & Rowe, 2002). Cota-Robles et al. (2002) used a subset of the Add Health dataset’s first timepoint ($N = 5,550$; ages 11 to 17) to assess how early pubertal timing affected boys’ concurrent nonviolent and violent behaviors. The nonviolent behaviors index included 11 items while the violent behaviors index included 4 items. They were able to conclude that boys’ early pubertal timing did affect both nonviolent ($\beta = .13$) and violent behaviors ($\beta = .11$) during the first wave of data collection. While these coefficients were similar, the researchers suggested the effect of early maturation on these behaviors could still be due to different processes and could paint a different picture if measured longitudinally. Nevertheless, these findings suggest a possibility that the role of pubertal timing may differ in the development of these two separate domains of externalizing behaviors and opens a new avenue of research using longitudinal data.

Therefore, the overarching aim of the current investigation focuses on how early maturation affects these two possibly distinct types of externalizing behaviors – nonviolent and violent behaviors – and the longevity of the pubertal timing effect on the development of these behaviors over the course of adolescence and young adulthood. In reviewing the literature in the subsequent sections, I will first discuss the various ways the pubertal effect is conceptualized and measured. Secondly, I will evaluate the literature on the reasons why entering puberty earlier than same-sex, same-age peers negatively affects externalizing behaviors. Finally, I will review the current literature on the longevity of this effect.
Pubertal Status, Pubertal Tempo, and Pubertal Timing

Puberty is a series of hormonal events typically occurring anywhere between ages 10 and 16 years. Puberty is composed of two predominant stages: adrenarche and gonadarche (Dorn, Dahl, Woodward, & Biro, 2006; Grumbach, 2002; Mundy et al., 2015). Adrenarche is the maturation of the hypothalamic-pituitary-adrenal (HPA) axis and is the earliest event in the pubertal transition. The hypothalamus activates the pituitary gland, which stimulates the adrenal glands to release hormones such as testosterone, cortisol, and dehydroepiandrosterone (DHEA). These hormones contribute to the first development of body hair, facial hair in boys, and acne. Typically developing individuals begin the adrenarcheal process between 6- and 8-years old (Dorn et al., 2006). Afterwards (around age 9 or 10 for girls, and 1 year later for boys; Dorn et al., 2006), gonadarche begins by means of the hypothalamic-pituitary-gonadal (HPG) axis. The gonadotropic releasing hormone in the hypothalamus regulates the production of luteinizing hormone and follicle-stimulating hormone from the pituitary gland (Plant, 1986; 2002). The increase in these hormones during puberty induces maturation of the ovaries and testes, as well as fully develops the secondary sexual characteristics (Dorn et al., 2006). For girls, this leads to the development of breasts and eventually menarche. For boys, this leads to the development of testes and sperm production. It is important to recognize that the onset of puberty can be considered a brain event, meaning that fluctuations in these axes can cause changes in the hormones produced by each gland, which have various local and systemic effects on the body. These hormone surges and fluctuations combined with a stressful environment or context, may increase the risk for adolescents to have maladaptive behaviors during this sensitive transition period (Maninger, Wolkowitz, Reus, Epel, & Mellon, 2009; Mundy et al., 2015; Rudolph, 2014).
When assessing how puberty affects an adolescent’s behaviors, researchers typically use one or more of three indices of pubertal maturation: pubertal status, pubertal tempo, and pubertal timing. Pubertal status refers to how far along the adolescent has developed in terms of the progression of puberty. The physical changes to a child’s body are measured via multiple types of assessments (e.g., self-reported age at menarche, clinician-reported physical stages; Dorn et al., 2006) that all point to the stage a growing adolescent is at in development. For instance, the well-known Tanner Stages assigns stages to each puberty-related bodily change with Stage 1 = prepubescent or sexually immature to Stage 5 = postpubescent or sexually mature (Tanner, 1971). These stages are designed to aid clinicians and scientists in following an adolescent’s development of secondary sexual characteristics and are commonly referred to as an adolescent’s pubertal status. There is some evidence showing that pubertal status is related to externalizing behaviors in youths. For example, Flannery, Rowe, & Gulley (1993) found that females with an advanced pubertal status are more likely to engage in self-reported delinquency. Furthermore, pubertal status has also been found to be significantly, positively associated with caregivers’ reports of both males’ and females’ externalizing behaviors (Ge, Brody, Conger, & Simons, 2006).

Pubertal tempo delineates how quickly or slowly an adolescent completed pubertal transition. A typically developing adolescent will progress through puberty within 4 years of adrenarche (Susman et al., 2010), but individual tempos can range anywhere between 1 year to 7 or more years (Mendle, 2014). An individual who has a faster tempo tends to have increased levels of psychological, behavioral, and peer relationship problems in later development (Marceau, Ram, Houts, Grimm, & Susman, 2011), while an individual who progresses through puberty more slowly tends to have adequate time (as do the parents) to
adjust to the physical, cognitive, emotional, and social pubertal changes (Marceau, Ram, & Susman, 2014).

Lastly – and most importantly for this study – pubertal timing ranks the adolescent’s physical development in comparison to their same-age, same-sex peers. An adolescent is deemed to be an early maturer, on-time maturer, or late-maturer depending upon one’s relative standing to their peers’ status (Ge, Brody, Conger, Simmons, & Murray, 2002). Therefore, pubertal timing can be thought of as the adolescent’s pubertal stage compared to same-sex, same-age peers. When assessing pubertal timing, researchers often start from measuring pubertal status. Researchers ask adolescents about their pubertal stage (e.g., through Pubertal Development Scale, Petersen, Crockett, Richards, & Boxer, 1988), or use objective measures, such as clinician-reported pubertal status, and then compare each adolescent’s maturation level to that of same-age, same-sex peers in the data to create pubertal timing scores (Natsuaki, Biehl, Ge, 2009; Ge, Conger, & Elder, 2001). Alternatively, because adolescents are well aware of their own pubertal timing ranking (Mendle, 2014), pubertal timing can also be assessed via a subjective measure, usually in the form of a single-item question such as, “Compared to other girls (or boys) your age, how physically mature do you feel you are?”

Among the three indices of puberty (status, tempo, and timing), pubertal timing is the most consistent correlate of externalizing behaviors (Beltz, Corley, Bricker, Wadsworth, & Berenbaum, 2014; Marceau et al., 2014; Rudolph, 2014). Prior literature investigating the link between early pubertal timing and externalizing behaviors (Magnusson, Stattin, & Allen, 1985; Flannery et al., 1993, Mendle, Turkheimer, & Emery, 2007; Mrug, Elliot, Davies, Tortolero, Cuccaro, & Schuster, 2014) finds a consistent picture, showing that early
maturation is associated with elevated levels of aggression, conduct problems, oppositional
defiant symptoms, theft, and vandalism (Caspi & Moffitt, 1991; Graber, Lewinsohn, Seeley,
& Brooks-Gunn, 1997; Hemphill et al., 2010), as well as increased risky and norm-breaking
behaviors (Flannery et al., 1993; Oldehinkel, Verhulst, & Ormel, 2011; Weichold,
Silbereisen, & Schmitt-Rodermund, 2003). For example, Dimler & Natsuaki (2015) analyzed
40 effect sizes and found that early pubertal timing was significantly associated with overall
externalizing behaviors for both boys and girls (r = .18). Another recent meta-analysis
(Ullsperger & Nikolas, 2017) expanded our meta-analysis’ results by looking at early
pubertal timing’s effect on specific externalizing behaviors. Their results indicated again that
eye maturation had a moderate but significant effect on overall externalizing behaviors (d =
.22), and separately had an effect on antisocial behavior (d = .17), and an even stronger effect
for substance use (d = .27). The results of this more recent meta-analysis give more leverage
to the conjecture that pubertal timing may differentially affect nonviolent and violent
behaviors. There are multiple theories and hypotheses as to why and how this association
exists, as discussed below.

Models of Pubertal Timing Effects

There are several hypotheses that researchers use to explain the associations between
early pubertal timing and externalizing behaviors (see Ge & Natsuaki, 2009 for a review).
Specifically, the hormonal influence hypothesis states that the sharp increase in hormones
such as cortisol, testosterone, estradiol, and other sex and stress hormones that occur during
the pubertal transition increases the risk of developing aggressive or delinquent behaviors by
means of multiple avenues (e.g., stress reactivity or environmental mediation). Another
hypothesis suggests that the gap between physical and psychological (i.e., cognitive and
emotional) (im)maturities places early physical maturers at risk for developing externalizing behaviors. This maturation disparity hypothesis asserts that earlier maturing adolescents face multiple challenges and stressors with fewer cognitive and emotional resources than their typically-timed peers (Ge et al., 2001; Ge & Natsuaki, 2006; Petersen & Taylor, 1980). Early maturers' externalizing behaviors are reflections of a disparity between their slow-developing cognitive and emotional development and their body's fast-paced physical and hormonal development, lending to a host of social and emotional demands for which the adolescent is not yet equipped (Ge & Natsuaki, 2009; Moffitt, 1993). These challenges and demands may create problems with emotional regulation due to the rapid hormonal changes, and fewer cognitive and psychological capacities (Marceau et al, 2014). For example, the prefrontal cortex is not fully developed in adolescence yet the rest of the body, including the endocrine and reproductive systems are becoming mature, creating problems in regards to self-regulatory control (Blakemore & Choudhury, 2006; Casey, Jones, & Hare, 2008). Early maturing individuals often confront issues that are typically adult issues (e.g., sexual, relational), but these adolescents lack the cognitive and psychological maturity needed to face these challenges. According to the maturational disparity hypothesis, early maturers are more susceptible to adverse psychosocial and psychological outcomes due to their diminished cognitive capacity in compared to the needs of the social and emotional demands during puberty.

Complementary to the maturational disparity hypothesis is the developmental readiness hypothesis. This hypothesis posits that early maturation has more detrimental outcomes for early maturing adolescents as they lack the necessary preparation and social support to support and be ready for these early major pubertal changes (Ge & Natsuaki,
2006; Petersen & Taylor, 1980). Entering into puberty earlier than peers increases the adolescents’ vulnerability to multiple types of stressors (i.e., familial) and social responsibilities that are not typical for their chronological age (Caspi, Lyman, Moffitt, & Silva, 1993). Lastly, the contextual amplification hypothesis (Ge & Natsuaki, 2009) states that the deleterious effects of an individuals’ early pubertal timing are amplified by an adverse situation (e.g., delinquent peers). On the other hand, a positive context (e.g., a supportive or close parent-child relationship) may mitigate or ease the negative effects of the early pubertal timing (Marceau & Jackson, 2017; Natsuaki, 2013). This hypothesis views this association as an accumulation of risks, such that early puberty is a risk and its effects are accrued with other adverse risk factors (e.g., disadvantaged neighborhood and deviant peers). Thus, this hypothesis states that context moderates the effects of early pubertal timing and externalizing behaviors (Ge, Natsuaki, Jin, & Biehl, 2011). Although these hypotheses all point to a general empirical and theoretical consensus that links early pubertal maturation to adolescent externalizing behaviors, there is not a general agreement regarding how long this effect lasts and if this effect differentially affects specific types of externalizing behaviors (i.e., nonviolent and violent behaviors).

Longevity of Early Pubertal Maturation’s Effect

Typically, the pubertal transition begins between ages 6 and 8 and is completed between ages 14 and 16 (Dorn et al., 2006). Given the time-limited nature of the event, most studies that assess puberty have focused on collecting data in adolescence and examining how puberty affects adolescent behaviors. However, there is limited knowledge regarding whether the effects of early pubertal timing still exist long after puberty is completed (i.e., late adolescence and early adulthood). With a surge in the availability of long-term
longitudinal studies, researchers have begun to examine whether the adverse effect of early maturation is lasting or transient.

Available evidence suggests that the adverse effect of early maturation is rather short-lived and is contained within the bounds of adolescence (Boden et al., 2011; Natsuaki et al., 2009; Obeidallah, Brennan, Brooks-Gunn, Kindlon, & Earls, 2000; Smith-Woolley, Rimfield, & Plomin, 2017). Among studies that have examined this longitudinal effect, there is evidence that, compared to on-time maturers or late maturers, early maturers experience more externalized hostile feeling (e.g., getting into frequent arguments) in late adolescence (Ge et al., 2001), but may not experience any major psychopathology in adulthood (Graber et al., 2004). Similarly, adult females who were formerly early maturers in adolescence were more likely than formerly on-time maturers to have antisocial behavior and conduct behavior disorders in emerging adulthood, but not after the age of 21 (Boden et al., 2011; Graber et al., 2004).

However, there has been some evidence showing that the pubertal timing effect goes beyond adolescence. For instance, Najman, Hayatbakhsh, McGee, Bor, O’Callaghan, & Williams (2009) conducted a long-term longitudinal study in which more than 2,700 mothers and children were followed from when the children were ages 3 days, 6 months, 5 years, 14 years, and 21 years. Their results indicated that early pubertal timing at age 14 was associated with increased levels of aggression and delinquency at both 14-years and 21-years old for females only. Copeland, Shanahan, Miller, Costello, Angold, & Maughan (2010) found that young women who entered puberty earlier than peers had significantly elevated conduct problems between the ages of 14- and 16-years old, and for a small group of these early maturers, some of these conduct problems persisted into ages 19- and 21-years old.
Given the results of prior studies, addressing the question of whether pubertal timing is an adolescent-limited or a more persistent risk factor for the development of externalizing behaviors warrants attention as the severity of this effect may help to qualify the level of benefit to be gained from early intervention efforts.

Although prior literature have been successful in revealing associations of (or lack thereof) pubertal timing effects and adulthood externalizing behaviors, the theoretical mechanisms that may explain these associations are less well-understood. One hypothesis, known as the *attenuation hypothesis* (Copeland et al., 2010), suggests that early pubertal timing’s effect weakens in adulthood due to general development trends towards increases in emotional and psychological health and maturity towards the transition to adulthood. Moffitt’s (1993) theory regarding adolescent-limited behaviors is aligned with this hypothesis. According to her theory, adolescents who are biologically mature (i.e., have gone through the pubertal transition) but are not yet chronologically mature (i.e., still at a young chronological age) may engage in externalizing behaviors due to being in a maturity gap. As noted in the *maturational disparity hypothesis*, these adolescents who feel trapped in this maturity gap may engage in adult-like behaviors during adolescence in an attempt to make a statement about their maturity. And thus, by definition, the behaviors of their choice are either ones that do not impose serious damages to their or others’ current and future wellbeing (e.g., nonviolent behaviors that are not injurious or aggressive to other persons, such as stealing from a store) or behaviors that are no longer delinquent once adulthood is reached (e.g., drinking alcohol).

*The selective persistence hypothesis*, on the other hand, suggests that early pubertal timing has lasting effects that permeate multiple areas of functioning. Theoretically, this
hypothesis posits that early puberty increases the likelihood that adolescents encounter other ‘snares’ such as arrests, addiction, and other behaviors that would decrease the probability of a successful transition to adulthood. The interaction between these potential ‘snares’ and early puberty may heighten the risk for adjustment difficulties across multiple outcomes (Copeland et al., 2010).

To understand these mixed findings and theories regarding the longevity of early pubertal maturation on externalizing behaviors, we conducted a meta-analysis to address this question by examining if the effect size of early maturation on externalizing behaviors is qualified by the intervals between the time at which puberty was assessed and the time at which externalizing behavior was assessed (Dimler & Natsuaki, 2015). The results showed that the effect size was indeed moderated by this timing effect, indicating that early maturation was an adolescent-limited risk factor \( r_s = .226 \) and \( .100 \) for concurrent and longitudinal effect of early maturation, respectively. However, our meta-analysis included only few studies which were truly longitudinal in nature \( (n = 16) \) and even fewer that assessed the pubertal timing effect into adulthood \( (n = 2) \). Thus, more long-term longitudinal studies that span from adolescence to adulthood are in need.

While these studies are notable and set a firm foundation for future studies, what is also lacking is how early pubertal timing affects long-term externalizing behavior outcomes and if these adverse effects of early pubertal timing are seen when separated into distinct types of externalizing behaviors (i.e., nonviolent and violent behaviors). Therefore, a primary purpose of this study is to examine if early pubertal timing has a long-lasting effect on subtypes of externalizing behaviors (i.e., nonviolent and violent behaviors)
Differential Impact of Pubertal Timing on Nonviolent and Violent Externalizing Behaviors

According to Moffitt (1993)’s maturational gap idea, early maturing adolescents are thrust into a changing biological and social environment without the mature emotional or cognitive resources of late-adolescence or young adulthood. These early maturers feel this gap more than late maturers and tend to engage in adolescent-limited delinquency, typically consisting of rebellious behaviors meant to indicate independence (i.e., truancy, lying to parents), adult-like actions (i.e., drinking alcohol) and status offenses, but once they reach adulthood, these behaviors either diminish or become age-typical behaviors (Hofstra et al., 2000). For example, girls who do not reach menarche by age 15 are significantly less likely to engage in delinquent behaviors such as stealing, running away, and even bullying, compared to girls who reach menarche earlier (Caspi & Moffitt, 1991). Additionally, a 3-year longitudinal study included 454 adolescents ages 9 to 13 years to assess if the effect of pubertal timing was differentially associated with three types of delinquencies: status offenses (e.g., running away from home), property offenses (e.g., purposefully damaged someone’s property), and person offenses (e.g., carrying a concealed weapon) (Negriff, Ji, & Trickett, 2011). Results indicated that pubertal timing was associated with nonviolent status offenses ($r = 0.16$), but not associated with nonviolent property offenses ($r = .05$) or violent person offenses ($r = 0.08$). Thus, it is possible that early maturation is particularly influential in predicting non-violent, delinquent behaviors during adolescence (the time they still experience the age maturity gap).

According to Moffitt’s theory, while early maturers may also engage in more serious offenses, such as physical aggression, violence, or weapon-use, pubertal timing is a smaller
fraction of the etiology of these serious behaviors. Violent behaviors differ not just behaviorally, but also developmentally and etiologically from non-violent behaviors such as rule-breaking (Hinshaw, 2002; Loeber, Burke, & Pardini, 2009; Moffitt, 1993). Adolescents who engage in violent behaviors typically show a continuous history and stability of these behaviors, while nonviolent behaviors do not usually exhibit cross-situational continuity (Moffitt, 1993; Moffitt & Caspi, 2001; Pihlakoski, Sourander, Aromaa, Rautava, Helenius, & Sillanpaa, 2006; Wertz et al., 2015). For instance, the majority of the variance of violent behaviors is accounted for by genetics, while the variance of nonviolent behaviors is more accounted for by environmental influences (Wertz et al., 2016), even in early maturers (Harden & Mendle, 2012). It seems that, compared to nonviolent behaviors, violent behaviors are not as well-linked to exerting independence or being caught in a maturity gap between physical and emotional/cognitive maturity, but instead come from a different etiology, even in the early maturers.

While not abundant, there are a few studies to suggest that early pubertal timing may affect subtypes of externalizing behaviors differently. For example, Ge, Conger, Simons, Brody, and Murry (2002) used a multisite, cross-sectional design with boys ages 10 to 12 ($N = 867$) to assess how pubertal timing affected symptoms of attention deficit/hyperactivity disorder (ADHD), oppositional defiance disorder (ODD), and conduct disorder (CD). ADHD is characterized as inattentiveness, hyperactivity, and impulsivity while ODD symptoms are classified by extreme anger, irritable moods, and argumentative behaviors (American Psychiatric Association, 2013). While these behaviors can be severe, they are largely nonviolent. On the other hand, CD symptoms are typically comprised of violent and callous-unemotional behaviors (American Psychiatric Association, 2013) and are a robust predictor
of serious antisocial behaviors later in life (Pardini & Fite, 2010). While pubertal timing was significantly associated with all three outcomes \((rs = .26, .20, \text{ and } .12, \text{ respectively})\), the strongest effects were seen in ADHD and ODD symptoms. Additionally, Ullsperger and Nikolas (2017) analyzed the results of 79 studies and found slightly different effect sizes for distinct forms of externalizing behaviors (e.g., antisocial behavior \([d = .17]\), substance use \([d = .27]\) and risky sexual behavior \([d = .34]\)). In these studies, the small to modest effect sizes were found to be significant at all ages assessed and also greatly vary in strength of the effect, thus indicating that early maturation may have a differential effect on both nonviolent and violent behaviors.

Cross-sectional studies with adolescents are important for understanding if there is an effect of pubertal timing on different types of externalizing behaviors during adolescence, but a longitudinal study is important for understanding how long this effect persists. There are few longitudinal studies that have examined this effect. For instance, a study of a group of early-maturing adolescents in Taiwan indicated that early maturers engaged in more overall externalizing behaviors throughout adolescence than their on-time or late-maturing counterparts, but their early maturation did not predict long-term, distinct delinquent behaviors except for engaging in fights (Tsai, Strong, & Lin, 2015). As stated above, Negriff et al. (2011) found that pubertal timing was positively associated with concurrent nonviolent status offenses, but not property or person offenses, and, furthermore, early pubertal timing was not associated with these distinct offenses three years later when the participants were 12 to 16 years old.

These studies paint a picture that early pubertal timing may have a differential effect on types of externalizing behaviors, but there is not a general consensus as to which distinct
behaviors are affected and how these behaviors are affected over time. Further, no longitudinal studies to date have assessed how this effect occurs throughout adolescence and into adulthood in nonviolent and violent behaviors, therefore, a principal aim of this study is to fill this critical gap.

**Methodological Issues on Measuring Externalizing Behaviors over Time**

When tracking externalizing behaviors (or any behavior) over a long period of time, it is important to consider possible qualitative changes in the behavior over time. Patterson (1993) was one of the first to empirically test how antisocial behaviors qualitatively change over time by using a two-factor latent growth model. He explains how externalizing behaviors can begin as truancy and substance use, then shift one of two ways as the adolescent becomes older: the addition of nonantisocial problem behaviors (e.g., noncompliance, temper tantrums, academic problems) or the addition of antisocial acts (e.g., stealing, lying, police arrests, substance use). Factor analysis results demonstrated that the factor structure of deviancy between the ages of 10 to 14 years old was altered significantly, suggesting qualitative and dynamic changes of externalizing behaviors and a pattern of age-related change over a developmentally-sensitive time. His results were formative for understanding that externalizing behaviors in childhood are constantly being transformed into seemingly new externalizing behaviors in adolescence (i.e., a chimera effect), but the underlying patterns may not be changing over time.

The transformative nature of externalizing behaviors poses a methodological challenge in longitudinal designs. That is, the same sets of items cannot be used repeatedly to reliably measure the behavior of interest. However, many longitudinal analyses (e.g., growth curve analysis) typically require the same measurements over time to track how the behavior
changes over time, but development requires measurements that adapt in order to ask developmentally-appropriate questions. Researchers have taken to assessing measurement invariance via exploratory and confirmatory factor analyses to be certain the behaviors they are assessing in childhood or adolescence are the same behaviors in adulthood, even if the manifestations of those behaviors are different. Using confirmatory factor analysis, Odgers et al. (2008) successfully demonstrated measurement invariance for males’ conduct problems from ages 7 through 26 years and for females’ conduct problems from ages 7 through 15 years. This approach yields developmentally sensitive results in that it allows for the identification of age-appropriate behaviors in adolescence (e.g., lying to parents or caregivers) and adulthood (e.g., aggression against partners and children) and utilizes more items of the measures over time than simply using the common questions across timepoints by assessing the common and unique items in developmentally-appropriate measures.

**Study Overview**

This present study is designed to ask the following questions: (1) does early maturation have a differential effect on nonviolent vs. violent externalizing behavior problems? If so, does this effect last through adulthood or dissipate after adolescence? And (2) if so, is the pubertal timing effect short-lived or long lasting? I hypothesize (1) that early maturation affects specifically nonviolent behaviors; and (2) that the effect of early maturation is mainly constrained to adolescence and dissipates as adolescents approach adulthood. Based on previous findings from meta-analyses suggesting a lack of notable sex differences in early pubertal timing’s effect on externalizing behaviors, I did not have any hypotheses regarding sex differences (see Dimler & Natsuaki, 2015 and Ullsperger &
Nikolas, 2017), but given that boys and girls experience puberty differently, I analyzed them separately.
CHAPTER 2: METHOD

The National Longitudinal Study of Adolescent to Adult Health

This study is based on the National Longitudinal Study of Adolescent to Adult Health (known as the Add Health study; Harris, 2013; Harris et al., 2009), an on-going, four-wave longitudinal study examining adolescents’ health and risk behaviors and their outcomes in young adulthood. During the wave 1 data collection (1994-1995), Add Health recruited more than 90,000 adolescents in the United States who were enrolled in 7th to 12th grades. Of these students, over 20,000 completed the in-home questionnaire. During wave 2 (1996), Add Health collected data in the homes of 14,738 of the students and young adults. Wave 3 (2001-2002) included 15,170 adolescents and young adults from wave 1. In 2007-2009 (wave 4), 15,701 of students, now all young adults, were reexamined. All participants were original participants from wave 1 (participants are not able to enter into the study at a later wave). Attrition bias was estimated to be very small (see Brownstein, Kalsbeek, Tabor, Entzel, Daza, & Harris, 2011 for more details). Details of the study design are available at http://www.cpc.unc.edu/projects/addhealth.

The Current Study Sample

The current study is based on data from a subset of adolescents who participated in waves 1 or 2 of data collection and were part of the public-use dataset. The public-use dataset consists of 6,504 adolescents in wave 1 (\(M_{age} = 15.5\) years, 51.6% female, 48.4% male), 4,834 adolescents in wave 2 (\(M_{age} = 16.0\) years, 52.1% female, 47.9% male), 4,882 young adults in wave 3 (\(M_{age} = 21.8\) years, 53.9% female, 46.1% male), and 5,114 young adults in wave 4 (\(M_{age} = 28.3\) years, 54.0% female, 46.0% male).
In this current study, I used all individuals who were 12-16 years old at the time of the wave 1 assessment. When asking an age-sensitive question (e.g., the effects of pubertal timing), there needs to be enough variation in the puberty item(s) in order to get at the nuanced effects of pubertal timing. Advantages of selecting individuals aged 12 to 16 years lie in its ability to delineate age-sensitive trajectories over time. This approach has been successfully applied to the Add Health data in previous work (e.g., Natsuaki, Biehl, & Ge, 2009). When I applied this approach to the current study, the sample became 4,255 12-16-year old adolescents at wave 1 ($M_{age} = 14.6$ years; 52.8% female; 64.5% White, 24.5% Black, 3.4% Asian/Pacific Islander, 1.7% Native American, 5.6% marked as other, 0.3% refused or did not know; 11.4% also marked Hispanic in addition to their race). Wave 2 included 3,864 adolescents ($M_{age} = 15.38$ years; 52.8% female). There were 3,297 young adults in wave 3 ($M_{age} = 20.8$ years; 42.7% female) and 3,411 young adults in wave 4 ($M_{age} = 27.5$ years; 44.2% female). Aside from age, there were no differences in race/ethnicity proportions, socioeconomic status, or externalizing behaviors in the current study sample compared to the full public-use dataset. Individuals must have been present in either wave 1 or 2 to be considered as part of the current study sample, as pubertal timing data was pulled from these waves.

Measures

**Pubertal Timing.** Participants were asked about pubertal maturation at waves 1 and 2. In this study, pubertal status in both sexes combined three sources of information: 1) one interviewer-report item, 2) one self-report subjective perception on pubertal status compared to other peers, and 3) three self-reported items about sex-specific secondary sexual characteristics.
For the one-item interviewer report item, the interviewer answered the item, “how physically mature was the respondent compared with other adolescents of his/her age?” on a 5-point scale (1 = very immature to 5 = very mature). For the self-report subjective perception item, adolescents were asked, “how advanced is your physical development compared to other boys/girls your age?” on a 5-point scale (1 = I look younger than most to 5 = I look older than most).

For the self-report sex-specific characteristics scale, boys indicated their growth of underarm hair on a 5-point scale (1 = I have no hair at all to 5 = I have a whole lot of hair). They also reported thickness of their facial hair using a 4-point scale (1 = I have a few scattered hairs, but the growth is not thick to 4 = the hair is very thick, like a grown man’s facial hair). Additionally, boys used a 5-point scale to describe changes in their voice (1 = it is about the same as when you were in grade school to 5 = it is a whole lot lower than when you were in grade school and it is as low as an adult man’s voice). These three items were combined after being adjusted for the differences in the response format by standardization. To create boys’ overall pubertal status score, I first standardized each item, then aggregated these 3 items to create a standardized self-report sex-specific characteristics scale. Then, I standardized each of the three scales (i.e., interviewer’s impression, self-report subjective perception of pubertal status, and the self-report sex-specific characteristics scale), aggregated them, and then standardized again within age to create a pubertal timing score (α = 0.626).

Similarly, girls’ pubertal status was measured based on the girls’ reports of their breast development, curviness of body, and age at menarche. Using a 5-point scale (1 = my breasts are about the same size as when I was in grade school to 5 = my breasts are a whole
lot bigger than when I was in grade school), girls described their breast development. Curviness of their body was also measured using a 5-point scale ($1 = \text{my body is about as curvy as when I was in grade school}$ to $5 = \text{my body is a whole lot more curvy than when I was in grade school}$). Girls were also asked whether they had menstruated ($1 = \text{no}$ and $5 = \text{yes}$), and if so, their age of menarche. It has been shown that self-report measure of menarche is reliable and valid (Brooks-Gunn, Warren, Rosso, & Gargiulo, 1987; Dorn & Biro, 2011).

Additionally, the association between pubertal timing and externalizing behaviors does not change whether one measures female pubertal timing or status with age of menarche compared to other measures (e.g., Pubertal Development Scale [Petersen et al., 1988] and Tanner Stages [Marshall & Tanner, 1969, 1970]; Dimler & Natsuaki, 2015), and has been used reliably in previous studies using the Add Health dataset (Natsuaki et al., 2009). The three measures of pubertal status (i.e., the standardized average of the 3 sex-specific body characteristics; the interviewer rating, and the self-reported subjective perception item) were standardized and then averaged to create the total score of girls’ pubertal status. Then, the total pubertal status was standardized by age to create girls’ pubertal timing score ($\alpha = 0.613$).

These questions were asked at wave 1, and again at wave 2. I primarily used the puberty data on wave 1, but missing cases at wave 1 were supplemented by the responses at wave 2 if available in the wave 2 data ($n = 18$ and 34 for males and females, respectively). In the case where the wave 2 puberty data was used, I standardized the pubertal status (thus, creating pubertal timing) using the age of the participant from wave 2 instead of wave 1.

**Externalizing behaviors.** Externalizing behaviors were assessed by utilizing self-report measures. Because of the study’s aims, I utilized only the items in the measures that
pertained to the deviant behavior that the participant perpetuated (as opposed to witnessing deviant behavior perpetuated by someone else). Three indices of externalizing behaviors are used in this study: total externalizing, nonviolent, and violent behaviors. The distinction between nonviolent and violent items were based on prior research using the Add Health dataset (e.g., Beaver, Connolly, Schwartz, Boutwell, Barnes, & Nedelec, 2016; Harden & Mendle, 2012; Haynie & South, 2005; Mears, Cochran, & Beaver, 2013) and face validity. Tables 1 and 2 show all the items used in this study. Because Add Health is a long-term longitudinal study that spans across adolescence and adulthood, the availability of the items and phrases of items change across waves; as shown in Tables 1 and 2, some items were assessed across waves (i.e., common items) and others were added and deleted in later waves (i.e., unique items). I used both common and unique items to construct the three indices of externalizing behaviors.

Nonviolent Behaviors. Nonviolent and delinquent behaviors, which are defined as behaviors such as property damage, theft, lying to guardians, running away from home, and selling drugs while the violent items assessed behaviors targeted toward another individual such as fighting and using weapons, were examined from waves 1, 2, 3, and 4. In waves 1 and 2, two separate questionnaires assessed externalizing behaviors: a delinquency scale and a fighting & violence scale. The fighting & violence scale asked the participants to report their recent behaviors on a 3-point scale ($0 = \text{never}$ to $2 = \text{more than once}$) while the delinquency scale utilized a 4-point scale ($0 = \text{never}$ to $3 = 5 \text{ or more times}$). Waves 3 and 4 assessed delinquency and violence slightly differently. In these waves, the delinquency scale and the fighting & violence scale were combined into one scale and participants answered all items on a 4-point scale ($0 = \text{never}$ to $3 = 5 \text{ or more times}$). Six items were consistently asked
of participants in all four waves (i.e., common nonviolent items, Table 1) and seven items were asked in at least one of the waves (i.e., unique nonviolent items, Table 2). I extracted these items based on face validity and prior literature (e.g., Beaver et al., 2016) and created the total nonviolent behavior scores in each wave ($\alpha$s = .762, .748, .681, .610, for Waves 1 to 4, respectively).

**Violent Behaviors.** Violent behaviors were assessed during a structured home interview with the youth at all four waves. Items asked about the frequency or presence of violent behaviors in the past 12 months, including items such as “In the past 12 months, how often did you hurt someone badly enough to need bandages or care from a doctor or nurse?” Similar to the nonviolent scale, waves 3 and 4 assessed violence with one scale and participants answered all items on a 4-point scale (0 = never to 3 = 5 or more times). Three items were consistently asked of participants in all four waves (i.e., common violent items, Table 1) and four items were asked in at least one of the waves (i.e., unique violent items, Table 2). Analogous to the nonviolent behavior scale, I extracted these items based on face validity and prior literature (e.g., Beaver et al., 2016) to create the total violent behavior scores in each wave ($\alpha$s = .743, .697, .524, .598).

**Age.** For each adolescent, age was calculated by subtracting the adolescents’ date of birth from the date of the interviews across four waves. Age was centered at 12-years old, the average age of puberty for the typically-developing adolescents in this sample, in order to yield a meaningful intercept in growth curve analysis.

**Covariates**

**Socioeconomic status.** Socioeconomic status was used as a covariate in the current study as prior studies indicate that individuals with low socioeconomic status or those that
live in socioeconomically disadvantaged neighborhoods are exposed to multiple chronic stressors (Leventhal & Brooks-Gunn, 2000) which can increase existing vulnerabilities, such as early pubertal timing (White, Deardorff, Liu, & Gonzales, 2013) and externalizing behaviors (Defoe, Farrington, & Loeber, 2013; McLaughlin, Costello, Leblanc, Sampson, & Kessler, 2012 Obeidallah et al., 2000). I used level of maternal education from Wave 1 as an indicator of an adolescent’s socioeconomic status. If adolescents or their mothers were missing data on these items, I supplemented this item from the Wave 2 data.

**Race.** I used race as a covariate given that pubertal timing’s effect on externalizing behaviors may operate differently depending on racial/ethnic background. For example, there is evidence that Black girls tend to mature earlier than Caucasian and Latina girls (Mendle et al., 2007; Parent et al., 2003), and as this study was not designed to assess race/ethnicity differences in the effect of pubertal timing on externalizing behaviors, I coded race such that $0 = \text{White}$ and $1 = \text{non-White minorities}$.

**Data Analytic Plan**

**Preliminary Analysis.** Data was cleaned and analyzed with SPSS version 24 (IBM Corp., 2016). First, using Little’s test, I analyzed the pattern of attrition to assess any patterns of nonrandom missingness. Second, descriptive analyses examined the means, variability, and normality statistics (e.g., skewness, kurtosis) for each of the study variables. For the variables that did not meet the distributional assumptions, square root or log transformations were computed. Correlation analyses also evaluated associations between the pubertal timing index and delinquency measures in each wave.

**Longitudinal Measurement Invariance.** There are two reasons that motivated me to conduct the measurement invariance analysis. First, the current investigation incorporated
items of externalizing behaviors that were assessed across waves (common items) and that were assessed only some of the waves (unique items). In order to show that these items tap onto the construct of externalizing behaviors (nonviolent and violent forms) over time, it is necessary to test whether the construct is invariant over time (Reise, Widaman, & Pugh, 1993; Widaman, Ferrer, & Conger, 2010). Second, focusing on the common items, previous studies have used multiple waves of Add Health data to track the changes in externalizing behaviors (e.g., Beaver et al., 2016; Mendle, Ryan, & McKone, 2017), but no study has tested such longitudinal invariance via a confirmatory factor analysis. The structure and meaning of the constructs could change despite the use of the common items across all waves (Pitts, West, & Tein, 1996), thus it is important to ensure the measurements are invariant before analyzing the timepoints.

After evaluating the patterns of correlations, I fit a measurement invariance model (Widaman, et al., 2010) using the full public-use dataset for overall externalizing behaviors using Mplus (Muthén & Muthén, 1998-2017). I used the full public-used dataset (as opposed to the smaller sample) in order to maximize the amount of variance in externalizing behaviors at each wave. To fit the measurement invariance model, I utilized a technique called parceling, which has been shown to improve the psychometric properties of measures (e.g., increasing variances, raising reliabilities; Kishton & Widaman, 1994; Bandalos, 2002; Widaman et al., 2010). To do this, I separated the common items and unique items across each wave and created a latent variable of overall wave externalizing behavior (i.e., a latent variable of wave 1 externalizing behavior made up of four manifest variables: nonviolent common items across all waves, nonviolent items that were unique only to wave 1, violent common items across all waves, and violent items that were unique only to wave 1; see
Figure 1). Thus, 9 items were assessed consistently in all four waves (see Tables 1 and 2 for a full table of common and unique items, respectively). Of these 9 items, six items listed on Table 1 were common items to assess nonviolent delinquent behaviors in all four waves while three items were common items to assess violent behaviors in all four waves. Common items across all waves were summed to create an overall ‘common nonviolent behavior items’ parcel and a ‘common violent behavior items’ parcel. While prior studies only utilized these common items to create either an overall externalizing scale, nonviolent delinquency scale, or violent delinquency scale (e.g., Beaver et al., 2016; Haynie & South, 2005; Mears et al., 2013), the current study utilized all pertinent items in each measure at each wave via a confirmatory factor model. The remaining items at each wave were summed to create a ‘unique nonviolent behavior items’ and a ‘unique violent behavior items’ parcel (Table 2).

Following this parceling, I computed multiple configural factorial invariance analyses in Mplus 8.0 (Muthén & Muthén, 1998-2017) so as to account for missing data using Full Information Maximum Likelihood (FIML). Because likelihood ratio tests are not as sensitive to differences in fit indices when the sample size is large, I utilized a battery of other fit indices to assess model fit (Widaman et al., 2010), including the root mean square error of approximation (RMSEA; MacCallum, Browne, & Sugawara, 1996), comparative fit index (CFI; Bentler, 1990), Tucker Lewis Index (TLI; Tucker & Lewis, 1973), and standardized root mean square residual (SRMR; Hu & Bentler, 1999), Akaike information criteria (AIC; Akaike, 1974), and Bayesian information criteria (BIC; Schwarz, 1978). Good model fit was indicated by CFI and TLI values greater than .90, RMSEA and SRMR values below .08, and AIC and BIC values that were smaller than the next most parsimonious model. In cases where the fit indices indicated contradictory interpretations, I used the suggestions from Lai
& Green (2016) to use MacCallum et al.’s (1996) RMSEA interpretations to indicate excellent (.01), good (.05), and mediocre (.08) fit, respectively.

I fit a baseline configural invariance model (Model A) for externalizing behaviors with the previously mentioned latent variables of externalizing behaviors with the parcels. Model B was then evaluated with all within-wave and between-wave covariances freely estimated. This meant that the common item parcels for nonviolent and violent behaviors were correlated with the unique parcels for nonviolent and violent behaviors, respectively, within and between each wave. Once these results were evaluated, Model C’s configural invariance model analyzed only the significant within- and between-wave covariances. The means of the latent variables were fixed at zero. Using Model C as a base, at each wave of data, the loading for the common nonviolent item parcel was fixed at one and the common violent item parcel was set to be equal across waves. The factor variances and intercepts at each wave were freely estimated (Tyrell, 2017; van de Schoot, Lugtig, & Hox, 2012).

**Growth Curve Analyses.** Once measurement invariance was established, I conducted growth curve analyses (Singer, 1998; Singer & Willett, 2003) in order to test my main hypotheses using SAS PROC MIXED (SAS Institute, 2011). These models included the smaller sample size of adolescents ages 12-16 years old in wave 1 in order to have a proper amount of variance in the pubertal timing variable. Utilizing the full sample would have skewed the pubertal timing variable as there were individuals through age 21 in wave 1. In these models, I tested the trajectories of total externalizing behaviors, nonviolent, and violent behaviors over time at the within-person change (Level-1) and tested the role of pubertal timing at the between-person change (Level-2). It is important to note that I separately analyzed the trajectory of total externalizing behaviors, nonviolent behaviors, and
violent behaviors, each separately for males and females. Additionally, I computed the means for each outcome for each wave in an attempt to better assess engagement of behaviors as opposed to using the sums, as there were differing number of items in each wave. The outlined steps were performed for each outcome and each sex separately.

First, I conducted an unconditional means model (Model A) which used externalizing behaviors as outcomes in the model estimating an intercept only. This unconditional means model separated the variation in the outcome behavior into the estimated within-person variance and estimated between-person variance. This also provided a baseline for evaluating the shapes of nonviolent and violent behavior trajectories. Next, I conducted an unconditional linear growth model (Model B) which included age as a predictor of externalizing trajectories. This acted as a baseline model for change over time. The fit of this model was compared to Model A by using fit indices such as the log-likelihood ratio, AIC, and BIC. Next, similar to prior research (e.g., Bongers et al., 2004), I added a quadratic term of age for the rate of change and ran an unconditional quadratic model (Model C) to determine if the shape of nonviolent and violent externalizing behavior trajectories from ages 12 to 30 was best described as curvilinear.

Once the shape of the behavior was determined for each outcome, I tested my main hypothesis (i.e., a main effect of pubertal timing on total externalizing, nonviolent, and violent behaviors) by running the same models as above but using pubertal timing as the linear term (Model D) and then adding the puberty x age interaction term (Model E). The puberty x age interaction term tested the persistence of the early maturation effect. If the best fitting model was a quadratic model (as opposed to a linear model), I instead used pubertal timing as the linear term and age as the quadratic term to assess the speed at which the
outcome behaviors increase or decrease (Model D). I subsequently added a puberty x $\text{age}^2$
interaction term (Model E) to assess a possible curvilinear persistence of the early maturation
effect. I ran these models separately for overall externalizing behavior and each of the two
types of externalizing behaviors (nonviolent vs. violent behaviors), and each model was
analyzed separately for sex.
CHAPTER 3: RESULTS

Aim: To examine a longitudinal, differential effect of early pubertal timing on nonviolent and violent behaviors from early adolescence to adulthood.

Preliminary Analyses

Descriptives. Table 3 provides the means and standard deviations of age, total externalizing behaviors, nonviolent behaviors, and violent behaviors from waves 1 through 4, separated by sex. Examination of the means over time revealed that there was a downward trend of engaging in overall externalizing behaviors, nonviolent behaviors, and violent behaviors across four waves for both males and females. On average, males reported higher mean levels of externalizing, nonviolent, and violent behaviors than females at all time points and there was a seemingly steep decline in these behaviors after adolescence was completed in wave 2.

Correlations. The bivariate correlation matrix of the study variable using the entire sample is presented in Table 4. Overall, age was positively correlated with concurrent externalizing behaviors at wave 1 \((r = .08, p < .01)\) and negatively correlated with externalizing behaviors at wave 3 \((r = -.07, p < .01)\). Maternal education was only associated with violent behaviors in wave 3 such that lower maternal education was correlated with an increase in individuals’ violent behaviors \((r = -.11, p = .05)\). Race was associated with overall externalizing behaviors as well as specific nonviolent and violent behaviors, meaning that minority races/ethnicities were more likely to engage in general externalizing behaviors at wave 1 \((r = .04, p = .01)\) and 4 \((r = .06, p < .01)\) and violent behaviors across all waves \((rs = .09, .07, .05, \text{ and } .07, p < .01 \text{ for waves 1 to 4, respectively})\). White adolescents were more likely than minorities to engage in nonviolent behaviors at wave 2 \((r = -.03, p < .05)\). As these
results show, race may be a significant predictor in the outcome variables, thus I controlled for its effects in the subsequent models. As expected, males were more likely than females to engage in overall externalizing behaviors as well as nonviolent and violent behaviors at all time points. For this reason, I analyzed males’ and females’ outcomes separately in the subsequent analyses. Lastly, externalizing behaviors were moderately stable over time with stability coefficients ranging from .22 - .58 (p < .01), .16 - .55 (p < .01), and .20 - .51 (p < .01) for overall externalizing, non-violent, and violent behaviors, respectively.

Table 5 illustrates the correlation matrix of the study variable by sex. Males’ pubertal timing was positively correlated with overall externalizing behaviors at waves 1 and 2 (rs = .14 and .13, ps < .01), and were positively correlated with waves 1 and 2 nonviolent (rs = .12 and .10, ps < .01) and violent (rs = .13 and .12, ps < .01) behaviors. This indicates that earlier maturing males at wave 1 engaged in overall externalizing, nonviolent, and violent behaviors during adolescence than later-maturing counterparts. For females, pubertal timing was also positively associated with overall externalizing behaviors at wave 1 (r = .06, p < .01). It was also associated with nonviolent behaviors at wave 1 (r = .07, p = .01), but not with violent behaviors. This suggests that females who entered into puberty earlier than same-age female peers were more likely to engage in overall externalizing and nonviolent behaviors during adolescence than later maturing girls.

**Longitudinal Measurement Invariance**

Prior to the estimation of the longitudinal growth model, a longitudinal invariance model was conducted to assess measurement invariance of externalizing behaviors over the course of early adolescence to young adulthood in both males and females. The full sample
of the public-use Add Health dataset was used to assess for measurement invariance in order to have enough variation in the externalizing behaviors.

A baseline configural invariance model was evaluated to determine whether the structure of externalizing behaviors was statistically invariant in all four waves (Figure 1 and appendix A). The results suggested that the model did not fit the data well, \( \chi^2(98) = 1301.278, p<.001 \), RMSEA = .043 [.041, .046], CFI = .819, TLI = .779, SRMR=.048, AIC = 120963.332, BIC = 121329.387. Both theory and recommended modification indices suggest that the inclusion of within-wave and between-wave covariances between the parcels of the same construct would improve model fit. Therefore, Model B evaluated all within-wave and between-wave covariances of the parcels. Results indicated an improvement, but still not good, fit, \( \chi^2(89) = 1116.663, p<.001 \), RMSEA = .042 [.040, .044], CFI = .846, TLI = .792, SRMR=.046, AIC = 120565.411, BIC = 120992.475. My next step was to include only the significant within- and between-wave covariances (Model C), which yielded adequate fit, \( \chi^2(93) = 1085.707, p<.001 \), RMSEA = .041 [.038, .043], CFI = .857, TLI = .801, SRMR=.045, AIC = 120507.272, BIC = 120907.220. While the CFI may denote an inadequate model fit, the RMSEA and SRMR suggest adequate, even good, model fit, Lai & Green (2016) state that low CFI does not necessarily mean that the model is misspecified or that the data have flaws because there could be many reasons for these differences such as the differing numbers of items in each unique parcel. Additionally, the concept of strict cutoffs for these fit indices is still debated, as there are multiple instances of contradictory fit indices (Lai & Green, 2016). Therefore, based on the RMSEA and SRMR compared to Model B, Model C was chosen as the base configural model in which I assessed for weak, strong, or strict measurement invariance.
Following the identification of this best fitting configural invariance model (Model C), a weak invariance model (Model D) based on the best fitting configural invariance model (Model C) tested whether the factor loadings for externalizing behaviors were invariant across time. Model D showed an improvement in fit to the data when compared with Model C, $\Delta \chi^2(3) = 6.17, \text{ns}$ (Sattora & Bentler, 2010), and the fit indices for the overall model suggested that Model D fit the data adequately (Lai & Green, 2016), $\chi^2(96) = 1047.704, p<.001, \text{RMSEA} = .039 \ [.037, .041], \text{CFI} = .857, \text{TLI} = .821, \text{SRMR} = .045$. Next, I tested a strong invariance model in which the factor loadings and intercepts were invariant across time, but the full strong invariance model did not fit well. Per suggestions from Widaman et al. (2010), I then conducted a model that relaxed intercepts in order to achieve partial strong invariance (Model E). Model E continued to fit the data adequately (Lai & Green, 2016), $\chi^2(98) = 1079.935 \ p<.001, \text{RMSEA} = .039 \ [.037, .041], \text{CFI} = .852, \text{TLI} = .819, \text{SRMR} = .045, \Delta \chi^2(2) = 1.084, \text{ns}$ (Sattora & Bentler, 2010), therefore, Model E was the final model chosen. The standardized factor loadings for the item parcels in Model E ranged from .219 to .426 (Table 6, Figure 1 and appendix A).

The results from the comparison of the measurement invariance models suggest that the measures have partial strong factorial invariance, such that the factor loadings are invariant across time and the intercepts are partially invariant across time, specifically the common items (Widaman et al., 2010). Additionally, the nonviolent and violent factor loadings indicate that the two types of externalizing behaviors are indeed distinct from one another. This can be seen in the nonviolent items, both common and unique, loading in similar strengths to each other (e.g., .22 - .31) and violent items, both common and unique, loading in similar strengths to each other (e.g., .39 - .42). Finally, the latent variables of
overall externalizing behaviors at each wave were moderately to strongly associated with all other data waves of externalizing behaviors at the \( p < .001 \) level. Together, these results of Model E indicated partial strong measurement invariance of the externalizing behaviors from early adolescence to young adulthood.

**Longitudinal Trajectory of Externalizing Behaviors as a Function of Age and Pubertal Timing**

Because the previous analysis demonstrated the measurement invariance, I aggregated the unique and common items for each wave to create the overall externalizing, nonviolent, and violent behavior scores. In order to account for the differing number of items in each wave (e.g., 17 total items in wave 1 and 12 total items in wave 3), I used the mean score of each outcome for each individual to adjust for the varying number of items across waves. I then performed a series of multilevel models using SAS PROC MIXED (Singer, 1998; Singer & Willett, 2003) to model the trajectories of overall externalizing behaviors, nonviolent behaviors, and violent behaviors as a function of age and pubertal timing. I separately analyzed males and females. Tables 7 through 9 present the estimated parameters for all 6 models described in the data analytical plan. In these analyses, parameter estimates are interpreted similarly to unstandardized coefficients reported in regression-based analyses, which indicate an increase or decrease in the outcome behavior with a unit increase of independent variables. I used fit indices such as the log-likelihood ratio, AIC, and BIC, and a chi-square difference test to determine which model fit the data best for each outcome within each sex. All coefficients stated below and in Tables 7 through 9 were estimated with maximum-likelihood estimation and an unstructured covariance matrix.
**Overall Externalizing Behaviors.**

*Males.* First, I tested an unconditional means model (Model A), which serves as a baseline to compare sequential growth models. This model included overall externalizing behaviors in the model estimating an intercept only. This model describes the variation in externalizing behaviors (Singer & Willett, 2003).

As shown in Table 7 both estimated within- and between-person variances from the unconditional means model (Model A) were significant ($\sigma^2 = 1.83$, $\sigma^0 = 0.42$, $p < .001$). This model also indicated that an estimated 81.4% of the total variation in externalizing behaviors is due to differences between adolescents ($\hat{\rho} = 0.8137$). A subsequent unconditional linear growth model (Model B) included adolescent centered age (at age 12) and overall externalizing behaviors. This was compared to Model A with a chi-square difference test indicating that Model B fit better than Model A, $\chi^2(2) = 3065.5$. The Pseudo $R^2$ suggests that Model B explained 39.9% of the within-person variation in externalizing behaviors that is associated with linear time. This unconditional linear growth model provides us with a baseline for evaluating subsequent models with our predictor and quadratic term included.

Next, I added a quadratic term for the rate of change (i.e., centered age) and ran an unconditional quadratic model (Model C), which fit better than Model B, as assessed by a chi-square difference test ($\chi^2(2) = 540.8$). The fixed effect linear and quadratic terms were significant at the $p < .001$ level, with significant random effects as well. Model C explained 88.5% of the within-person variation in externalizing behaviors that is associated with linear and quadratic age. This final unconditional model yielded a significant, negative coefficient for the linear term of age ($\gamma = -0.31$, $p < .001$) and a positive coefficient for the quadratic term ($\gamma = 0.01$, $p < .001$). This indicates that the trajectory of males’ overall externalizing
behaviors was best approximated as a slight inverse J-shaped curve (see Figure 2). Most other random effects were significant at the \( p < .001 \) level as well, notable are the intercept and linear slope (\( \sigma_0^2 = 4.60, \sigma_1^2 = 0.05 \)).

Once the shape of the trajectory of externalizing behaviors was determined (i.e., Model C with age and age\(^2\)), I added pubertal timing as an additional linear term. Thus, models D (utilizing an age x pubertal timing term) and E (utilizing an age x pubertal timing and age\(^2\) x pubertal timing) were designed to test the lingering pubertal timing effect on the trajectory of externalizing behaviors. Model E fit the data best as indicated by comparing Model D and E’s log-likelihood ratios, AICs, and BICs. Age was again significant, as both a linear and quadratic term (\( \gamma_s = -0.38, 0.01, \) both \( p < .001 \)), indicating a decline in engaging in externalizing behaviors over time with a very slight increase as age progressed in the late-20s. The pubertal timing term was positive and significant (\( \gamma = 0.38 p < .001 \)), indicating that more mature boys at age 12 (i.e., early pubertal timing) engaged in more externalizing behaviors than later maturing counterparts. The interaction between pubertal timing and age was significant (\( \gamma = -0.05 p < .001 \)) and the interaction between the quadratic age term and pubertal timing as also significant (\( \gamma = 0.002 p < .001 \)). These findings suggest that earlier maturing males engage in more overall externalizing behaviors than on-time or late-maturing individuals but decline in the engagement at a more rapid pace than their on-time or late-maturing counterparts (see Figure 2).

**Females.** Females’ results for this outcome followed similar results and are outlined in Table 7. I again tested an unconditional means model (Model A), which was the baseline to compare sequential growth models. This model included overall externalizing behaviors in
the model estimating an intercept only, thus describing the variation in externalizing behaviors (Singer & Willett, 2003).

The unconditional means model (Model A) indicated that an estimated 84.17% of the total variation in externalizing behaviors is due to differences between adolescents ($\hat{\beta} = 0.8417$). Both estimated within- and between-person variances from the unconditional means model were significant ($\sigma^2_{\epsilon} = 1.05, \sigma^2_0 = 0.20, p < .001$). Race was positively and significantly associated with overall externalizing behaviors, suggesting that minority races engaged in more overall externalizing behaviors ($\gamma = 0.10, p < .01$). A subsequent unconditional linear growth model (Model B) included adolescent centered age (centered at age 12) and overall externalizing behaviors and fit better than Model A ($\chi^2(2) = 5811.4$). The Pseudo $R^2$ suggests that Model B explained 47.9% of the within-person variation in externalizing behaviors that is associated with linear time. Race was positively and significantly associated with overall externalizing behaviors in this model as well ($\gamma = 0.04, p < .05$). The unconditional quadratic model (Model C) fit better than Model B, the unconditional linear model ($\chi^2(2) = 1437.5$), demonstrating a significant, negative coefficient for the linear term of age ($\gamma = -0.27, p < .001$) and a positive coefficient for the quadratic term ($\gamma = 0.009, p < .001$). This indicates that the trajectory of females’ overall externalizing behaviors was also approximated as a slight inverse J-shaped curve (see Figure 2). This model explained 59.5% of the within-person variation in externalizing behaviors that is associated with linear and quadratic age. Most other random effects were significant at the $p < .001$ level as well, notable are the intercept and linear slope ($\sigma^2_0 = 3.17, \sigma^2_1 = 0.04$). Race was not significantly associated with externalizing behaviors in this model or any other subsequent model for females’ overall externalizing behaviors.
Analogous to the male models, I added pubertal timing in the models. Thus, models D (utilizing an age x pubertal timing term) and E (utilizing an age x pubertal timing and age\(^2\) x pubertal timing) were designed to test how pubertal timing’s effect affects the trajectory of externalizing behaviors. Model E fit the data best as indicated by comparing Model D and E’s log-likelihood ratios, AICs, and BICs. The pubertal timing term was positive and significant (\(\gamma = 0.11, p = .01\)), indicating that compared to later maturing peers, early maturing girls at age 12 engaged in more overall externalizing behaviors. The interaction between pubertal timing and age was significant and negative (\(\gamma = -0.02, p < .01\)) and the interaction between the quadratic age term and pubertal timing is also significant (\(\gamma = 0.0008, p < .05\)). To facilitate the interpretation of these coefficients, I illustrated the trajectories of overall externalizing behaviors by three pubertal timing groups (i.e., early, on-time, and late-maturing girls) in Figure 10. As shown the figure, earlier maturing females engaged in more overall externalizing behaviors than on-time or late-maturing individuals but decline in the engagement at a more rapid pace than their on-time or late-maturing counterparts.

**Nonviolent Behaviors.**

**Males.** To begin, I tested an unconditional means model (Model A) to describe the variation in nonviolent behaviors for males (Singer & Willett, 2003). As shown in table 8 both estimated within- and between-person variances from the unconditional means (Model A) model were significant (\(\sigma_\varepsilon^2 = 0.03, \sigma_0^2 = 0.008, p < .001\)). This model also indicated that an estimated 21.7% of the total variation in nonviolent behaviors is due to differences between adolescents (\(\hat{\rho} = 0.2117\)). A subsequent unconditional linear growth model (Model B) included adolescent centered age (centered at age 12) and nonviolent behaviors. This was compared to Model A, with a chi-square difference test indicating that Model B fit better
than Model A ($\chi^2(2) = 1947.9$). The Pseudo $R^2$ suggests that Model B explained 28.05% of the within-person variation in externalizing behaviors that is associated with age. This unconditional linear growth model provides us with a baseline for evaluating subsequent models with our predictor and quadratic term included. This subsequent unconditional quadratic model (Model C) fit better than Model B ($\chi^2(2) = 169.4$) and the fixed effect linear and quadratic terms were significant at the $p < .001$ level (γs = -0.02 and 0.0005, respectively), with significant random effects as well, notably the intercept and linear slope ($\sigma_0^2 = 0.05$, $\sigma_1^2 = 0.0006$, both $p < .001$). Model C explained 34.70% of the within-person variation in nonviolent behaviors that is associated with linear time.

Analogous to the overall externalizing models, I added pubertal timing in the equations. Thus, models D (adding an age x pubertal timing term) and E (adding an age x pubertal timing and age$^2$ x pubertal timing terms) were designed to test pubertal timing’s effect on the trajectory of nonviolent behaviors. Model E fit the data best as indicated by comparing Model D and E’s log-likelihood ratios, AICs, and BICs. Age was again significant, as both a linear and quadratic term (γs = -0.02, 0.0005, both $p < .001$), indicating a decline in engaging in nonviolent behaviors over time with a very slight increase as age progressed in the late-20s. The pubertal timing term was positive and significant ($\gamma = 0.04 \ p < .001$), indicating that more mature boys at age 12 (i.e., early pubertal timing males) engaged in more nonviolent behaviors than on-time or late maturing males. The interaction between pubertal timing and age was significant ($\gamma = -0.006 \ p < .001$) and the interaction between the quadratic age term and pubertal timing is also significant ($\gamma = 0.0002 \ p < .01$). These findings suggest that earlier maturing males engage in more nonviolent behaviors than
on-time or late-maturing individuals but decline in the engagement at a more rapid pace than their on-time or late-maturing counterparts (see Figure 5).

**Females.** Similar to males, the unconditional means model (Model A) nonviolent behaviors to describe the variation in externalizing behaviors (Singer & Willett, 2003). As shown in Table 8 both estimated within- and between-person variances from the unconditional means model were significant ($\sigma^2_e = 0.02, \sigma^2_0 = 0.003, p < .001$) and an estimated 86.3% of the total variation in nonviolent behaviors is due to differences between adolescents ($\hat{\rho} = 0.8629$). The linear growth model (Model B) included adolescent centered age (centered at age 12). This model fit better than Model A ($\chi^2(2) = 2070.8$) and explained 35.8% of the within-person variation in nonviolent behaviors that is associated with age. The unconditional quadratic model (Model C) fit better than the unconditional linear model ($\chi^2(2) = 1823.3$) with the fixed effect linear and quadratic terms significant at the $p < .001$ level ($\gamma$s = -0.03 and 0.001, respectively), with significant random effects as well. Model C explained 48.6% of the within-person variation in nonviolent behaviors that is associated with age (see Figure 3). Models D and E tested pubertal timing’s effect on the trajectory of nonviolent behaviors. Model E fit the data best as indicated by comparing Model D and Es log-likelihood ratios, AICs, and BICs. Age was again significant, as both a linear and quadratic term ($\gamma$s = -0.03, 0.001, both $p < .001$), indicating a decline in engaging in nonviolent behaviors over time with a very slight increase as age progressed in the late-20s. The pubertal timing term was positive and significant ($\gamma = 0.01 p < .05$), indicating that more mature girls at age 12 (i.e., early pubertal timing females) engaged in more nonviolent behaviors. The interaction between pubertal timing and age was significant ($\gamma = -0.002 p < .05$) and the interaction between the quadratic age term and pubertal timing is also significant ($\gamma = 0.0001$
These findings suggest that earlier maturing females engage in more nonviolent behaviors than on-time or late-maturing individuals but decline in the engagement at a more rapid pace than their on-time or late-maturing counterparts (see Figure 6).

**Violent Behaviors.**

**Males.** Similar to previous models, Model A, an unconditional means model, included violent behaviors estimating an intercept only (Singer & Willett, 2003). As shown in Table 9 both estimated within- and between-person variances from the unconditional means model were significant ($\sigma^2_\varepsilon = 0.03$, $\sigma^2_0 = 0.008$, $p < .001$) and an estimated 79.2% of the total variation in violent behaviors is due to differences between adolescents ($\hat{\beta} = 0.7917$). Race significantly predicted the propensity to engage in violent behaviors ($\gamma = 0.15$, $p < .01$), such that minorities were more likely to engage in violent behaviors. The linear growth model (Model B) included adolescent centered age (centered at age 12) and nonviolent behaviors, which fit better than Model A ($\chi^2(2) = 1251.6$) and explained 22.5% of the within-person variation in violent behaviors that is associated with age. The subsequent unconditional quadratic model (Model C) did not fit better than the unconditional linear model. This best fitting model suggests that for every 1 year of age, males’ violent behaviors decrease by .01 points (see Figure 4). Moving forward, I added pubertal timing in the models. Thus, models D (using pubertal timing as a fixed effect) and E (using pubertal timing as well as adding a pubertal timing x age term) were designed to test pubertal timing’s effect on the linear trajectory of externalizing behaviors. Model E fit the data best as indicated by comparing Model D and E’s log-likelihood ratios, AICs, and BICs. Age was significant ($\gamma = -0.01$, $p < .001$), indicating a decline in engaging in externalizing behaviors over time. Race significantly predicted violent behaviors in this model as well ($\gamma = .02$, $p < .001$). The
pubertal timing term was positively and significantly associated with males’ violent behaviors ($\gamma = 0.03, p < .001$) and the pubertal timing x age interaction term indicated that earlier maturing males engaged in more violent behaviors ($\gamma = -0.002, p < .001$). These results suggest that males who enter puberty earlier than same-sex, same-age peers engage in more violent behaviors but this effect seems to dissipate in the mid-20s, with the early maturers behaving similar to the late maturers at this age range (see Figure 7).

**Females.** Likewise, Model A, an unconditional means model, included violent behaviors estimating an intercept only to describe the variation in violent behaviors for females (Singer & Willett, 2003). As shown in table 9 both estimated within- and between-person variances from the unconditional means model were significant ($\sigma^2 \varepsilon = 0.02 \sigma^2 \theta = 0.003, p < .001$) and an estimated 83.9% of the total variation in violent behaviors is due to differences between adolescents ($\hat{\rho} = 0.8391$). Similar to the males’ violent model, females’ race was positively and significantly associated with the propensity to engage in violent behaviors ($\gamma = 0.03, p < .001$). This suggests that females who were minority races engaged in more violent behaviors than White females. The linear growth model (Model B) included adolescent centered age (centered at age 12) and violent behaviors fit better than Model A ($\chi^2(2) = 1307.1$) and explained 19.3% of the within-person variation in violent behaviors that is associated with age. Again, race was significantly and positively associated with violent behaviors ($\gamma = 0.03, p < .001$). The subsequent unconditional quadratic model (Model C) did not fit better than Model B. This final unconditional linear model suggests that for every 1 year of age, females’ violent behaviors decrease by .007 points (see Figure 4). Analogous to the male violent behavior model, I added pubertal timing (models D and E). Model E fit the data best as indicated by comparing Model D and E’s log-likelihood ratios, AICs, and BICs.
Race was significant in this final model, indicating minority races engaged in more violent behaviors ($\gamma = .02, p < .001$). In Model E, age was again significant ($\gamma = -0.007, p < .001$), indicating a decline in engaging in externalizing behaviors over time. The pubertal timing term and pubertal timing x age term were not significant, indicating no significant difference between earlier maturing females and on-time or late maturing females. (see Figure 7).
CHAPTER 4: GENERAL DISCUSSION

Years of empirical evidence have documented the adverse effects of early pubertal timing on concurrent externalizing behaviors (Dimler & Natsuaki, 2015; Ullsperger & Nikolas, 2017). Most of these studies have concluded that this effect only occurs in adolescence (e.g., Mrug et al., 2008), but there are a number of studies which find a longitudinal effect of early pubertal timing (e.g., Mensah et al., 2013), leading to inconclusiveness about early pubertal timing’s effect on the trajectory of externalizing behaviors. Part of the reason for this discrepancy may be due to the notion that externalizing behaviors may be too broad of a term to describe a wide range of behaviors. Pubertal timing has been shown to separately affect nonviolent and violent externalizing behaviors (Cota-Robles et al., 2002), thus the main aim of this study was to assess if pubertal timing has a differential, longitudinal effect on two separate domains of externalizing behaviors - nonviolent and violent behaviors.

Using data from a large, diverse nationally representative sample of adolescents who are followed over 14 years, the current study sought to assess if this pubertal timing effect lasts through adulthood and, if so, if it lasts for either nonviolent or violent behaviors. Specifically, this study asked the following questions: (1) does early maturation have a differential effect on nonviolent vs. violent externalizing behavior problems?; and (2) if so, is the pubertal timing effect constrained to adolescence or does it last into young adulthood? I hypothesized (1) that early maturation would affect specifically nonviolent behaviors; and (2) that the effect of early maturation would be mainly short-lived and dissipate as adolescents become adults. Based on meta-analytic findings suggesting a lack of notable sex differences in early pubertal timing’s effect on externalizing behaviors, I did not have any hypotheses.
Regarding sex differences, but I analyzed them separately as boys and girls experience puberty differently.

Overall, the results supported the hypotheses. Using longitudinal growth curve analyses, I demonstrated that both males and females who experienced earlier pubertal timing reported elevated overall externalizing and nonviolent behaviors throughout adolescence but became indistinguishable from on-time and late-maturers in adulthood. For violent behaviors, I saw a similar short-lived effect of early maturation for males, but not females. The results suggested that pubertal timing may differentially affect these two domains of externalizing behaviors for each sex.

**Early Pubertal Timing and Trajectory of Overall Externalizing, Nonviolent, and Violent Behaviors**

When initially fitting the age trajectory of externalizing, nonviolent, and violent behaviors, the results replicated prior findings such that violent behaviors decreased linearly over time and nonviolent behaviors followed a quadratic pattern with a faster decrease in these behaviors in late adolescence/early young adulthood. For instance, Bongers et al. (2004) found that violent behaviors such as aggression decreased linearly with age throughout adolescence while nonviolent behaviors (e.g., oppositional behaviors) followed a curvilinear trajectory, indicating an increase in adolescence (from childhood), and a fast decrease in these behaviors in late adolescence.

This furthers the supposition that nonviolent and violent behaviors may be different concepts. At a descriptive level, this study has possible theoretical implications for Moffitt’s (1993) taxonomy of the development of antisocial behavior. While I was not able to assess childhood externalizing behaviors, the results suggest that externalizing and nonviolent
behaviors may peak during adolescence, lending possible support for an adolescence-limited view of externalizing behaviors, specifically nonviolent behaviors. In general, the association of early maturation with externalizing behaviors is based on early maturing adolescents displaying greater levels of nonviolent behaviors such as property damage, vandalism, shoplifting, rule-breaking, truancy, and lying to parents (Mendle & Ferrero, 2012). In the current study, it seems these adolescents were able to recover from these behaviors as their behaviors, especially for females, were nonviolent and mostly adult-like or independence-seeking behaviors, thus not being considered delinquent once young adulthood is reached.

On the other hand, violent behaviors decreased linearly over time, possibly providing credence to Steinberg and Cauffman’s (1996) theory of the desistance from antisocial and violent behavior. This theory posits that the growth of psychosocial maturity in adolescence is the root of desistance from antisocial behavior from adolescence to adulthood. Adolescents also gain more self-control as they transition into adulthood, thus being able to better refrain from antisocial behavior in adulthood (Gottfredson & Hirschi, 1990). It is important to note that these theories do not state that the desire to engage in these behaviors have desisted, but simply the self-restraint needed to not engage in the behaviors has increased. While I did not assess for psychosocial maturity, the data follow the trend of the theories. In this study, it seemed the adolescents were able to recover from these behaviors as well, but it is important to note that group trajectories were not assessed, therefore, it is possible that, as Moffit (1993) proposed, there were still individuals who persisted in engaging in violent behaviors. While these descriptive results are fascinating and informative about the general trends of nonviolent and nonviolent behaviors, how pubertal timing affects these externalizing behavior trajectories was the main focus of the current investigation.
The results further indicated that entering puberty earlier than peers affected both males’ and females’ overall externalizing behaviors at age 12, but especially affected their nonviolent behaviors. Surprisingly, early puberty was shown to affect males’ violent behaviors as well. This effect ($\gamma = .24$) was much smaller than the effect early maturation had on overall externalizing behaviors and nonviolent behaviors ($\gamma$s = .76 and .43, respectively), but it was significant nonetheless. This builds on previous literature (Cota-Robles et al., 2002; Ullsperger and Nikolas, 2017) by suggesting that early pubertal timing has a separate effect on nonviolent and violent behaviors between the sexes. Lastly, early maturers’ overall externalizing, nonviolent, and violent were indistinguishable from on-time and late maturers’ overall externalizing, nonviolent, and violent behaviors, respectively, after adolescence (Figures 5-7), thus supporting the hypothesis that the pubertal timing effect would be constrained to adolescence.

These results replicate prior research supporting the attenuation hypothesis (e.g., Copeland et al., 2010; Graber et al., 2004). This hypothesis states that while early maturation has adverse effects, by adulthood, these effects diminish as the early, on-time, and late maturing adolescents reach physical, emotional, and cognitive maturity into adulthood. It has been suggested that theoretically, the effect of early pubertal timing attenuates due to two possible reasons: the early maturers truly declined in their engagement of overall, nonviolent, and violent externalizing behaviors or the on-time and late maturers ‘caught-up’ to the early maturers’ behaviors (Caspi et al., 1993). Based on the evidence of the current study and prior research (e.g., Copeland et al., 2010; Deardorff et al., 2013), the former explanation is more probable in that early maturers decreased their externalizing behaviors as early pubertal timing ceased being a risk factor for all outcomes after adolescence (i.e., after wave 2).
The effect of early pubertal timing on males’ violent behaviors may suggest that other mechanisms may be at play, as the estimate is substantially smaller than the effect of early maturation on overall externalizing and nonviolent behaviors for males. For instance, prior research with this dataset (Harden & Mendle, 2012) found that early maturers’ violent behaviors were more influenced by genetics than were nonviolent behaviors. Thus, among early maturers, individual differences in violent behaviors explained by individual differences in pubertal timing may be small. Males’ violent behaviors may be affected by early pubertal timing for a few other possible reasons. One possibility is that parents and teachers may view these early maturing males as being not just physically mature, but also emotionally mature and self-sufficient, therefore offering less supervision and monitoring (Haynie & Piquero, 2006). Another reason is that by engaging in aggressive and violent behaviors, the early maturing males come into contact with other individuals who are likely to commit these same behaviors. Finally, early pubertal timing may act as a trigger to such a high level of emotional and cognitive distress and instability, that it leads boys to act out in ways that are considered as aggressive (Schreck, Burek, Stewart, & Mitchell Miller, 2007). This final supposition seems likely in that it supports a number of theoretical frameworks. Gottfredson & Hirschi’s (1990) and Steinberg & Cauffman’s (1996) theories suggest the growth of psychosocial maturity during the adolescence to adulthood transition contributes to the decline of antisocial behaviors once adolescents enter adulthood. Thus, the early maturing males that are engaging in these violent behaviors are even less prepared in terms of psychosocial maturity than their on-time or late-maturing counterparts, but still follow the trend of decreasing in engagement of violent behaviors as they grow older.
Additionally, since early maturation does not affect violent behaviors in females, this insinuates that the findings commonly seen in the literature for females’ early maturation and externalizing behaviors may actually be driven by nonviolent behaviors. For instance, Carter et al.’s (2009) results suggest that female early maturers are significantly more likely to engage in externalizing behaviors, confirming other empirical literature showing comparable results (e.g., Caspi et al., 1993; Kaltiala-Heino, Marttunen, Rantanen, & Rimpelä, 2003; Skoog, Stattin, Ruiselove, & Özdemir, 2013). The key here is that the externalizing behavior measures in these studies consisted of items that are all nonviolent in nature (e.g., arguing with adults, stealing money, drinking alcohol). As the research for the effect of early pubertal timing on overall externalizing behaviors is more extensive and consistent for females than for males (possibly due to menarche, a clear indicator of puberty, Negriff & Susman, 2011), this finding helps clarify that the differential effect of early pubertal timing on nonviolent and violent behaviors may be due to females’ externalizing behaviors being measured mostly by nonviolent behaviors.

Unfortunately, this finding does not clarify why a few studies still find an association between female early maturation and violent behaviors (e.g., Harden & Mendle, 2012), but one reason may be sampling procedures. For example, Harden and Mendle (2012) used a sample of twin and sibling females, which prior research has suggested that sibling externalizing behaviors can significantly affect the other sibling’s externalizing behaviors (Defoe et al., 2013; Natsuaki, Ge, Reiss, & Neiderhiser, 2009). On the other hand, it is important to note that the studies which use both males and females in their sample indicate the main effect of early maturation on violent behaviors is more salient in males than in females (e.g., Ge et al., 2002).
Overall, the results of the longitudinal growth analyses aided in the understanding of the differential and longitudinal effect of early pubertal timing on externalizing, nonviolent, and violent behaviors in both males and females, suggesting that early maturers engage in more externalizing and nonviolent behaviors than on-time or late maturers, but only early maturing males engage in an increased amount of violent behaviors.

**Developmental Consideration on Measures of Externalizing Problems**

One of the methodological challenges that plagues any long-term longitudinal study is that an outward display of the psychological construct of interest may change over time as the physical, cognitive, and behavioral capacity of a child change with age. This phenomenon is known as heterotypic continuity (Caspi, 1998; Kagan, 1969), and the heterotypic continuity of externalizing problems has been recognized in the literature (Patterson, 1993). For instance, writing a fraudulent check may represent a nonviolent externalizing behavior in adulthood but not in adolescence. One of the unique features of this study is that it incorporates age-appropriate items of violent and nonviolent behaviors in assessing externalizing behaviors from early adolescence (i.e., age 12) through young adulthood (i.e., age 30).

Prior to testing the main hypotheses, I assessed a measurement invariance model for overall externalizing behaviors using parceling to separate the common items and unique items across each wave, thus creating a latent variable of overall wave externalizing behavior. The latent variables of externalizing behaviors at each wave were made up of four parcels: common nonviolent behaviors (i.e., items assessed at each timepoint), unique nonviolent behaviors (i.e., items assessed at any timepoint, but not continuously), common violent behaviors, and unique violent behaviors. This factorial invariance model assessed two
concepts: 1) the heterotypic continuity of nonviolent and violent behaviors, respectively, over
time, and 2) that nonviolent and violent behaviors are distinct from each other and this
distinctness carries over all four waves. The latent variables of overall externalizing
behaviors at each wave were moderately to strongly associated with all other data waves of
externalizing behaviors, and while these interrelationships cannot (and should not) be
completely relied upon as evidence that the same constructs are involved in different
contexts, they can aid in identifying theoretical mechanisms or processes that are general
across people over time (Nesselroade, Ram, Gerstorf, & Hardy, 2009).

Underneath the general level of intercorrelations, specific factor loadings were
revealed to be small to moderate. Although the resulting factor loadings were small to
moderate, they were consistent over time within waves (Table 6, Model E), indicating partial
strong factorial invariance (Widaman et al., 2010). Additionally, the nonviolent and violent
factor loadings indicate that the two types of externalizing behaviors are indeed distinct from
one another. This supports previous research from a similar longitudinal, Canadian nationally
representative sample (Miller et al., 2009) in which a two-factor model of physical and
indirect aggression was stable across time, lending support for the concept of externalizing
behaviors being comprised of two distinct behaviors. Assessing measurement invariance in
this way was a developmentally sensitive approach, yielding pertinent information for the
puberty literature. My results went beyond a two-factor model of externalizing behaviors
(i.e., overall nonviolent and overall violent behaviors) in order to identify the behaviors that
are developmentally salient behaviors in adolescence (e.g., running away from home) and in
adulthood (e.g., writing a fraudulent check). By using this developmentally sensitive
approach, I was able to assess developmental change within individuals that may have caused
shifts in the ways that questions were interpreted, even within the common items across time (Hertzog & Nesselroade, 2003). For example, changes in self-reported nonviolent behaviors could reflect changes in actual engagement of the behaviors or merely changes in how the participants interpreted and responded to the scales’ items. Thus, by using this approach, I was able to indicate that, despite potential changes in interpretation to even the common items, the structure was the same over time. Additionally, although pubertal timing was not a part of the invariance model, displaying the invariance in externalizing measurement helped to further clarify how much regard to place in the results for the pubertal timing effect on externalizing behaviors. The effect of early pubertal timing on externalizing behaviors for males and females, especially in regards to early maturing females’ nonviolent behaviors, is now more notable knowing that the underlying factor structure of the measures is the same, despite different measurements over time. Furthermore, not only is this effect partitioned by the type of externalizing behavior, but the parceling of items over the four waves and including the unique behaviors in adolescence and adulthood allowed for the effect of puberty to be assessed longitudinally with as much measurement information as possible.

**Strengths, Limitations, and Future Directions**

The current study drew on a multi-wave, multi-informant longitudinal study of a large and diverse sample of adolescents. Notable strengths of this investigation included the examination of separate types of externalizing behaviors and utilizing three reports of pubertal timing to create a composite score for this predictor variable. Importantly, this study was also able to assess which type of externalizing behaviors (i.e., nonviolent or violent behaviors) has been driving the common finding that early pubertal maturation is related to engaging in more externalizing behaviors, and when this effect dissipates. To my knowledge,
this study was also the first study to assess the measurement invariance of these two types of externalizing behaviors over the course of ages 12 through 30 in Add Health. Finally, this study was able to detect possible differences between males and females in how early pubertal timing differentially affects externalizing behaviors and the magnitude at which these specific behaviors are affected. Despite the contributions of this study to the existing developmental psychopathology literature, there are several limitations that must qualify the interpretation of the results but lead to promising future research endeavors.

First, the current study’s results show low factor loadings in the measurement invariance model, which could be due to a number of reasons. In order to parcel the data, I divided the items into four groups: common nonviolent behaviors, unique nonviolent behaviors, common violent behaviors, and unique violent behaviors. This reduced the total number of items in each parcel anywhere from 3-7 items (i.e., the common violent parcel was crafted with only 3 items). I also only used the items in which the participant engaged in the behavior (e.g., “How often did you hurt someone badly enough to need bandages or care from a doctor or nurse?”), not the items that were perpetrated onto the individual (e.g., “How often were you jumped?”), which reduced the number of total items in each parcel, which, coupled with skewed data, has been shown to affect model fit and factor loadings (Marsh, Hau, Balla, & Grayson, 1998; Hau & Marsh, 2004). Future research should focus on continuing the extrapolation of nonviolent and violent behaviors in a multimethod manner in order to understand how these behaviors change over time as well as utilize measures that have more than 3-7 items in each parcel. Future studies need to replicate these results more in depth, but based on prior studies using similar longitudinal, nationally representative datasets, I remain confident in the findings that there is heterotypic continuity in nonviolent
and violent behaviors over time and that nonviolent and violent behaviors are distinct (e.g., Beaver et al., 2016; Broidy et al., 2003; Burt & Neiderhiser, 2009; Miller et al., 2009; Olino et al., 2018). Additionally, as the factor loadings were small to moderate, a promising area of future research is to continue to replicate these and Miller et al.’s (2009) results of a two-factor externalizing behavior variable.

Second, the measurements for externalizing behaviors were all self-report. Prior theory and research states that externalizing behaviors reported by different reporters (e.g., self, parent, teacher, and mental health worker reports) are likely to be more reliable such that younger adolescents may not always indicate the true amount of engagement in externalizing behaviors due to social desirability and social norms (van de Mortel, 2008). It should be noted that while self-report is valuable for its unique and independent perspective, there is no optimal informant or gold-standard reporter, and having multiple informants allows researchers to glean a fuller and more reliable picture (De Los Reyes et al., 2015; Kraemer et al., 2003; Stanger & Lewis, 1993). As Cole (1987) cautions, the factor analyzed (i.e., externalizing behaviors) could be a result of the nominalistic fallacy – just because a researcher names the factor being analyzed does not dictate that we actually know what it is. For example, I labeled the latent constructs as externalizing behaviors, but the factor may actually be measuring ‘self-reported externalizing behaviors.’ Thus, a different confirmatory factor analysis using a combination of methods (i.e., self-report, parent-report, and teacher-report) may yield a stronger invariance model and more robust growth curve analysis results. Additionally, I used the means of each type of externalizing behavior outcome, but future research would benefit from using factor scores in growth models or even using latent growth models in order to parse out the effect of early pubertal timing on different outcomes.
Third, as prior research has shown, pubertal timing may even have a differential effect on three types of externalizing behaviors: status offenses, property offenses, and person offenses (e.g., Negriff et al., 2011). The current study was not able to assess externalizing behaviors in this way as there would have been too few items in each parcel. For instance, there were 5 items that assessed status offenses with 1 item common throughout all four waves and 4 items that were in at least one wave, 8 items for property offenses with 5 common items and 2 unique items, and finally, 7 items for person offenses with 4 common items and 3 unique items. While the current study focused on a two-factor view of externalizing behaviors due to these limited number of items, utilizing a three-factor view in future research may prove to provide even more clarity on the magnitude and longevity of early maturation’s effect on different types of externalizing behaviors.

Fourth, due the scope of the study and the categorical nature of race/ethnicity, I coded race into a dichotomous variable of white vs. non-white groups. This crude measure of race does not convey the diversity within the non-White racial/ethnic groups. Attending to the nuanced differences within the ethnic minority populations in the puberty research is important because prior work has shown a differential timing of puberty across ethnic groups, such that Black girls tend to mature earlier than Caucasian and Latino/a individuals (Parent et al., 2003; Sun et al., 2002) and early maturers’ externalizing behaviors may be differentially affected based on their race/ethnicity, and even ethnic subgroup (e.g., Carter, Caldwell, Matusko, Antonucci, & Jackson, 2011; Cavanagh, 2009). On the other hand, Lynne, Graber, Nichols, Brooks-Gunn, & Botvin (2007) found that early maturation predicted externalizing behaviors, both nonviolent and violent, in Latino/a and Black adolescents as well as in White adolescents, without a differential effect. This issue is likely
muddied due to racial differences in pubertal timing in American males and females being deeply fused with socioeconomic status. For instance, Obeidallah et al. (2000) found a significant difference in pubertal timing between Caucasian and Latina girls, but this association was not significant once controlling for socioeconomic status. In the current study, socioeconomic status was only assessed via maternal education obtainment. Future research should conduct race/ethnicity and socioeconomic status sensitive analyses by including maternal education and other indicators, such as family income, caregivers’ occupational prestige, as well as environmental contexts such as disadvantaged neighborhoods.

Finally, future research should determine both risk and protective factors that may mediate the effect of early maturation on externalizing behaviors. For example, Kweon, Yun, Park, & Kim (2017) found that early pubertal timing’s effect on delinquency is partially mediated by the child’s attachment to the parents such that early pubertal timing may lead to poor parental attachment, which may then contribute to an increase in delinquent behaviors. Additionally, early pubertal timing is associated with peer deviance, suggesting that early maturers may be more vulnerable to deviant peer influences, and specifically for nonviolent behaviors (Mrug et al., 2014). Future research would benefit by assessing these and other pertinent moderators and mediators, with special attention on risk and protective factors for violent and nonviolent behaviors.

**Implications and Conclusions**

The current investigation addressed several gaps in the existing scientific literature on early pubertal timing’s effects on two domains of externalizing behaviors for both males and females from early adolescence through young adulthood. The findings in this study
suggested early pubertal timing affected nonviolent and violent behaviors differently, such that early pubertal timing affected nonviolent behaviors and this effect is constrained to adolescence in both males and females. Interestingly, violent behaviors seemed to follow a different pattern, such that early pubertal timing had an adverse effect on males’ violent behaviors, but not females’ violent behaviors. There has previously been mixed research in how early pubertal timing affects the trajectory of externalizing behaviors, possibly due to the notion that externalizing behaviors is too broad of a term. Thus, the current study partitioned externalizing behaviors into nonviolent and violent behaviors in order to fill a critical gap in the scientific literature as well as aid theorists and interventionists.

Furthermore, these data suggest that intervention efforts aimed at mitigating the deleterious effects of early pubertal timing on violent and, especially, nonviolent behaviors should happen as early in adolescence as possible. Intervention work should prioritize prevention of these behaviors as well as provide support for both parents of adolescents who are early maturers and for the adolescents themselves. Specifically, preparing pre-adolescents for the biological and psychosocial changes of puberty has been shown to lower other maladaptive behaviors in adolescents (e.g., disordered eating and low self-esteem, Cousineau et al., 2011) and it is possible that similar intervention efforts will also lower externalized maladaptive behaviors.

Overall, understanding the longevity of the associations between early pubertal timing and two separate domains of externalizing behaviors offers new challenges and insights to researchers and interventionists as well as highlights that there may actually be a qualitative difference between the association of early pubertal timing on nonviolent and violent behaviors. This study suggests researchers may need to be cautious about conclusions
drawn from aggregating both domains when assessing this effect in the future and instead, intentionally evaluate separate types of externalizing behaviors with regards to pubertal timing and adolescence.
References


Natsuaki, M. N. (2013). Puberty in context: Toward a more nuanced understanding of


Abnormal Child Psychology. doi:https://doi.org/10.1007/s10802-018-0398-6


Table 1. Common Items of Nonviolent and Violent Behaviors.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Wave 1</th>
<th>Wave 2</th>
<th>Wave 3</th>
<th>Wave 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Delinquency Scale</td>
<td>Fighting &amp; Violence Scale</td>
<td>Delinquency Scale</td>
<td>Fighting &amp; Violence Scale</td>
</tr>
<tr>
<td>Nonviolent</td>
<td>2. In the past 12 months, how often did you deliberately damage property that didn’t belong to you?</td>
<td>2. In the past 12 months, how often did you deliberately damage property that didn’t belong to you?</td>
<td>1. In the past 12 months, how often did you deliberately damage property that didn’t belong to you?</td>
<td>1. In the past 12 months, how often did you deliberately damage property that didn’t belong to you?</td>
</tr>
<tr>
<td>Nonviolent</td>
<td>4. How often did you take something from a store without paying for it?</td>
<td>4. How often did you take something from a store without paying for it?</td>
<td>8. In the past 12 months, how often did you buy, sell, or hold stolen property?</td>
<td>8. In the past 12 months, how often did you buy, sell, or hold stolen property?</td>
</tr>
<tr>
<td>Nonviolent</td>
<td>9. In the past 12 months, how often did you steal something worth more than $50?</td>
<td>7. In the past 12 months, how often did you steal something worth more than $50?</td>
<td>2. In the past 12 months, how often did you steal something worth more than $50?</td>
<td>2. In the past 12 months, how often did you steal something worth more than $50?</td>
</tr>
<tr>
<td>Nonviolent</td>
<td>10. How often did you go into a house or building to steal something?</td>
<td>8. How often did you go into a house or building to steal something?</td>
<td>3. How often did you go into a house or building to steal something?</td>
<td>3. How often did you go into a house or building to steal something?</td>
</tr>
<tr>
<td>Nonviolent</td>
<td>12. How often did you sell marijuana or other drugs?</td>
<td>10. How often did you sell marijuana or other drugs?</td>
<td>5. How often did you sell marijuana or other drugs?</td>
<td>5. How often did you sell marijuana or other drugs?</td>
</tr>
<tr>
<td>Question</td>
<td>Question</td>
<td>Question</td>
<td>Question</td>
<td>Category</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>11. How often did you use or threaten to use a weapon to get something from someone?</td>
<td>9. How often did you use or threaten to use a weapon to get something from someone?</td>
<td>4. How often did you use or threaten to use a weapon to get something from someone?</td>
<td>4. How often did you use or threaten to use a weapon to get something from someone?</td>
<td>Violent</td>
</tr>
<tr>
<td>14. In the past 12 months, how often did you take part in a fight where a group of your friends was against another group?</td>
<td>13. In the past 12 months, how often did you take part in a fight where a group of your friends was against another group?</td>
<td>7. In the past 12 months, how often did you take part in a fight where a group of your friends was against another group?</td>
<td>7. In the past 12 months, how often did you take part in a fight where a group of your friends was against another group?</td>
<td>Violent</td>
</tr>
<tr>
<td>7. In the past 12 months, how often did you pull a knife or gun on someone?</td>
<td>6. In the past 12 months, how often did you pull a knife or gun on someone?</td>
<td>18H. In the past 12 months, how often did you pull a knife or gun on someone?</td>
<td>19. In the past 12 months, how often did you pull a knife or gun on someone?</td>
<td>Violent</td>
</tr>
</tbody>
</table>
Table 2. *Unique Items of Nonviolent and Violent Behaviors.*

<table>
<thead>
<tr>
<th>Wave 1</th>
<th>Wave 2</th>
<th>Wave 3</th>
<th>Wave 4</th>
<th>Construct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delinquency Scale</td>
<td>Fighting &amp; Violence Scale</td>
<td>Delinquency Scale</td>
<td>Fighting &amp; Violence Scale</td>
<td>Delinquency &amp; Violence</td>
</tr>
<tr>
<td>1. In the past 12 months, how often did you paint graffiti or signs on someone else's property or in a public place?</td>
<td>1. In the past 12 months, how often did you paint graffiti or signs on someone else's property or in a public place?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. In the past 12 months, how often did you lie to your parents or guardians about where you had been or whom you were with?</td>
<td>3. In the past 12 months, how often did you lie to your parents or guardians about where you had been or whom you were with?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. How often did you run away from home?</td>
<td>5. How often did you run away from home?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. How often did you drive a car without its owner's permission?</td>
<td>6. How often did you drive a car without its owner's permission?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. How often were you loud, rowdy, or unruly in a public place?</td>
<td>12. How often were you loud, rowdy, or unruly in a public place?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Frequency</td>
<td>Violence Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the past 12 months, how often did you use someone else's credit card, bank card, or automatic teller card without their permission or knowledge?</td>
<td>9. In the past 12 months, how often did you use someone else's credit card, bank card, or automatic teller card without their permission or knowledge?</td>
<td>Nonviolent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the past 12 months, how often did you deliberately write a bad check?</td>
<td>10. In the past 12 months, how often did you deliberately write a bad check?</td>
<td>Nonviolent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often did you get into a serious physical fight?</td>
<td>5. In the past 12 months, how often did you get into a serious physical fight?</td>
<td>Violent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often did you hurt someone badly enough to need bandages or care from a doctor or nurse?</td>
<td>22. How often did you hurt someone badly enough to need bandages or care from a doctor or nurse?</td>
<td>Violent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the past 12 months, how often did you use a weapon in a fight?</td>
<td>10/17. In the past 12 months, how often did you use a weapon in a fight?</td>
<td>Violent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the last 12 months, have you carried a weapon at school?</td>
<td>11. In the last 12 months, have you carried a weapon at school?</td>
<td>Violent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. *Means and Standard Deviations for Age, Externalizing Behaviors, and Subtypes by Sex and Wave*

<table>
<thead>
<tr>
<th>Wave</th>
<th>Age</th>
<th>Externalizing Behaviors</th>
<th>Nonviolent Behaviors</th>
<th>Violent Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave 1</td>
<td>14.59 (1.18)</td>
<td>3.77 (3.49)</td>
<td>2.22 (2.29)</td>
<td>1.56 (1.68)</td>
</tr>
<tr>
<td>Wave 2</td>
<td>15.41 (1.21)</td>
<td>2.77 (3.21)</td>
<td>1.86 (2.15)</td>
<td>0.91 (1.55)</td>
</tr>
<tr>
<td>Wave 3</td>
<td>20.90 (1.25)</td>
<td>0.93 (1.57)</td>
<td>0.65 (1.23)</td>
<td>0.28 (0.66)</td>
</tr>
<tr>
<td>Wave 4</td>
<td>27.54 (1.26)</td>
<td>0.55 (1.19)</td>
<td>0.32 (0.80)</td>
<td>0.24 (0.66)</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave 1</td>
<td>14.51 (1.19)</td>
<td>2.75 (2.81)</td>
<td>1.89 (1.95)</td>
<td>0.86 (1.34)</td>
</tr>
<tr>
<td>Wave 2</td>
<td>15.36 (1.22)</td>
<td>2.10 (2.37)</td>
<td>1.62 (1.71)</td>
<td>0.48 (1.11)</td>
</tr>
<tr>
<td>Wave 3</td>
<td>20.79 (1.25)</td>
<td>0.45 (0.92)</td>
<td>0.25 (0.71)</td>
<td>0.20 (0.53)</td>
</tr>
<tr>
<td>Wave 4</td>
<td>27.38 (1.25)</td>
<td>0.20 (0.68)</td>
<td>0.14 (0.53)</td>
<td>0.06 (0.32)</td>
</tr>
</tbody>
</table>
Table 4. Correlations for Study Variables.

|      | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   | 19   | 20   |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1.   | age1 | --   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 2.   | age2 | .97  | --   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 3.   | age3 | .92  | .91  | --   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 4.   | age4 | .92  | .92  | .90  | --   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 5.   | sex  | -.03 | -.02 | -.04 | -.06 | --   |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 6.   | momedu | .03  | .01  | -.01 | -.01 | -.12 | --   |      |      |      |      |      |      |      |      |      |      |      |      |
| 7.   | race | .00  | .01  | .02  | .01  | .01  | .00  | --   |      |      |      |      |      |      |      |      |      |      |      |
| 8.   | Mpubtim | .00  | .01  | .02  | .01  | n/a  | .01  | .04  | --   |      |      |      |      |      |      |      |      |      |      |
| 9.   | Fpubtim | .00  | .01  | .02  | .01  | .01  | .00  | n/a  | .01  | --   |      |      |      |      |      |      |      |      |      |
| 10.  | ext1 | .08  | .09  | .09  | .09  | -.16 | -.02 | .04  | .14  | .06  | --   |      |      |      |      |      |      |      |      |
| 11.  | ext2 | .02  | .02  | .02  | .02  | -.12 | .00  | .01  | .13  | .04  | .58  | --   |      |      |      |      |      |      |      |
| 12.  | ext3 | -.08 | -.07 | -.08 | -.08 | -.19 | -.12 | .02  | .02  | -.01 | .29  | .35  | --   |      |      |      |      |      |      |
| 13.  | ext4 | -.03 | -.03 | -.03 | -.02 | -.18 | .05  | .06  | .01  | .02  | .22  | .18  | .29  | --   |      |      |      |      |      |
| 14.  | NV1  | .11  | .11  | .12  | .11  | -.08 | .00  | -.01 | .12  | .07  | .91  | .54  | .26  | .18  | --   |      |      |      |      |
| 15.  | NV2  | .03  | .03  | .03  | .02  | -.06 | .01  | -.03 | .10  | .03  | .52  | .90  | .29  | .14  | .55  | --   |      |      |      |
| 16.  | NV3  | -.08 | -.07 | -.08 | -.08 | -.20 | -.07 | .00  | .00  | -.01 | .20  | .21  | .89  | .24  | .20  | .22  | --   |      |      |
| 17.  | NV4  | -.05 | -.03 | -.05 | -.04 | -.13 | .04  | .03  | .01  | .03  | .17  | .14  | .28  | .87  | .16  | .12  | .26  | --   |      |
| 18.  | V1   | .02  | .02  | .04  | .04  | -.23 | -.05 | .09  | .13  | .02  | .82  | .45  | .24  | .20  | .50  | .31  | .13  | .13  | --   |
| 19.  | V2   | .01  | .00  | .00  | .01  | -.16 | -.01 | .07  | .12  | .03  | .47  | .79  | .32  | .18  | .34  | .45  | .13  | .12  | .51  | --   |
| 20.  | V3   | -.04 | -.04 | -.04 | -.03 | -.06 | -.11 | .05  | .04  | .00  | .31  | .42  | .66  | .20  | .23  | .26  | .25  | .14  | .32  | .52  | --   |
| 21.  | V4   | .00  | .02  | .01  | .01  | -.17 | .03  | .07  | .02  | .00  | .18  | .15  | .17  | .75  | .12  | .09  | .10  | .32  | .20  | .18  | .19  |

Notes. MOMEDU = maternal education; MPUTTIM = males pubertal timing index; FPUTTIM = female pubertal timing index; EXT = externalizing behaviors; NV = nonviolent behaviors; V = violent behaviors.

**p < .01. *p < .05
Table 5. Correlations for Study Variables by Sex.

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. age1</td>
<td>--</td>
<td>.94 *</td>
<td>.92 **</td>
<td>.92 **</td>
<td>.08</td>
<td>-.01</td>
<td>.00</td>
<td>.07 *</td>
<td>-.11 **</td>
<td>-.05</td>
<td>.10 **</td>
<td>.04</td>
<td>-.12 **</td>
<td>-.08 **</td>
<td>.01</td>
<td>.02</td>
<td>-.03</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>2. age2</td>
<td>.95 *</td>
<td>--</td>
<td>.91 **</td>
<td>.91 **</td>
<td>.05</td>
<td>-.01</td>
<td>.04</td>
<td>.08 *</td>
<td>-.11 **</td>
<td>-.03</td>
<td>.11 **</td>
<td>.05</td>
<td>-.12 **</td>
<td>-.06 **</td>
<td>.02</td>
<td>.02</td>
<td>-.03</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>3. age3</td>
<td>.92 **</td>
<td>.92 **</td>
<td>--</td>
<td>.91 **</td>
<td>-.02</td>
<td>.00</td>
<td>.01</td>
<td>.08 *</td>
<td>-.11 **</td>
<td>-.04</td>
<td>.10 **</td>
<td>.05</td>
<td>-.13 **</td>
<td>-.07 **</td>
<td>.03</td>
<td>.02</td>
<td>-.02</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>4. age4</td>
<td>.92 **</td>
<td>.93 **</td>
<td>.90 **</td>
<td>--</td>
<td>-.01</td>
<td>.01</td>
<td>-.01</td>
<td>.07 *</td>
<td>-.11 **</td>
<td>-.04</td>
<td>.09 **</td>
<td>.03</td>
<td>-.13 **</td>
<td>-.06 **</td>
<td>.02</td>
<td>.02</td>
<td>-.02</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>5. momedu</td>
<td>-.05</td>
<td>-.05</td>
<td>-.02</td>
<td>-.03</td>
<td>--</td>
<td>-.01</td>
<td>-.07</td>
<td>-.09</td>
<td>-.02</td>
<td>-.14</td>
<td>.06</td>
<td>-.03</td>
<td>-.09</td>
<td>.02</td>
<td>-.15</td>
<td>-.03</td>
<td>-.19</td>
<td>-.09</td>
<td></td>
</tr>
<tr>
<td>6. race</td>
<td>.01</td>
<td>.04</td>
<td>.04</td>
<td>.02</td>
<td>.02</td>
<td>--</td>
<td>-.10 **</td>
<td>.00</td>
<td>.00</td>
<td>.03</td>
<td>.08 **</td>
<td>-.03</td>
<td>-.03</td>
<td>.01</td>
<td>.06 *</td>
<td>.04</td>
<td>.06 *</td>
<td>.04</td>
<td>.06 *</td>
</tr>
<tr>
<td>7. pubtim</td>
<td>.00</td>
<td>.01</td>
<td>.02</td>
<td>-.01</td>
<td>.08</td>
<td>-.04</td>
<td>--</td>
<td>.14 **</td>
<td>.13 **</td>
<td>.02</td>
<td>.01</td>
<td>.12 **</td>
<td>.10 **</td>
<td>.00</td>
<td>-.01</td>
<td>.13 **</td>
<td>.12 **</td>
<td>.04</td>
<td>.02</td>
</tr>
<tr>
<td>8. ext1</td>
<td>.09 **</td>
<td>.09 *</td>
<td>.10 **</td>
<td>.11 **</td>
<td>.03</td>
<td>.09 **</td>
<td>.06 *</td>
<td>--</td>
<td>.55 **</td>
<td>.23 **</td>
<td>.22 **</td>
<td>.91 **</td>
<td>.50 **</td>
<td>.18 **</td>
<td>.17 **</td>
<td>.83 **</td>
<td>.44 **</td>
<td>.20 **</td>
<td>.19 **</td>
</tr>
<tr>
<td>9. ext2</td>
<td>.00</td>
<td>-.01</td>
<td>-.02</td>
<td>.00</td>
<td>.00</td>
<td>.03</td>
<td>.04</td>
<td>.61 **</td>
<td>--</td>
<td>.24 **</td>
<td>.17 **</td>
<td>.51 **</td>
<td>.91 **</td>
<td>.20 **</td>
<td>.13 **</td>
<td>.43 **</td>
<td>.81 **</td>
<td>.20 **</td>
<td>.15 **</td>
</tr>
<tr>
<td>10. ext3</td>
<td>-.07 **</td>
<td>-.05 *</td>
<td>-.08 **</td>
<td>-.07 **</td>
<td>-.15</td>
<td>.03</td>
<td>-.02</td>
<td>.34 **</td>
<td>.52 **</td>
<td>--</td>
<td>.30 **</td>
<td>.23 **</td>
<td>.22 **</td>
<td>.92 **</td>
<td>.30 **</td>
<td>.16 **</td>
<td>.19 **</td>
<td>.67 **</td>
<td>.17 **</td>
</tr>
<tr>
<td>11. ext4</td>
<td>-.03</td>
<td>-.01</td>
<td>-.05 *</td>
<td>-.02</td>
<td>.00</td>
<td>.05 *</td>
<td>.02</td>
<td>.16 **</td>
<td>.14 **</td>
<td>.17 **</td>
<td>--</td>
<td>.19 **</td>
<td>.14 **</td>
<td>.25 **</td>
<td>.86 **</td>
<td>.19 **</td>
<td>.16 **</td>
<td>.25 **</td>
<td>.78 **</td>
</tr>
<tr>
<td>12. NV1</td>
<td>.12 **</td>
<td>.12 **</td>
<td>.12 **</td>
<td>.13 **</td>
<td>.03</td>
<td>.01</td>
<td>.07 **</td>
<td>.91 **</td>
<td>.56 **</td>
<td>.30 **</td>
<td>.14 **</td>
<td>--</td>
<td>.53 **</td>
<td>.20 **</td>
<td>.16 **</td>
<td>.54 **</td>
<td>.32 **</td>
<td>.17 **</td>
<td>.15 **</td>
</tr>
<tr>
<td>13. NV2</td>
<td>.01</td>
<td>.01</td>
<td>.00</td>
<td>.00</td>
<td>.02</td>
<td>-.03</td>
<td>.03</td>
<td>.53 **</td>
<td>.90 **</td>
<td>.38 **</td>
<td>.10 **</td>
<td>.56 **</td>
<td>--</td>
<td>.21 **</td>
<td>.13 **</td>
<td>.31 **</td>
<td>.49 **</td>
<td>.13 **</td>
<td>.11 **</td>
</tr>
<tr>
<td>14. NV3</td>
<td>-.05</td>
<td>-.03</td>
<td>-.05 *</td>
<td>-.06 **</td>
<td>-.10</td>
<td>-.01</td>
<td>-.02</td>
<td>.15 **</td>
<td>.19 **</td>
<td>.83 **</td>
<td>.11 **</td>
<td>.18 **</td>
<td>.22 **</td>
<td>--</td>
<td>.29 **</td>
<td>.10 **</td>
<td>.12 **</td>
<td>.32 **</td>
<td>.09 **</td>
</tr>
<tr>
<td>15. NV4</td>
<td>-.03</td>
<td>-.02</td>
<td>-.04</td>
<td>-.03</td>
<td>.07</td>
<td>.00</td>
<td>.03</td>
<td>.14 **</td>
<td>.12 **</td>
<td>.15 **</td>
<td>.89 **</td>
<td>.15 **</td>
<td>.10 **</td>
<td>.13 **</td>
<td>--</td>
<td>.13 **</td>
<td>.10 **</td>
<td>.17 **</td>
<td>.34 **</td>
</tr>
<tr>
<td>16. V1</td>
<td>.02</td>
<td>.02</td>
<td>.03</td>
<td>.04</td>
<td>.02</td>
<td>.16 **</td>
<td>.02</td>
<td>.78 **</td>
<td>.45 **</td>
<td>.30 **</td>
<td>.13 **</td>
<td>.44 **</td>
<td>.29 **</td>
<td>.07 **</td>
<td>.08 **</td>
<td>--</td>
<td>.47 **</td>
<td>.19 **</td>
<td>.19 **</td>
</tr>
<tr>
<td>17. V2</td>
<td>-.03</td>
<td>-.03</td>
<td>-.03</td>
<td>-.01</td>
<td>-.02</td>
<td>.10 **</td>
<td>.03</td>
<td>.48 **</td>
<td>.75 **</td>
<td>.52 **</td>
<td>.15 **</td>
<td>.34 **</td>
<td>.38 **</td>
<td>.07 **</td>
<td>.10 **</td>
<td>.53 **</td>
<td>--</td>
<td>.24 **</td>
<td>.17 **</td>
</tr>
<tr>
<td>18. V3</td>
<td>-.05 *</td>
<td>-.05 *</td>
<td>-.07 **</td>
<td>-.03</td>
<td>-.06</td>
<td>.05 *</td>
<td>-.01</td>
<td>.40 **</td>
<td>.65 **</td>
<td>.64 **</td>
<td>.12 **</td>
<td>.28 **</td>
<td>.37 **</td>
<td>.10 **</td>
<td>.09 **</td>
<td>.43 **</td>
<td>.81 **</td>
<td>--</td>
<td>.23 **</td>
</tr>
<tr>
<td>19. V4</td>
<td>-.02</td>
<td>.01</td>
<td>-.04</td>
<td>.00</td>
<td>-.07</td>
<td>.11 **</td>
<td>-.01</td>
<td>.10 **</td>
<td>.10 **</td>
<td>.09 **</td>
<td>.65 **</td>
<td>.05 **</td>
<td>.04</td>
<td>.03</td>
<td>.24 **</td>
<td>.14 **</td>
<td>.15 **</td>
<td>.12 **</td>
<td>--</td>
</tr>
</tbody>
</table>

**Notes.** Males’ correlations are above the diagonal; MOMEDU = maternal education; Race = 0 for white, 1 for minorities; PUBTIM = pubertal timing index; EXT = externalizing behaviors; NV = nonviolent behaviors; V = violent behaviors.

**p < .01. *p < .05**
Table 6. *Unstandardized Model Fit Indices and Factor Loadings for Factorial Invariance Models of Externalizing Behaviors for the Full Public Dataset of Add Health*

<table>
<thead>
<tr>
<th>RMSEA [CI]</th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
<th>Model D</th>
<th>Model E</th>
</tr>
</thead>
<tbody>
<tr>
<td>.043 [.041, .046]</td>
<td>.042 [.040, .044]</td>
<td>.041 [.038, .043]</td>
<td>.039 [.037, .041]</td>
<td>.039 [.037, .041]</td>
<td></td>
</tr>
<tr>
<td>SRMR</td>
<td>.048</td>
<td>.046</td>
<td>.045</td>
<td>.045</td>
<td>.045</td>
</tr>
<tr>
<td>CFI</td>
<td>.819</td>
<td>.846</td>
<td>.851</td>
<td>.857</td>
<td>.852</td>
</tr>
<tr>
<td>TLI</td>
<td>.779</td>
<td>.792</td>
<td>.801</td>
<td>.821</td>
<td>.819</td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>1301.278</td>
<td>1116.663</td>
<td>1085.707</td>
<td>1047.704</td>
<td>1079.935</td>
</tr>
<tr>
<td>df</td>
<td>98</td>
<td>89</td>
<td>93</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td>AIC</td>
<td>120963.332</td>
<td>120565.411</td>
<td>120507.272</td>
<td>120536.692</td>
<td>120579.541</td>
</tr>
<tr>
<td>BIC</td>
<td>121329.387</td>
<td>120992.475</td>
<td>120907.220</td>
<td>120916.304</td>
<td>120945.601</td>
</tr>
</tbody>
</table>

**Factor Loadings**

| W1EXT | | | | | |
|------|------|------|------|------|
| w1cnv | .192 | .191 | .278 | .314 | .313 |
| w2unv | .289 | .289 | .295 | .303 | .302 |
| w1cv | .419 | .432 | .430 | .426 | .424 |
| w1uv | .423 | .430 | .408 | .396 | .394 |
| W2EXT | | | | | |
| w2cnv | .192 | .191 | .191 | .219 | .219 |
| w2unv | .290 | .290 | .288 | .296 | .294 |
| w2cv | .624 | .657 | .429 | .426 | .424 |
| w2uv | .452 | .450 | .407 | .395 | .393 |
| W3EXT | | | | | |
| w3cnv | .211 | .211 | .191 | .219 | .218 |
| w3unv | .291 | .291 | .288 | .296 | .294 |
| w3cv | .419 | .432 | .393 | .389 | .374 |
| w3uv | .423 | .431 | .406 | .394 | .393 |
| W4EXT | | | | | |
| w4cnv | .192 | .191 | .191 | .219 | .218 |
| w4unv | .289 | .289 | .288 | .296 | .294 |
| w4cv | .419 | .432 | .429 | .426 | .424 |
| w4uv | .423 | .430 | .407 | .395 | .393 |

**Notes.** EXT = externalizing behavior latent variable; CNV = common parcel of nonviolent behaviors; UNV = unique parcel of nonviolent behaviors; CV = common parcel of violent behaviors; UV = unique parcel of violent behaviors; Model A = baseline configural invariance model; Model B = configural invariance model with within- and between-wave covariances; Model C = configural invariance model with significant within- and between-wave covariances; Model D = weak factorial invariance model; Model E = partial strong invariance model.
Table 7. Model Fit for Externalizing Behaviors by Sex with Unstandardized Parameter Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Model A Males</th>
<th>Model A Females</th>
<th>Model B Males</th>
<th>Model B Females</th>
<th>Model C Males</th>
<th>Model C Females</th>
<th>Model D Males</th>
<th>Model D Females</th>
<th>Model E Males</th>
<th>Model E Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.076***</td>
<td>0.678***</td>
<td>1.887***</td>
<td>1.412***</td>
<td>2.497***</td>
<td>1.943***</td>
<td>2.472***</td>
<td>1.943***</td>
<td>2.471***</td>
<td>1.943***</td>
</tr>
<tr>
<td>Race(^a)</td>
<td>0.066</td>
<td>0.098*</td>
<td>0.104***</td>
<td>0.0380*</td>
<td>0.092**</td>
<td>0.015</td>
<td>0.103***</td>
<td>0.010</td>
<td>0.105***</td>
<td>0.01</td>
</tr>
<tr>
<td>Pubertal Timing</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>0.226***</td>
<td>0.0286</td>
<td>0.383***</td>
<td>0.112*</td>
<td></td>
</tr>
<tr>
<td>Rate of Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-----</td>
<td>-----</td>
<td>-0.114***</td>
<td>-0.093**</td>
<td>-0.308***</td>
<td>-0.268***</td>
<td>-0.309***</td>
<td>-0.268***</td>
<td>-0.309***</td>
<td>-0.267***</td>
</tr>
<tr>
<td>Age \times Pubertal Timing</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-0.015***</td>
<td>-0.003</td>
<td>-0.055***</td>
<td>-0.020**</td>
<td></td>
</tr>
<tr>
<td>Age(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.010***</td>
<td>0.009***</td>
<td>0.010***</td>
<td>0.009***</td>
<td>0.010***</td>
</tr>
<tr>
<td>Age(^2) \times Pubertal Timing</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>0.0009***</td>
<td>0.0008*</td>
</tr>
<tr>
<td>Variance Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within-person</td>
<td>1.829***</td>
<td>1.055***</td>
<td>1.097***</td>
<td>0.550***</td>
<td>0.943***</td>
<td>0.428***</td>
<td>0.950***</td>
<td>0.426***</td>
<td>0.946***</td>
<td>0.425***</td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In intercept</td>
<td>0.419***</td>
<td>0.198***</td>
<td>2.218***</td>
<td>1.169***</td>
<td>4.604***</td>
<td>3.176***</td>
<td>4.489***</td>
<td>3.200***</td>
<td>4.496***</td>
<td>3.194***</td>
</tr>
<tr>
<td>In linear slope</td>
<td>-----</td>
<td>-----</td>
<td>0.005***</td>
<td>0.003***</td>
<td>0.053***</td>
<td>0.041***</td>
<td>0.052***</td>
<td>0.042***</td>
<td>0.052***</td>
<td>0.042***</td>
</tr>
<tr>
<td>Goodness of Fit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2 log likelihood</td>
<td>24051.4</td>
<td>24983.9</td>
<td>20985.9</td>
<td>19172.5</td>
<td>20445.1</td>
<td>17735.0</td>
<td>20157.8</td>
<td>17410.1</td>
<td>20145.8</td>
<td>17404.1</td>
</tr>
<tr>
<td>AIC</td>
<td>24059.4</td>
<td>24991.9</td>
<td>20999.9</td>
<td>19186.5</td>
<td>20465.1</td>
<td>17757.0</td>
<td>20181.8</td>
<td>17436.1</td>
<td>20171.8</td>
<td>17432.1</td>
</tr>
<tr>
<td>BIC</td>
<td>24081.8</td>
<td>25014.8</td>
<td>21039.1</td>
<td>19226.5</td>
<td>20521.2</td>
<td>17819.8</td>
<td>20248.8</td>
<td>17510.2</td>
<td>20244.5</td>
<td>17511.9</td>
</tr>
</tbody>
</table>

Note: \(^a\)Race = 0 for Whites, 1 for minorities.

*\(p < .05\). **\(p < .01\). ***\(p < .001\).
Table 8. Model Fit for Nonviolent Behaviors by Sex with Unstandardized Parameter Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Model A Males</th>
<th>Model A Females</th>
<th>Model B Males</th>
<th>Model B Females</th>
<th>Model C Males</th>
<th>Model C Females</th>
<th>Model D Males</th>
<th>Model D Females</th>
<th>Model E Males</th>
<th>Model E Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.137***</td>
<td>0.103***</td>
<td>0.223***</td>
<td>0.195***</td>
<td>0.253***</td>
<td>0.256***</td>
<td>0.253***</td>
<td>0.257***</td>
<td>0.253***</td>
<td>0.257***</td>
</tr>
<tr>
<td>Race^a</td>
<td>-0.001</td>
<td>-0.003</td>
<td>0.008*</td>
<td>0.003</td>
<td>0.008*</td>
<td>0.001</td>
<td>0.090*</td>
<td>0.002</td>
<td>0.010*</td>
<td>0.002</td>
</tr>
<tr>
<td>Pubertal Timing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate of Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td>-0.013***</td>
<td>-0.013***</td>
<td>-0.0225***</td>
<td>-0.035***</td>
<td>-0.023***</td>
<td>-0.034***</td>
<td>-0.023***</td>
<td>-0.034***</td>
</tr>
<tr>
<td>Age x Pubertal Timing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age^2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0005***</td>
<td>0.001***</td>
<td>0.0005***</td>
<td>0.001***</td>
</tr>
<tr>
<td>Age^2 x Pubertal Timing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance Components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within-person</td>
<td>0.030***</td>
<td>0.021***</td>
<td>0.021***</td>
<td>0.013***</td>
<td>0.019***</td>
<td>0.011***</td>
<td>0.019***</td>
<td>0.011***</td>
<td>0.019***</td>
<td>0.011***</td>
</tr>
<tr>
<td>Level 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In intercept</td>
<td>0.003***</td>
<td>0.003***</td>
<td>0.032***</td>
<td>0.021***</td>
<td>0.046***</td>
<td>0.047***</td>
<td>0.045***</td>
<td>0.047***</td>
<td>0.045***</td>
<td>0.047***</td>
</tr>
<tr>
<td>In linear slope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goodness of Fit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2 log likelihood</td>
<td>-3310.5</td>
<td>-7146.7</td>
<td>-5258.4</td>
<td>-9712.5</td>
<td>-5427.8</td>
<td>-11535.8</td>
<td>-5346.6</td>
<td>-11438.6</td>
<td>-5352.1</td>
<td>-11442.5</td>
</tr>
<tr>
<td>AIC</td>
<td>-3302.5</td>
<td>-7138.7</td>
<td>-5244.4</td>
<td>-9704.5</td>
<td>-5405.8</td>
<td>-11515.8</td>
<td>-5320.6</td>
<td>-11414.6</td>
<td>-5324.1</td>
<td>-11416.5</td>
</tr>
<tr>
<td>BIC</td>
<td>-3280.1</td>
<td>-7115.9</td>
<td>-5205.1</td>
<td>-9681.6</td>
<td>-5344.1</td>
<td>-11458.6</td>
<td>-5248.0</td>
<td>-11346.2</td>
<td>-5245.9</td>
<td>-11342.4</td>
</tr>
</tbody>
</table>

Note: ^aRace = 0 for Whites, 1 for minorities.
*p < .05, **p < .01, ***p < .001.
Table 9. Model Fit for Violent Behaviors by Sex with Unstandardized Parameter Coefficients

<table>
<thead>
<tr>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
<th>Model D</th>
<th>Model E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.115***</td>
<td>0.046***</td>
<td>0.194***</td>
<td>0.102***</td>
</tr>
</tbody>
</table>
| Race  
  Race = 0 for Whites, 1 for minorities. | 0.154** | 0.032*** | 0.021** | 0.026*** | 0.019* | 0.046*** | 0.025*** | 0.017** | 0.025*** | 0.017*** |
| Pubertal Timing | ----- | ----- | ----- | ----- | ----- | ----- | 0.010*** | -0.0005 | 0.032*** | 0.005 |
| Rate of Change | | | | | | | | | | |
| Age | ----- | ----- | -0.011*** | -0.007*** | -0.035*** | -0.025*** | -0.011*** | -0.007*** | -0.011*** | -0.007*** |
| Age x Pubertal Timing | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | -0.002*** | -0.0005 |
| Age^2 | ----- | ----- | ----- | ----- | 0.002 | 0.001* | ----- | ----- | ----- | ----- |
| Age^2 x Pubertal Timing | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |

Variance Components

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-person</td>
<td>0.031***</td>
</tr>
<tr>
<td>In intercept</td>
<td>0.008***</td>
</tr>
<tr>
<td>In linear slope</td>
<td>-----</td>
</tr>
</tbody>
</table>

Goodness of Fit

| -2 log likelihood | -3014.6 | -9373.9 | -4266.2 | -10681.0 | 7102.3 | 2411.4 | -4223.2 | -11706.3 | -4248.7 | -11705.6 |
| AIC | -3006.6 | -9359.9 | -4252.2 | -10673.0 | 7124.3 | 2433.4 | -4207.2 | -11690.3 | -4230.7 | -11687.6 |
| BIC | -2984.1 | -9343.1 | -4213.0 | -10650.1 | 7185.9 | 2496.2 | -4162.5 | -11644.7 | -4180.5 | -11636.3 |

Note: *Race = 0 for Whites, 1 for minorities.

*p < .05. **p < .01. ***p < .001.
Figure 1. Partial strong factor invariance model for externalizing behaviors with unstandardized parameter coefficients.

*p < .05, **p < .01
Figure 2. Externalizing behavior trajectory in males and females.
Figure 3. Nonviolent behavior trajectory in males and females.
Figure 4. Violent behavior trajectory in males and females.
Figure 5. Externalizing behavior trajectories by age, sex, and pubertal timing.
Figure 6. Nonviolent behavior trajectories by age, sex, and pubertal timing.
Figure 7. Violent behavior trajectories by age, sex, and pubertal timing.
Appendix A

The Full Set of Unstandardized Parameters for Figure 1 (Partial Strong Factorial Invariance Model for Externalizing Behaviors Using the Full Public Dataset from Add Health)

MODEL RESULTS

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>S.E.</th>
<th>Est./S.E.</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>W4EXT BY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W4CNV</td>
<td>1.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td>W4UNV</td>
<td>0.134</td>
<td>0.025</td>
<td>5.426</td>
<td>0.000</td>
</tr>
<tr>
<td>W4CV</td>
<td>0.502</td>
<td>0.025</td>
<td>20.114</td>
<td>0.000</td>
</tr>
<tr>
<td>W4UV</td>
<td>0.347</td>
<td>0.037</td>
<td>9.320</td>
<td>0.000</td>
</tr>
<tr>
<td>W3EXT BY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W3CNV</td>
<td>1.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td>W3UNV</td>
<td>0.155</td>
<td>0.024</td>
<td>6.347</td>
<td>0.000</td>
</tr>
<tr>
<td>W3CV</td>
<td>0.502</td>
<td>0.025</td>
<td>20.114</td>
<td>0.000</td>
</tr>
<tr>
<td>W3UV</td>
<td>0.139</td>
<td>0.016</td>
<td>8.665</td>
<td>0.000</td>
</tr>
<tr>
<td>W2EXT BY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W2CNV</td>
<td>1.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td>W2UNV</td>
<td>0.752</td>
<td>0.029</td>
<td>25.881</td>
<td>0.000</td>
</tr>
<tr>
<td>W2CV</td>
<td>0.502</td>
<td>0.025</td>
<td>20.114</td>
<td>0.000</td>
</tr>
<tr>
<td>W2UV</td>
<td>0.963</td>
<td>0.050</td>
<td>19.376</td>
<td>0.000</td>
</tr>
<tr>
<td>W1EXT BY</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W1CNV</td>
<td>1.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td>W1UNV</td>
<td>0.910</td>
<td>0.031</td>
<td>29.567</td>
<td>0.000</td>
</tr>
<tr>
<td>W1CV</td>
<td>0.502</td>
<td>0.025</td>
<td>20.114</td>
<td>0.000</td>
</tr>
<tr>
<td>W1UV</td>
<td>0.774</td>
<td>0.040</td>
<td>19.361</td>
<td>0.000</td>
</tr>
<tr>
<td>W3EXT WITH</td>
<td>W4EXT</td>
<td>0.097</td>
<td>0.016</td>
<td>5.995</td>
</tr>
<tr>
<td>W2EXT WITH</td>
<td>W4EXT</td>
<td>0.083</td>
<td>0.012</td>
<td>7.118</td>
</tr>
<tr>
<td>W2EXT WITH</td>
<td>W3EXT</td>
<td>0.151</td>
<td>0.021</td>
<td>7.086</td>
</tr>
<tr>
<td>W1EXT WITH</td>
<td>W4EXT</td>
<td>0.102</td>
<td>0.013</td>
<td>7.751</td>
</tr>
<tr>
<td>Variable</td>
<td>Coefficient 1</td>
<td>Coefficient 2</td>
<td>Coefficient 3</td>
<td>Coefficient 4</td>
</tr>
<tr>
<td>----------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>W3EXT</td>
<td>0.164</td>
<td>0.021</td>
<td>7.636</td>
<td>0.000</td>
</tr>
<tr>
<td>W2EXT</td>
<td>0.484</td>
<td>0.039</td>
<td>12.419</td>
<td>0.000</td>
</tr>
<tr>
<td>W1UNV WITH W1UV</td>
<td>-0.093</td>
<td>0.017</td>
<td>-5.562</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W2UNV WITH W2UV</td>
<td>-0.073</td>
<td>0.025</td>
<td>-2.862</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W4UNV WITH W3UNV</td>
<td>0.004</td>
<td>0.001</td>
<td>2.761</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W2UV WITH W1UV</td>
<td>0.213</td>
<td>0.026</td>
<td>8.255</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W4EXT</td>
<td>0.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td>W3EXT</td>
<td>0.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td>W2EXT</td>
<td>0.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td>W1EXT</td>
<td>0.000</td>
<td>0.000</td>
<td>999.000</td>
<td>999.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intercepts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W1CNV</td>
<td>0.705</td>
<td>0.016</td>
<td>44.663</td>
<td>0.000</td>
</tr>
<tr>
<td>W2CNV</td>
<td>0.705</td>
<td>0.016</td>
<td>44.663</td>
<td>0.000</td>
</tr>
<tr>
<td>W3CNV</td>
<td>0.350</td>
<td>0.015</td>
<td>23.614</td>
<td>0.000</td>
</tr>
<tr>
<td>W4CNV</td>
<td>0.180</td>
<td>0.009</td>
<td>18.923</td>
<td>0.000</td>
</tr>
<tr>
<td>W1UNV</td>
<td>1.248</td>
<td>0.016</td>
<td>78.046</td>
<td>0.000</td>
</tr>
<tr>
<td>W2UNV</td>
<td>1.024</td>
<td>0.016</td>
<td>64.548</td>
<td>0.000</td>
</tr>
<tr>
<td>W3UNV</td>
<td>0.058</td>
<td>0.004</td>
<td>13.783</td>
<td>0.000</td>
</tr>
<tr>
<td>W4UNV</td>
<td>0.026</td>
<td>0.003</td>
<td>9.034</td>
<td>0.000</td>
</tr>
<tr>
<td>W1CV</td>
<td>0.290</td>
<td>0.008</td>
<td>36.130</td>
<td>0.000</td>
</tr>
<tr>
<td>W2CV</td>
<td>0.290</td>
<td>0.008</td>
<td>36.130</td>
<td>0.000</td>
</tr>
<tr>
<td>W3CV</td>
<td>0.125</td>
<td>0.007</td>
<td>18.867</td>
<td>0.000</td>
</tr>
<tr>
<td>W4CV</td>
<td>0.080</td>
<td>0.006</td>
<td>13.646</td>
<td>0.000</td>
</tr>
<tr>
<td>W1UV</td>
<td>0.855</td>
<td>0.017</td>
<td>51.573</td>
<td>0.000</td>
</tr>
<tr>
<td>W2UV</td>
<td>0.855</td>
<td>0.017</td>
<td>51.573</td>
<td>0.000</td>
</tr>
<tr>
<td>W3UV</td>
<td>0.020</td>
<td>0.002</td>
<td>8.456</td>
<td>0.000</td>
</tr>
<tr>
<td>W4UV</td>
<td>0.053</td>
<td>0.004</td>
<td>14.625</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Variances</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W4EXT</td>
<td>0.125</td>
<td>0.018</td>
<td>7.052</td>
<td>0.000</td>
</tr>
<tr>
<td>W3EXT</td>
<td>0.274</td>
<td>0.032</td>
<td>8.485</td>
<td>0.000</td>
</tr>
<tr>
<td>W2EXT</td>
<td>0.662</td>
<td>0.052</td>
<td>12.607</td>
<td>0.000</td>
</tr>
<tr>
<td>W1EXT</td>
<td>0.762</td>
<td>0.056</td>
<td>13.528</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Residual Variances

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>W1CNV</td>
<td>0.874</td>
<td>0.037</td>
<td>23.818</td>
<td>0.000</td>
</tr>
<tr>
<td>W2CNV</td>
<td>0.755</td>
<td>0.038</td>
<td>19.829</td>
<td>0.000</td>
</tr>
<tr>
<td>W3CNV</td>
<td>0.489</td>
<td>0.036</td>
<td>13.607</td>
<td>0.000</td>
</tr>
<tr>
<td>W4CNV</td>
<td>0.240</td>
<td>0.022</td>
<td>10.717</td>
<td>0.000</td>
</tr>
<tr>
<td>W1UNV</td>
<td>0.661</td>
<td>0.024</td>
<td>27.406</td>
<td>0.000</td>
</tr>
<tr>
<td>W2UNV</td>
<td>0.618</td>
<td>0.021</td>
<td>30.054</td>
<td>0.000</td>
</tr>
<tr>
<td>W3UNV</td>
<td>0.054</td>
<td>0.004</td>
<td>14.619</td>
<td>0.000</td>
</tr>
<tr>
<td>W4UNV</td>
<td>0.026</td>
<td>0.003</td>
<td>9.007</td>
<td>0.000</td>
</tr>
<tr>
<td>W1CV</td>
<td>0.248</td>
<td>0.011</td>
<td>22.101</td>
<td>0.000</td>
</tr>
<tr>
<td>W2CV</td>
<td>0.249</td>
<td>0.013</td>
<td>18.888</td>
<td>0.000</td>
</tr>
<tr>
<td>W3CV</td>
<td>0.087</td>
<td>0.007</td>
<td>11.991</td>
<td>0.000</td>
</tr>
<tr>
<td>W4CV</td>
<td>0.094</td>
<td>0.009</td>
<td>10.239</td>
<td>0.000</td>
</tr>
<tr>
<td>W1UV</td>
<td>0.753</td>
<td>0.025</td>
<td>29.527</td>
<td>0.000</td>
</tr>
<tr>
<td>W2UV</td>
<td>0.665</td>
<td>0.048</td>
<td>13.927</td>
<td>0.000</td>
</tr>
<tr>
<td>W3UV</td>
<td>0.013</td>
<td>0.002</td>
<td>8.544</td>
<td>0.000</td>
</tr>
<tr>
<td>W4UV</td>
<td>0.035</td>
<td>0.003</td>
<td>13.515</td>
<td>0.0</td>
</tr>
</tbody>
</table>