EXAMINING ASSOCIATIONS BETWEEN INTERNALIZING BEHAVIOUR,
CORTISOL REACTIVITY, AND PHYSIOLOGICAL COORDINATION IN TWO
DIFFERENTIALLY POTENT CHALLENGES

by

Jennifer Khoury

Bachelor of Science, University of Toronto, 2011

Master of Arts, Ryerson University, 2013

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Abstract

EXAMINING ASSOCIATIONS BETWEEN INTERNALIZING BEHAVIOUR, CORTISOL REACTIVITY, AND PHYSIOLOGICAL COORDINATION, IN TWO DIFFERENTIALLY POTENT CHALLENGES

Doctor of philosophy, 2017

Jennifer Khoury

Psychology, Ryerson University

Background: Research examining associations between child internalizing behaviours and cortisol reactivity is equivocal, with studies suggesting positive, negative and non-significant associations. The present study assessed three primary confounds that contribute to these inconsistencies: 1) the differential effectiveness of laboratory challenges in eliciting cortisol reactivity; 2) the impact of coordination between the Hypothalamic-Pituitary-Adrenal axis and the Sympathetic-Adrenal-Medullary system (assessed via salivary alpha-amylase (sAA)); and 3) variation in the measurement of internalizing behaviour, specifically, parent versus child ratings. The primary aims of this study were to assess internalizing behaviours in relation to both cortisol reactivity and coordination between cortisol and sAA, measured in two distinct challenges.

Method: A community sample of 8-10 year olds (N= 52) participated in two laboratory challenges, across two study sessions: 1) the Trier Social Stress Test-Child Version (TSST-C), a potent social-evaluative challenge, and 2) a less-potent competition challenge, composed of a puzzle and mirror-tracing task. Saliva was collected at several time points before and after each challenge. Saliva was later assayed to extract cortisol and sAA. Child-reported depressive

symptoms were assessed using the Child Depression Inventory, and maternal-reported internalizing problems were assessed using the Child Behavior Checklist. Multilevel modelling was conducted using Hierarchical Linear Modeling.

Results: In the TSST-C, child-reported depressive symptoms were significantly associated with a declining cortisol trajectory. Maternal-reported internalizing problems were not associated with cortisol and internalizing behaviour did not moderate the impact of sAA levels on cortisol levels (i.e., coordination) in the TSST-C. With regards to the competition challenge, maternal-reported internalizing behaviours predicted cortisol-sAA coordination, such that children with more internalizing behaviours who experienced higher sAA levels also had higher cortisol reactivity. However, there were no significant associations between child-reported depressive symptoms, cortisol reactivity, or coordination between sAA and cortisol reactivity in the competition challenge.

Conclusions: Results are discussed in the context of allostatic load and in relation to theories of physiological coordination. These findings underscore the importance of differential stressor contexts, physiological coordination, and the informant of internalizing behaviours moderating associations between internalizing behaviour and cortisol reactivity. Future research should integrate these factors in models of physiological stress and developmental psychopathology.

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Examining associations between internalizing behaviour, cortisol reactivity, and physiological coordination, in two differentially potent challenges

Stress physiology plays an essential role in nearly all human physical and mental health processes (Gallagher, Reid, & Ferrier, 2009; Reynolds, 2013; Turner-Cobb, 2005) across the lifespan (Lesage et al., 2006; Levine, 2005; Meaney & Szyf, 2005). Over the past several decades, researchers have explored the Hypothalamic-Pituitary-Adrenal (HPA) axis as a primary biological system mediating stress responses in humans. HPA activation leads to the production of the hormone cortisol, which is secreted in response to stress (Chrousos, 2009). Importantly, activation of the HPA axis can be adaptive, enabling organisms to respond efficiently and effectively to perceived threats, however, inflexible and chronic activation is neurobiologically and psychologically damaging (Chrousos, 2009; McEwen & Seeman, 1999; Miller, Chen, & Zhou, 2007). In particular, extensive research demonstrates that atypical cortisol responsivity is associated with internalizing behaviours during childhood and adolescence (Gunnar & Quevedo, 2007; O'Keane, Frodl, & Dinan, 2012). However, research associating cortisol responsivity to child internalizing behaviours is equivocal, with studies suggesting positive (Booij et al., 2013), negative (Harkness et al., 2011) and non-significant (Attwood et al., 2011) associations.

There are several confounds that potentially contribute to the inconsistencies within the cortisol literature. First, it is difficult to interpret associations between internalizing behaviours and cortisol reactivity across (and, at times, within) studies because stressor paradigms vary in potency and utility of eliciting a stress response (e.g., Gunnar, Talge & Herrera, 2009). Second, the HPA axis is activated in coordination with the Sympathetic-Adrenal-Medullary (SAM) system, and the nature of associations between internalizing behaviours and cortisol reactivity is impacted by this physiological coordination (e.g., El-Sheikh, Erath, Buckhalt, Granger, & Mize,

2008). Third, associations between internalizing behaviours and cortisol reactivity vary depending on the reporter (children or parents) of internalizing behaviours (e.g., Hartman, Hermanns, de Jong, & Ormel, 2013).

Given these confounds, the primary aim of this study is to elucidate the potential deleterious effects of internalizing behaviours on cortisol activity, controlling for the differential potency of stressor paradigms, HPA and SAM coordination, and the rater of internalizing behaviours, both methodologically and statistically.

With regards to the stressor paradigm as a confound, I will examine how internalizing behaviours are associated with cortisol reactivity in two distinct stressor paradigms, which were specifically designed to differentially elicit cortisol responsivity. For reasons discussed below, I did not include reactivity to both challenges in a single equation, but the assessment of reactivity in two challenges, albeit independently, does permit examination of generalizability of findings. In addition, I address coordination between the HPA and SAM systems.

There are several ways of measuring SAM activation, including levels of catecholamines in blood (e.g., noradrenaline, norepinephrine), as well as physiological measures (e.g., skin conductance, heart rate) (e.g., Schumacher, Kirschbaum, Fydrich, & Ströhle, 2013). Research has shown that salivary alpha-amylase (sAA), an enzyme found in saliva, is a good marker of SAM activity and is associated with other SAM indices (Chatterton et al., 1996; Rohleder et al., 2004). In the present study I assess HPA and SAM coordination by statistically assessing sAA as a moderator of cortisol reactivity in each of these differentially potent laboratory challenges.

Lastly, I conduct separate statistical analyses to examine whether parent-reported or child-reported internalizing behaviours are differentially associated with cortisol reactivity, in both of the laboratory stressors. Although prior research has independently assessed how the

stressor paradigm, physiological coordination, and the rater of internalizing problems may confound associations between internalizing behaviour and cortisol reactivity, rarely do studies account for a combination of confounds (see Table 1), and this is the first study to simultaneously account for all three of these factors.

Table 1: *Summary of prior research that assesses the stressor paradigm, physiological coordination, and the rater of internalizing problems as confounds to the association between cortisol and internalizing problems.*

Study	Multiple Stressor Paradigms	Coordination between cortisol and sAA	Multiple Informants
Attwood et al. (2011)		X	
Bae et al. (2015)		X	
Booij et al. (2013)			
Chen et al. (2015)			
El-Sheikh et al. (2008)		X	
Granger et al. (1994)			
Harkness et al. (2011)		X	
Hartman et al. (2013)			X
Hill-Soderlund et al. (2015)		X	
Janssens et al. (2012)			
Keenan et al. (2013)			X
Koss et al. (2014)		X	
Laurent et al. (2015)	X		
Laurent et al. (2016)	X		
LeMoult et al. (2015)			
Spies et al. (2011)			
Spinrad et al. (2009)		X	
Steege et al. (2017)			
Suzuki et al. (2013)			
Vigil et al. (2010)		X	

Note: X = confound assessed in the study; sAA = salivary alpha amylase.

In order to understand how the stressor paradigm, physiological coordination, and the rater of internalizing behaviours potentially confound associations between internalizing behaviours and cortisol reactivity, I will first provide an overview of the cortisol literature more broadly, discuss associations between HPA and SAM physiological systems, and then discuss internalizing behaviours in relation to HPA and SAM activity. Within these broader areas of literature review, I will highlight the importance of potential confounds, namely, the stressor paradigm, coordination between HPA and SAM systems, and the rater of internalizing behaviours.

Hypothalamic-Pituitary-Adrenal (HPA) Axis

As organisms interact with the environment, stress systems are constantly titrated in response to internal and external inputs. Following this activation, a cascade of neurological, physiological and behavioural changes ensue, with the ultimate goal of maintaining a dynamic equilibrium, known as homeostasis (Chrousos, 2009). The HPA axis is one of the most important, and heavily researched, stress regulatory systems in the human body (Kaltsas & Chrousos, 2007). The HPA system, including its end product, cortisol, is central to physiological regulation under stressful circumstances, as well as adaptive coping on a day-to-day basis (Habib et al., 2000). The HPA axis is constantly receiving input from the external environment and responding in a dynamic way, in order to achieve neurochemical stability (Danese & McEwen, 2012). However, for some individuals, internal and external stressors can lead to atypical activation of the HPA axis and connected neurobiological systems (e.g., SAM system), which can have devastating metabolic, immunologic, and psychological implications (Chrousos, 2009; Kaltsas & Chrousos, 2007).

Associations between the HPA axis and the Sympathetic-Adrenal-Medullary (SAM)

System. In order to adequately capture the stress response, it is important to understand HPA activity in the context and function of other stress networks. Despite the vast interest that cortisol has received in past decades, the HPA axis is connected to other stress networks, for example, the SAM system. The HPA and SAM stress systems are organized in a hierarchical fashion, with one or both systems being sequentially and preferentially activated depending on the nature, intensity and duration of the stressor (Del Giudice et al., 2011). For example, in many instances, strong activation of the HPA axis is not required, because the threat is managed sufficiently by the faster acting SAM system (Del Giudice et al., 2011).

SAM activity can be marked by salivary alpha-amylase. Salivary alpha-amylase (sAA) is a digestive enzyme produced by salivary glands in the oral cavity (Granger et al., 2006). Salivary alpha-amylase is a known marker of stress reactivity (Granger et al., 2006), and correlates highly with other stress indices (e.g., norepinephrine) associated with activation of the SAM system (Chatterton et al., 1996). The SAM system produces rapid and short-lasting effects. Although the SAM system is one of the initial stress systems to be activated, its effects are preparatory and can have a long-lasting impact on bodily responses (e.g., activation of cardiovascular system, maintenance of blood pressure) to stress (Ulrich-Lai & Herman, 2009). In fact, sAA increases relatively quickly (5 to 10 minutes) after the onset of a stressor (Granger, Kivlighan, El-Sheikh, Gordis, & Stroud, 2008; Nater et al., 2005, 2006). In comparison, cortisol peaks approximately 20 to 40 minutes after the onset of a stressor (Dickerson & Kemeny, 2004). Importantly, activation of each of these systems is integrated and co-regulated through overlapping neurobiological circuitry.

Neurocircuitry of the HPA axis. The HPA response is initialized by paraventricular nuclei (PVN) activation in the hypothalamus (see Figure 1). PVN trigger the release of two hormones, corticotrophin-releasing hormone (CRH) and arginine vasopressin (AVP) (Ulrich-Lai & Herman, 2009). CRH then generates the release of adrenocorticotrophic hormone (ACTH), which is transported to the adrenal cortex of the adrenal gland, where it produces glucocorticoid hormones, one of which is cortisol (Gunnar & Quevedo, 2007). Importantly, the HPA axis includes a negative feedback loop to initiate stress recovery and prevent prolonged activation (Guilliams & Edwards, 2010). When cortisol reaches an optimal level it binds to glucocorticoid receptors (GRs), which activate pathways back to the PVN and stop the production of CRH and ACTH (Sapolsky, Romero, & Munck, 2000). Thus, GRs are particularly important for stress recovery and the minimization of cortisol overproduction, which could potentially have deleterious long-term effects (Guilliams & Edwards, 2010).

Figure 1. Hypothalamic-Pituitary-Adrenal Axis negative feedback loop.

Overlapping neurocircuitry of HPA and SAM systems. The sympathetic response is coordinated by the locus coeruleus (LC). There are two main routes of sympathetic activation. The first involves direct activation of noradrenergic organs, and the second involves activation of the adrenal medulla, which triggers the release of catecholamines including epinephrine (adrenaline) and norepinephrine into the bloodstream (Goldstein & Kopin, 2008; Gunnar & Vazquez, 2006). It is the activation of the adrenal medulla and the resulting hormonal pathway that comprises the SAM system (Del Giudice, Ellis, & Shirtcliff, 2011).

Although the HPA and SAM systems are comprised of distinct neurocircuitry (as discussed above), the activation of both systems is coordinated by shared structures and overlapping hormonal products (Figure 2). In terms of anatomy, the amygdala initiates and controls both HPA and SAM responses (Ganzel et al., 2010; Gold & Chrousos, 2002; Herman et al., 2003). In response to perceived stress, the amygdala stimulates PVN in the hypothalamus as well as the LC, thereby initializing the HPA responses (Kaltsas & Chrousos, 2007). In addition, the medial prefrontal cortex (mPFC) acts as a top-down coordinator of both HPA and SAM responses, with some components of the mPFC stimulating HPA and SAM responses, and other components inhibiting these responses (e.g., reducing the HPA response by regulating the duration of glucocorticoid secretion) (Ulrich-Lai & Herman, 2009). Given the vast interconnections of the PFC with other brain structures (e.g., amygdala, hippocampus), the PFC appears to act as the principal coordinator of HPA and SAM neurobiological stress reactivity (Ulrich-Lai & Herman, 2009).

Figure 2. Overlapping neurocircuitry of the Hypothalamic-Pituitary-Adrenal (HPA) Axis and Sympathetic-Adrenal-Medullary (SAM) system.

In addition, CRH neurons in the hypothalamus and noradrenergic neurons are activated and inhibited by shared neurotransmitters (Stratakis & Chrousos, 1995). These neurons also have reciprocal connections, permitting modulation across HPA and SAM systems (Stratakis & Chrousos, 1995). For instance, noradrenergic neurons in the LC can stimulate the release of CRH in the PVN, but circulating cortisol inhibits noradrenergic neuronal activity in the LC and reduces CRH production (Habib et al., 2001; Valentino et al., 1998; Sapolsky et al., 2000). It is this overlapping neurocircuitry as well as the complementary activation that suggests that these two stress systems operate in a coordinated fashion.

Cortisol indices. Cortisol is commonly measured in terms of acute responsiveness to laboratory and naturalistic stressors. Over decades of research, a plethora of cortisol indices have been used to represent baseline levels, total output, reactivity and recovery (Khoury et al., 2015). Many previous studies include fewer than four saliva collection points, thus limiting the ability to examine cortisol trajectories and increasing the reliance on point estimates. Of the numerous point estimates used to characterize cortisol responses to acute challenge, total cortisol output and cortisol reactivity, indexed by area under the curve with respect to ground and increase (AUC_G and AUC_I , respectively), appear to be the best indices of cortisol output and cortisol change (Khoury et al., 2015). Area under the curve with respect to ground (AUC_G) represents total cortisol output; it assesses both the difference between single measurement points and the distance of measurement points from the ground, thereby taking into account the absolute baseline level (Fekedulegn et al., 2007; see Figure 3). Area under the curve with respect to increase (AUC_I), measures cortisol change from baseline over subsequent time points, and does not take into account baseline levels (Fekedulegn et al., 2007; Figure 3). AUC_I is a reliable indicator of cortisol change and thus captures the stress system's response to

environmental challenge (Atkinson et al., 2016; Fekedulegn et al., 2007; Khoury et al., 2015). However, measurement issues arise when using AUC_I and other point estimates. For instance, the same AUC_I value can indicate multiple types of cortisol trajectories (Atkinson, Jamieson, Khoury, Ludmer, & Gonzalez, 2016; Fekedulegn et al., 2007). As shown in Figure 4, an AUC_I value of 3.35 can represent two very distinct patterns of cortisol reactivity, one indicating a rapid increase followed by an intense decline back to baseline, while the other representing a more blunted increase without a return to baseline. This ambiguity makes it difficult to determine the meaning of AUC_I levels within a single laboratory challenge and limits comparisons of cortisol reactivity findings across studies.

Figure 3. Area under the curve with respect to ground (Panel A) and area under the curve with respect to increase (Panel B).

Figure 4. Area under the curve with respect to increase (AUC_1), representing a stress response to a single challenge. Robust AUC_1 with return to baseline and blunted AUC_1 without return to baseline, both AUC_1 values are equivalent (3.35).

Taken together, it is difficult to interpret what constitutes an adaptive cortisol response, especially when the majority of studies measuring cortisol responses use different point estimates, which have ambiguous interpretative value. More recently, cortisol has been indexed by trajectories across different time points and stressor paradigms (e.g., Laurent, Ablow, & Measelle, 2012), providing a more refined picture of the dynamic stress response process that encompasses acute cortisol reactivity and recovery (as discussed below). In this study, I adopt a trajectory approach. But in addition to using more refined indices of cortisol, a more refined analysis of the HPA homeostasis process is also required to understand adaptive stress reactivity.

Achieving Allostasis: Flexibility in Stress Responsivity

Stress responsivity involves a complex set of dynamics, which when functioning optimally can lead to regulation of the stress system and maintenance of other bodily functions (metabolism, immune system function etc.), but when functioning atypically can lead to a plethora of adverse neurobiological, immunological, and psychological effects (Danese & McEwen, 2012). *Allostasis* refers to the biological changes that function to maintain neurobiological stability (Sterling & Eyer, 1988; Goldstein & McEwen, 2002). *Allostatic load* refers to the ‘wear and tear’ caused by too much stress or ineffective management of allostasis (i.e., the stress response persists when stress is over, and/or the stress response is not turned on adequately when needed) (McEwen, 2007). McEwen (1998) outlined different stress responses to frequent and repeated stressors, some of which are adaptive while others are associated with allostatic load. An adaptive response to a single stressor includes abrupt reactivity, followed by recovery (return to baseline levels). An adaptive response to repeated stressors involves an initial activation of the stress response followed by recovery, and with repeated stressors (or “hits”) the magnitude of this response attenuates. In contrast, lack of adaptation is seen either as a)

a prolonged (i.e., sustained) response (including a lack of recovery), which results from an inability to shut off the allostatic response after stress is terminated, or b) an inadequate or blunted response, which results in increased activation of compensatory or other stress mediators (McEwen, 1998). Thus a ‘healthy’ stress response depends on elasticity; in the case of the HPA axis, the ability to a) produce a pronounced cortisol reaction when threatened and b) down-regulate this response, that is, maintain a stable level of cortisol when no longer under acute threat (McEwen & Seeman, 1999).

To date, very few studies have measured cortisol reactivity across multiple challenges, and thus do not assess allostatic load as it pertains to repeated stress, across similar or distinct contexts (Atkinson et al., 2016). It is important to measure stress reactivity across distinct contexts because a) laboratory paradigms differ in their ability to elicit HPA and SAM responses, and thus potentially influence HPA and SAM coordination; and b) individual differences (such as internalizing behaviour) are associated with stress reactivity differently across contexts. Below I present three lines of research that underscore the importance of assessing cortisol reactivity in distinct challenges. The first type of evidence is offered through literature reviews, which suggest that stressor paradigms used across different studies vary in potency and capability to evoke cortisol responses (i.e., Dickerson & Kemeny, 2004; Gunnar et al., 2009; Jansen, Beijers, Riksen-Walraven, & de Weerth, 2010). The second line of research is in the form of single studies that directly compare the effectiveness of multiple stressor paradigms to elicit cortisol responses, allowing for the assessment of intra-individual variability in stress responsivity (e.g., Laurent, Ablow, & Measelle, 2012). This second line of research examines overall group differences in cortisol reactivity, assessed across multiple, and differentially potent laboratory paradigms. Although this body of research examines cortisol reactivity within the same subjects, these studies do not directly assess how individual differences might impact one’s ability to adjust their physiological stress reaction, in response to the potency of each specific challenge. The

third line of research directly examines cortisol flexibility, that is, how individual differences (e.g., on a psychological variable) moderate one's ability to titrate their physiological stress response in accordance with the potency of divergent stressors (e.g., Atkinson et al., 2016). These three lines of research are discussed below.

Differentially potent laboratory challenges. Extensive research has been conducted using a variety of different laboratory challenges, all aimed to elicit stress reactivity. Interestingly, over time, this research has revealed that these laboratory challenges diverge in their effectiveness to evoke HPA responsivity. A systematic review (Gunnar et al., 2009) and a meta-analysis (Jansen et al., 2010) outlined the differential effectiveness of common stressor paradigms to elicit cortisol responses across development. Although effect sizes were not directly compared, results from Jansen et al. suggest that parent-child separation challenges may elicit a stronger cortisol response ($d = .34$) for infants compared to frustration challenges ($d = .13$). In addition, social-evaluative threat challenges are the most potent for older children (Gunnar et al., 2009) and adults (Dickerson & Kemeny, 2004). Similarly, in adults, emotion-induction paradigms are less potent, eliciting a negative cortisol response (Dickerson & Kemeny, 2004). Taken together, this research suggests that across development, stronger cortisol responses are elicited by threatening challenges, whereas weaker responses are elicited by emotion-based challenges.

In addition to these systematic reviews, researchers have begun to utilize multiple stressors within a single study to examine whether some paradigms evoke stronger cortisol responses. To examine whether the paradigms had a differential effectiveness to elicit a cortisol response, Stroud and colleagues (2009) employed a between-subject design wherein adolescents were assigned to complete one of two different laboratory challenges. By examining inter-individual, between-stressor variability, Stroud et al. (2009) showed that adolescents who participated in a Trier Social Stress Test (TSST;

Kirschbaum, Pirke, & Hellhammer, 1993) had higher cortisol responses, compared to the adolescents who participated in a peer rejection stressor. However, given that this study examined *between-subject* variability, the interpretation of these results are limited by the numerous individual factors that vary across participants and potentially contributed to distinct responses within each stressor.

In addition, researchers have begun to employ designs wherein differentially potent stressor paradigms are used to examine *intra-individual*, between challenge variability. These studies use *within-subject* designs to demonstrate that stressor paradigms elicit distinct cortisol responses, depending on the potency of each stressor. However, these studies do not examine whether individual differences might impact participants' ability to titrate their stress response across challenges. Instead this line of research simply shows that the same group of individuals who participate in multiple challenges, demonstrate variant cortisol responses. In this line of research, allostasis is operationalized as a variable response across challenges, i.e., strong response to potent challenge and diminished response to less potent challenge. For example, Maruyama et al. (2012) showed that healthy adults, who participated in both the TSST and an electrical stimulation stressor, demonstrated higher cortisol responses in the TSST compared to electrical stimulation stressor. In a sample of mother-infant dyads, Laurent, Ablow, and Measelle (2012) also examined intra-individual, between challenge variability. Laurent et al. (2012) demonstrated that infants had a strong cortisol response to a separation stressor and a less pronounced response to clean up task. These studies further advance the literature by using within-subject designs to examine intra-individual variability in stress responses. However, this research does not directly examine psychological variables that could potentially impact an individual's ability to titrate their cortisol responses across differentially evocative stressor paradigms.

Examining individual differences as predictors of flexibility in cortisol responses, assessed across differentially potent laboratory paradigms. In addition to considering stressor potency

differences, it is important to consider whether intra-individual factors impact flexibility of stress responses across distinct stressors, on the assumption that some individuals are better able to titrate response better than others. As outlined by Atkinson and colleagues (2016), a “flexible response is [one that is] titrated in an ecologically appropriate manner to the degree/type of challenge” (p. 4). In accordance with this definition, several criteria must be met to adequately capture flexible stress responsivity. First, multiple and differentially potent challenges must be used with the same sample of individuals to draw conclusions regarding intra-individual variability in stress reactivity between challenges. Second, differential stress reactivity across challenges must be predicted (i.e., moderated) by a relevant feature of the individual. Further to this second requirement, the studies discussed below demonstrate flexible stress responsivity using statistical comparisons to show that individuals differentially titrate cortisol reactivity to the nature of the challenge, depending on some relevant feature pertaining to themselves or their environment.

Atkinson et al. (2013) showed that maternal sensitivity predicted infants’ cortisol flexibility across challenges. That is, infants of more sensitive mothers show adaptive cortisol flexibility — a robust increase in cortisol in response to a potent and threatening separation challenge and a robust decline in cortisol in response to a less potent frustration challenge. In contrast, infants of less sensitive mothers showed less dramatic down- and up-regulation, respectively. Atkinson et al. (2013) argued that flexible cortisol reactivity across variant challenges is central to adaptive responses in infants, and maternal factors (i.e., sensitivity) influence this flexibility (Atkinson et al., 2013). Utilizing the same sample, Ludmer et al. (2015) replicated these results by examining the interaction between maternal depressive symptoms and infant genetics across these two differentially potent challenges. Findings indicated that infants whose mothers endorsed more maternal depressive symptoms show reduced cortisol flexibility across challenges, but only if the infants were also genetically vulnerable (i.e., had

high-susceptibility dopaminergic genotypes). Additional research is needed to understand cortisol flexibility across different stressors in samples of children and adults. Given the fact that distinct challenges evoke differential response, this study explored the impact of child internalizing problems on cortisol reactivity in response to differentially potent stressors.

Coordination between HPA and SAM Systems

As discussed above, overlapping neurocircuitry as well as complementary neurobiological activation suggests that the HPA and SAM stress systems operate in a coordinated fashion. As stated by Bauer and colleagues (2002), “the SAM and HPA systems are anatomically and physiologically connected in the central nervous system, although much remains to be determined about the nature of the systems’ coordination at the physiological response level as well as the behavioral consequences of this coordination or its disruption” (p. 105). More recently, researchers have emphasized the need for concurrent assessment of HPA and SAM systems in order to decipher the nature of coordination and its’ association with behavior and psychopathology (Bauer et al., 2002; Granger & Fortunato, 2008). Concurrent assessment of cortisol and sAA might improve our understanding of HPA dysregulation, allostatic overload, and associated adverse health outcomes. Preliminary evidence suggests that the ratio of cortisol to sAA is a better indicator of stress dysregulation compared to either index alone (Ali & Pruessner, 2012). However, the combined effects of the HPA and SAM circuits are quite complex, and multiple theories have been proposed to explain the nature of the coordination between these two systems.

For decades, research has examined how atypical HPA activity impacts behavioural, emotional and social experiences across development. Bauer and colleagues (2002) were among the first to propose that associations between HPA activity and social-emotional outcomes are likely impacted by coordination between HPA and SAM systems. Bauer and colleagues (2002) proposed a comprehensive

outline of how HPA and SAM are coordinated, suggesting that cross-system activation can be coordinated in either an *additive* or *interactive* model. The *additive* model suggests that HPA and SAM activation work in conjunction in an inverted “U” shape fashion, such that a moderate level of arousal in both systems is optimal. Further, low activation in one system paired with high activation in another (i.e., asynchronous activity) is also adaptive, whereas high or low activation in both systems (i.e., synchronous activity) is maladaptive (Bauer et al., 2002). However, HPA and SAM activity are non-redundant and often complementary. As such, the *interactive* model proposes that optimal functioning occurs when a balance between systems is achieved. The interactive model suggests that coupled low, moderate, or high activation in both systems is most adaptive, whereas a mismatch (high activation in one system and low activation in another) is maladaptive (Bauer et al., 2002). Chen and colleagues elaborated on the additive and interaction models, stipulating statistical techniques for specifying interaction models (Chen, Raine, Soyfer, & Granger, 2015). That is, interactive models can be measured using ratio or interactive terms, where the ratio approach assumes a unidirectional association between the two systems, in contrast the interaction model, which does not specify the strength or direction of associations. The interaction model allows for a unidirectional or bidirectional association between systems (Chen et al., 2015). Chen et al. suggest that the ratio approach should be used when the two systems have opposite/suppressive effects and the interaction approach should be used when the strength and direction of one system’s effect on an outcome is dependent on the level of the other system. Reeves et al. (2016) elaborated on this theory to suggest that the ratio approach is best used when HPA and SAM coordination is the dependent variable of interest (because the HPA/SAM ratio can be computed as a single variable), whereas the interaction approach is best used when examining coordination as a predictor (Reeves, Fisher, Newman, & Granger, 2016). In line with this latter

approach, I used an interaction method in the present study to assess the effect of sAA on cortisol as an outcome.

The Adaptive Calibration Model (ACM; Del Giudice et al., 2011) is one model that intricately connects environmental experiences across development and stress system coordination. The ACM explains individual differences in stress responsively by drawing extensively on evolutionary and developmental biology. At its core, ACM postulates that individual differences in stress responsivity result from *conditional adaptation*, which is an evolutionarily-based ability of an organism to modify its phenotypic developmental trajectory to match environmental conditions. ACM proposes four resulting patterns of coordination: *sensitive*, *buffered*, *vigilant*, and *unemotional* (see Table 2, adapted from Del Giudice et al., 2011). The *sensitive* phenotype involves high levels of HPA reactivity and relatively moderate levels of SAM reactivity, which allows the individual to receive environmental feedback and adjust system activation accordingly. It is predicted that the sensitive phenotype evolves from a safe, protected, and supportive environment. This is partially supported by research suggesting that infants of more sensitive mothers have higher cortisol reactivity (Blair et al., 2006). However, theoretical and empirical findings suggest that “high cortisol reactivity” depends on the type of challenge (e.g., Gunnar et al., 2009; Jansen et al., 2010), and is most accurately indexed by cortisol flexibility, measured across differentially potent challenges (Atkinson et al., 2016). To this end, more comprehensive support of the sensitive phenotype comes from research showing that sensitive caregiving predicts high cortisol reactivity in a potent separation challenge and steeper cortisol declines in a less potent frustration challenge (Atkinson et al., 2013). The *buffered* phenotype is characterized by moderate HPA activity and low/moderate SAM activity. This phenotype is hypothesized to evolve in moderately stressful environments, wherein repeated exposure to stress early in life results in down-regulation of the HPA and SAM systems. The *vigilant* pattern involves high reactivity of both the HPA

and SAM systems. This phenotype is proposed to evolve from highly stressful environments that consist of repeated physical and social threats. The vigilant phenotype differs from the sensitive phenotype in that it is marked by slower HPA recovery to threat (Gunnar & Vazquez, 2006; Pruessner et al., 1997), and hypocortisolism in response to long-term stress. Lastly, the *unemotional* profile is marked by blunted HPA and SAM activity. This profile is associated with severe and chronic stress early in life (Gunnar and Vazquez, 2006; Gustafsson et al., 2010; Tarullo and Gunnar, 2006). Overall, the literature presented thus far suggests that 1) HPA reactivity, in particular cortisol flexibility (measured across dissimilar laboratory challenges), is an important index of allostasis, and 2) HPA activation is intricately associated with SAM activation. The next section will explore whether HPA and SAM coordination may differ depending on the type of stressor paradigm used to elicit these responses.

Table 2. *HPA and SAM profiles of the four responsivity patterns in the ACM*

Physiological profile	Responsivity Patterns			
	Sensitive	Buffered	Vigilant	Unemotional
SNS	High/moderate	Low/moderate	High	Low
HPA	High	Moderate	High	Low

Note: ACM= Adaptive Calibration Model; SNS = Sympathetic Nervous System; HPA =

Hypothalamic-Pituitary-Adrenal axis; table adapted from Del Giudice et al. (2011)

Differential situational triggers of HPA and SAM activation. The relative differential activation of the HPA and SAM systems is likely related to the nature of the challenge (Laurent, Powers & Granger, 2013; Lundberg & Frankenhaeuser, 1980). It has been theorized that the HPA axis responds intensely to threatening situations, whereas the SAM system responds more strongly to general challenge (Frankenhaeuser, 1982; Nigg, 2006). The meaning of the response within each of these systems also differs; HPA activation is highly related to imminent threat or direct distress, whereas the SAM system is not associated with distress or negative affect, and is more so associated with general arousal implied during effortful challenge (Laurent et al., 2013; Lundberg & Frankenhaeuser, 1980). In addition, HPA activation is prominent when the stressor has a social-evaluative component and is perceived as unpredictable and uncontrollable, whereas SAM activation is believed to be associated with controllable challenges (Flinn, 2006; Frankenhaeuser, Lundberg, & Forsman, 1980; Lundberg & Frankenhaeuser, 1980; Peters, Godaert, Ballieux et al., 1998). In general, laboratory stressors differ in the degree to which they elicit stress responses. More importantly, the degree to which a stressor elicits a stress response may differ depending on the type of stress system activated (i.e., HPA vs. SAM); that is, some stressors may be highly potent for eliciting HPA, but not SAM, activation, and vice versa. Therefore, when investigating HPA activity across multiple, and differentially potent challenges, it is important to concomitantly examine how coordination with the SAM system may influence this HPA flexibility.

Although theory suggests that HPA and SAM systems are activated by different stressors, empirical studies that examine the differential potency of stressors to evoke cortisol and sAA responses show mixed findings. An initial study conducted by Lundberg and Frankenhaeuser (1980) found that a self-paced (i.e., controllable) reaction-time task elicited strong noradrenaline, but not cortisol, reactivity, whereas a vigilance task elicited strong noradrenaline and cortisol reactivity. Based on these

preliminary findings, Lundberg and Frankenhauser (1980) suggested that the SAM system is more strongly activated by controllable and effortful tasks, whereas the HPA axis is activated by distressing and effort-demanding tasks. Additional studies have employed different stressors, often resulting in equivocal findings in regard to the differential activation of the HPA and SAM systems. For example, research utilizing the TSST (Kirschbaum, Pirke, & Hellhammer, 1993) produced equivocal findings; some studies indicated that this paradigm elicited a stronger cortisol compared to sAA response (Giles et al., 2014), while others demonstrated that this paradigm produced non-significant differences in cortisol and sAA responses (e.g., Kramer et al., 2012). A recent study of healthy men examined cortisol and sAA responses to four stressors, the TSST, the Stroop challenge (Stroop, 1935), the Cold Pressor Task, and a physical exercise, bicycle ergometer test (Skoluda et al., 2015). This study demonstrated that the highest cortisol response was evoked by the TSST, whereas the highest sAA response was evoked by the physical exercise ergometer test. Similarly, Laurent et al. (2012) found that infants demonstrated a strong cortisol response to a separation stressor and a less pronounced response to clean up task; in contrast, infants demonstrated a strong sAA response to the clean-up task and a less pronounced sAA response to the separation stressor.

This preliminary research suggests that cortisol and sAA responses may be sensitive to different types of stressors. Some of the aforementioned research on cortisol and sAA reactivity suggests that some socially threatening stressors evoke a stronger cortisol (relative to sAA) response, whereas other (i.e., effortful challenge) stressors evoke a stronger sAA response. However this research is in its infancy and should be interpreted cautiously. Nonetheless, this literature suggests the possibility that coordination between cortisol and sAA may differ across these two categories (i.e., socially threatening vs. competition) of stressor paradigms.

Thus far, I have argued that the HPA axis is a primary stress network with widespread health implications. In association, I presented preliminary theoretical and empirical evidence suggesting that a key component of allostasis and allostatic load is inflexible cortisol reactivity, as assessed across differentially potent stressors. Further, given the associations between HPA activity and SAM activity, which likely differ across distinct challenges, I proposed that sAA levels might confound cortisol flexibility findings.

In addition to the factors discussed above, features of the individual (child, in the case of the present study) influence stress reactivity. In prior research, although the overall sample may not show a robust cortisol increase in response to a given challenge, some individuals (e.g., those with a particular temperament) demonstrated a strong cortisol response (Gunnar, Brodersen, Krueger, & Rigatuso, 1996; Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996). Beginning in childhood and continuing through adolescence and adulthood, individual psychological factors can “impact the internal homeostatic state of an individual”, and thus have widespread impact on stress reactivity (Tofoli et al., 2011, p. 229). As such, the following section will focus on how internalizing difficulties, a prevalent set of mental health problems, are associated with HPA activity.

Childhood Internalizing Behaviours

Internalizing behaviours are a constellation of difficulties, including depression, withdrawal, anxiety, and somatic symptoms, which lead to significant distress and have implications for social and psychological adjustment throughout development (Caspi, Bem, & Elder, 1989). Internalizing behaviours are a set of common mental health problems that occur across the lifespan, including childhood and adolescence (Chavira, Stein, Bailey, & Stein, 2004; Costello, Mustillo, Erkanli, Keeler, & Angold, 2003). Early internalizing behaviours increase risk for the development of more severe disorders in adolescence and adulthood (Barber & Olson, 2004; Graber & Sontag, 2009; Lopez, Turner,

& Saavedra, 2005; Twenge & Nolen-Hoeksema, 2002). Furthermore, subcomponents of internalizing behaviours, such as anxiety and depression, often co-occur throughout childhood and adolescence (Axelson & Birmaher, 2001; Essau, 2008; Garber & Weersing, 2010), with comorbidity estimates reaching up to 75% (Angold, Costello, & Erkanli, 1999; Avenevoli, Stolar, Dierker, & Merikangas, 2001; Yorbik, Birmaher, Axelson, Williamson, & Ryan, 2004). Importantly, individual differences in internalizing behaviours are known to be associated with stress physiology, namely HPA activity. Before examining the specific associations between internalizing behaviours and cortisol reactivity, it is important to consider moderators of this association. Below I highlight that, similar to the broader HPA literature, the literature examining internalizing behaviours in relation to cortisol reactivity has important confounds, namely the stressor paradigm used to evoke cortisol reactivity, the informant of internalizing behaviours (because parent and child ratings are often discrepant), and coordination between cortisol and sAA.

Child internalizing behaviours and HPA activity. Extensive research suggests that children who experience more internalizing behaviours are more likely to evince atypical HPA reactivity (El-Sheikh et al., 2008; Halligan et al., 2007). The association between internalizing behaviours and atypical HPA activity has been shown concurrently (e.g., Harkness et al., 2011; Ulrike, Reinhold, & Dirk, 2013) and longitudinal research demonstrates that atypical cortisol puts children at higher risk to later develop depressive problems (Booij, Bouma, de Jonge, Ormel, & Oldehinkel, 2013; Hailligan et al., 2007; LeMoult et al., 2015). Research examining diurnal cortisol levels, demonstrates higher levels of diurnal cortisol in samples with higher self-reported (Van den Bergh & Claste, 2009) and parent-reported (LeMoult et al., 2015) internalizing behaviours. However, the direction of the effect of internalizing behaviours and HPA activity in laboratory experiments is equivocal. In adults, it is well accepted that depression is associated with cortisol hyperactivity (Young et al., 2000), however, studies

with children and adolescents indicate that higher self- and parent-reported internalizing behaviours are associated with both elevated (e.g., Booij et al., 2013) and blunted (e.g., Harkness et al., 2011) cortisol levels. The distinct stressor paradigms utilized, coordination between cortisol and sAA, as well as the reporter (parent or child) of internalizing behaviours, might explain these inconsistent findings.

Internalizing behaviours in relation to cortisol reactivity in the TSST-C. The association between child internalizing behaviours and cortisol reactivity likely depends on the challenge used to elicit stress, given that laboratory paradigms differ substantially in their effectiveness in eliciting cortisol reactivity. Here I discuss how internalizing behaviours are associated with cortisol reactivity across differentially potent laboratory challenges. When examining child and adolescent cortisol reactivity, the majority of studies utilize the child-version of the TSST (TSST-C; Buske-Kirschbaum et al., 1997), which is a developmentally appropriate social (telling a story in front of judges) and cognitive (arithmetic calculations, also before judges) performance task. The TSST-C typically elicits a strong cortisol response followed by a return to baseline (Gunnar et al., 2009). Given the social-cognitive threat involved in this challenge, a strong cortisol response followed by a decline is believed to be typical and adaptive. Although the TSST-C is known to elicit cortisol reactivity, individuals with higher internalizing behaviours show distinct cortisol responses compared to those with lower levels of internalizing behaviours. For example, adolescents with high self-reported depressive symptoms demonstrated a blunted cortisol response during the TSST-C (Harkness et al., 2011). Interestingly, the chronicity of depressive symptoms had a curvilinear association with cortisol reactivity in a similar social-evaluative stressor, such that adolescents with chronic self-reported depressive symptoms demonstrated blunted cortisol reactivity (Booij et al., 2013). Importantly, the majority of the studies to date that assess internalizing behaviours in relation to cortisol reactivity in the TSST-C, focus on samples of adolescents. Fewer studies examine these associations in middle-childhood samples.

Overall, this literature suggests that self-reported depressive symptoms are associated with blunted cortisol reactivity in the TSST-C.

Internalizing behaviours in relation to cortisol reactivity in other (non-TSST-C) stressors.

Similar to studies using the TSST-C, children with clinically elevated and sub-clinical depressive symptoms had blunted cortisol reactivity during challenges deemed to be mildly stressful (Suzuki et al., 2013). In addition, in response to the Cold Pressor Task (CPT), female adolescents with higher depressive symptoms (based on semi-structured clinical interviews of both children and mothers) demonstrated blunted reactivity compared to the rest of the sample (Keenan et al., 2013). In this study, only female adolescents were included to avoid potential sex differences, which typically become present after the onset of puberty (Stroud, Papandonatos, Williamson, & Dahl, 2011). Other studies have implemented a conflict discussion task to assess cortisol reactivity. Spies et al. (2011) found that adolescents who reported higher levels of internalizing behaviours, demonstrated blunted cortisol responses during a conflict discussion task. In contrast, Steeger et al. (2017) did not find a significant association between maternal-reported internalizing behaviours and adolescents' cortisol response during a conflict discussion task. Similarly, Granger, Weisz and Kauneckis (1994) found that child-reported depressive symptoms were not significantly associated with cortisol reactivity during a conflict discussion task. Taken together, these findings suggest somewhat equivocal associations between internalizing difficulties and cortisol reactivity in various non-TSST stressors.

The existing literature suggests that adolescents with internalizing behaviours appear to have blunted cortisol reactivity in response to the potent TSST-C. However, there are more contradictory findings when examining internalizing behaviours in the context of less potent stressors (e.g., problem solving task). Importantly, the majority of this research has been conducted with samples of adolescents, and thus it remains unclear how the age of the sample might impact associations between

internalizing behaviour and cortisol reactivity, measured across different stressor contexts. Thus, based on the existing literature, it is premature to draw conclusions about the association between internalizing behaviours and cortisol reactivity (assessed using multiple stressors).

Internalizing behaviours in relation to cortisol reactivity across multiple stressors. Laurent and colleagues (2015) conducted the first study to assess the association between internalizing behaviours, specifically, maternal-reported anxiety symptoms, and cortisol reactivity measured across multiple stressors. In addition to expanding the literature by employing two distinct stressor paradigms, this study included a middle-childhood sample. Children participated in both the TSST-C and a problem-solving stressor when they were between 9 and 10 years old. Generalized anxiety was associated with elevated cortisol in both challenges, specific phobia was associated with elevated cortisol levels in the TSST-C, and OCD was associated with prolonged cortisol (i.e., limited recovery) following a problem-solving stressor. Although this study examined how anxiety symptoms moderated cortisol reactivity across two, differentially potent, stressor paradigms, the findings do not indicate that children with lower anxiety symptoms demonstrate a more flexible cortisol response (i.e., higher cortisol levels in the more-potent challenge and lower levels in the less-potent challenge). This may be related to the nature of the stressors (i.e., the conflict discussion task may have been similarly potent as the TSST-C) or the specific internalizing moderator (anxiety) chosen. Nonetheless, Laurent et al. (2015) demonstrate the nuances in the associations between anxiety and cortisol reactivity, emphasizing the importance of using multiple stressor paradigms to assess these associations.

Laurent and colleagues (2016) conducted a second study to assess the differential relations between internalizing and externalizing behaviour problems and cortisol reactivity in response to two different stressors (Laurent, Vergara-Lopez, & Stroud, 2016). Youth (age 8 to 17) participated in both a performance (including public speaking, mental arithmetic, and mirror tracing components) and

interpersonal (peer rejection) stressor paradigm. Findings suggest the overall maternal-reported internalizing behaviours were not associated with cortisol reactivity in the performance challenge; however internalizing behaviours predicted an earlier cortisol peak (more negative linear term) and a less dynamic (rapidly changing) overall response curve (more positive quadratic term) in the interpersonal stressor. Further exploration of the components of internalizing behaviour suggests that anxious and withdrawal components of internalizing behaviour were driving the effect on cortisol reactivity in the interpersonal stressor. In addition, although global internalizing behaviours were not predictive of cortisol reactivity in the performance challenge, anxiety-specific symptoms were related to high cortisol levels during this challenge. Further, for females only, anxiety was associated with a later cortisol peak and more dynamic response curve during the performance challenge (in direct contrast to associations in the interpersonal stressor). These findings suggest that the associations between the specific type of internalizing behaviour measured and cortisol reactivity differ depending on gender and depending on the nature of the stressor paradigm. Further research is required to examine associations between internalizing behaviours and cortisol reactivity in multiple, and distinct, challenges, as well as to assess other potential moderators (e.g., gender) of these associations.

Differences in parent-reported and child-reported internalizing behaviours. In addition to the stressor paradigm used, another important factor that convolutes the association between internalizing behaviours and cortisol levels is the rater (i.e., parent or self) of internalizing behaviours. The low correlation (typically falling in the .20s) between parent and child/adolescent reports of psychopathology is noted as one of the most robust findings in the developmental psychopathology literature (Achenbach & Rescorla, 2001; De Los Reyes & Kazdin, 2005). Overall, correlations between parents and children are low to moderate in magnitude, with lower correlations for internalizing problems compared to externalizing problems (Kazdin, 1994). Internalizing difficulties, specifically,

are endorsed more by youth than their parents (Carlson, Kashani, Thomas, Vaidya, & Daniel, 1987; Zahn-Waxler, Klimes-Dougan, & Slattery, 2000), likely because of the internal and private nature of these difficulties. Despite the discrepancy between parent and child reports, both are thought to represent a valid, though unique, perspective on child difficulties. Taken together, this research suggests that given the unique predictive utility, reports from children and parents should be collected when examining internalizing behaviours.

Specifically, in relation to cortisol reactivity, studies that use adolescent self-reported depression or internalizing scales have shown that these symptoms are often associated with blunted cortisol reactivity (e.g., Janssens et al., 2012; Spies et al., 2011). Studies that use parent-reports to assess internalizing behaviours (i.e., using the CBCL; Achenbach, 2001) in samples of children and adolescents, have not found significant associations with cortisol reactivity (Attwood et al., 2011; Koss et al., 2014; Spinrad et al., 2009). To date, one study has separately assessed parent- and child-reported difficulties in relation to cortisol reactivity. Hartman, Hermanns, de Jong, and Ormel (2013) examined parent and adolescent reported internalizing behaviour in association with cortisol reactivity in a social-evaluative stressor (very similar to the TSST-C). Adolescent-reported, but not parent-reported, internalizing behaviour predicted cortisol responses. These findings suggest that the relation between cortisol reactivity and internalizing problems is likely impacted by the rater of such difficulties. However, given that only one study has directly examined this possibility, future research is needed to understand the potential impact of different raters on these associations.

Taken together, the literature to date demonstrates that internalizing problems are associated with cortisol levels, though these associations differ depending on the stressor paradigm and reporter of internalizing behaviours. Given the paucity of this literature and the methodological differences across studies (see Table 1), it is difficult to directly compare findings while taking into account these

potential moderators. For example, only one study to date (Hartman et al., 2013) has included multiple informants of internalizing behaviours. In addition, only two studies to date (Laurent et al., 2015; Laurent et al., 2016) have examined associations between internalizing behaviours and intra-individual cortisol flexibility, assessed across multiple stressors. In addition to these potential conceptual and methodological factors related to the associations between internalizing behaviours and cortisol reactivity, there is physiological evidence that suggests that SAM activity, marked by sAA, may also be linked to these associations.

Internalizing behaviours and HPA and SAM coordination. Recent research suggests that sAA is associated with child and adolescent internalizing behaviours (e.g., Allwood et al., 2011; Hill-Soderlund et al., 2015). Given that activation of the HPA axis and SAM system are coordinated, the relations amongst cortisol, sAA, and internalizing behaviours are important to understanding atypical stress responsivity. Research has begun to examine associations among cortisol, sAA, and internalizing behaviours; however results are highly ambiguous and studies vary in terms of the type of stressor paradigm used, the rater (parent or child) of internalizing behaviours, and the specific outcome of interest (i.e., cortisol or internalizing behaviour).

Using an amalgamation of several different stressors (including cognitive, interpersonal conflict, and frustration activities), El-Sheikh et al. (2008) found that sAA moderated the impact of cortisol in predicting child internalizing behaviours, such that children who had both higher cortisol levels and higher sAA levels experienced greater internalizing behaviours. These findings are in line with Baurer et al.'s (2002) synchronous additive model of coordination and Del Giudice et al.'s (2011) vigilant pattern of coordination, both indicative of a maladaptive coordination pattern. Koss et al. (2015) examined how cortisol and sAA reactivity in response to a conflict vignette jointly predict child internalizing behaviours in the context of high/low family conflict. The results of this study suggest that

children in a high conflict environment who evince low cortisol and high sAA levels experience the highest degree of internalizing behaviours. Allwood et al. (2011) also demonstrated that cortisol and sAA responses, to either a performance or peer-rejection stressor, interacted to predict child/adolescent behavior, but the nature of this interaction differed from other findings. Allwood et al. (2011) showed that individuals with high cortisol reactivity and low sAA reactivity had the highest behaviour problems (indicated by highest total score on the CBCL). Further, it is important to highlight that these findings may differ because these studies examined different outcomes, that is, El-Sheikh et al. and Koss et al. assessed internalizing-specific outcomes, whereas, Allwood et al. assessed a combination of internalizing and externalizing difficulties. The mismatch in cortisol and sAA coordination found by these three studies is consistent with the asynchronous interactive model of coordination (Baurer et al., 2002).

In the three aforementioned studies, internalizing behaviour was the outcome of interest. In contrast, Bae et al. (2015) was interested in how internalizing behaviours interacted with sAA to predict cortisol reactivity during the TSST-C, in a sample of 8-14 year olds. Bae et al. found that higher internalizing behaviours coupled with a steeper sAA decline predicted lower cortisol during the TSST-C. In contrast to the aforementioned studies, additional studies have not found significant associations between cortisol, sAA, and internalizing behaviours (Chen et al., 2015; Vigil et al., 2010). As discussed above, challenges vary in their potency to elicit cortisol and sAA responses, a particularly important potential confound in the context of the present study, which addresses cortisol-sAA coordination. In addition, of course, the informant of internalizing behaviours in this research is also likely an important factor. However, the few aforementioned studies that examine the association between physiological coordination and internalizing problems all used parent-reported internalizing behaviours. Thus, it remains unclear whether the informant of internalizing behaviours impacts

associations with physiological coordination. The specific associations between the child-reported and parent-reported internalizing problems on physiological coordination, will be directly assessed in the present study.

It is important to note that all of the aforementioned research is correlational in nature, and thus causal associations between internalizing behaviours, sAA, and cortisol have not been established. I highlight this point because the present study, similar to that of Bae et al. (2015), explores cortisol reactivity as an outcome, given our aim is to better understand factors that predict cortisol reactivity. As demonstrated by Bae et al., one system (e.g., SAM) can interact with psychological variables (i.e., internalizing behaviour) to predict functioning in another system (e.g., HPA). To this end, the interaction between other psychological variables (i.e., maltreatment status) and sAA has been shown to predict cortisol levels (Gordis et al., 2008). As such, I will explore the interaction between internalizing behaviours and sAA in the prediction of cortisol reactivity.

Taken together, the HPA literature demonstrates that 1) it is advantageous to assess cortisol reactivity across multiple contexts, given that situational stressors differ in the degree to which they elicit cortisol reactivity and flexibility across these challenges is an important metric in itself; 2) adaptive cortisol reactivity depends on coordination with the SAM system; and 3) individual differences in internalizing behaviours are likely related the aforementioned associations. However, research that simultaneously examines the associations between cortisol, sAA, and internalizing behaviours is limited and highly ambiguous. Findings may vary based on type of paradigm used to elicit stress as well as the reporter of internalizing behaviours. Given that the features of these studies vary so widely, it is difficult to determine consistent patterns across studies. In addition, much of this research is conducted with samples of adolescents; there is a dearth of literature examining these associations in middle-childhood. Given the impact of puberty on HPA activity (Stroud et al., 2011), it

is important to examine these associations in middle childhood. Based on the above literature review, it is apparent that cortisol findings are confounded by a number of factors, including the stressor paradigm used to elicit a given stress response, coordination between cortisol and sAA activity, and the rater (parent or child) of internalizing behaviours.

The Current Study

Overall, this study aims to improve on the extant literature by 1) elucidating associations between internalizing behaviours and cortisol reactivity, and 2) assessing associations between internalizing behaviours and cortisol-sAA coordination, in a sample of 8-10 year-old children. I do so by employing several methodological controls, namely 1) utilizing two challenges, specifically designed to differentially elicit cortisol and sAA reactivity; 2) assessing sAA levels in coordination with cortisol levels in both of these challenges; and 3) using parent and child reports of internalizing behaviours. As such, this study is specifically designed to improve upon the methodological shortcomings in the extant literature. In doing so, this will be the first study to assess internalizing behaviours as they relate to both cortisol reactivity as well as coordination between cortisol and sAA, in two differentially potent challenges. In accordance with these study aims, I propose two hypotheses:

Hypothesis 1: I expect that internalizing behaviours will have distinct associations with cortisol reactivity in the two, differentially potent challenges. In particular, children with lower levels of internalizing behaviours will mount high cortisol reactivity in the potent TSST-C and minimal reactivity in the non-potent challenge. In contrast, children with higher levels of internalizing behaviours will demonstrate blunted cortisol reactivity in the TSST-C and either heightened or blunted reactivity in the non-potent challenge. To be clear, I will not statistically test whether internalizing problems are differentially predictive of cortisol responses *across* these two challenges (i.e., flexibility) for reasons discussed below, however, our methodological design

permits the examination of associations amongst internalizing behaviours and cortisol reactivity, within each of these respective challenges.

Hypothesis 2: Internalizing behaviours are associated with coordination between salivary alpha-amylase and cortisol reactivity in both challenges. Given prior research (e.g., Bae et al., 2015), I expect that in the potent stressor, higher internalizing behaviour problems will be associated with lower cortisol and lower sAA, and in the non-potent challenge, higher internalizing behaviour problems will be associated with higher cortisol and higher sAA. However, given prior inconsistent findings (i.e., coordination in the positive and negative direction) the specific directions of these hypotheses are tentative.

Methods

Participants

A total of 52 community-dwelling mother-child dyads, who are part of our laboratory's longitudinal study ($N = 297$) (Atkinson et al., 2013), participated in the current study. Families whose children ranged in age from 8.5 to 10 years old were contacted to participate in the present study. During the recruitment period, a total of 114 families had children between the ages of 8.5 and 10 years old, and thus were contacted to participate. Of these 114 families, I was unable to contact 42 families (because of change in contact information), 5 moved out of the Greater Toronto Area (GTA), 11 were interested but their schedules did not permit participation during the study period, and 4 were not interested in participating. The current sample did not differ from the larger longitudinal sample by sex ($t(330) = 0.57, p = .57$), ethnicity ($t(322) = 0.96, p = .34$), maternal education ($t(330) = -.31, p = .76$), or income ($t(237) = -1.15, p = .25$). Therefore, to my knowledge the individuals who participated in the present study did not differ on important demographic variables compared to the larger study sample. The larger study recruited mother-child dyads from postings and in-person visits at community centers as well as baby show conventions in the GTA. Inclusion criteria at the onset of this longitudinal study were that infants were healthy with no major developmental disorder, pregnancy was over 32 weeks; mothers were 18 years or older at childbirth, had no known hormonal disorders, and were fluent in English.

Children in this sample ranged from 8.5 to 10 years of age ($M = 8.88, SD = 0.70$). The samples included 29 male children (55.7%). The majority of the sample was Caucasian (76.5%), with a smaller proportion of Asian (7.8%), East-Indian (2.0%), Afro-Canadian (2.0%) and 'mixed' ethnicities (11.8%). The sample was primarily from middle to high socio-economic backgrounds (69.5% family income $> \$100,000$). All demographic information was collected during the current study sessions in

order to account of possible changes over time, given that this longitudinal research has spanned almost one decade. Of the 52 children who participated in the study, 46 completed both study sessions; five families could not be reached to schedule the second session, and one mother declined participation in the second session, expressing concern that study procedures were too stressful for the child. In addition, one child was excluded from the sample due to a diagnosis of Autism Spectrum Disorder (ASD), which prevented standard implementation of study procedures. Two other children had a reported ‘high-functioning’ ASD diagnosis but were able to complete standard study procedures¹. In total, the final sample included 51 children, 45 of whom completed both study sessions. All 51 children were included in the analyses, given that multi-level modeling allows for missing data (explained further below).

Procedure

Mother-child dyads participated in two laboratory-based study sessions, approximately three weeks apart (*Median* = 2.00 weeks, *Interquartile Range* = 2.00 weeks, range 1 day-12 weeks), at Ryerson University. Each study session lasted two hours. At the beginning of each session, the experimenter explained study procedures to children and mothers and obtained assent and consent, respectively. After the consent process, children and mothers relaxed for 15 minutes, during this time two baseline saliva samples were collected (-15 min and 0 min). During this baseline period, dyads completed initial measures of positive and negative affect as well as a visual analog rating of momentary stress (baseline self-reported stress are commonly captured at the same time as physiological measures; e.g., Doom, Doyle, & Gunnar, 2015). Immediately after the second saliva sample was taken (0 min), children participated in a 20-minute challenge. During one visit, children participated in a performance stressor, the child-appropriate version of the Trier Social Stress Test

¹ Results did not differ whether these two individuals were included in the sample or excluded. Thus, these individuals were retained in the sample and included in the subsequent analyses.

(TSST-C; Buske-Kirschbaum et al., 1997). During the other visit, the children participated in a competition challenge, which included a timed puzzle task and an adapted mirror-tracing activity (Bostock, Hamer, Wawrzyniak, Mitchell, & Steptoe, 2011; Hammer et al., 2006). The duration of each challenge was equivalent (20 minutes), in order to minimize differential timing effects of cortisol/sAA trajectory. After each challenge, the experimenter gave children positive feedback about their performance. The order of the challenges was randomly determined in order to achieve counterbalancing (49% of the sample participated in the TSST-C during the first session). Following these challenges, mothers and children completed questionnaires (including a demographic questionnaire, the Child Depression Inventory (CDI), and the Child Behavior Checklist (CBCL)). In total, saliva was sampled before (-15 and 0 min) and after (+5, +10, +20, +40, and +60 min) each challenge. During the first study session, children were weighed and their height was measured to later calculate their Body Mass Index (BMI) (calculated by the weight in kg divided by the square of the height in metres (i.e., kg/m^2); World Health Organization, 2017) as a covariate of stress reactivity. Procedures occurred between 1300h and 1800h to control for circadian effects on cortisol and sAA. This time frame is based on my review of the typical start and end times used in studies that examine cortisol in response to laboratory stress (e.g., Bostock, Hamer, Wawrzyniak Mitchell, & Steptoe, 2011; Chopra et al., 2009).

Measures

The Trier Social Stress Test- Child Version (TSST-C). The TSST (Kirschbaum, Pirke, & Hellhammer, 1993) is an uncontrollable, social-evaluative, performance challenge, which has been adapted for children 7 years and older (TSST-C; Buske-Kirschbaum et al., 1997). The TSST-C consisted of a 5-minute instructional period, 5-minute preparation period, 5-minute speech, and 5-minute arithmetic task (20 minutes total). The TSST-C began with the experimenter reading the child

the beginning of a story (see Appendix 1) in front of two expert judges, the child was then given time to prepare the rest of the story in a separate room, thereafter the child finished telling the story as excitingly as possible in front of two expert judges. If a child finished their story before five minutes elapsed or did not speak for 20 seconds, one of the judges prompted them that there was time remaining and asked them to continue. After completing the story portion of the task, the judge asked the child to serially subtract the number 7 from 758 as quickly as possible, without making mistakes. During the arithmetic task, if the child made a mistake the judge instructed them to stop and start the task over again. Children were informed that the task would be video-recorded and later reviewed by the expert judges. Two confederates in laboratory coats acted as expert judges and displayed a neutral expression throughout the challenge. The TSST has been shown to reliably elicit cortisol responses in both children and adults (Buske-Kirschbaum et al., 1997; Dickerson & Kemeny, 2004; Kirschbaum et al., 1993; Kirschbaum & Hellhammer, 1994; Yim, Quas, Cahill, & Hayakawa, 2010).

Competition Challenge. Children completed a competition challenge, which consisted of a 5-minute instruction period, 5-minute mirror tracing task (Bostock et al., 2011; Hammer et al., 2006) and a 10-minute puzzle activity. At the beginning of this challenge, children were told they are going to participate in a competition and that their performance will be compared to that of the other children in the study, so they should try to perform their best by doing the tasks as quickly as possible without making mistakes. First, children completed the adapted (described below) 5-minute mirror tracing activity (Bostock et al., 2011; Hammer et al., 2006). During this activity, a piece of paper with the outline of a star shape was placed underneath a mirror tracing apparatus (see Appendix 2), such that children could only see the reflection of the star through a mirror. Children were asked to trace the outline of a star by looking at the reflection in a mirror. They were told to try their best to trace the star as quickly as they can, without making mistakes (i.e., tracing over the lines of the star). Children were

told they should trace another star when they are finished tracing the first. Unlike the original mirror-tracing task (Bostock et al., 2011; Hammer et al., 2006), this task was adapted so that the apparatus did not buzz when children made a mistake. This feedback was not included in this task to prevent interference with the amount of effort put forth in the challenge. The second part of the competition was a 100-piece puzzle to be completed within 10-minute time limit (see Appendix 3). The puzzle was designed to be too complex to complete within this time frame. Children were asked to work as quickly as they could to complete the puzzle. They were instructed that if they finished the puzzle they would be given another one to complete. Children were told that the child who finishes the most puzzles wins the competition. None of the children completed the puzzle in the time provided.

Ethical considerations. The aforementioned challenges are deemed to be no more stressful than stressors encountered in everyday life (Buske-Kirschbaum et al., 1997; Kirschbaum et al., 1993; Zilioli & Watson, 2012). If the child became noticeably upset during either of the challenges, the confederate judges or experimenter asked them if they were okay to continue. The experimenters emphasized that the children were free to stop participation at any time, without penalty. Mothers observed all procedures and were also free to terminate at any time should they wish. In no case did mothers terminate the challenge prematurely. A total of ten and four children prematurely terminated the TSST-C and competition challenge, respectively (only one child terminated both challenges prematurely)². Immediately after all challenges, the experimenter provided positive performance feedback to the child. In addition, after the TSST-C, the experimenter explained that the judge's flat affect was not a reflection of their performance, but rather was a tactic to make the challenge more stressful. Further, at the end of this session (i.e., after the last saliva sample is taken) children were offered an opportunity to

² Children who terminated the TSST-C or competition challenge prematurely did not differ in their cortisol levels from those who completed the challenges [$t(267) = -1.43, p = .15$ and $t(304) = 1.26, p = .21$, for TSST-C and competition challenge, respectively].

meet the expert judges so that they could receive positive verbal and non-verbal feedback. Complete disclosure was provided at the end of each study session. That is, during the session with the TSST-C, children were told that the judges are actually university student volunteers and during the session with the competition, children were told that their performance on the competition would not actually be compared to that of other children in the study.

Saliva collection and assays. Acute HPA and SAM activity were measured by salivary cortisol and alpha amylase, respectively. To avoid contamination, participants were asked to refrain from drinking, eating, or brushing their teeth for one hour before saliva sampling (Kirschbaum & Hellhammer, 1994, 1989). In response to an intake inventory, all participants reported having complied with these requests, however, one child sipped water during the session due to hiccups. Saliva was collected from children, using sorbettes (Salimetrics, State College PA). Saliva was collected seven time points throughout both study sessions (-15, 0, +5, +10, +20, +40, and +60 min), to sufficiently measure baseline, reactivity and recovery (Dickerson & Kemeny, 2004; Yim et al., 2010). Cortisol was assayed using the -15, 0, +10, +20, +40, and +60 min samples, whereas sAA was assayed using the -15, 0, +5, +10, and +20 min samples, given that cortisol peaks between +20 and +40 min and sAA peaks between +5 and +10 min (Dickerson & Kemeny, 2004; Nater & Rohleder, 2009; Villani, in prep).

After collection, sorbettes were placed in a 2-mL cryovial, sealed, and stored at -70°C. Samples were thawed overnight in the refrigerator before they were assayed. Saliva samples were centrifuged for 20 min at 3000 rpm at 4 °C for cortisol assays and for 15 min at 3000 rpm at 4 °C for alpha-amylase assays. Saliva was assayed using cortisol and alpha-amylase immunoassay kit (Salimetrics, State College, PA). Samples from each child across both sessions were assayed together. All samples were assayed in duplicate and average values were used in analyses. For cortisol, the inter-assay variation

was 7.96% and the intra-assay variation was 8.45%. For sAA, the inter-assay variation was 9.43% and the intra-assay variation was below 5% for low, medium, and high samples.

Questionnaires. Children and their mothers completed several questionnaires following the challenge in the first study session.

Child-reported depressive symptoms. Child self-reported depressive symptoms were assessed using the 27-item Child Depression Inventory, Second Edition (CDI-2; Kovacs, 1992). The CDI-2 is a comprehensive measure of depressive symptoms for children and adolescents 7 to 17 years old. The CDI-2 yields a total score of depressive symptoms within the past two-weeks, as well as four subscales: negative mood, negative self-esteem, ineffectiveness, and interpersonal problems. The CDI is a psychometrically sound measure, with high reliability and predictive validity in both community and clinical samples of children and adolescents (Masip, Amador-Campos, Gómez-Benito, & Gándara, 2010).

Maternal reported internalizing behaviours. Given that parent and child-reported internalizing difficulties have been shown to be differentially associated with cortisol outcomes (e.g., Attwood et al., 2011; Spies et al., 2011) and that using multiple informants is considered best practice when assessing child and youth psychopathology (Achenbach, 2009; Jensen et al., 1999; Lahey et al., 1996), mothers completed the parent-version of the Child Behavior Check List for school-aged children, 6-18 years old (CBCL 6-18; Achenbach, 2001). The CBCL is one of the most frequently used and empirically validated measures of child psychopathology. The CBCL has been validated in numerous clinical and community samples, worldwide (e.g., Breland-Noble & Weller, 2012; Malik, 2008). The instrument produces eight syndrome scales (Withdrawn, Somatic Complaints, Anxious/Depressed, Social Problems, Thought Problems, Attention Problems, Delinquent Behavior and Aggressive Behavior) as well as a Total Problem Score and two broad subscales, the Internalizing and Externalizing scales. Of

importance for the current study, the Internalizing scale consists of the Withdrawn, Somatic Complaints and Anxious/Depressed syndrome subscales.

Demographics and covariates. Demographic information, including the age, sex, BMI, and ethnicity of children, as well as family income were examined as potential covariates. In addition, the time gap between sessions, and sleep and waking times were assessed as covariates, as these variables can potentially influence HPA and sAA trajectories (e.g., Goldberg et al., 2003; Ruttle, Javaras, Klein, Armstrong, Burk, & Essex, 2013; Stadler et al., 2012).

Data Preparation and Analytic Approach

Data were analyzed using multilevel modelling (MLM) with maximum likelihood (*Hierarchical Linear Modeling, Version 7*, Raudenbush, Bryk, Cheong, Congdon, du Toit, 2011) to account for interdependence of cortisol and sAA samples across time and within individual participants. MLM is ideal for physiological (i.e., cortisol) analyses because it accounts for different initial values of the dependent variable (i.e., intercept) and different rates of change within and across individuals (growth trajectories, i.e., slopes) and it permits the examination of how predictors of interest influence these associations (Hruschka, Kohrt, & Wrothman, 2005; Singer & Willet, 2003; Willett & Sayer, 1994). Rather than employing several linear regression analyses to assess these associations, MLM permits refined examinations of trajectories in a single analysis. The use of trajectories are advantageous in comparison to summary physiological indices, such as area under the curve with respect to change (AUC_I), which can be considered crude measurements due to the loss of intra-individual variability across physiological assessment time points (Hruschka et al., 2005). In addition, MLM derives parameter estimates by employing a full information maximum likelihood (FIML) technique, thus allowing for data to be missing at Level 1 (in this case, cortisol and sAA) (Hruschka et al., 2005; Hibel et al., 2009; Laurent et al., 2015). Further, MLM does not require data

points to be evenly spaced in time, thus permitting analyses of cortisol and sAA collected at different time points (Atkinson et al., 2013).

A two-level multi-level model was used to assess child sAA and cortisol trajectories across collection time (i.e., -15, 0, 5, 10, 20, 30, 40, and 60 min; Level 1) nested within individual children (Level 2). Four separate multi-level models were conducted to assess associations in both challenges (i.e., TSST-C and puzzle/mirror-tracing competition) and both psychological predictors (i.e., child-reported depressive symptoms and maternal reported internalizing behaviours). A total of four models was tested (1. TSST-C and child-reported depressive symptoms, 2. TSST-C and maternal reported internalizing behaviours; 3. Competition challenge and child-reported depressive symptoms; 4. Competition challenge and maternal reported internalizing behaviours). Intra-class correlations (ICC) depicting the variance accounted for between levels support the use of nesting procedures. For the null models the ICCs were .56 and .64 for the TSST-C and competition challenge, respectively. The ICC represents the percentage of variance between units at different levels; thus, 36% to 44% of the variance in cortisol was between time and individual.

For all models, cortisol was inputted as the outcome variable. Level 1 predictors included sAA (group mean centered), linear time (coded as -1, 0, 1, 2, 3, 4, corresponding to the -15, 0, 10, 20, 40, and 60 min; uncentered) and quadratic time (coded as 3.3, -0.6, -2.6, -2.6, -0.6, 3.3, corresponding to the -15, 0, 10, 20, 40, and 60 min; uncentered). In order to minimize multi-collinearity between linear time and quadratic time, orthogonal polynomial contrasts were used to represent quadratic time (Little, 2013; Raudenbush et al., 1995). Given its relevance for understanding the structure of the data, regardless of significance, linear time was retained in all models. In addition to sAA, linear time, and quadratic time as main effects, interaction terms between sAA and each time variable (i.e., sAA x linear time, sAA x quadratic time) were also entered as Level 1 predictors. At Level 2, the relevant

internalizing predictor (either child-reported or maternal-reported) was entered (grand mean centered). In addition, at Level 2, several two-way and three-way interactions between the Level 2 internalizing predictor and Level 1 predictors were entered (i.e., linear time x predictor, quadratic time x predictor, sAA x predictor, linear time x sAA x predictor, quadratic time x sAA x predictor).

A multi-step, bottom-up approach, using the full maximum likelihood estimation procedure was used to derive the final model. Theoretical considerations, significance testing, a comparison of model fit using the log-likelihood ratio test, and an estimate of variance explained (for fixed effects) were used to determine final model components, including fixed and random effects (Raudenbush & Byrk, 2002). The random effects (slopes) for linear time, quadratic time, and sAA were tested at Level 1. Final estimation without robust standard errors (given the small sample size) was used to interpret fixed effects. Once a parsimonious model was established, the influence of potential covariates was assessed and if significant, the covariates were retained in the final model. All final models were re-estimated using restricted maximum likelihood for a conservative estimation of variance-covariance structure. The equations and results corresponding to each step of this bottom up model-building approach are included in Appendix 4. The equations and results from the final models are reported below.

Results

Descriptive Results and Exploring Covariates

Descriptive statistics (i.e., means, standard deviations, and ranges) for untransformed and log-transformed cortisol and sAA, child-reported depressive symptoms, and maternal-reported internalizing problems are presented in Table 3. Cortisol and sAA values were log transformed to address positive skew. Child self-reported depressive symptoms scores ranged from 0 to 30 ($M = 7.57$, $SD = 6.15$). In total, 12% of the sample reported CDI scores in the Clinical range, 8% reported scores in the Borderline Clinical range, 80% reported scores in the Non-Clinical range. Maternal-reported internalizing scores ranged from 0 to 22 ($M = 8.00$, $SD = 5.81$). In total, 23% of the sample reported internalizing scores in the Clinical range, 12% reported scores in the Borderline Clinical range, 65% reported scores in the Non-Clinical range. Correlations between cortisol, sAA, child-reported depressive symptoms, and maternal reported internalizing problems are shown in Table 4.

Table 3. *Descriptive statistics.*

	M	SD	Range
Cortisol TSST-C (untransformed)			
-15 min	4.2703	3.59971	0.7-19.07
0 min	4.2937	4.15839	1.04-24.49
10 min	9.3536	16.48566	1.14-86.25
20 min	8.2945	13.63331	1.36-73.58
40 min	5.5243	6.70677	1.46-35.27
60 min	4.3026	3.19565	1.41-18.98
sAA TSST-C (untransformed)			
-15 min	68.8185	43.61579	9.84-205.66
0 min	67.066	42.4926	8.12-190.90
5 min	76.7814	49.9943	10.82-198.44
10 min	65.292	44.00245	8.69-238.46
20 min	60.09	32.82355	10.33-147.93
Cortisol COMP (untransformed)			
-15 min	3.4412	2.1291	0.43-12.55
0 min	3.1376	2.07347	0.68-14.46
10 min	2.9078	1.92033	0.39-11.76
20 min	2.8236	1.90579	0.37-10.93
40 min	2.9998	1.78156	0.62-12.3
60 min	3.658	2.79261	0.52-17.53
sAA COMP (untransformed)			
-15 min	71.9889	45.04542	16.56-239.44
0 min	70.3159	38.27412	10-167.77
5 min	64.6422	29.9924	8.69-136.78
10 min	63.8885	36.60485	9.02-158.42
20 min	64.9998	36.8897	9.59-152.36
CDI self-reported depression	7.57	6.146	0-30
CBCL maternal-reported internalizing symptoms	8.00	5.811	0-22

Note: TSST= Trier Social Stress Test- Child Version; COMP = Competition challenge (Puzzle/mirror tracing activities); sAA = salivary alpha amylase; CDI = Child Depression Inventory; CBCL= Child Behaviour Checklist.

Table 4. *Correlations between salivary cortisol, salivary alpha amylase, and internalizing predictors.*

	1.	2.	3.	4	5.	6.
1. log Cortisol TSST	---					
2. log Cortisol COMP	.40**	---				
3. sAA TSST	-.10	-.10	---			
4. sAA COMP	-.09	.20**	.55**	---		
5. CDI	-.08	-.06	.26**	.19**	---	
6. CBCL Internalizing	-.16*	-.04	.30**	.04	.18	---

Note: TSST= Trier Social Stress Test; COMP = Competition challenge (puzzle and mirror tracing activities); sAA = salivary alpha amylase (log transformed); CDI = Child Depression Inventory total score; CBCL = Child Behavior Checklist Internalizing subscale.

* $p < .05$, ** $p < .01$

Several socio-demographic factors (i.e., child age, sex, BMI, ethnicity and family income), as well as wake and breakfast time, were assessed as potential covariates with child salivary cortisol (Table 4). In regard to child sex, females showed higher mean cortisol levels in the TSST-C compared to males ($t(249) = -2.62, p < .01$), however, there were not significant sex-specific cortisol differences in the competition challenge ($t(297) = -0.62, p = .54$). Child sex and wake and breakfast time were significantly correlated with salivary cortisol and thus were examined as potential covariates in subsequent MLM models. Potential covariates were included in the most parsimonious MLM model, however none of the potential covariates were significant, thus they were removed from the final MLM model.

Table 5. *Correlations between potential covariates and salivary cortisol.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Log salivary cortisol	---								
2. BMI	.01	---							
3. Sex	.09*	.17**	---						
4. Age	-.03	.04	-.23**	---					
5. Ethnicity	.09*	-.08	-.01	-.09*	---				
6. Family income	.08	.02	-.17**	-.002	-.05	---			
7. Wake time	.10*	-.03	.12	.06	-.07	.18	---		
8. Breakfast time	.15**	.02	.07	.01	-.004	.55**	.08	---	
9. Time (days) between lab visits	-.16**	-.11	.09	-.29**	-.24**	-.06	-.09	-.11**	---

Note: BMI = Body Mass Index

* $p < .05$, ** $p < .01$

Visual Inspection of Cortisol and Alpha Amylase Trajectories Across Challenges

Salivary cortisol and sAA trajectories of all participants across time and challenge are depicted in Figure 5 Panel A and B, respectively. As shown in Panel A of Figure 5, in the TSST-C paradigm (grey dashed line), cortisol levels peak at approximately 20 minutes and then decline and returns to baseline by 60 minutes; in contrast, in the puzzle/mirror tracing competition (black solid line), cortisol levels decline from baseline to 20 minutes and then begin to increase. It is possible that the post-20 minute increase is associated with the completion of study questionnaires (completed between 10 and 30 minutes post-challenge) or the post-challenge uncontrolled free time. Overall, this demonstrates that the TSST-C elicits a relatively strong cortisol response, whereas the competition challenge does not. As shown in Panel B, sAA appears to peak at 5 minutes and return to baseline by 20 minutes post-TSST-C; whereas, sAA declines continuously from baseline to 20 minutes post-competition challenge. Taken together, this visual inspection of cortisol and sAA values suggests that across the entire sample as a whole, the TSST-C elicits both cortisol and sAA reactivity, whereas cortisol and sAA decline across time in the competition challenge.

A

B

Figure 5. Panel A depicts salivary cortisol trajectories across the Trier Social Stress Test (TSST) and puzzle/mirror challenge (COMPETITION). Panel B depicts salivary alpha amylase (sAA) trajectories across the Trier Social Stress Test-Child Version (TSST-C) and puzzle/mirror challenge (COMPETITION).

Main Analyses

Trier Social Stress Test-Child Version (TSST-C). Two separate models were used to examine the effect of child self-reported depressive symptoms and maternal-reported internalizing problems on cortisol trajectories in the TSST-C.

Child-reported depressive symptoms predicting cortisol in the TSST-C. The final model fit the data significantly better than the null model ($\chi^2(6) = 52.95, p < .001$). The final model (shown in equation 1) accounted for 61% of the variance between individuals. Model coefficients and standard errors of fixed effects are shown in Table 6. At Level 1, the fixed effect for time as a quadratic function significantly improved model fit. The random effect (slopes) for quadratic time was significant ($\chi^2(38) = 98.37, p < .001$) and significantly improved model fit, and thus slopes were allowed to vary across quadratic time in the model. The fixed effect of linear time was retained in the model, although it was not significant. The fixed effect of sAA as well as the interactions between sAA and linear and quadratic time were entered at Level 1, however they were not significant, and thus were ultimately removed after testing for potential higher level interactions (see Appendix 4.1). In addition, the random effects of linear time and sAA were tested, but because they were unreliable estimates, were not significant, and did not improve model fit, they were not retained in the model.

At Level 2, child-reported depressive symptoms (CDI), as well as the interactions between CDI and Level 1 predictors (i.e., CDI x sAA, CDI x linear time, CDI x quadratic time, CDI x linear time x sAA, CDI x quadratic time x sAA) were entered as fixed effects. The CDI x linear time and CDI x quadratic time interactions were significantly different from zero ($p < .05$), indicating that the regression of cortisol on child depressive symptoms varies across time (see Figures 6 and 7). The addition of the CDI x linear time and CDI x quadratic time interactions led to significantly improved model fit, $\chi^2(1) = 13.02, p < .01$, and accounted for 31% additional variance. All other Level 2

interactions were not significant (Appendix 4.1) and thus were removed from the final model. Covariates (i.e., sex, ethnicity, wake and eating time) were also added at Level 2, but were not significant and did not significantly improve model fit, and thus were removed from the final model (Table 6).

Equation 1:

Level-1 Model

$$\text{Log Cortisol TSST-C} = B0 + B1 * \text{Linear Time} + B2 * \text{Quadratic Time} + r$$

Level-2 Model

$$B0 = Y00 + Y01 * \text{Child Depression (CDI)} + u0$$

$$B1 = Y10 + Y11 * \text{CDI}$$

$$B2 = Y20 + Y21 * \text{CDI} + u2$$

Mixed Model

$$\begin{aligned} \text{Log Cortisol TSST-C} = & Y00 + Y01 * \text{CDI} + Y10 * \text{Linear Time} + Y11 * \text{CDI} \\ & * \text{Linear Time} + Y20 * \text{Quadratic Time} + Y21 * \text{CDI} * \\ & \text{Quadratic Time} + u0 + u2 * \text{Quadratic Time} + r \end{aligned}$$

Table 6. *Fixed effect estimates from the final 2-level multilevel model with child-reported depression predicting log transformed cortisol levels in the Trier Social Stress Test.*

Fixed Effect	γ	SE	t
Intercept	.57	.04	13.63***
CDI	-.005	.007	-0.76
Linear time	.008	.007	1.20
Quadratic time	-.02	.007	-2.44*
Linear time*CDI	-.003	.001	-2.52*
Quadratic time*CDI	.003	.001	2.63*
Random Effect	Variance	Standard Deviation	Chi-Square (df)
Intercept	.06	.25	493.87(38)***
Quadratic Time slope	.01	.04	98.37 (38)***
Level-1	.03	.17	

Note. CDI = Child Depression Inventory.

* $p < .05$, ** $p < .01$, *** $p < .001$

In order to better understand the CDI x linear time interaction, a multilevel model interaction computation tool was used (Preacher, Curran, & Bauer, 2006). Conditional values of the mean, as well as 1 standard deviation (SD) above and below the mean were selected for the child-reported depressive symptom predictor. All time points were included for linear sampling time (-1, 0, 1, 2, 3, 4). Simple slope analyses for the significant two-way interaction between linear time and CDI predicting salivary cortisol, demonstrated a marginally significant association between salivary cortisol and time at high levels of depressive symptoms ($\beta = -0.03$, $SE = .02$, $z = 1.82$, $p = .069$), but not at moderate ($\beta = -0.01$, $SE = .01$, $z = 1.21$, $p = .23$) or low levels of depressive symptoms ($\beta = 0.004$, $SE = .01$, $z = 0.62$, $p = .53$) (Figure 6). Similarly, the two-way interaction between CDI and quadratic time was plotted using the same conditional values of mean, as well as 1 SD above and below the mean of the moderator variable (Aiken & West, 1991; Dawson, 2014). This representation shows a similar effect, such that individuals with lower levels of depressive symptoms show an increase followed by a decline in cortisol over time, whereas individuals with higher levels of depressive symptoms show an initial decline followed by a slight increase in cortisol across time (Figure 7).

Child Depressive Symptoms by Linear Time Interaction in the TSST

Figure 6. Interaction between self-reported child depressive symptoms and saliva sampling time (linear) predicting log transformed cortisol levels in the Trier Social Stress Test.

Figure 7. Interaction between self-reported child depressive symptoms and saliva sampling time (quadratic) predicting log transformed cortisol levels in the Trier Social Stress Test.

Maternal-reported internalizing behaviours predicting cortisol in the TSST-C. The final model fit the data significantly better than the null model ($\chi^2(3) = 22.71, p < .001$). The final model (shown in equation 2) accounted for 66% of the variance between individuals. The predictor of interest, maternal-reported internalizing problems (CBCL), was not significant as a main effect or interaction (e.g., CBCL x time or CBCL x sAA). At Level 1, the fixed effect for time as a quadratic function significantly improved model fit. The random effect (slopes) for quadratic time was significant ($\chi^2(39) = 111.93, p < .001$) and significantly improved model fit, and thus slopes were allowed to vary across quadratic time in the model. The fixed effect of linear time was retained in the model, although it was not significant. The fixed effect of sAA as well as the interactions between sAA and linear and quadratic time were also entered at Level 1, however they were not significant, and thus were ultimately removed after testing for potential higher level interactions (see Appendix 4.2). At level 2, maternal-reported internalizing problems (CBCL), as well as the interaction between CBCL and Level 1 predictors (i.e., CBCL x sAA, CBCL x linear time, CBCL x quadratic time, CBCL x linear time x sAA, CBCL x quadratic time x sAA) were entered as fixed effects (see Appendix 4.2). The maternal reported internalizing behaviours as well as all Level 2 interactions were not significantly different from zero and did not significantly improve model fit. All non-significant Level 1 and Level 2 effects were removed from the model. The final model (Equation 2) included linear and quadratic time as fixed effects, and quadratic time as a random effect (Table 7).

Equation 2:

Level-1 Model

$$\text{Log Cortisol TSST-C} = B0 + B1 * \text{Linear Time} + B2 * \text{Quadratic Time} + r$$

Level-2 Model

$$B0 = Y00 + u0$$

$$B1 = Y10$$

$$B2 = Y20 + u2$$

Mixed Model

$$\begin{aligned}\text{Log Cortisol TSST-C} = & Y00 + Y10 * \text{Linear Time} + Y20 * \text{Quadratic Time} \\ & + u0 + u2 * \text{Quadratic Time} + r\end{aligned}$$

Table 7. *Fixed effect estimates from the final 2-level multilevel model with maternal-reported internalizing problems predicting log transformed cortisol levels in the Trier Social Stress Test.*

Fixed Effect	γ	SE	t
Intercept	.57	.04	13.46***
Linear time	.008	.007	1.18
Quadratic time	-.02	.008	-2.27*
Random Effect	Variance	Standard Deviation	Chi-Square (df)
Intercept	.06	.25	502.64 (39)***
Quadratic Time slope	.001	.04	111.93 (39)***
Level-1	.03	.17	

* $p < .05$, ** $p < .01$, *** $p < .001$

Competition Challenge. Two separate models were used to examine the effect of child self-reported depressive symptoms and maternal-reported internalizing behaviours on child cortisol trajectories in the competition challenge.

Child-reported depressive symptoms predicting cortisol in the competition challenge. The final model fit the data significantly better than the null model ($\chi^2(3) = 18.69, p < .001$). The final model (shown in equation 3) accounted for 67% of the variance between individuals. At Level 1, the fixed effect for time as a quadratic function significantly improved model fit. The random effect (slopes) for quadratic time was significant ($\chi^2(45) = 61.53, p = .05$) and significantly improved model fit, and thus slopes were allowed to vary across quadratic time in the model. The fixed effect of linear time was retained in the model, although it was not significant. The fixed effect of sAA as well as the interactions between sAA and linear and quadratic time were also entered at Level 1, and although they were not significant they were retained to test for potential higher level interactions (see Appendix 4.3). At level 2, CDI as well as the interaction between CDI and Level 1 predictors (i.e., CDI x sAA, CDI x linear time, CDI x quadratic time, CDI x linear time x sAA, CDI x quadratic time x sAA) were entered as fixed effects (see Appendix 4.3). The three-way interaction between CDI x linear time x sAA approached significance (efficient estimate = .02, SE = .01, $p = .07$). Improvement in model fit approached significance, $\chi^2(1) = 3.27, p = .07$, and 1.5% additional variance was accounted for (Appendix 4.3). Given that this interaction was not significant or did not significantly improve model fit, it was removed from the model. No other Level 2 main effects or interactions were significant or significantly improved model fit. All non-significant Level 1 and Level 2 effects were removed from the model (Appendix 4.3). The final model (Equation 3) included linear and quadratic time as fixed effects, and quadratic time as a random effect (Table 8). All of the tested covariates were non-significant, and thus were removed from the final model.

Equation 3:

Level-1 Model

$$\text{Log Cortisol COMP} = B0 + B1 * \text{Linear Time} + B2 * \text{Quadratic Time} + r$$

Level-2 Model

$$B0 = Y00 + u0$$

$$B1 = Y10$$

$$B2 = Y20 + u2$$

Mixed Model

$$\text{Log Cortisol COMP} = Y00 + Y10 * \text{Linear Time} + Y20 * \text{Quadratic Time} + u0 + u2 * \text{Quadratic Time} + r$$

Table 8. *Fixed effect estimates from the final 2-level multilevel model with child-reported depression predicting log transformed cortisol levels in the Competition challenge.*

Fixed Effect	γ	SE	t
Intercept	.43	.03	12.51***
Linear time	-.0001	.01	-0.04
Quadratic time	.01	.004	3.27**
Random Effect	Variance	Standard Deviation	Chi-Square (df)
Intercept	.05	.22	611.45(45)***
Quadratic Time slope	.0002	.02	61.54 (45)*
Level-1	.02	.15	

Note. CDI = Child Depression Inventory; sAA = salivary alpha amylase.

‡ = .075, * $p < .05$, ** $p < .01$, *** $p < .001$

Maternal-reported internalizing behaviours predicting cortisol in the competition challenge.

The final model fit the data significantly better than the null model ($\chi^2(1) = 38.68, p < .001$). The final model (shown in equation 4) accounted for 63% of the variance between individuals. Model coefficients and standard errors of fixed effects are shown in Table 8. At Level 1, the fixed effect for time as a quadratic function significantly improved model fit. The random effect (slopes) for quadratic time was significant ($\chi^2(41) = 81.81, p < .001$) and significantly improved model fit, and thus slopes were allowed to vary across quadratic time in the model. The fixed effect of linear time was retained in the model, although it was not significant. At Level 1, the fixed effects of sAA as well as the interactions between sAA and linear and quadratic time were not significant, however they were retained to test for potential higher level interactions (see Appendix 4.4).

At Level 2, maternal-reported internalizing behaviours (CBCL), as well as the interactions between CBCL and Level 1 predictors were entered as fixed effects. The CBCL x sAA interaction was significantly different from zero ($p < .05$), indicating that coordination between cortisol and sAA varies across levels of internalizing behaviours. The addition of the CBCL x sAA interaction led to significantly improved model fit, $\chi^2(1) = 5.05, p < .05$. All other Level 2 interactions were not significant (Appendix 4.1) and thus were removed from the final model. Covariates were also added at Level 2, but were not significant, and thus were removed from the final model (Table 9).

Equation 4:

Level-1 Model

$$\text{Log Cortisol TSST-C} = B0 + B1 * \text{Linear Time} + B2 * \text{Quadratic Time} + B3 * \text{sAA} + r$$

Level-2 Model

$$B0 = Y00 + Y01 * \text{Maternal-reported internalizing (CBCL)} + u0$$

$$B1 = Y10$$

$$B2 = Y20 + u2$$

$$B3 = Y30 + Y31 * \text{CBCL}$$

Mixed Model

$$\begin{aligned} \text{Log Cortisol TSST-C} = & Y00 + Y01*CBCL + Y10*Linear\ Time + \\ & Y20*Quadratic\ Time + Y30*sAA + Y31*CBCL \times sAA + u0 + \\ & u2*Quadratic\ Time + r \end{aligned}$$

Table 9. *Fixed effect estimates from the final 2-level multilevel model with maternal-reported internalizing problems predicting log transformed cortisol levels in the Competition challenge.*

Fixed Effect	γ	SE	t
Intercept	.454	.03	14.70***
Internalizing	-.002	.005	-0.30
Linear time	-.001	.01	-0.13
Quadratic time	.01	.007	1.84
sAA	.01	.10	0.08
sAA* Internalizing	.05	.02	2.24*

Random Effect	Variance	Standard Deviation	Chi-Square (df)
Intercept	.03	.18	351.81(40)***
Quadratic Time slope	.001	.03	81.81 (41)***
Level-1	.02	.14	

Note. sAA = salivary alpha amylase.

* $p < .05$, ** $p < .01$, *** $p < .001$

In order to better understand the CBCL x sAA interaction, a multilevel model interaction computation tool was used (Preacher, Curran, & Bauer, 2006). Conditional values of the mean, as well as 1 standard deviation (SD) above and below the mean were selected for the maternal-reported internalizing behaviour predictor. Simple slope analyses for the significant two-way interaction between sAA and internalizing behaviours predicting salivary cortisol, demonstrated a significant association between salivary cortisol and sAA (i.e., coordination) at high levels of internalizing behaviours ($\beta = 0.63$, $SE = .29$, $z = 2.18$, $p < .05$) and at moderate levels of internalizing behaviours ($\beta = 0.36$, $SE = .18$, $z = 1.99$, $p < .05$), but not at low levels of internalizing behaviours ($\beta = 0.10$, $SE = .11$, $z = 0.91$, $p = .36$) (Figure 8). As shown in Figure 8, for individuals with high or moderate levels of internalizing behaviours, high levels of sAA are associated with high cortisol levels, whereas low levels of sAA are associated with low cortisol levels. In contrast, for individuals with lower levels of internalizing behaviours, the level of sAA (high or low) does not impact the level of cortisol (black line).

Internalizing by sAA interaction in the Competition Challenge

Figure 8. Interaction between maternal-reported internalizing problems and log transformed salivary alpha-amylase predicting log transformed cortisol levels in the competition challenge.

Discussion

The present study assessed cortisol secretion patterns in the context of child internalizing problems while accounting for three primary factors that confound associations between cortisol and internalizing behaviours: 1) the differential effectiveness of stressor paradigms to elicit cortisol reactivity, 2) coordination between cortisol and sAA, and 3) the reporter (self or parent) of internalizing behaviour. This study assessed cortisol reactivity as it is related to internalizing behaviours as well as coordination with sAA in two stressor paradigms, which were specifically designed to differentially activate cortisol and sAA responses. The TSST-C is a frequently used, uncontrollable, social-evaluative stressor, which elicits strong cortisol responses in healthy children and adults (e.g., Dickerson & Kemeny, 2004; Gunnar et al., 2009). In contrast, I developed a less-potent competition-based challenge, composed of a puzzle and mirror-tracing task. This competition challenge was selected in an attempt to elicit a strong sAA response, given that the SAM system (and sAA as a result) is theorized to be more strongly activated by controllable, effort-based challenges (Laurent, Powers & Granger, 2013; Lundberg & Frankenhaeuser, 1980). In addition, given prior inconsistencies in parent and child reports (e.g., Hartman et al., 2013), I examined internalizing behaviours using both the child-reported CDI and the maternal-reported Internalizing subscale of the CBCL. This is the first study to simultaneously address the three aforementioned confounds in the cortisol literature. Findings partially support the hypothesis that internalizing behaviours are associated with cortisol reactivity and cortisol—sAA coordination, however, findings differ based on the challenge and the reporter (mother or child) of internalizing behaviours.

Summary of Findings

In order to appreciate the findings as they specifically relate to internalizing behaviours, it is important to examine the general pattern of findings within the sample as a whole. Overall, mean

cortisol and sAA levels across the entire sample suggest that the TSST-C is a potent stressor that elicits both cortisol and sAA reactivity (Figure 5 A & B, grey dashed line). In contrast, in the competition challenge, cortisol declines from baseline to 20 minutes and then returns to baseline levels at 60 minutes, whereas sAA declines steadily throughout the challenge (Figure 5 A & B, black solid line). Taken together, it appears that cortisol and sAA increased in response to the TSST-C, whereas, cortisol and sAA declined in response to the competition challenge.

Consistent with our findings, many prior studies suggest that the TSST-C results in a strong cortisol and sAA response (e.g., Granger et al., 2006; Rohleder et al., 2004; Nater et al., 2006; as detailed below). In contrast, given that the competition challenge was designed to activate the SAM system, I did not expect that sAA would decline in this challenge. Prior research suggests that the SAM system is activated by controllable, self-paced, and effortful challenges (Lundberg & Frankenhaeuser, 1980). In line with this initial research, Laurent et al. (2012) found that infants demonstrated a strong sAA response to the clean-up task and a less pronounced sAA response to the separation stressor. Although the competition challenge in the present study was designed to be effort-based and controllable, for the majority of the sample, it did not elicit a strong sAA response. Given that the competition challenge is a new procedure, it is possible that the level of effort (or lack thereof) elicited by this particular challenge contributed to the declining sAA response.

Several other studies show mixed findings in terms of which types of challenges elicit sAA reactivity. For example, studies that employ uncontrollable and distressing challenges, such as a noise burst paired with an arm restraint (Shea et al., 2006), and viewing negative affect-inducing pictures (van Stegeren et al., 2008), result in increased sAA reactivity, however, other studies that employ similar procedures, such as noise (Morrison et al., 2003) or response to conflict vignettes (Koss et al., 2014) did not result in increased sAA reactivity. In addition, individual differences, such as age, might

impact sAA reactivity across challenges. For example, Stroud et al. (2009) found that school-aged children did not mount strong sAA reactivity in response to either a performance-based or interpersonal challenge. In contrast, adolescents mounted a strong sAA response to the interpersonal challenge but not the performance challenge. This suggests that age might impact which types of challenges activate sAA responsivity. Perhaps the nature of the competition challenge in the present study was not potent enough to elicit a sAA response in our sample of school-age children. Given that this is the first study to use the mirror tracing and puzzle tasks to compose the competition challenge, it remains unclear if the declining sAA response is related to the nature of the stressor or sample characteristics (e.g., age). Overall, it remains unclear which types of challenges elicit a strong vs. weak sAA response, given the limited number of studies that assess sAA across multiple challenges. Additional research is required to understand the types of challenges that elicit relative differences in cortisol and sAA responsivity.

Interestingly, although the competition challenge is not effective in eliciting a strong sAA response across the entire sample, there is a significant correlation between sAA and cortisol ($r = .20$) in the competition challenge, suggesting weak but significant coordination in this challenge. In comparison, there was not a significant correlation between cortisol and sAA ($r = -.10$) in the TSST-C. The significant correlation between cortisol and sAA in the competition challenge but not the TSST-C may reflect the similar trajectories of these two analytes in the competition challenge. That is, both cortisol and sAA decline across the first four sample points in the competition challenge, whereas cortisol and sAA show different patterns of change in the TSST-C. Further this is in line with the proposed hierarchical activation of the HPA and SAM systems, that is, very potent and distressing challenges (e.g., TSST-C) elicit an initial SAM response followed by a strong HPA response, whereas less potent challenges may not require strong HPA *or* SAM activation, and may be sufficiently managed by the parasympathetic nervous system (Del Giudice et al., 2011). Although these

correlations tell us something about the overall associations between cortisol and sAA, more refined analyses are required to adequately understand the nature of physiological coordination.

To investigate whether internalizing behaviours predicted cortisol reactivity and cortisol-sAA coordination, MLM analyses were conducted. In total, this study utilized four separate MLM analyses to examine cortisol reactivity in two challenges (TSST-C and competition) and using two types of internalizing behaviours (maternal-reported CBCL internalizing behaviour and child-reported CDI difficulties).

Trier Social Stress Test- Child Version. In the TSST-C stressor, I found a significant CDI x time interaction, such that children with higher self-reported depressive symptoms, compared to those with lower self-reported depressive symptoms, evinced a decline in cortisol over time throughout the TSST-C (Figure 6 and 7). This finding will be discussed in relation to prior research that examines associations between blunted cortisol reactivity and depression, as well as theoretical models of hypocortisolism. Unlike child-reported depressive symptoms, maternal-reported internalizing behaviours did not predict cortisol reactivity in the TSST-C. In addition, I did not find significant coordination between sAA and cortisol in the TSST-C.

Competition challenge. In the competition challenge, child-reported depressive symptoms did not significantly predict cortisol reactivity. However, maternal-reported internalizing behaviours significantly predicted coordination between sAA and cortisol, such that higher sAA predicted higher cortisol levels, but only for children with high or moderate levels of internalizing behaviours (Figure 8). These findings will be discussed in more detail as they relate to prior empirical studies as well as theoretical models of HPA and SAM coordination.

Associations between Child Depressive Symptoms and Cortisol Reactivity in the TSST-C

Results indicate that cortisol trajectories declined across time for those with higher self-reported depressive symptoms, compared to those with lower depressive symptoms. More specifically, as shown in Figure 7, individuals with higher self-reported depressive symptoms showed an initial decline in cortisol, followed by a return to baseline levels, whereas, individuals with lower depressive symptoms showed an initial increase in cortisol, followed by return to baseline. This finding is consistent with prior research that demonstrates that adolescents who had higher depressive symptoms showed blunted cortisol reactivity in the TSST-C (Booij et al., 2013; Harkness et al., 2011). More specifically, Harkness et al. (2011) examined the combined role of clinical levels of depression and maltreatment history in predicting cortisol reactivity in a sample of adolescents. Adolescents with more severe depression exhibited a blunted cortisol response during the TSST-C, regardless of their maltreatment history; whereas, adolescents with mild/moderate depressive symptoms and a maltreatment history produced more prolonged cortisol reactivity. In addition, Booij et al. (2013), using a community sample of adolescents, examined how the chronicity of depressive symptoms (measured using self- and parent-reported questionnaires) was associated with cortisol reactivity in the TSST. The findings suggested a curvilinear association between depression and cortisol reactivity, such that recent-onset depressive problems predicted an increased cortisol response, and more chronic depressive problems predicted a blunted cortisol response. Further, the present findings in combination with these aforementioned studies, suggest that depressive symptoms are associated with blunted cortisol reactivity in both community and clinical samples. As outlined above, most prior research that examines associations between internalizing behaviours and cortisol reactivity in the TSST-C, is conducted with adolescent samples. Therefore, less is known about how internalizing behaviours predict cortisol reactivity in the TSST-C in school-age children.

The present findings extend prior research by demonstrating that higher depressive symptoms are associated with blunted cortisol reactivity in the TSST-C, in a sample of 8-10 year-old children. To my knowledge, this is the first study to demonstrate the specific association between depressive symptoms (not broader internalizing behaviours) and cortisol reactivity to the TSST-C in a sample of 8-10 year olds. Given that research shows a marked increase in depression after the onset of puberty and throughout adolescence (Patton et al., 2008; Stroud et al., 2011), the current findings suggest that blunted cortisol reactivity may also be associated with depressive symptoms earlier in childhood (prior to puberty), which potentially has important implications for future basic and applied research (discussed in detail below). Future longitudinal research is needed to determine whether associations between internalizing behaviour and cortisol reactivity in middle childhood is predictive of subsequent difficulties.

The current findings that children with higher self-reported depressive symptoms show blunted cortisol reactivity in the TSST-C can be understood in the context of allostatic load. Allostasis is the process by which diverse physiological and neurobiological systems adjust and adapt in response to environmental changes, to achieve homeostasis (McEwen, 1998; McEwen & Seeman, 1999). However, over time, repeated stress may result in the “wear and tear” of the stress response system (allostatic load). As outlined by McEwan (1998), both prolonged stress responses (increased cortisol secretion and failure to recover) or blunted/inadequate responses are considered to be maladaptive markers of allostatic overload. McEwan also outlines that blunted HPA activity may result in altered activity of adjoining stress systems (e.g., SAM system, immune system), which can lead to adverse health outcomes. It is important to note that although allostatic load has often been conceptualized within the context of repeated life stress (and often trauma), I did not measure these variables directly in the present study. In fact, the current sample is relatively low-risk. Here, I am using the allostatic

load framework simply to interpret the blunting cortisol reactivity findings as they relate to internalizing behaviours, and to understand how these associations are potentially related to life stress.

Prior research suggests that hypocortisolism (i.e., blunted cortisol response) is associated with a number of physical illnesses and mental health problems in adults, including depression and Post-Traumatic Stress Disorder (Fries, Hesse, Hellhammer, & Hellhammer, 2005; Heim, Ehler & Hellhammer, 2000). It is hypothesized that hypocortisolism occurs in response to repeated exposure to stress (discussed in more detail below). It has been proposed that blunted cortisol could result from previous periods of high cortisol earlier in development, including in the prenatal period and early childhood (Charmandari, Kino, Souvatzoglou, & Chrousos, 2003). For example, pre-pubescent children demonstrated blunted cortisol responses in face of stressful family circumstances (Hankin, Badanes, Abela, & Watamura, 2010). It was concluded that this attenuation prevented children from having to repeatedly mount a cortisol reaction in response to repeated and uncontrollable daily stressors.

In addition to being associated with hypocortisolism, exposure to stressful life events, both major and minor, is one of the most strongly associated risk factors for depression across the lifespan. With regard to developmental psychopathology, extensive research has highlighted the importance of psychosocial stress in the development and maintenance of internalizing problems (e.g., Cicchetti & Toth, 1991; Haggerty, Sherrod, Garmezy, & Rutter, 1994). For example, extreme stressful life events, such as the death of a parent or severe maltreatment, are associated with higher levels of depression in youth (Kendler, Kuhn, & Prescott, 2004; Williamson, Birmaher, Dahl, & Ryan, 2005). In addition, less severe stressful life events, such as daily hassles (O'Sullivan, 2004), are also associated with increased depressive problems. It is important to note that stressful life events do not induce depressive symptoms in all individuals (e.g., Bonanno, 2004). Rather, diathesis stress models of depression

(Hammen, 2005) posit that preexisting vulnerability factors potentiate risk for depression during stressful life events. Extensive research has examined atypical HPA activity as a key biological risk factor that potentiates risk in the face of stressful life events (Colich, Kircanski, Foland-Ross, & Gotlib, 2015; Foland-Ross et al., 2013). Taken together, independent research suggests that stressful life events, major and minor, are associated with hypocortisolism as well as the etiology and maintenance of internalizing behaviours. Again, although allostatic load is proposed as a potential mechanism that may account for the associations between life stress, depression, and blunted cortisol activity, this study did not directly assess life stress or trauma, and thus it is unclear whether allostatic load actually accounts for the present findings.

Although research shows that hypoactive HPA activity as a result of allostatic overload is maladaptive, additional theory and research outlines *how* repeated stress may result in blunted cortisol responsivity. Heim and colleagues (2000) propose a model that consists of several potential biological *mechanisms* and psychological and environmental *determinants* of hypocortisolism. In particular, potential mechanisms that underlie the development and maintenance of hypocortisolism include: 1) reduction in the synthesis of different agents of the HPA axis (i.e., corticotropin releasing factor (CRF), ACTH, cortisol); 2) initial hypersecretion which results in adaptive down regulation of CRF receptors; 3) increased feedback sensitivity of the HPA axis, due to initial increased levels of circulating cortisol; and 4) morphological changes to the adrenal gland (Heim et al., 2000).

In addition to these biological mechanisms, Heim et al. noted several determinants that impact hypocortisolism. Of particular importance to the present findings, the characteristics of the stressor (including the nature, frequency, intensity, controllability and predictability) and the individual's coping style likely impact hypocortisolism. A detailed discussion of these determinants, as well as the supporting research, is beyond the scope of this discussion (refer to Heim et al., 2000). However,

through the design of this study, I have directly addressed how the characteristics of the stressor impact cortisol reactivity. In particular, the TSST-C is designed to be an intense social-evaluative stressor that is deemed to be uncontrollable and unpredictable, and evokes a strong HPA response (e.g., Dickerson & Kemeny, 2004). This compares to the competition challenge, which is designed to be more effort-based and controllable.

In addition, I will briefly elaborate on how one's coping style can impact hypocortisolism, as this determinant is particularly relevant to the association between blunted cortisol and depression. Environmental stress at some point in time and to some degree is inevitable. A person's coping style may mediate the development of a maladaptive stress response, in particular, hypocortisolism. Research suggests that passive coping, denial, and withdrawal are specifically associated with hypocortisolism (Katz, Weiner, Gallagher, & Hellman, 1970; Wolff, Hofer, & Mason, 1964). Interestingly, the same symptoms that are associated with hypocortisolism also characterize depression. For example, trait rejection sensitivity was associated with both depressed mood and hypocortisolism in young women (Tops, Riese, Oldehinkel, Rijdsdijk, & Ormel, 2008). Therefore, our finding that children with higher depressive symptoms experience blunted cortisol reactivity can be understood in the context of hypocortisolism, a marker of allostatic overload, which can result from an interchange between stressful life events and ineffective coping.

Flexibility of cortisol responsivity. This study was designed to assess whether internalizing behaviours have distinct associations with cortisol reactivity in two differentially potent challenges. Although I was unable to statistically compare results across studies, given the nature of the study design and for the sake of completeness, these findings will be discussed as they relate to flexibility. Prior research from our group (e.g., Atkinson et al., 2016) has highlighted the importance of assessing cortisol flexibility, given that distinct stressors differentially elicit cortisol responses, and individual

psychological variables predict adaptive cortisol responsivity (i.e., high response to potent challenge, low response to non-potent challenge). Ideally, the present study would have directly examined cortisol flexibility by statistically comparing cortisol trajectories *across* the two challenges. However, this would have resulted in 5 main effects and 11 interactions in the MLM model, which was not feasible with our sample size. Unfortunately, there is not a rule of thumb for the number of individuals needed to have sufficient power to detect effects in MLM models. The sample size at the highest level (i.e., Level 2, individuals in the present study) is the main limiting factor of the design (Snijders, 2005). In addition, larger clusters of Level 2 variables are required when testing random effects (slopes and intercepts) in addition to fixed effects (Snijders, 2005). To gain a rough estimate, I look to power recommendations in multiple regression analyses. In multiple regressions, a minimum of 20 subjects per variable is recommended (i.e., over 300 subjects needed to test the current model). However, given that interaction terms only account for residual variance and that more power is required when testing random effects, this is likely a very low estimate. Although the small study sample prevented me from statistically assessing whether internalizing behaviours differentially predicted cortisol reactivity *across* these two challenges (i.e., flexibility), I experimentally controlled for the potency of the challenge, thereby allowing for more methodological clarity when interpreting my findings.

Findings indicate that child-reported depressive symptoms were associated with blunted cortisol reactivity in the TSST-C, however I did not find significant associations between child-reported depressive symptoms and cortisol levels in the competition challenge. It is possible that I did not find a significant association between depressive symptoms and cortisol in the competition challenge because of limited power to detect effects. Alternatively, it is possible that the nature of this challenge simply did not elicit a differential cortisol response between those with high or low depressive symptoms. In relation to the above discussion of hypocortisolism and allostatic load, it is conceivable that children

with higher self-reported depressive symptoms demonstrate blunted cortisol responses across both challenges, and I did not find a statistical difference in cortisol trajectories in the competition challenge because children with low levels of depression also demonstrated a decline in cortisol in the competition challenge (see Figure 9). In line with this interpretation, based on the visual inspection of these graphs, it appears that children with higher levels of self-reported depression evince declining cortisol responses in both challenges. These are intriguing findings that are consistent with prior work and potentially support the notion of cortisol flexibility. In our study, an adaptive cortisol response, would be indicated by a cortisol increase (followed by a return to baseline) in the potent TSST-C and a steady decline in cortisol in the non-potent competition challenge, which is shown in the overall sample trajectories (Figure 5).

Figure 9. Visual depiction of cortisol trajectories in the Trier Social Stress Test-Child Version (TSST-C) and Competition challenge, for those with high (+1 SD) and low (-1 SD) self-reported depressive symptoms (measured using the Child Depression Inventory; CDI).

Only two prior studies (Laurent et al., 2015, 2016) have examined the association between internalizing problems and cortisol reactivity across two distinct challenges. Laurent et al. (2015) demonstrated that specific child anxiety problems had unique associations with cortisol reactivity in the TSST-C and a problem solving challenge. More specifically, generalized anxiety was associated with elevated cortisol in both challenges, specific phobia was associated with elevated cortisol levels in the TSST-C, and OCD was associated with limited cortisol recovery after the problem-solving challenge. In addition, Laurent et al. (2016) examined broader maternal-reported internalizing problems as they related to cortisol reactivity in a sample of 8-16 year olds who participated in a performance (similar to the TSST-C) and an interpersonal rejection challenge. Interestingly, Laurent et al. found that overall maternal-reported internalizing symptoms predicted an earlier cortisol peak in the interpersonal stressor, however in contrast to the present study findings, internalizing behaviours were not associated with cortisol reactivity in the performance challenge. Although the total scale score of internalizing symptoms was not predictive of cortisol reactivity in the performance challenge, anxiety-specific symptoms were related to high cortisol levels during this challenge. These findings were also moderated by sex, such that for females only, anxiety was associated with a later cortisol peak during the performance challenge. Taken together, the findings of the current study, along with these two prior studies, suggest that the associations between internalizing behaviours and cortisol reactivity differ depending on the nature of the stressor paradigm, and perhaps the type of internalizing behaviour (e.g., depression or anxiety). Nonetheless, future work with a larger sample is needed to directly assess whether internalizing problems *differentially predict* cortisol reactivity *across* two distinct challenges.

Coordination of Cortisol and sAA

In addition to examining cortisol reactivity, the current study aimed to assess coordination between cortisol and sAA, within two distinct challenges. It is well established that the HPA and SAM

systems operate in parallel to produce a coordinated physiological response to stress; however, as stated by El-Sheikh et al. (2008), “the optimal type of co-action between these systems is not well-understood” (p. 603). The current findings indicate that children with higher maternal-reported internalizing behaviours who experienced higher sAA also experienced higher cortisol in the competition challenge. It is important to note that unlike our cortisol reactivity findings (i.e., depressive symptoms predicted a blunted cortisol trajectory in the TSST-C), these coordination findings are based on mean levels of cortisol and sAA, *not* trajectories. Given the three-way interaction between time, sAA and internalizing behaviours was not a significant predictor of cortisol levels, I cannot say that coordination between sAA-cortisol trajectories varied by internalizing behaviours, I can only discuss coordination between overall (average) cortisol-sAA levels. In addition, in contrast to the significant physiological coordination in the competition challenge, I did not find significant cortisol—sAA coordination in the TSST-C. It is unclear why the competition challenge and not the TSST-C elicited strong coordination. However, I attempt to explain these findings in the context of prior theory and research.

These results can be understood in the context of the *additive model* of HPA and SAM activation proposed by Bauer et al. (2002). The *additive model* suggests that the HPA and SAM systems operate in conjunction, with optimal functioning occurring when each system is activated at a moderate level or one system is highly activated while the other is not (i.e., asynchronous activity), and thus synchronously high (or low) activation in both systems is maladaptive (Bauer et al., 2002). In the present case, in the competition challenge, high activation in both systems is associated with higher levels of internalizing behaviour problems. Although somewhat counter-intuitive given the literature associating internalizing behaviour problems with blunted cortisol reactivity (including our current findings that higher self-reported depressive symptoms are associated with blunted cortisol reactivity in

the TSST-C), the nature of the competition challenge may explain why internalizing behaviour problems are associated with higher coordination (high cortisol and high sAA) in this challenge (discussed below).

In addition, these findings can be understood within the context of the ACM, and partially support the *vigilant* phenotype from the ACM (Del Giudice et al., 2011). The ACM proposes that individual differences in stress responsivity result from adaptation to environmental conditions. The vigilant phenotype is characterized by high reactivity of both the HPA and SAM systems, and evolves from a life history of being exposed to highly stressful environments that consist of repeated external threats. Therefore, individuals with the vigilant pattern of responsivity adapt to their stressful environments by mounting high cortisol and sAA activity, indiscriminately, across contexts (whether these contexts are in fact, threatening and dangerous). Our present findings only partially support the vigilant stress-response profile, because internalizing behaviours were only associated with high cortisol and high sAA reactivity in the competition challenge, not the TSST-C. Therefore, rather than internalizing behaviours being associated with an indiscriminant hyper-active response across contexts, it appears that coordination between systems might be context-specific.

This coordination finding is particularly interesting given that, for the overall sample, both cortisol and sAA tended to decline in the competition challenge (see Figure 5, black solid lines). The competition challenge used in the current study was specifically designed to be a non-potent, controllable and effort-based challenge. Although I expected this challenge to elicit a sAA response (given that it is effort-based), this challenge was not effective in evoking an increase in cortisol or sAA, in the overall sample. This suggests that although the majority of the sample experienced a decline in cortisol and sAA in this non-potent challenge, those with higher internalizing behaviour problems experienced synchronous higher activation of both the HPA and SAM systems. In order to understand

how these findings relate to previous studies on coordination, it is important to consider the type of challenge used to elicit stress responses. In the context of our competition challenge, a typical response appears to be one of low cortisol and sAA responsivity (Figure 5), however, in more potent challenges (as has been used in previous studies, discussed below) a typical/adaptive response might be higher cortisol and sAA responsivity.

It is difficult to compare the present study results to other coordination findings in the literature, because other studies use different types of challenges, and no previous study has examined coordination across multiple challenges. Similar to my results, El-Sheikh et al. (2008) found that that synchronously high levels of cortisol and sAA coordination were associated with higher internalizing problems. However, El-Sheikh et al. used a composition of challenges to elicit stress, including a cognitive assessment, listening to a recording of two adults arguing, and a star-tracing activity. Given a composition of challenges were used (some of which overlap with the TSST-C and competition challenge used in the present study), it is unclear what aspect of the challenge effectively elicited coordination.

Interestingly, Bae et al. (2015) used the potent TSST-C challenge and found that higher levels of internalizing behaviours were associated with lower cortisol and lower sAA. Although I did not find significant coordination in the TSST-C, these findings may be related to the present study results for the competition challenge. At the surface, the current findings that internalizing behaviours were associated with higher cortisol and higher sAA in the competition challenge seem contradictory to Bae et al.'s findings, because they found that internalizing behaviours were associated with lower cortisol and lower sAA. Although I recognize that, unlike Bae et al., I did not find coordination in the TSST-C, the present study findings for the competition challenge may be in line with this prior research. Our less-potent challenge elicited coordination at the high level (i.e., high cortisol and high sAA) for

children with higher internalizing behaviour problems, which is interpreted as an atypical response in comparison to overall sample trajectory (see Figure 5). Bae et al. used the potent TSST-C challenge to elicit coordination at the low level (i.e., low cortisol and low sAA for children with higher internalizing behaviour problems), a pattern of coordination that was similarly interpreted as a non-adaptive/atypical response. Therefore, when taking into account the difference between the TSST-C and the competition challenges, our findings may be partially consistent with those of Bae and colleagues. Of course, our non-significant coordination findings in the TSST-C directly contradict Bae et al.'s work. The present inconsistent findings highlight the importance of assessing how internalizing behaviour problems impact coordination across variant stressors.

The current results only indicate significant cortisol—sAA coordination in the competition challenge, and not in the TSST-C. It is unclear why the competition challenge and not the TSST-C would elicit strong coordination. In particular, Del Giudice et al. (2011) proposed that potent stressors result in the activation of both stress systems, so one might predict that the potent TSST-C would elicit high coordination. In line with this theory, Bae et al. demonstrated significant cortisol—sAA coordination in the TSST-C. It is important to note, Bae et al. had a much larger sample ($N = 169$) and thus significantly more power to detect a coordination effect in the TSST-C. Therefore, it is possible that this study's low sample size (and resulting low power), contributed to my inability to detect differences in coordination between those with varying levels of internalizing behaviours in the TSST-C. However, it is premature to speculate about the nature of cortisol and sAA coordination as it relates to internalizing behaviours, particularly as it is assessed in different stressor contexts, because this literature is in its infancy and is ambiguous to date.

The Reporter of Internalizing Behaviours Impacts Associations with Cortisol Responsivity

In addition to controlling for the stressor paradigm and cortisol-sAA coordination as confounds, this study was also designed to control for different raters of internalizing behaviours. The results indicate that child-reported depressive symptoms predicted lower cortisol reactivity in the TSST-C, whereas maternal-reported internalizing behaviours predicted coordination between cortisol and sAA in the competition challenge. Within the overarching developmental psychopathology literature, it is well known that parent and child reports of internalizing behaviours often do not align (Achenbach & Rescorla, 2001; De Los Reyes & Kazdin, 2005). In the current study, child-reported depressive symptoms were not significantly correlated with maternal-reported internalizing behaviours ($r = .18, p = .24$). Given the low correlation, it is understandable that parent and child reports act as unique predictors of cortisol reactivity. This inconsistency in parent-reported and child-reported associations is in line with previous research. For example, using the TSST-C, Hartman et al. (2013) found that child-reported internalizing behaviours were significantly associated with cortisol, whereas maternal-reported internalizing behaviours were not. In contrast, other research using a conflict discussion task, found that maternal-reported internalizing behaviours interacted with family stress to predict cortisol reactivity (Steege et al., 2017). This suggests that a combination of the informant of internalizing behaviours and the type of stressor used to evoke a cortisol response might be associated with these inconsistent findings. That is, child-reported difficulties may be more strongly associated with cortisol reactivity in certain types of stressors, whereas maternal-reported problems may be associated with stress reactivity in other kinds of stressors. Given that this is the first study to concurrently examine multiple informants of internalizing behaviours as they relate to cortisol reactivity in two distinct challenges (see Table 1), it is difficult to speculate on reasons and future work is needed to further investigate these associations.

In addition, inconsistent findings may also be associated with the type of measure used, rather than the rater, per se. That is, in this study children completed a depression inventory, whereas mother completed a broader internalizing inventory. The CDI consists of items, which assess negative mood, low self-esteem, ineffectiveness and interpersonal problems, whereas the CBCL internalizing subscale includes items related to depressed mood, withdrawal, anxiety, and somatic symptoms. Various aspects of internalizing symptomatology, such as anxiety and somatic symptoms (e.g., Janssens et al., 2012; Laurent et al., 2015), are uniquely associated with cortisol responsivity. Thus, it is possible the different constructs captured with the CBCL and CDI account, at least in part, for the differing results. Taken together, these inconsistencies underscore the need to use multiple reporters of analogous internalizing problems (i.e., child and parent reports of depressive symptoms (CDI), or youth and parent reports of broader internalizing behaviour (YSR and CBCL)) when assessing the association between internalizing symptoms and child cortisol responsivity.

Additional Considerations: Age and Sex

The present findings should be discussed in relation to two important sample characteristics: age and sex. As outlined above, this study extends prior research by demonstrating that higher self-reported depressive symptoms are associated with blunted cortisol reactivity in the TSST-C and higher maternal-reported internalizing problems are associated with increased physiological coordination (higher sAA and higher cortisol) in a competition challenge, in a sample of 8-10 year-old children. This age group is unique in that it is between early childhood and the onset of puberty and adolescence. Although extensive research suggests that internalizing problems increase after the onset of puberty (e.g., Stroud et al., 2011), the present findings suggest that the risk for internalizing problems, at least at a physiological level, might begin prior to puberty. Ultimately, longitudinal research is required to

determine if atypical cortisol reactivity in middle childhood is predictive of the chronicity and severity of internalizing problems in later childhood and adolescence.

Del Giudice, Angeleri, and Manera (2009) apply an evolutionary-based developmental psychobiological theory to suggest that the developmental transition from early to middle childhood (labeled as the *juvenile transition*) is a critical period of behavioural, psychological, and biological development. Although a comprehensive exploration of this theory is beyond the scope of this discussion, it is important to outline the unique physiological changes that occur during middle childhood, which underscore the need to study HPA and SAM activity in this age group. The transition to middle childhood often marks the onset of *adrenarche*, defined as a maturational phase that is characterized by hormonal and structural changes, which typically occurs at 7 years in western countries (although the age ranges between 5 and 10, depending on the country; Del Giudice et al., 2009). During this time period, the adrenal glands begin to secrete increased androgens (Dorn & Rotenstein, 2004; Rainey, Carr, Sasano, Suzuki, & Mason, 2002). In addition, the adrenal cortex increases in size and weight (Auchus & Rainey, 2004; Dhom, 1973), with particular increases in size of areas of the adrenal cortex that produce dehydroepiandrosterone (DHEA), a sex hormone associated with HPA activity.

For example, cortisol affects the activity of the sex-hormones system and sex hormones (e.g., DHEA) regulate the activity of stress pathways (e.g., Tilbrook, Turner, & Clarke, 2002). In addition, androgens and estrogens affect the stress system by directly influencing cortisol synthesis, as well as CRH synthesis in the hypothalamus (Viau, 2002; Viau, Bingham, Davis, Lee, & Wong, 2005).

Related, this developmental period marks a transition in social buffering of cortisol responses. In contrast to infancy and early childhood, where parental figures act as the primary social buffer of a child's stress response (reviewed by Hostinar & Gunnar, 2013), beginning in middle-childhood,

children are able to utilize friends and parents equally as buffers for HPA activity (e.g., Doom, Doyle, & Gunnar, 2016). For example, 7- to 12-year-old girls who had a phone conversation with their mothers a after the TSST-C demonstrated lower salivary cortisol levels post-stressor (Seltzer, Ziegler, & Pollak, 2010). In addition, in a study with 10- to 11-year-olds, daily stressful events were associated with lower cortisol levels if children had a friend at the time of the stressful event (Adams, Santo, & Bukowski, 2011). This suggests the emergence of a unique association between stress regulation and social relationships in middle childhood.

In addition, middle childhood marks a drastic change in children's cognitive and behavioural development. For example, between 5 and 7 years old, there is a marked increase in attention control, planning, reflection, and self-regulation abilities (Collins, 1984; Sameroff & Haith, 1996; Weisner, 1996). Therefore, given the unique biological, social, and cognitive changes associated with middle childhood, this is an important sample to study, particularly when examining associations between stress physiology and the onset of mental health difficulties. Although most research focuses on infancy and adolescence, there has been a recent push to begun to assess cortisol reactivity within middle childhood (de Veld, Riksen-Walraven, de Weerth, 2012; 2014; Jaffe et al., 2015). Future research is needed to examine associations between stress physiology (including both HPA and SAM activity) and internalizing symptoms in middle childhood.

In addition, sex is an important sample characteristic associated with stress reactivity. In the present study, although females had higher mean cortisol levels in the TSST-C compared to males, there were no significant sex differences in cortisol in the competition challenge, and sex was not a significant covariate in any of the MLM models. In addition, neither self-reported depressive symptoms nor maternal-reported internalizing problems differed by sex. These null-findings related to sex might be associated with the age of the present sample. Some research suggests that prior to puberty there are

few differences between males and females in HPA activity, and that sex differences become apparent during adolescence (Booth, Granger, & Shirtcliff, 2008) and persist through adulthood (Kudielka & Kirschbaum, 2005). In contrast, a recent meta-analysis suggests that sex differences are present earlier in childhood, with cortisol levels higher in boys than girls before the age of 8 and lower in boys compared to girls after the age of 8 (der Voorn et al., 2017). In line with this meta-analysis, individual research studies suggest that sex differences become present as early as middle childhood (Leppert, Kushner, Smith, Lemay & Dougherty, 2016; Lopez-Duran, Hajal, Olson, Felt, & Vazquez, 2009). Similarly, Laurent et al. (2016) found specific sex differences in cortisol reactivity as they relate to internalizing and externalizing behaviour problems in a sample of individuals aged 8 to 16 years old. It is possible that sex-specific differences in cortisol reactivity are associated with age, however it was also suggested by Laurent and colleagues (2016) that sex-specific stress differences are associated with the nature of the challenge, such that females respond more strongly to interpersonal stressors compared to performance stressors. This is a relatively novel area of study that requires much further investigation across age groups and distinct challenges.

Study Strengths

To date, research examining the association between cortisol reactivity and childhood internalizing behaviours is equivocal. This literature is complicated by several methodological downfalls and inconsistencies, including single stressor designs, absence of the examination of physiological coordination, and different raters of internalizing behaviours. The current study aimed to address these issues. To begin, this study assessed cortisol reactivity within two distinct stressors. The cortisol literature is plagued by inconsistent findings, which in many cases can be understood in relation to differentially stressful paradigms used across studies. This is only the third study to examine how internalizing behaviours are associated with cortisol responses in two different stressor paradigms,

and this is the first to specifically examine these associations in a middle-childhood sample. Although I was unable to directly examine cortisol flexibility, because our low sample size limited statistical comparisons of cortisol reactivity across stressors, the methodological design of this study enables the exploration of how internalizing behaviours relate to cortisol reactivity in each of these two distinct challenges.

Second, given that the HPA axis does not operate in isolation, this study examined cortisol and sAA coordination. Research shows that the combination of cortisol to sAA is a better indicator of stress dysregulation compared to either index alone (Ali & Pruessner, 2012). Although stress research is moving towards concurrent cortisol and sAA measurement, this is the first study to examine HPA-SAM coordination in two different stressors. This furthers our understanding of how the characteristics of the stressor may influence physiological coordination.

Third, given the low concordance between parent and child reports of psychopathology as well as the inconsistent findings between parent and child reported internalizing behaviour problems and cortisol reactivity, this study used both mother and child reports of internalizing behaviours. The use of multiple raters proved fruitful, as findings differed based on the reporter of symptoms.

In addition to examining these three main confounds, this study advances the literature by using a refined statistical approach to assess cortisol trajectories. Instead of using point estimates such as AUC_G and AUC_I , this study used MLM to measure cortisol sampled across multiple time points. The use of cortisol trajectories enables the examination of the potential nuances in cortisol patterns (e.g., declining slopes). In addition, using MLM accounts for and examines intra-individual differences in intercepts and slopes of cortisol.

Limitations and Future Directions

This study is not without limitations that should be addressed in future work. First and foremost, this was a small sample to test complex multilevel models, which increases the likelihood of Type 1 and Type 2 errors. It is possible that our inconsistent findings (e.g., coordination in one stressor but not the other) were associated with limited power. Further, reduced power might explain why I only found mean level coordination (i.e., sAA x internalizing behaviour) and were not able to find coordination across cortisol and sAA trajectories (i.e., time x sAA x internalizing behaviour). It is a limitation of the study that the coordination findings are restricted to overall (mean level) associations between sAA and cortisol. Future work with a larger sample may be able to detect more refined coordination findings that relate to sAA and cortisol trajectories across time.

Related, given the small sample, I was not able to make statistical comparisons to examine cortisol flexibility. That is, I could not statistically assess how internalizing behaviour problems predicted intra-individual cortisol reactivity *across* the two study challenges. Future research that includes a larger sample and permits more complex statistical investigations, should examine how internalizing behaviour problems relate to cortisol flexibility, assessed using differentially potent challenges. This study should also be replicated with a larger sample size to determine the reliability and generalizability of findings.

Related to generalizability, this study used a community sample of children who were relatively low risk in terms of their socio-demographic profile (e.g., SES) as well as the severity of their internalizing behaviour problems (the majority of children did not have symptoms in the clinical range). Replication with more at-risk and clinical samples is necessary in order to generalize findings. In addition, replication with more sample variability (i.e., including low risk, at at-risk, and clinical samples) may help elucidate these associations, given the potential for stronger effects in samples with greater variability.

In addition, I was unable to contact 42 families from the original study sample, and thus the sample for the current study may not be representative of the original sample or the population it represents (Atkinson et al., 2013). However, the present subsample did not significantly differ on any demographic variables.

An additional limitation of this study is that a total of 10 children terminated the stressor paradigm prematurely. Although I did not find significant differences in cortisol responsivity between those who completed the challenges and those who asked to terminate early, this may nonetheless confound the study design and findings. Interesting, no other studies using children mention whether participants requested discontinuation of the stressor prematurely. In order to ensure the study was ethical, all children in the present study were told they had the right to discontinue at any time. Given these ethical considerations are ubiquitous, it is unclear whether other studies did not report having children who choose to terminate the stressor early.

Finally, although a strength of this study was the use of both parent and child-reported internalizing behaviours, the specific type of measures used may have complicated the interpretation of findings. That is, the parent-reported CBCL Internalizing scale is a broadband measure of internalizing problems that includes depression, withdrawal, anxiety and somatic symptoms, whereas the child-reported depression inventory is an exclusive measure of depressive symptoms. Future research should compare effects of self- and parent-reported internalizing behaviour problems, as well as specific subcomponents, including anxiety, depression, somatic symptoms, in order to completely disentangle these associations. In future work, it will be fruitful to have both parents and children report on broadband measures (e.g., YSR and CBCL) as well as specific symptom measures (e.g., parent and child versions of CDI) to tease apart whether differences are related to the reporter or the type of symptom.

Conclusion

The present findings indicate that internalizing behaviours are associated with cortisol reactivity and the coordination of cortisol and sAA, however findings differ depending on the stressor paradigm and the reporter (mother or child) of internalizing behaviour problems. In the potent TSST-C, children with higher self-reported depressive symptoms experienced a decline in cortisol across time, however those with lower depressive symptoms showed a robust cortisol increase and return to baseline. In contrast, self-reported depressive symptoms were not associated with cortisol reactivity in the less potent competition challenge. In addition, maternal-reported internalizing behaviours were associated with cortisol-sAA coordination in the competition challenge, such that those with higher internalizing behaviour problems who experienced higher sAA also experienced higher cortisol in this non-potent challenge. No significant associations between maternal-reported internalizing behaviours and cortisol or cortisol-sAA coordination were found in the TSST-C. Taken together, these results suggest that internalizing behaviours are associated with child cortisol reactivity, but this association may be dependent on the stressor paradigm used, coordination with sAA, and the reporter of internalizing behaviour. These findings point to the complexity of the association between internalizing behaviour problems and stress physiology, indicating that future work is needed to truly understand these nuanced associations in order to decipher precisely how stress physiology is associated with internalizing problems. Further, given that these relations are present in middle-childhood, this work suggests that early stress regulation may have the potential to influence future risk for adverse biological and psychological development.

Appendix 1

Trier Social Stress Test –Child Version: Story

Yesterday my best friend Robert and I went home from school. Suddenly, we had the idea to visit Mr. Greg who lived in the big old house located in the dark forest near our town. Mr. Greg was a crazy old man and our parents didn't like the idea that we sometimes went visiting him. There was a rumor in town that there was a mystery about the old house. When we arrived at the house we were surprised that the door was open. Suddenly we heard a strange noise and cautiously, we entered the dark hall. . . .

Appendix 2

Competition Challenge – Star shape for tracing

Competition Challenge – Mirror tracing apparatus

Appendix 3

Competition Challenge – Puzzle

Appendix 4.1

Model Equations and Results: Self-Reported Depression in the TSST

Model 1:

Level-1 Model

$$LG_CORT = B0 + r$$

Level-2 Model

$$B0 = G00 + u0$$

Mixed Model

$$LG_CORT = G00 + u0 + r$$

$$\sigma^2 = 0.04527$$

$$\text{Standard error of } \sigma^2 = 0.00454$$

tau

$$\text{INTRCPT1, B0} = 0.05815$$

Standard error of tau

$$\text{INTRCPT1, B0} = 0.01472$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.885

The value of the log-likelihood function at iteration 4 = -1.154789E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect		Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For	INTRCPT1, B0					
	INTRCPT2, G00	0.581962	0.040537	14.356	39	0.000

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, level-1,	u0 r	0.24114 0.21277	0.05815 0.04527	39	347.85694	0.000

Statistics for the current model

Deviance = 23.095770
Number of estimated parameters = 3

Model 2

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

Mixed Model

$$LG_CORT = G00 + G10*TIME + u0 + r$$

$$\sigma^2 = 0.04505$$

$$\text{Standard error of } \sigma^2 = 0.00452$$

tau

$$\text{INTRCPT1}, B0 = 0.05819$$

Standard error of tau

$$\text{INTRCPT1}, B0 = 0.01472$$

Random level-1 coefficient	Reliability estimate
INTRCPT1, G0	0.885

The value of the log-likelihood function at iteration 4 = -1.105267E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.569990	0.042281	13.481	39	0.000
For TIME slope, B1					
INTRCPT2, G10	0.007995	0.008024	0.996	198	0.320

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.24122	0.05819	39	349.61705	0.000
level-1, r	0.21224	0.04505			

Statistics for the current model

Deviance = 22.105337
Number of estimated parameters = 4

Model comparison test

Chi-square statistic = 0.99043
Degrees of freedom = 1
P-value = >.500

Model 3

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM + u0 + r$$

$$\sigma^2 = 0.04258$$

$$\text{Standard error of } \sigma^2 = 0.00427$$

tau

$$\text{INTRCPT1, B0} = 0.05865$$

Standard error of tau

$$\text{INTRCPT1, B0} = 0.01473$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.892

The value of the log-likelihood function at iteration 4 = -5.464535E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value	

For INTRCPT1, B0						
INTRCPT2, G00	0.570786	0.042204	13.525	39	0.000	
For TIME slope, B1						
INTRCPT2, G10	0.008037	0.007801	1.030	197	0.304	
For QUAD_TIM slope, B2						
INTRCPT2, G20	-0.018488	0.005452	-3.391	197	0.001	

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1,	u0	0.24219	0.05865	39	370.14487	0.000
level-1,	r	0.20635	0.04258			

Statistics for the current model

Deviance = 10.929069
 Number of estimated parameters = 5

Model comparison test

Chi-square statistic = 11.17627
 Degrees of freedom = 1
 P-value = 0.001

Model 4

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \\ B3 &= G30 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ u0 + r \end{aligned}$$

$$\sigma^2 = 0.04378$$

Standard error of $\sigma^2 = 0.00520$

tau

INTRCPT1,B0 0.06191

Standard error of tau

INTRCPT1,B0 0.01672

Random level-1 coefficient	Reliability estimate
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INTRCPT1, G0	0.875
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The value of the log-likelihood function at iteration 5 = -1.152421E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
<hr/>					
For INTRCPT1, B0					
INTRCPT2, G00	0.574991	0.045890	12.530	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.021358	0.014592	1.464	139	0.146
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.014418	0.009612	-1.500	139	0.136
For LG_SAA slope, B3					
INTRCPT2, G30	0.253683	0.129530	1.958	139	0.052

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.24882	0.06191	35	289.72802	0.000
level-1, r	0.20924	0.04378			

Statistics for the current model

Deviance = 23.048416
Number of estimated parameters = 6

Model comparison test

Chi-square statistic = 12.11935
Degrees of freedom = 1
P-value = <0.001

Model 5

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \\ B3 &= G30 \\ B4 &= G40 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ u0 + r \end{aligned}$$

$$\sigma^2 = 0.04350$$

$$\text{Standard error of } \sigma^2 = 0.00516$$

tau

$$\text{INTRCPT1,B0} \quad 0.06061$$

Standard error of tau

$$\text{INTRCPT1,B0} \quad 0.01640$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.873

The value of the log-likelihood function at iteration 7 = -1.071677E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Coefficient Error Approx. T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.574508 0.045468 12.636 35 0.000
For TIME slope, B1
INTRCPT2, G10 0.024608 0.014766 1.666 138 0.098
For QUAD_TIM slope, B2
INTRCPT2, G20 -0.013325 0.009619 -1.385 138 0.168
For LG_SAA slope, B3
INTRCPT2, G30 0.175319 0.143004 1.226 138 0.222
For SAAXTIME slope, B4
INTRCPT2, G40 -0.102169 0.080155 -1.275 138 0.205

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect Standard Deviation Variance Component df Chi-square P-value

INTRCPT1, u0 0.24618 0.06061 35 286.02241 0.000
level-1, r 0.20856 0.04350

Statistics for the current model

Deviance = 21.433540
Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 1.61488
 Degrees of freedom = 1
 P-value = 0.201

Model 6

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + r \end{aligned}$$

$$\sigma^2 = 0.04339$$

$$\text{Standard error of } \sigma^2 = 0.00515$$

tau

$$\text{INTRCPT1, B0} = 0.06030$$

Standard error of tau

$$\text{INTRCPT1, B0} = 0.01632$$

Random level-1 coefficient	Reliability estimate
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INTRCPT1, G0	0.873
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The value of the log-likelihood function at iteration 7 = -1.044688E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.574178	0.045364	12.657	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.023018	0.014905	1.544	137	0.125
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.013869	0.009635	-1.439	137	0.152
For LG_SAA slope, B3					
INTRCPT2, G30	0.190863	0.144380	1.322	137	0.188
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.036269	0.120208	-0.302	137	0.763
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.048619	0.066122	0.735	137	0.463

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.24555	0.06030	35	285.37308	0.000
level-1, r	0.20830	0.04339			

Statistics for the current model

Deviance = 20.893763
Number of estimated parameters = 8

Model comparison test

Chi-square statistic = 0.53978
Degrees of freedom = 1

P-value = >.500

Model 7

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10 + u1$$

$$B2 = G20 + u2$$

$$B3 = G30$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} = & G00 \\ & + G10*\text{TIME} \\ & + G20*\text{QUAD_TIM} \\ & + G30*\text{LG_SAA} \\ & + G40*\text{SAAXTIME} \\ & + G50*\text{SAAXQ_TI} \\ & + u0 + u1*\text{TIME} + u2*\text{QUAD_TIM} + r \end{aligned}$$

$$\sigma^2 = 0.02301$$

$$\text{Standard error of } \sigma^2 = 0.00387$$

tau

INTRCPT1,B0	0.05426	-0.00050	-0.00562
TIME,B1	-0.00050	0.00178	-0.00136
QUAD_TIM,B2	-0.00562	-0.00136	0.00171

Standard errors of tau

INTRCPT1,B0	0.01457	0.00322	0.00264
TIME,B1	0.00322	0.00150	0.00079
QUAD_TIM,B2	0.00264	0.00079	0.00086

tau (as correlations)

INTRCPT1,B0	1.000	-0.051	-0.583
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TIME,B1 -0.051 1.000 -0.780
QUAD_TIM,B2 -0.583 -0.780 1.000

Random level-1 coefficient		Reliability estimate
INTRCPT1, G0		0.876
TIME, G1		0.310
QUAD_TIM, G2		0.492

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Standard Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.578179	0.041389	13.969	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.018567	0.013039	1.424	35	0.163
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.015377	0.009896	-1.554	35	0.129
For LG_SAA slope, B3					
INTRCPT2, G30	0.023501	0.135326	0.174	67	0.863
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.000986	0.096991	-0.010	67	0.992
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.065483	0.054359	1.205	67	0.233

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.23293	0.05426	35	308.83017	0.000
TIME slope, u1	0.04220	0.00178	35	46.71912	0.089
QUAD_TIM slope, u2	0.04137	0.00171	35	66.59813	0.001
level-1, r	0.15168	0.02301			

Statistics for the current model

Deviance = -24.902481
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 45.79624
Degrees of freedom = 5
P-value = <0.001

Model 8

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 + u3 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + u3*LG_SAA + r \end{aligned}$$

$$\sigma^2 = 0.02610$$

$$\text{Standard error of } \sigma^2 = 0.00383$$

tau

INTRCPT1,B0	0.05567	-0.00567	0.05148
QUAD_TIM,B2	-0.00567	0.00246	0.00106

LG_SAA,B3	0.05148	0.00106	0.06877
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Standard errors of tau

INTRCPT1,B0	0.01452	0.00263	0.03051
QUAD_TIM,B2	0.00263	0.00087	0.00684
LG_SAA,B3	0.03051	0.00684	0.09499

tau (as correlations)

INTRCPT1,B0	1.000	-0.484	0.832
QUAD_TIM,B2	-0.484	1.000	0.082
LG_SAA,B3	0.832	0.082	1.000

Random level-1 coefficient	Reliability estimate
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INTRCPT1, G0	0.897
QUAD_TIM, G2	0.586
LG_SAA, G3	0.110

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
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For INTRCPT1, B0					
INTRCPT2, G00	0.579201	0.042204	13.724	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.018162	0.011711	1.551	67	0.126
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.014479	0.011209	-1.292	35	0.205
For LG_SAA slope, B3					
INTRCPT2, G30	0.033248	0.138032	0.241	35	0.811
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.020239	0.096141	-0.211	67	0.834
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.061312	0.058838	1.042	67	0.301

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard	Variance	df	Chi-square	P-value
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Deviation		Component				

INTRCPT1,	u0	0.23595	0.05567	35	343.33414	0.000
QUAD_TIM slope,	u2	0.04964	0.00246	35	84.54331	0.000
LG_SAA slope,	u3	0.26225	0.06877	35	26.12914	>.500
level-1,	r	0.16154	0.02610			

Statistics for the current model

Deviance = -17.717672
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 38.61144
Degrees of freedom = 5
P-value = <0.001

Model 9

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \end{aligned}$$

$$+ u0 + u2*QUAD_TIM + r$$

$$\sigma^2 = 0.02685$$

$$\text{Standard error of } \sigma^2 = 0.00368$$

tau

INTRCPT1,B0	0.05347	-0.00709
QUAD_TIM,B2	-0.00709	0.00296

Standard errors of tau

INTRCPT1,B0	0.01403	0.00283
QUAD_TIM,B2	0.00283	0.00099

tau (as correlations)

INTRCPT1,B0	1.000	-0.563
QUAD_TIM,B2	-0.563	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.896
QUAD_TIM, G2	0.706

The value of the log-likelihood function at iteration 12 = 7.103355E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.577792	0.041535	13.911	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.019582	0.011791	1.661	102	0.100
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.015151	0.011855	-1.278	35	0.210
For LG_SAA slope, B3					
INTRCPT2, G30	0.013329	0.132117	0.101	102	0.920
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.030696	0.097449	-0.315	102	0.753
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.057450	0.059370	0.968	102	0.336

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1,	u0	0.23124	0.05347	35	365.69491	0.000
QUAD_TIM slope,	u2	0.05443	0.00296	35	126.62201	0.000
level-1,	r	0.16387	0.02685			

Statistics for the current model

Deviance = -14.206709
 Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 35.10047
 Degrees of freedom = 2
 P-value = <0.001

Model 10

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CDI_TOTA) + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

LG_CORT = G00 + G01*CDI_TOTA
 + G10*TIME
 + G20*QUAD_TIM
 + G30*LG_SAA
 + G40*SAAXTIME
 + G50*SAAXQ_TI
 + u0 + u2*QUAD_TIM + r

sigma^2 = 0.02686

Standard error of sigma^2 = 0.00368

tau

INTRCPT1,B0	0.05354	-0.00711
QUAD_TIM,B2	-0.00711	0.00296

Standard errors of tau

INTRCPT1,B0	0.01405	0.00283
QUAD_TIM,B2	0.00283	0.00099

tau (as correlations)

INTRCPT1,B0	1.000	-0.565
QUAD_TIM,B2	-0.565	1.000

 Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.896
QUAD_TIM, G2	0.706

The value of the log-likelihood function at iteration 15 = 7.103656E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.577822	0.041578	13.897	34	0.000
CDI_TOTA, G01	0.000159	0.005980	0.027	34	0.979

For TIME slope, B1						
INTRCPT2, G10	0.019582	0.011792	1.661	102	0.100	
For QUAD_TIM slope, B2						
INTRCPT2, G20	-0.015154	0.011855	-1.278	35	0.210	
For LG_SAA slope, B3						
INTRCPT2, G30	0.013277	0.132121	0.100	102	0.920	
For SAAXTIME slope, B4						
INTRCPT2, G40	-0.030643	0.097455	-0.314	102	0.754	
For SAAXQ_TI slope, B5						
INTRCPT2, G50	0.057533	0.059403	0.969	102	0.335	

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
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INTRCPT1, u0		0.23140	0.05354	34	366.15520	0.000
QUAD_TIM slope, u2		0.05442	0.00296	35	126.62145	0.000
level-1, r		0.16388	0.02686			

Statistics for the current model

Deviance = -14.207312
Number of estimated parameters = 11

Model comparison test

Chi-square statistic = 0.00060
Degrees of freedom = 1
P-value = >.500

Model 11

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$B1 = G10 + G11*(CDI_TOTA)$$

$$B2 = G20 + G21*(CDI_TOTA) + u2$$

B3 = G30
 B4 = G40
 B5 = G50

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

LG_CORT = G00 + G01*CDI_TOTA
 + G10*TIME + G11*CDI_TOTA*TIME
 + G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM
 + G30*LG_SAA
 + G40*SAAXTIME
 + G50*SAAXQ_TI
 + u0 + u2*QUAD_TIM + r
 sigma^2 = 0.02691

Standard error of sigma^2 = 0.00369

tau

INTRCPT1,B0	0.05187	-0.00616
QUAD_TIM,B2	-0.00616	0.00231

Standard errors of tau

INTRCPT1,B0	0.01366	0.00254
QUAD_TIM,B2	0.00254	0.00084

tau (as correlations)

INTRCPT1,B0	1.000	-0.563
QUAD_TIM,B2	-0.563	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.893
QUAD_TIM, G2	0.653

The value of the log-likelihood function at iteration 12 = 1.015602E+001

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Standard Error	Approx. T-ratio	d.f.	P-value
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For INTRCPT1, B0						
INTRCPT2, G00	0.575841	0.041021	14.038	34	0.000	
CDI_TOTA, G01	-0.005401	0.006587	-0.820	34	0.418	
For TIME slope, B1						
INTRCPT2, G10	0.019895	0.011801	1.686	101	0.095	
CDI_TOTA, G11	-0.000805	0.001831	-0.440	101	0.661	
For QUAD_TIM slope, B2						
INTRCPT2, G20	-0.014358	0.011069	-1.297	34	0.203	
CDI_TOTA, G21	0.003700	0.001763	2.098	34	0.043	
For LG_SAA slope, B3						
INTRCPT2, G30	0.006402	0.130299	0.049	101	0.961	
For SAAXTIME slope, B4						
INTRCPT2, G40	-0.038118	0.097847	-0.390	101	0.698	
For SAAXQ_TI slope, B5						
INTRCPT2, G50	0.063729	0.058371	1.092	101	0.278	

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value	

INTRCPT1, u0	0.22774	0.05187	34	354.24107	0.000	
QUAD_TIM slope, u2	0.04804	0.00231	34	106.28432	0.000	
level-1, r	0.16404	0.02691				

Statistics for the current model

Deviance = -20.312047
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 6.10473
Degrees of freedom = 2
P-value = 0.046

Model 12

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CDI_TOTA) + u0 \\ B1 &= G10 + G11*(CDI_TOTA) \\ B2 &= G20 + G21*(CDI_TOTA) + u2 \\ B3 &= G30 + G31*(CDI_TOTA) \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*CDI_TOTA \\ &+ G10*TIME + G11*CDI_TOTA*TIME \\ &+ G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM \\ &+ G30*LG_SAA + G31*CDI_TOTA*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.02681$$

$$\text{Standard error of } \sigma^2 = 0.00367$$

tau

INTRCPT1,B0	0.05196	-0.00611
QUAD_TIM,B2	-0.00611	0.00231

Standard errors of tau

INTRCPT1,B0	0.01367	0.00254
QUAD_TIM,B2	0.00254	0.00084

tau (as correlations)

INTRCPT1,B0	1.000	-0.558
QUAD_TIM,B2	-0.558	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.893
QUAD_TIM, G2	0.654

The value of the log-likelihood function at iteration 12 = 1.027566E+001
The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.576236	0.041049	14.038	34	0.000
CDI_TOTA, G01	-0.005265	0.006596	-0.798	34	0.430
For TIME slope, B1					
INTRCPT2, G10	0.019482	0.011809	1.650	100	0.102
CDI_TOTA, G11	-0.001036	0.001887	-0.549	100	0.584
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.014466	0.011068	-1.307	34	0.200
CDI_TOTA, G21	0.003549	0.001789	1.984	34	0.055
For LG_SAA slope, B3					
INTRCPT2, G30	0.002433	0.130482	0.019	100	0.985
CDI_TOTA, G31	-0.009091	0.018528	-0.491	100	0.625
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.039123	0.097700	-0.400	100	0.690
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.062574	0.058387	1.072	100	0.286

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.22794	0.05196	34	356.00490	0.000
QUAD_TIM slope, u2	0.04810	0.00231	34	106.68700	0.000
level-1, r	0.16373	0.02681			

Statistics for the current model

Deviance = -20.551316
Number of estimated parameters = 14

Model comparison test

Chi-square statistic = 0.23927

Degrees of freedom = 1
P-value = >.500

Model 13

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CDI_TOTA) + u0 \\ B1 &= G10 + G11*(CDI_TOTA) \\ B2 &= G20 + G21*(CDI_TOTA) + u2 \\ B3 &= G30 + G31*(CDI_TOTA) \\ B4 &= G40 + G41*(CDI_TOTA) \\ B5 &= G50 + G51*(CDI_TOTA) \end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*CDI_TOTA \\ &+ G10*TIME + G11*CDI_TOTA*TIME \\ &+ G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM \\ &+ G30*LG_SAA + G31*CDI_TOTA*LG_SAA \\ &+ G40*SAAXTIME + G41*CDI_TOTA*SAAXTIME \\ &+ G50*SAAXQ_TI + G51*CDI_TOTA*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.02632$$

$$\text{Standard error of } \sigma^2 = 0.00361$$

tau

INTRCPT1,B0	0.05150	-0.00615
QUAD_TIM,B2	-0.00615	0.00237

Standard errors of tau

INTRCPT1,B0	0.01354	0.00254
QUAD_TIM,B2	0.00254	0.00085

tau (as correlations)

INTRCPT1,B0 1.000 -0.556
 QUAD_TIM,B2 -0.556 1.000

 Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.894
 QUAD_TIM, G2 0.664

The value of the log-likelihood function at iteration 12 = 1.127346E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.576468	0.040849	14.112	34	0.000
CDI_TOTA, G01	-0.004632	0.006583	-0.704	34	0.486
For TIME slope, B1					
INTRCPT2, G10	0.018425	0.011736	1.570	98	0.120
CDI_TOTA, G11	-0.001491	0.001897	-0.786	98	0.434
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.015360	0.011145	-1.378	34	0.177
CDI_TOTA, G21	0.003203	0.001810	1.770	34	0.086
For LG_SAA slope, B3					
INTRCPT2, G30	-0.022841	0.132088	-0.173	98	0.863
CDI_TOTA, G31	-0.013468	0.023356	-0.577	98	0.565
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.076497	0.101433	-0.754	98	0.453
CDI_TOTA, G41	-0.029327	0.022228	-1.319	98	0.190
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.046151	0.059460	0.776	98	0.440
CDI_TOTA, G51	-0.016100	0.012472	-1.291	98	0.200

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.22694	0.05150	34	359.29088	0.000
QUAD_TIM slope, u2	0.04872	0.00237	34	109.98901	0.000
level-1, r	0.16224	0.02632			

Statistics for the current model

Deviance = -22.546928

Number of estimated parameters = 16

Model comparison test

Chi-square statistic = 1.99561

Degrees of freedom = 2

P-value = >.500

Model 14

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM + u0 + u2*QUAD_TIM + r$$

$$\sigma^2 = 0.03125$$

$$\text{Standard error of } \sigma^2 = 0.00350$$

tau

INTRCPT1,B0	0.06080	-0.00648
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QUAD_TIM,B2	-0.00648	0.00159
-------------	----------	---------

Standard errors of tau

INTRCPT1,B0	0.01478	0.00227
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QUAD_TIM,B2	0.00227	0.00056
-------------	---------	---------

tau (as correlations)

INTRCPT1,B0	1.000	-0.658
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QUAD_TIM,B2 -0.658 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.921
QUAD_TIM, G2 0.646

The value of the log-likelihood function at iteration 9 = 1.052137E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Coefficient Error Approx. T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.570175 0.041846 13.625 39 0.000
For TIME slope, B1
INTRCPT2, G10 0.007899 0.006683 1.182 158 0.239
For QUAD_TIM slope, B2
INTRCPT2, G20 -0.018134 0.007856 -2.308 39 0.026

Final estimation of variance components:

Random Effect Standard Deviation Variance Component df Chi-square P-value

INTRCPT1, u0 0.24658 0.06080 39 505.77276 0.000
QUAD_TIM slope, u2 0.03994 0.00159 39 112.62900 0.000
level-1, r 0.17677 0.03125

Statistics for the current model

Deviance = -21.042742
Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 31.97181
Degrees of freedom = 2
P-value = <0.001

Model 15

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 + G01*CDI_TOTA \\ & + G10*TIME \\ & + G20*QUAD_TIM \\ & + u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.03125$$

$$\text{Standard error of } \sigma^2 = 0.00350$$

tau

INTRCPT1,B0	0.06015	-0.00637
QUAD_TIM,B2	-0.00637	0.00160

Standard errors of tau

INTRCPT1,B0	0.01463	0.00225
QUAD_TIM,B2	0.00225	0.00056

tau (as correlations)

INTRCPT1,B0	1.000	-0.650
QUAD_TIM,B2	-0.650	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.920
QUAD_TIM, G2	0.646

The value of the log-likelihood function at iteration 17 = 1.053410E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.570171	0.041651	13.689	38	0.000
CDI_TOTA, G01	-0.000996	0.005736	-0.174	38	0.863
For TIME slope, B1					
INTRCPT2, G10	0.007898	0.006683	1.182	158	0.239
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.018132	0.007856	-2.308	39	0.026

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.24525	0.06015	38	500.72287	0.000
QUAD_TIM slope, u2	0.03994	0.00160	39	112.63293	0.000
level-1, r	0.17677	0.03125			

Statistics for the current model

Deviance = -21.068192
Number of estimated parameters = 8

Model comparison test

Chi-square statistic = 0.02545
Degrees of freedom = 1
P-value = >.500

Model 16

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$B1 = G10 + G11*(CDI_TOTA)$$

$$B2 = G20 + G21*(CDI_TOTA) + u2$$

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$LG_CORT = G00 + G01*CDI_TOTA$$

$$+ G10*TIME + G11*CDI_TOTA*TIME$$

$$+ G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM$$

$$+ u0 + u2*QUAD_TIM + r$$

$$\sigma^2 = 0.03001$$

$$\text{Standard error of } \sigma^2 = 0.00337$$

tau

INTRCPT1,B0	0.05778	-0.00538
QUAD_TIM,B2	-0.00538	0.00125

Standard errors of tau

INTRCPT1,B0	0.01406	0.00200
QUAD_TIM,B2	0.00200	0.00048

tau (as correlations)

INTRCPT1,B0	1.000	-0.632
QUAD_TIM,B2	-0.632	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.920
QUAD_TIM, G2	0.599

The value of the log-likelihood function at iteration 9 = 1.704713E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					

INTRCPT2, G00	0.570134	0.040821	13.967	38	0.000
CDI_TOTA, G01	-0.005225	0.006706	-0.779	38	0.441
For TIME slope, B1					
INTRCPT2, G10	0.007889	0.006550	1.205	157	0.230
CDI_TOTA, G11	-0.002731	0.001076	-2.539	157	0.012
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.018110	0.007232	-2.504	38	0.017
CDI_TOTA, G21	0.003207	0.001187	2.701	38	0.010

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.24037	0.05778	38	500.08540	0.000
QUAD_TIM slope, u2	0.03540	0.00125	38	99.60631	0.000
level-1, r	0.17324	0.03001			

Statistics for the current model

Deviance = -34.094262
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 13.02607
Degrees of freedom = 2
P-value = 0.002

Model 17

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + G01*(CHILD_EA) + G02*(CHILD_WA) + G03*(CDI_TOTA) + G04*(CHILD_SE) + G05*(CHILD_AG) + G06*(ETHNICIT) + u0$$

$$B1 = G10 + G11*(CDI_TOTA)$$

$$B2 = G20 + G21*(CDI_TOTA) + u2$$

CHILD_EA CHILD_WA CDI_TOTA CHILD_SE CHILD_AG ETHNICIT have been centered around the grand mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} = & G00 + G01*CHILD_EA + G02*CHILD_WA + G03*CDI_TOTA \\ & + G04*CHILD_SE + G05*CHILD_AG + G06*ETHNICIT \\ & + G10*TIME + G11*CDI_TOTA*TIME \\ & + G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM \\ & + u0 + u2*QUAD_TIM + r \end{aligned}$$

$\sigma^2 = 0.03001$

Standard error of $\sigma^2 = 0.00337$

tau

INTRCPT1,B0	0.05290	-0.00498
QUAD_TIM,B2	-0.00498	0.00125

Standard errors of tau

INTRCPT1,B0	0.01297	0.00191
QUAD_TIM,B2	0.00191	0.00048

tau (as correlations)

INTRCPT1,B0	1.000	-0.611
QUAD_TIM,B2	-0.611	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.913
QUAD_TIM, G2	0.599

The value of the log-likelihood function at iteration 17 = 1.825936E+001

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Standard Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.570118	0.039298	14.507	33	0.000
CHILD_EA, G01	0.000008	0.000009	0.835	33	0.410
CHILD_WA, G02	0.000001	0.000009	0.100	33	0.921
CDI_TOTA, G03	-0.004972	0.006692	-0.743	33	0.463
CHILD_SE, G04	0.052399	0.070454	0.744	33	0.462

CHILD_AG, G05	-0.029413	0.053625	-0.548	33	0.587
ETHNICIT, G06	-0.007570	0.012766	-0.593	33	0.557
For TIME slope, B1					
INTRCPT2, G10	0.007885	0.006549	1.204	157	0.230
CDI_TOTA, G11	-0.002732	0.001076	-2.539	157	0.012
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.018101	0.007234	-2.502	38	0.017
CDI_TOTA, G21	0.003208	0.001188	2.701	38	0.010

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>						
INTRCPT1, u0		0.23000	0.05290	33	462.68254	0.000
QUAD_TIM slope, u2		0.03542	0.00125	38	99.62584	0.000
level-1, r		0.17323	0.03001			

Statistics for the current model

Deviance = -36.518725
Number of estimated parameters = 15

Model comparison test

Chi-square statistic = 2.42446
Degrees of freedom = 5
P-value = >.500

Model 18 – Final Model

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$B1 = G10 + G11*(CDI_TOTA)$$

$$B2 = G20 + G21*(CDI_TOTA) + u2$$

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} = & G00 + G01*\text{CDI_TOTA} \\ & + G10*\text{TIME} + G11*\text{CDI_TOTA}*\text{TIME} \\ & + G20*\text{QUAD_TIM} + G21*\text{CDI_TOTA}*\text{QUAD_TIM} \\ & + u0 + u2*\text{QUAD_TIM} + r \end{aligned}$$

$$\sigma^2 = 0.03039$$

tau

INTRCPT1,B0	0.06101	-0.00567
QUAD_TIM,B2	-0.00567	0.00135

tau (as correlations)

INTRCPT1,B0	1.000	-0.623
QUAD_TIM,B2	-0.623	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.923
QUAD_TIM, G2	0.614

The value of the log-likelihood function at iteration 11 = -9.425943E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.570116	0.041833	13.628	38	0.000
CDI_TOTA, G01	-0.005227	0.006872	-0.761	38	0.452
For TIME slope, B1					
INTRCPT2, G10	0.007885	0.006591	1.196	157	0.233
CDI_TOTA, G11	-0.002732	0.001083	-2.523	157	0.013
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.018100	0.007422	-2.439	38	0.020
CDI_TOTA, G21	0.003208	0.001219	2.633	38	0.012

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>						
INTRCPT1,	u0	0.24700	0.06101	38	493.87197	0.000
QUAD_TIM	slope, u2	0.03679	0.00135	38	98.36939	0.000
level-1,	r	0.17433	0.03039			

Statistics for current covariance components model

Deviance = 18.851885
Number of estimated parameters = 4

Variance-Covariance components test

Chi-square statistic = 52.94615
Degrees of freedom = 6
P-value = <0.001

Appendix 4.2

Model Equations and Results: Maternal-Reported Internalizing in the TSST

Model 1:

Level-1 Model

$$LG_CORT = B0 + r$$

Level-2 Model

$$B0 = G00 + u0$$

Mixed Model

$$LG_CORT = G00 + u0 + r$$

$$\sigma^2 = 0.04527$$

$$\text{Standard error of } \sigma^2 = 0.00454$$

tau

$$\text{INTRCPT1, B0} = 0.05815$$

Standard error of tau

$$\text{INTRCPT1, B0} = 0.01472$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.885

The value of the log-likelihood function at iteration 4 = -1.154789E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard	Approx.				
	Coefficient	Error	T-ratio	d.f.	P-value	

For INTRCPT1, B0						
INTRCPT2, G00	0.581962	0.040537	14.356	39	0.000	

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, level-1, r	u0 0.24114 0.21277	0.05815 0.04527	39	347.85694	0.000

Statistics for the current model

Deviance = 23.095770
Number of estimated parameters = 3

Model 2

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

Mixed Model

$$LG_CORT = G00 + G10*TIME + u0 + r$$

$$\sigma^2 = 0.04505$$

$$\text{Standard error of } \sigma^2 = 0.00452$$

tau

$$INTRCPT1, B0 = 0.05819$$

Standard error of tau

$$INTRCPT1, B0 = 0.01472$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.885
--------------	-------

The value of the log-likelihood function at iteration 4 = -1.105267E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
<hr/>					
For INTRCPT1, B0					
INTRCPT2, G00	0.569990	0.042281	13.481	39	0.000
For TIME slope, B1					
INTRCPT2, G10	0.007995	0.008024	0.996	198	0.320

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.24122	0.05819	39	349.61705	0.000
level-1, r	0.21224	0.04505			

Statistics for the current model

Deviance = 22.105337
Number of estimated parameters = 4

Model comparison test

Chi-square statistic = 0.99043
Degrees of freedom = 1
P-value = >.500

Model 3

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM + u0 + r$$

$$\sigma^2 = 0.04258$$

$$\text{Standard error of } \sigma^2 = 0.00427$$

tau

$$\text{INTRCPT1, B0} = 0.05865$$

Standard error of tau

$$\text{INTRCPT1, B0} = 0.01473$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.892

The value of the log-likelihood function at iteration 4 = -5.464535E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.570786	0.042204	13.525	39	0.000
For TIME slope, B1					
INTRCPT2, G10	0.008037	0.007801	1.030	197	0.304
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.018488	0.005452	-3.391	197	0.001

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard	Variance	df	Chi-square	P-value	
	Deviation	Component				

INTRCPT1,	u0	0.24219	0.05865	39	370.14487	0.000
level-1, r	0.20635	0.04258				

Statistics for the current model

Deviance = 10.929069
Number of estimated parameters = 5

Model comparison test

Chi-square statistic = 11.17627
Degrees of freedom = 1
P-value = 0.001

Model 4

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \\ B3 &= G30 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ u0 + r \end{aligned}$$

sigma^2 = 0.04378

Standard error of sigma^2 = 0.00520

tau

INTRCPT1,B0 0.06191

Standard error of tau

INTRCPT1,B0 0.01672

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.875

The value of the log-likelihood function at iteration 5 = -1.152421E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Approx.
 Coefficient Error T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.574991 0.045890 12.530 35 0.000
For TIME slope, B1
INTRCPT2, G10 0.021358 0.014592 1.464 139 0.146
For QUAD_TIM slope, B2
INTRCPT2, G20 -0.014418 0.009612 -1.500 139 0.136
For LG_SAA slope, B3
INTRCPT2, G30 0.253683 0.129530 1.958 139 0.052

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect Standard Variance df Chi-square P-value
 Deviation Component

INTRCPT1, u0 0.24882 0.06191 35 289.72802 0.000
level-1, r 0.20924 0.04378

Statistics for the current model

Deviance = 23.048416

Number of estimated parameters = 6

Model comparison test

Chi-square statistic = 12.11935

Degrees of freedom = 1

P-value = <0.001

Model 5

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

$$B3 = G30$$

$$B4 = G40$$

LG_SAA has been centered around the group mean.

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM$$

$$+ G30*LG_SAA$$

$$+ G40*SAAXTIME$$

$$+ u0 + r$$

$$\sigma^2 = 0.04350$$

$$\text{Standard error of } \sigma^2 = 0.00516$$

tau

$$\text{INTRCPT1,B0} \quad 0.06061$$

Standard error of tau
INTRCPT1,B0 0.01640

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.873

The value of the log-likelihood function at iteration 7 = -1.071677E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
<hr/>					
For INTRCPT1, B0					
INTRCPT2, G00	0.574508	0.045468	12.636	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.024608	0.014766	1.666	138	0.098
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.013325	0.009619	-1.385	138	0.168
For LG_SAA slope, B3					
INTRCPT2, G30	0.175319	0.143004	1.226	138	0.222
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.102169	0.080155	-1.275	138	0.205

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.24618	0.06061	35	286.02241	0.000
level-1, r	0.20856	0.04350			

Statistics for the current model

Deviance = 21.433540
Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 1.61488
Degrees of freedom = 1
P-value = 0.201

Model 6

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} &= G00 \\ &+ G10*\text{TIME} \\ &+ G20*\text{QUAD_TIM} \\ &+ G30*\text{LG_SAA} \\ &+ G40*\text{SAAXTIME} \\ &+ G50*\text{SAAXQ_TI} \\ &+ u0 + r \end{aligned}$$

$$\text{sigma}^2 = 0.04339$$

$$\text{Standard error of } \text{sigma}^2 = 0.00515$$

tau

$$\text{INTRCPT1,B0} \quad 0.06030$$

Standard error of tau

$$\text{INTRCPT1,B0} \quad 0.01632$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.873
--------------	-------

The value of the log-likelihood function at iteration 7 = -1.044688E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
<hr/>					
For INTRCPT1, B0					
INTRCPT2, G00	0.574178	0.045364	12.657	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.023018	0.014905	1.544	137	0.125
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.013869	0.009635	-1.439	137	0.152
For LG_SAA slope, B3					
INTRCPT2, G30	0.190863	0.144380	1.322	137	0.188
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.036269	0.120208	-0.302	137	0.763
For SAAXQ TI slope, B5					
INTRCPT2, G50	0.048619	0.066122	0.735	137	0.463

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.24555	0.06030	35	285.37308	0.000
level-1, r	0.20830	0.04339			

Statistics for the current model

Deviance = 20.893763
Number of estimated parameters = 8

Model comparison test

Chi-square statistic = 0.53978
Degrees of freedom = 1
P-value = >.500

Model 7

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 + u1 \\ B2 &= G20 + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u1*TIME + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.02301$$

$$\text{Standard error of } \sigma^2 = 0.00387$$

tau

INTRCPT1,B0	0.05426	-0.00050	-0.00562
TIME,B1	-0.00050	0.00178	-0.00136
QUAD_TIM,B2	-0.00562	-0.00136	0.00171

Standard errors of tau

INTRCPT1,B0	0.01457	0.00322	0.00264
TIME,B1	0.00322	0.00150	0.00079
QUAD_TIM,B2	0.00264	0.00079	0.00086

tau (as correlations)

```
INTRCPT1,B0 1.000 -0.051 -0.583
TIME,B1 -0.051 1.000 -0.780
QUAD_TIM,B2 -0.583 -0.780 1.000
```

Random level-1 coefficient	Reliability estimate
INTRCPT1, G0	0.876
TIME, G1	0.310
QUAD_TIM, G2	0.492

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.578179	0.041389	13.969	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.018567	0.013039	1.424	35	0.163
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.015377	0.009896	-1.554	35	0.129
For LG_SAA slope, B3					
INTRCPT2, G30	0.023501	0.135326	0.174	67	0.863
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.000986	0.096991	-0.010	67	0.992
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.065483	0.054359	1.205	67	0.233

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.23293	0.05426	35	308.83017	0.000
TIME slope, u1	0.04220	0.00178	35	46.71912	0.089
QUAD_TIM slope, u2	0.04137	0.00171	35	66.59813	0.001
level-1, r	0.15168	0.02301			

Statistics for the current model

Deviance = -24.902481

Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 45.79624

Degrees of freedom = 5

P-value = <0.001

Model 8

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

$$B3 = G30 + u3$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\text{LG_CORT} = G00$$

$$+ G10*\text{TIME}$$

$$+ G20*\text{QUAD_TIM}$$

$$+ G30*\text{LG_SAA}$$

$$+ G40*\text{SAAXTIME}$$

$$+ G50*\text{SAAXQ_TI}$$

$$+ u0 + u2*\text{QUAD_TIM} + u3*\text{LG_SAA} + r$$

$$\sigma^2 = 0.02610$$

$$\text{Standard error of } \sigma^2 = 0.00383$$

tau

INTRCPT1,B0	0.05567	-0.00567	0.05148
QUAD_TIM,B2	-0.00567	0.00246	0.00106
LG_SAA,B3	0.05148	0.00106	0.06877

Standard errors of tau

INTRCPT1,B0	0.01452	0.00263	0.03051
QUAD_TIM,B2	0.00263	0.00087	0.00684
LG_SAA,B3	0.03051	0.00684	0.09499

tau (as correlations)

INTRCPT1,B0	1.000	-0.484	0.832
QUAD_TIM,B2	-0.484	1.000	0.082
LG_SAA,B3	0.832	0.082	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.897
QUAD_TIM, G2	0.586
LG_SAA, G3	0.110

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.579201	0.042204	13.724	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.018162	0.011711	1.551	67	0.126
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.014479	0.011209	-1.292	35	0.205
For LG_SAA slope, B3					
INTRCPT2, G30	0.033248	0.138032	0.241	35	0.811
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.020239	0.096141	-0.211	67	0.834
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.061312	0.058838	1.042	67	0.301

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.23595	0.05567	35	343.33414	0.000
QUAD_TIM slope, u2	0.04964	0.00246	35	84.54331	0.000
LG_SAA slope, u3	0.26225	0.06877	35	26.12914	>.500
level-1, r	0.16154	0.02610			

Statistics for the current model

Deviance = -17.717672

Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 38.61144

Degrees of freedom = 5

P-value = <0.001

Model 9

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

$$B3 = G30$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\text{LG_CORT} = G00$$

$$+ G10*\text{TIME}$$

$$+ G20*\text{QUAD_TIM}$$

+ G30*LG_SAA
+ G40*SAAXTIME
+ G50*SAAXQ_TI
+ u0 + u2*QUAD_TIM + r

sigma^2 = 0.02685

Standard error of sigma^2 = 0.00368

tau

INTRCPT1,B0	0.05347	-0.00709
QUAD_TIM,B2	-0.00709	0.00296

Standard errors of tau

INTRCPT1,B0	0.01403	0.00283
QUAD_TIM,B2	0.00283	0.00099

tau (as correlations)

INTRCPT1,B0	1.000	-0.563
QUAD_TIM,B2	-0.563	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.896
QUAD_TIM, G2	0.706

The value of the log-likelihood function at iteration 12 = 7.103355E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.577792	0.041535	13.911	35	0.000
For TIME slope, B1					
INTRCPT2, G10	0.019582	0.011791	1.661	102	0.100
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.015151	0.011855	-1.278	35	0.210
For LG_SAA slope, B3					
INTRCPT2, G30	0.013329	0.132117	0.101	102	0.920
For SAAXTIME slope, B4					

INTRCPT2, G40	-0.030696	0.097449	-0.315	102	0.753
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.057450	0.059370	0.968	102	0.336

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.23124	0.05347	35	365.69491	0.000
QUAD_TIM slope, u2	0.05443	0.00296	35	126.62201	0.000
level-1, r	0.16387	0.02685			

Statistics for the current model

Deviance = -14.206709
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 35.10047
Degrees of freedom = 2
P-value = <0.001

Model 10

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

B0 = G00 + G01*(INTERNAL) + u0

B1 = G10

B2 = G20 + u2

B3 = G30

B4 = G40

B5 = G50

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

LG_CORT = G00 + G01*INTERNAL
+ G10*TIME
+ G20*QUAD_TIM
+ G30*LG_SAA
+ G40*SAAXTIME
+ G50*SAAXQ_TI
+ u0 + u2*QUAD_TIM + r

$\sigma^2 = 0.02684$

Standard error of $\sigma^2 = 0.00368$

tau

INTRCPT1,B0	0.05138	-0.00658
QUAD_TIM,B2	-0.00658	0.00296

Standard errors of tau

INTRCPT1,B0	0.01354	0.00275
QUAD_TIM,B2	0.00275	0.00099

tau (as correlations)

INTRCPT1,B0	1.000	-0.534
QUAD_TIM,B2	-0.534	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.892
QUAD_TIM, G2	0.706

The value of the log-likelihood function at iteration 12 = 7.404451E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
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For INTRCPT1, B0						
INTRCPT2, G00	0.580055	0.040924	14.174	34	0.000	
INTERNAL, G01	-0.005303	0.006585	-0.805	34	0.426	
For TIME slope, B1						
INTRCPT2, G10	0.019737	0.011788	1.674	102	0.097	
For QUAD_TIM slope, B2						
INTRCPT2, G20	-0.015030	0.011847	-1.269	35	0.213	
For LG_SAA slope, B3						
INTRCPT2, G30	0.023748	0.133396	0.178	102	0.859	
For SAAXTIME slope, B4						
INTRCPT2, G40	-0.035057	0.097444	-0.360	102	0.720	
For SAAXQ_TI slope, B5						
INTRCPT2, G50	0.048527	0.060642	0.800	102	0.425	

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.22668	0.05138	34	352.51665	0.000
QUAD_TIM slope, u2	0.05437	0.00296	35	126.33625	0.000
level-1, r	0.16381	0.02684			

Statistics for the current model

Deviance = -14.808903
Number of estimated parameters = 11

Model comparison test

Chi-square statistic = 0.60219
Degrees of freedom = 1
P-value = >.500

Model 11

Level-1 Model

$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$

Level-2 Model

$B0 = G00 + G01*(INTERNAL) + u0$
 $B1 = G10 + G11*(INTERNAL)$
 $B2 = G20 + G21*(INTERNAL) + u2$
 $B3 = G30$
 $B4 = G40$
 $B5 = G50$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$LG_CORT = G00 + G01*INTERNAL$
 $+ G10*TIME + G11*INTERNAL*TIME$
 $+ G20*QUAD_TIM + G21*INTERNAL*QUAD_TIM$
 $+ G30*LG_SAA$
 $+ G40*SAAXTIME$
 $+ G50*SAAXQ_TI$
 $+ u0 + u2*QUAD_TIM + r$

$\sigma^2 = 0.02674$

Standard error of $\sigma^2 = 0.00366$

tau

INTRCPT1,B0	0.05009	-0.00616
QUAD_TIM,B2	-0.00616	0.00268

Standard errors of tau

INTRCPT1,B0	0.01323	0.00262
QUAD_TIM,B2	0.00262	0.00093

tau (as correlations)

INTRCPT1,B0	1.000	-0.532
QUAD_TIM,B2	-0.532	1.000

Random level-1 coefficient	Reliability estimate
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INTRCPT1, G0	0.890
QUAD_TIM, G2	0.686

The value of the log-likelihood function at iteration 12 = 9.117114E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.580562	0.040476	14.344	34	0.000
INTERNAL, G01	-0.007653	0.007097	-1.078	34	0.288
For TIME slope, B1					
INTRCPT2, G10	0.021617	0.011859	1.823	101	0.071
INTERNAL, G11	-0.001977	0.002070	-0.955	101	0.342
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.015758	0.011540	-1.366	34	0.181
INTERNAL, G21	0.002331	0.002081	1.120	34	0.270
For LG_SAA slope, B3					
INTRCPT2, G30	-0.039184	0.136930	-0.286	101	0.775
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.072500	0.100717	-0.720	101	0.473
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.064001	0.061317	1.044	101	0.299

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.22380	0.05009	34	345.14634	0.000
QUAD_TIM slope, u2	0.05177	0.00268	34	117.78837	0.000
level-1, r	0.16351	0.02674			

Statistics for the current model

Deviance = -18.234228
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 3.42532
Degrees of freedom = 2
P-value = 0.178

Model 12

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(\text{INTERNAL}) + u0 \\ B1 &= G10 + G11*(\text{INTERNAL}) \\ B2 &= G20 + G21*(\text{INTERNAL}) + u2 \\ B3 &= G30 + G31*(\text{INTERNAL}) \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} &= G00 + G01*\text{INTERNAL} \\ &+ G10*\text{TIME} + G11*\text{INTERNAL}*\text{TIME} \\ &+ G20*\text{QUAD_TIM} + G21*\text{INTERNAL}*\text{QUAD_TIM} \\ &+ G30*\text{LG_SAA} + G31*\text{INTERNAL}*\text{LG_SAA} \\ &+ G40*\text{SAAXTIME} \\ &+ G50*\text{SAAXQ_TI} \\ &+ u0 + u2*\text{QUAD_TIM} + r \end{aligned}$$

$$\text{sigma}^2 = 0.02673$$

$$\text{Standard error of sigma}^2 = 0.00366$$

tau

INTRCPT1,B0	0.05014	-0.00613
QUAD_TIM,B2	-0.00613	0.00267

Standard errors of tau

INTRCPT1,B0	0.01324	0.00261
QUAD_TIM,B2	0.00261	0.00093

tau (as correlations)

INTRCPT1,B0	1.000	-0.530
QUAD_TIM,B2	-0.530	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.890
QUAD_TIM, G2	0.686

The value of the log-likelihood function at iteration 12 = 9.125267E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.580661	0.040501	14.337	34	0.000
INTERNAL, G01	-0.007645	0.007100	-1.077	34	0.289
For TIME slope, B1					
INTRCPT2, G10	0.021672	0.011863	1.827	100	0.071
INTERNAL, G11	-0.001997	0.002076	-0.962	100	0.338
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.015610	0.011585	-1.347	34	0.187
INTERNAL, G21	0.002322	0.002080	1.116	34	0.272
For LG_SAA slope, B3					
INTRCPT2, G30	-0.039486	0.136984	-0.288	100	0.774
INTERNAL, G31	-0.002679	0.020792	-0.129	100	0.898
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.074246	0.101567	-0.731	100	0.466
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.062625	0.062174	1.007	100	0.316

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.22392	0.05014	34	345.58804	0.000
QUAD_TIM slope, u2	0.05170	0.00267	34	117.55099	0.000
level-1, r	0.16348	0.02673			

Statistics for the current model

Deviance = -18.250533

Number of estimated parameters = 14

Model comparison test

Chi-square statistic = 0.01631
Degrees of freedom = 1
P-value = >.500

Model 13

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(\text{INTERNAL}) + u0 \\ B1 &= G10 + G11*(\text{INTERNAL}) \\ B2 &= G20 + G21*(\text{INTERNAL}) + u2 \\ B3 &= G30 + G31*(\text{INTERNAL}) \\ B4 &= G40 + G41*(\text{INTERNAL}) \\ B5 &= G50 + G51*(\text{INTERNAL}) \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} &= G00 + G01*\text{INTERNAL} \\ &+ G10*\text{TIME} + G11*\text{INTERNAL}*\text{TIME} \\ &+ G20*\text{QUAD_TIM} + G21*\text{INTERNAL}*\text{QUAD_TIM} \\ &+ G30*\text{LG_SAA} + G31*\text{INTERNAL}*\text{LG_SAA} \\ &+ G40*\text{SAAXTIME} + G41*\text{INTERNAL}*\text{SAAXTIME} \\ &+ G50*\text{SAAXQ_TI} + G51*\text{INTERNAL}*\text{SAAXQ_TI} \\ &+ u0 + u2*\text{QUAD_TIM} + r \end{aligned}$$

$$\sigma^2 = 0.02643$$

$$\text{Standard error of } \sigma^2 = 0.00362$$

tau

INTRCPT1,B0	0.04914	-0.00652
QUAD_TIM,B2	-0.00652	0.00286

Standard errors of tau

INTRCPT1,B0	0.01299	0.00266
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QUAD_TIM,B2 0.00266 0.00096

tau (as correlations)

INTRCPT1,B0 1.000 -0.550

QUAD_TIM,B2 -0.550 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.889
QUAD_TIM, G2 0.702

The value of the log-likelihood function at iteration 13 = 9.626734E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Coefficient Error Approx. T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.577496 0.040249 14.348 34 0.000
INTERNAL, G01 -0.007983 0.007051 -1.132 34 0.266
For TIME slope, B1
INTRCPT2, G10 0.022661 0.012113 1.871 98 0.064
INTERNAL, G11 -0.001896 0.002090 -0.907 98 0.367
For QUAD_TIM slope, B2
INTRCPT2, G20 -0.018135 0.012018 -1.509 34 0.141
INTERNAL, G21 0.001630 0.002217 0.735 34 0.467
For LG_SAA slope, B3
INTRCPT2, G30 -0.041688 0.138260 -0.302 98 0.764
INTERNAL, G31 0.005869 0.025557 0.230 98 0.819
For SAAXTIME slope, B4
INTRCPT2, G40 -0.073310 0.101276 -0.724 98 0.471
INTERNAL, G41 0.000818 0.017453 0.047 98 0.963
For SAAXQ_TI slope, B5
INTRCPT2, G50 0.055921 0.062509 0.895 98 0.373
INTERNAL, G51 -0.008443 0.010798 -0.782 98 0.436

Final estimation of variance components:

Random Effect Standard Variance df Chi-square P-value
Deviation Component

INTRCPT1,	u0	0.22167	0.04914	34	342.49175	0.000
QUAD_TIM slope, u2		0.05344	0.00286	34	124.14538	0.000
level-1,	r	0.16258	0.02643			

Statistics for the current model

Deviance = -19.253467
Number of estimated parameters = 16

Model comparison test

Chi-square statistic = 1.00293
Degrees of freedom = 2
P-value = >.500

Model 14

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(INTERNAL) + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \end{aligned}$$

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*INTERNAL \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.02683$$

$$\text{Standard error of } \sigma^2 = 0.00368$$

tau

INTRCPT1,B0	0.05326	-0.00658
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QUAD_TIM,B2 -0.00658 0.00307

Standard errors of tau

INTRCPT1,B0 0.01399 0.00282

QUAD_TIM,B2 0.00282 0.00102

tau (as correlations)

INTRCPT1,B0 1.000 -0.515

QUAD_TIM,B2 -0.515 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.895

QUAD_TIM, G2 0.714

The value of the log-likelihood function at iteration 9 = 6.175171E+000

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Approx.
Coefficient Error T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.500946 0.162670 3.080 34 0.004
INTERNAL, G01 -0.007410 0.006800 -1.090 34 0.284
For TIME slope, B1
INTRCPT2, G10 0.017406 0.011413 1.525 104 0.130
For QUAD_TIM slope, B2
INTRCPT2, G20 -0.016026 0.011925 -1.344 35 0.188
For LG_SAA slope, B3
INTRCPT2, G30 0.046621 0.089924 0.518 104 0.605

Final estimation of variance components:

Random Effect Standard Variance df Chi-square P-value
Deviation Component

INTRCPT1, u0 0.23079 0.05326 34 364.43868 0.000
QUAD_TIM slope, u2 0.05541 0.00307 35 129.89187 0.000
level-1, r 0.16381 0.02683

Statistics for the current model

Deviance = -12.350342
Number of estimated parameters = 9

Model comparison test

Chi-square statistic = 1.13796
Degrees of freedom = 1
P-value = 0.286

Model 15

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM + u0 + u2*QUAD_TIM + r$$

$$\sigma^2 = 0.03125$$

$$\text{Standard error of } \sigma^2 = 0.00350$$

tau

$$\text{INTRCPT1,B0} \quad 0.06080 \quad -0.00648$$

$$\text{QUAD_TIM,B2} \quad -0.00648 \quad 0.00159$$

Standard errors of tau

$$\text{INTRCPT1,B0} \quad 0.01478 \quad 0.00227$$

$$\text{QUAD_TIM,B2} \quad 0.00227 \quad 0.00056$$

tau (as correlations)

$$\text{INTRCPT1,B0} \quad 1.000 \quad -0.658$$

$$\text{QUAD_TIM,B2} \quad -0.658 \quad 1.000$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.921
QUAD_TIM, G2 0.646

The value of the log-likelihood function at iteration 9 = 1.052137E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Approx.
 Coefficient Error T-ratio d.f. P-value

For INTRCPT1, B0
 INTRCPT2, G00 0.570175 0.041846 13.625 39 0.000
For TIME slope, B1
 INTRCPT2, G10 0.007899 0.006683 1.182 158 0.239
For QUAD_TIM slope, B2
 INTRCPT2, G20 -0.018134 0.007856 -2.308 39 0.026

Final estimation of variance components:

Random Effect Standard Variance df Chi-square P-value
 Deviation Component

INTRCPT1, u0 0.24658 0.06080 39 505.77276 0.000
QUAD_TIM slope, u2 0.03994 0.00159 39 112.62900 0.000
level-1, r 0.17677 0.03125

Statistics for the current model

Deviance = -21.042742
Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 31.97181
Degrees of freedom = 2
P-value = <0.001

Model 16

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + G01*(INTERNAL) + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 + G01*INTERNAL \\ & + G10*TIME \\ & + G20*QUAD_TIM \\ & + u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.03125$$

$$\text{Standard error of } \sigma^2 = 0.00350$$

tau

INTRCPT1,B0	0.05887	-0.00638
QUAD_TIM,B2	-0.00638	0.00160

Standard errors of tau

INTRCPT1,B0	0.01435	0.00223
QUAD_TIM,B2	0.00223	0.00056

tau (as correlations)

INTRCPT1,B0	1.000	-0.658
QUAD_TIM,B2	-0.658	1.000

Random level-1 coefficient	Reliability estimate
----------------------------	----------------------

INTRCPT1, G0	0.918
QUAD_TIM, G2	0.646

The value of the log-likelihood function at iteration 9 = 1.109741E+001

Model 17

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CHILD_EA) + G02*(CHILD_WA) + G03*(CHILD_SE) + \\ &G04*(CHILD_AG) \\ &+ G05*(ETHNICIT) + G06*(TIME_GAP) + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \end{aligned}$$

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*CHILD_EA + G02*CHILD_WA + G03*CHILD_SE \\ &+ G04*CHILD_AG + G05*ETHNICIT + G06*TIME_GAP \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.03124$$

$$\text{Standard error of } \sigma^2 = 0.00350$$

tau

INTRCPT1,B0	0.05558	-0.00603
QUAD_TIM,B2	-0.00603	0.00160

Standard errors of tau

INTRCPT1,B0	0.01361	0.00216
QUAD_TIM,B2	0.00216	0.00056

tau (as correlations)

INTRCPT1,B0	1.000	-0.641
QUAD_TIM,B2	-0.641	1.000

Random level-1 coefficient	Reliability estimate
----------------------------	----------------------

INTRCPT1, G0	0.914
QUAD_TIM, G2	0.646

The value of the log-likelihood function at iteration 17 = 1.175513E+001

Final estimation of fixed effects:

Standard	Approx.
----------	---------

Fixed Effect	Coefficient	Error	T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.577469	0.576548	1.002	33	0.324
CHILD_EA, G01	0.000007	0.000009	0.748	33	0.460
CHILD_WA, G02	0.000001	0.000009	0.142	33	0.888
CHILD_SE, G03	0.052238	0.069870	0.748	33	0.460
CHILD_AG, G04	-0.035407	0.054001	-0.656	33	0.517
ETHNICIT, G05	-0.008395	0.013396	-0.627	33	0.535
TIME_GAP, G06	-0.004146	0.016195	-0.256	33	0.800
For TIME slope, B1					
INTRCPT2, G10	0.007894	0.006682	1.181	158	0.239
For QUAD_TIM slope, B2					
INTRCPT2, G20	-0.018124	0.007859	-2.306	39	0.027

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.23575	0.05558	33	466.89930	0.000
QUAD_TIM slope, u2	0.03997	0.00160	39	112.65340	0.000
level-1, r	0.17675	0.03124			

Statistics for the current model

Deviance = -23.510258
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 2.44207
Degrees of freedom = 5
P-value = >.500

Model 18- Final model

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

Mixed Model

LG_CORT = G00

+ G10*TIME

+ G20*QUAD_TIM + u0 + u2*QUAD_TIM + r

sigma^2 = 0.03144

tau

INTRCPT1,B0 0.06246 -0.00665

QUAD_TIM,B2 -0.00665 0.00165

tau (as correlations)

INTRCPT1,B0 1.000 -0.654

QUAD_TIM,B2 -0.654 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.922

QUAD_TIM, G2 0.653

The value of the log-likelihood function at iteration 15 = -8.358201E-001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect		Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For	INTRCPT1, B0					
	INTRCPT2, G00	0.570166	0.042356	13.461	39	0.000
For	TIME slope, B1					
	INTRCPT2, G10	0.007897	0.006704	1.178	158	0.241
For	QUAD_TIM slope, B2					
	INTRCPT2, G20	-0.018129	0.007957	-2.278	39	0.028

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.24992	0.06246	39	502.64066	0.000
QUAD_TIM slope, u2	0.04067	0.00165	39	111.93177	0.000
level-1, r	0.17732	0.03144			

Statistics for current covariance components model

Deviance = 1.671640
Number of estimated parameters = 4

Variance-Covariance components test

Chi-square statistic = 22.71438
Degrees of freedom = 3
P-value = <0.001

Appendix 4.3

Model Equations and Results: Child-Reported Depression in the Competition Challenge

Model 1

Level-1 Model

$$LG_CORT = B0 + r$$

Level-2 Model

$$B0 = G00 + u0$$

Mixed Model

$$LG_CORT = G00 + u0 + r$$

$$\sigma^2 = 0.02518$$

$$\text{Standard error of } \sigma^2 = 0.00235$$

tau

$$\text{INTRCPT1, } B0 = 0.04528$$

Standard error of tau

$$\text{INTRCPT1, } B0 = 0.01032$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.915

The value of the log-likelihood function at iteration 2 = 5.970427E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect		Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For	INTRCPT1, B0					
	INTRCPT2, G00	0.426754	0.032796	13.012	45	0.000

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, level-1,	u0 r	0.21279 0.15868	0.04528 0.02518	45	542.32638	0.000

Statistics for the current model

Deviance = -119.408532
Number of estimated parameters = 3

Model 2

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

Mixed Model

$$LG_CORT = G00 + G10*TIME + u0 + r$$

$$\sigma^2 = 0.02518$$

$$\text{Standard error of } \sigma^2 = 0.00235$$

tau

$$\text{INTRCPT1}, B0 = 0.04528$$

Standard error of tau

$$\text{INTRCPT1}, B0 = 0.01032$$

Random level-1 coefficient	Reliability estimate
INTRCPT1, G0	0.915

The value of the log-likelihood function at iteration 2 = 5.970483E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.427036	0.033852	12.615	45	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.000188	0.005593	-0.034	229	0.973

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.21279	0.04528	45	542.32904	0.000
level-1, r	0.15868	0.02518			

Statistics for the current model

Deviance = -119.409659
Number of estimated parameters = 4

Model comparison test

Chi-square statistic = 0.00113
Degrees of freedom = 1
P-value = >.500

Model 3

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \end{aligned}$$

Mixed Model

$$LG_CORT = G00$$

+ G10*TIME
+ G20*QUAD_TIM + u0+ r

sigma^2 = 0.02376

Standard error of sigma^2 = 0.00222

tau

INTRCPT1,B0 0.04552

Standard error of tau

INTRCPT1,B0 0.01032

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.920

The value of the log-likelihood function at iteration 2 = 6.637930E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.426568	0.033794	12.623	45	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.000188	0.005433	-0.035	228	0.972
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.014040	0.003787	3.707	228	0.000

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.21335	0.04552	45	574.73653	0.000
level-1, r	0.15414	0.02376			

Statistics for the current model

 Deviance = -132.758591
 Number of estimated parameters = 5

Model comparison test

 Chi-square statistic = 13.34893
 Degrees of freedom = 1
 P-value = <0.001

Model 4

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \\ B3 &= G30 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ u0 + r \end{aligned}$$

$$\sigma^2 = 0.02400$$

$$\text{Standard error of } \sigma^2 = 0.00263$$

tau

$$\text{INTRCPT1, B0} = 0.03355$$

Standard error of tau

$$\text{INTRCPT1, B0} = 0.00839$$

 Random level-1 coefficient Reliability estimate

 $\text{INTRCPT1, G0} = 0.874$

The value of the log-likelihood function at iteration 4 = 5.055731E+001
The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.447353	0.031298	14.293	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.003697	0.009949	-0.372	164	0.711
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012138	0.006513	1.864	164	0.064
For LG_SAA slope, B3					
INTRCPT2, G30	0.069475	0.104917	0.662	164	0.509

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18317	0.03355	41	335.27577	0.000
level-1, r	0.15493	0.02400			

Statistics for the current model

Deviance = -101.114613
Number of estimated parameters = 6

Model comparison test

Chi-square statistic = 31.64398
Degrees of freedom = 1
P-value = <0.001

Model 5

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + u0$$

B1 = G10
 B2 = G20
 B3 = G30
 B4 = G40

LG_SAA has been centered around the group mean.

Mixed Model

LG_CORT = G00
 + G10*TIME
 + G20*QUAD_TIM
 + G30*LG_SAA
 + G40*SAAXQ_TI
 + u0+ r

sigma^2 = 0.02402

Standard error of sigma^2 = 0.00263

tau

INTRCPT1,B0 0.03338

Standard error of tau

INTRCPT1,B0 0.00835

```
-----
Random level-1 coefficient  Reliability estimate
-----
INTRCPT1, G0                0.874
-----
```

The value of the log-likelihood function at iteration 7 = 5.059164E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

```
-----
Fixed Effect      Standard      Approx.
                  Coefficient Error   T-ratio d.f.  P-value
-----
For  INTRCPT1, B0
  INTRCPT2, G00    0.447863  0.031295  14.311   41  0.000
For  TIME slope, B1
  INTRCPT2, G10   -0.003733  0.009953  -0.375  163  0.708
For QUAD_TIM slope, B2
  INTRCPT2, G20    0.012357  0.006568   1.881  163  0.062
```

For LG_SAA slope, B3

INTRCPT2, G30	0.066055	0.105757	0.625	163	0.533
---------------	----------	----------	-------	-----	-------

For SAAXQ_TI slope, B4

INTRCPT2, G40	0.010246	0.038970	0.263	163	0.793
---------------	----------	----------	-------	-----	-------

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18269	0.03338	41	333.54901	0.000
level-1, r	0.15499	0.02402			

Statistics for the current model

Deviance = -101.183276

Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 0.06866

Degrees of freedom = 1

P-value = >.500

Model 6

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

$$B3 = G30$$

$$B4 = G40$$

LG_SAA has been centered around the group mean.

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM$$

+ G30*LG_SAA
+ G40*SAAXTIME
+ u0+ r

sigma^2 = 0.02401

Standard error of sigma^2 = 0.00263

tau

INTRCPT1,B0 0.03292

Standard error of tau

INTRCPT1,B0 0.00826

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.872

The value of the log-likelihood function at iteration 7 = 5.087204E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value	

For INTRCPT1, B0						
INTRCPT2, G00	0.448626	0.031101	14.425	41	0.000	
For TIME slope, B1						
INTRCPT2, G10	-0.003568	0.009952	-0.358	163	0.720	
For QUAD_TIM slope, B2						
INTRCPT2, G20	0.012747	0.006559	1.943	163	0.054	
For LG_SAA slope, B3						
INTRCPT2, G30	0.021272	0.121117	0.176	163	0.861	
For SAAXTIME slope, B4						
INTRCPT2, G40	-0.042742	0.053627	-0.797	163	0.427	

Final estimation of variance components:

<hr/>						
Random Effect	Standard	Variance	df	Chi-square	P-value	
	Deviation	Component				
<hr/>						
INTRCPT1,	u0	0.18144	0.03292	41	329.66441	0.000

level-1, r 0.15496 0.02401

Statistics for the current model

Deviance = -101.744088

Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 0.62948

Degrees of freedom = 1

P-value = >.500

Model 7

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

$$B3 = G30$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM$$

$$+ G30*LG_SAA$$

$$+ G40*SAAXTIME$$

$$+ G50*SAAXQ_TI$$

$$+ u0 + r$$

$$\sigma^2 = 0.02399$$

$$\text{Standard error of } \sigma^2 = 0.00263$$

tau

INTRCPT1,B0 0.03298

Standard error of tau

INTRCPT1,B0 0.00827

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.872

The value of the log-likelihood function at iteration 7 = 5.092107E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
<hr/>					
For INTRCPT1, B0					
INTRCPT2, G00	0.448250	0.031144	14.393	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.003470	0.009952	-0.349	162	0.728
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012606	0.006571	1.918	162	0.057
For LG_SAA slope, B3					
INTRCPT2, G30	0.010942	0.125522	0.087	162	0.931
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.056589	0.069586	-0.813	162	0.417
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.015838	0.050548	-0.313	162	0.754

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.18161	0.03298	41	330.48039	0.000
level-1, r	0.15488	0.02399			

Statistics for the current model

Deviance = -101.842139

Number of estimated parameters = 8

Model comparison test

Chi-square statistic = 0.09805
Degrees of freedom = 1
P-value = >.500

Model 7.1

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 + u1 \\ B2 &= G20 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u1*TIME + r \end{aligned}$$

$$\sigma^2 = 0.02128$$

$$\text{Standard error of } \sigma^2 = 0.00269$$

tau

INTRCPT1,B0	0.02679	0.00284
TIME,B1	0.00284	0.00109

Standard errors of tau

INTRCPT1,B0	0.00730	0.00163
TIME,B1	0.00163	0.00076

tau (as correlations)

INTRCPT1,B0 1.000 0.526

TIME,B1 0.526 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.804

TIME, G1 0.335

The value of the log-likelihood function at iteration 18 = 5.512945E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.448832	0.028324	15.846	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.003913	0.010671	-0.367	41	0.716
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012734	0.006199	2.054	121	0.042
For LG_SAA slope, B3					
INTRCPT2, G30	-0.019857	0.124469	-0.160	121	0.874
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.051997	0.072871	-0.714	121	0.477
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.013151	0.048713	-0.270	121	0.788

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.16366	0.02679	41	218.48118	0.000
TIME slope, u1	0.03295	0.00109	41	63.83974	0.013
level-1, r	0.14587	0.02128			

Statistics for the current model

Deviance = -110.258891
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 8.41675
Degrees of freedom = 2
P-value = 0.015

Model 7.2

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} &= G00 \\ &+ G10*\text{TIME} \\ &+ G20*\text{QUAD_TIM} \\ &+ G30*\text{LG_SAA} \\ &+ G40*\text{SAAXTIME} \\ &+ G50*\text{SAAXQ_TI} \\ &+ u0 + u2*\text{QUAD_TIM} + r \end{aligned}$$

$$\sigma^2 = 0.01932$$

$$\text{Standard error of } \sigma^2 = 0.00244$$

tau

INTRCPT1,B0	0.03054	-0.00250
QUAD_TIM,B2	-0.00250	0.00081

Standard errors of tau

INTRCPT1,B0	0.00761	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0 1.000 -0.502

QUAD_TIM,B2 -0.502 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.874

QUAD_TIM, G2 0.485

The value of the log-likelihood function at iteration 13 = 5.810132E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.448835	0.029635	15.145	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.004024	0.008943	-0.450	121	0.654
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012700	0.007379	1.721	41	0.093
For LG_SAA slope, B3					
INTRCPT2, G30	-0.044759	0.122530	-0.365	121	0.716
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.062670	0.063017	-0.994	121	0.322
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.022977	0.049630	-0.463	121	0.644

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17476	0.03054	41	348.15708	0.000
QUAD_TIM slope, u2	0.02848	0.00081	41	82.19075	0.000
level-1, r	0.13901	0.01932			

Statistics for the current model

Deviance = -116.202640
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 14.36050
Degrees of freedom = 2
P-value = 0.001

Model 7.3

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

$$B3 = G30 + u3$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\text{LG_CORT} = G00$$

$$+ G10*\text{TIME}$$

$$+ G20*\text{QUAD_TIM}$$

$$+ G30*\text{LG_SAA}$$

$$+ G40*\text{SAAXTIME}$$

$$+ G50*\text{SAAXQ_TI}$$

$$+ u0 + u3*\text{LG_SAA} + r$$

$$\text{sigma}^2 = 0.02142$$

$$\text{Standard error of } \text{sigma}^2 = 0.00257$$

tau

$$\text{INTRCPT1,B0} \quad 0.03410 \quad 0.01807$$

$$\text{LG_SAA,B3} \quad 0.01807 \quad 0.18271$$

Standard errors of tau

$$\text{INTRCPT1,B0} \quad 0.00840 \quad 0.02546$$

$$\text{LG_SAA,B3} \quad 0.02546 \quad 0.12942$$

tau (as correlations)

$$\text{INTRCPT1,B0} \quad 1.000 \quad 0.229$$

$$\text{LG_SAA,B3} \quad 0.229 \quad 1.000$$

Random level-1 coefficient Reliability estimate

$$\text{INTRCPT1, G0} \quad 0.888$$

$$\text{LG_SAA, G3} \quad 0.259$$

The value of the log-likelihood function at iteration 13 = 5.325547E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.447252	0.031322	14.279	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.002080	0.009676	-0.215	121	0.830
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.014770	0.006349	2.326	121	0.022
For LG_SAA slope, B3					
INTRCPT2, G30	0.088260	0.145581	0.606	41	0.548
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.017040	0.068470	-0.249	121	0.804
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.017504	0.049914	-0.351	121	0.726

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18466	0.03410	41	376.10762	0.000
LG_SAA slope, u3	0.42744	0.18271	41	50.97844	0.137
level-1, r	0.14635	0.02142			

Statistics for the current model

Deviance = -106.510940
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 4.66880
Degrees of freedom = 2
P-value = 0.095

Model 7.4

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10 + u1$$

$$B2 = G20 + u2$$

$$B3 = G30$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 \\ & + G10*TIME \\ & + G20*QUAD_TIM \\ & + G30*LG_SAA \\ & + G40*SAAXTIME \\ & + G50*SAAXQ_TI \\ & + u0 + u1*TIME + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01858$$

$$\text{Standard error of } \sigma^2 = 0.00287$$

tau

INTRCPT1,B0	0.02869	0.00119	-0.00151
TIME,B1	0.00119	0.00030	-0.00038
QUAD_TIM,B2	-0.00151	-0.00038	0.00050

Standard errors of tau

INTRCPT1,B0	0.00759	0.00174	0.00128
TIME,B1	0.00174	0.00090	0.00047
QUAD_TIM,B2	0.00128	0.00047	0.00046

tau (as correlations)

INTRCPT1,B0	1.000	0.408	-0.399
TIME,B1	0.408	1.000	-0.990
QUAD_TIM,B2	-0.399	-0.990	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.826
TIME, G1	0.086
QUAD_TIM, G2	0.264

The value of the log-likelihood function at iteration 5844 = 5.928108E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.449907	0.028798	15.623	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.004279	0.009169	-0.467	41	0.643
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.013109	0.006770	1.936	41	0.060
For LG_SAA slope, B3					
INTRCPT2, G30	-0.058451	0.124465	-0.470	80	0.640
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.058670	0.063753	-0.920	80	0.360
For SAAXQ TI slope, B5					
INTRCPT2, G50	-0.007257	0.048452	-0.150	80	0.881

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.16939	0.02869	41	250.16030	0.000
TIME slope, u1	0.01725	0.00030	41	40.37455	>.500
QUAD_TIM slope, u2	0.02237	0.00050	41	52.37501	0.110
level-1, r	0.13631	0.01858			

Statistics for the current model

Deviance = -118.562156
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 16.72002
Degrees of freedom = 5
P-value = 0.005

Model 7.5

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 + u3 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + u3*LG_SAA + r \end{aligned}$$

$$\sigma^2 = 0.01306$$

$$\text{Standard error of } \sigma^2 = 0.00184$$

tau

INTRCPT1,B0	0.03249	-0.00238	0.01591
QUAD_TIM,B2	-0.00238	0.00136	-0.01654
LG_SAA,B3	0.01591	-0.01654	0.35653

Standard errors of tau

INTRCPT1,B0	0.00774	0.00135	0.02550
QUAD_TIM,B2	0.00135	0.00046	0.00677
LG_SAA,B3	0.02550	0.00677	0.15611

tau (as correlations)

INTRCPT1,B0 1.000 -0.358 0.148
 QUAD_TIM,B2 -0.358 1.000 -0.751
 LG_SAA,B3 0.148 -0.751 1.000

 Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.906
 QUAD_TIM, G2 0.611
 LG_SAA, G3 0.390

The value of the log-likelihood function at iteration 23 = 7.056640E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.448377	0.029730	15.082	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.002475	0.007755	-0.319	80	0.750
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.016188	0.007682	2.107	41	0.041
For LG_SAA slope, B3					
INTRCPT2, G30	0.069013	0.146916	0.470	41	0.641
For SAAXTIME slope, B4					
INTRCPT2, G40	0.020238	0.055943	0.362	80	0.718
For SAAXQ_TI slope, B5					
INTRCPT2, G50	0.006011	0.045773	0.131	80	0.896

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18024	0.03249	41	501.84897	0.000
QUAD_TIM slope, u2	0.03688	0.00136	41	134.85225	0.000
LG_SAA slope, u3	0.59710	0.35653	41	99.59270	0.000
level-1, r	0.11429	0.01306			

Statistics for the current model

Deviance = -141.132809
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 39.29067
Degrees of freedom = 5
P-value = <0.001

Model 8

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01932$$

$$\text{Standard error of } \sigma^2 = 0.00244$$

tau

INTRCPT1,B0	0.03054	-0.00250
QUAD_TIM,B2	-0.00250	0.00081

Standard errors of tau

INTRCPT1,B0	0.00761	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.502
QUAD_TIM,B2	-0.502	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.874
QUAD_TIM, G2	0.485

The value of the log-likelihood function at iteration 13 = 5.810132E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448835	0.029635	15.145	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.004024	0.008943	-0.450	121	0.654
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012700	0.007379	1.721	41	0.093
For LG_SAA slope, B3					
INTRCPT2, G30	-0.044759	0.122530	-0.365	121	0.716
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.062670	0.063017	-0.994	121	0.322
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.022977	0.049630	-0.463	121	0.644

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.17476	0.03054	41	348.15708	0.000
QUAD_TIM slope, u2	0.02848	0.00081	41	82.19075	0.000
level-1, r	0.13901	0.01932			

Statistics for the current model

Deviance = -116.202640
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 14.36050
Degrees of freedom = 2
P-value = 0.001

Model 9

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$
$$B1 = G10$$
$$B2 = G20 + u2$$
$$B3 = G30$$
$$B4 = G40$$
$$B5 = G50$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$LG_CORT = G00 + G01*CDI_TOTA$$
$$+ G10*TIME$$
$$+ G20*QUAD_TIM$$
$$+ G30*LG_SAA$$
$$+ G40*SAAXTIME$$
$$+ G50*SAAXQ_TI$$
$$+ u0 + u2*QUAD_TIM + r$$

$\sigma^2 = 0.01932$

Standard error of $\sigma^2 = 0.00244$

tau

INTRCPT1,B0	0.03036	-0.00249
QUAD_TIM,B2	-0.00249	0.00081

Standard errors of tau

INTRCPT1,B0	0.00757	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.500
QUAD_TIM,B2	-0.500	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.873
QUAD_TIM, G2	0.486

The value of the log-likelihood function at iteration 13 = 5.819549E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Standard Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.449382	0.029587	15.189	40	0.000
CDI_TOTA, G01	0.002028	0.004666	0.435	40	0.666
For TIME slope, B1					
INTRCPT2, G10	-0.004048	0.008941	-0.453	121	0.652
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012748	0.007383	1.727	41	0.092
For LG_SAA slope, B3					
INTRCPT2, G30	-0.049249	0.122925	-0.401	121	0.689
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.064493	0.063127	-1.022	121	0.309
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.022479	0.049647	-0.453	121	0.652

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
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INTRCPT1, u0	0.17423	0.03036	40	346.41998	0.000
QUAD_TIM slope, u2	0.02853	0.00081	41	82.32576	0.000
level-1, r	0.13899	0.01932			

Statistics for the current model

Deviance = -116.390985
Number of estimated parameters = 11

Model comparison test

Chi-square statistic = 0.18835
Degrees of freedom = 1
P-value = >.500

Model 10

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CDI_TOTA) + u0 \\ B1 &= G10 + G11*(CDI_TOTA) \\ B2 &= G20 + G21*(CDI_TOTA) + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*CDI_TOTA \\ &+ G10*TIME + G11*CDI_TOTA*TIME \\ &+ G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01914$$

Standard error of sigma^2 = 0.00242

tau

INTRCPT1,B0	0.03046	-0.00248
QUAD_TIM,B2	-0.00248	0.00082

Standard errors of tau

INTRCPT1,B0	0.00758	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.495
QUAD_TIM,B2	-0.495	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.875
QUAD_TIM, G2	0.492

The value of the log-likelihood function at iteration 13 = 5.868709E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.449743	0.029607	15.190	40	0.000
CDI_TOTA, G01	0.003188	0.004949	0.644	40	0.523
For TIME slope, B1					
INTRCPT2, G10	-0.004526	0.008914	-0.508	120	0.613
CDI_TOTA, G11	-0.001498	0.001510	-0.992	120	0.323
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012607	0.007386	1.707	40	0.096
CDI_TOTA, G21	-0.000696	0.001232	-0.564	40	0.576
For LG_SAA slope, B3					
INTRCPT2, G30	-0.047841	0.123267	-0.388	120	0.699
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.053158	0.063881	-0.832	120	0.407
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.016036	0.049908	-0.321	120	0.749

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17452	0.03046	40	350.27937	0.000
QUAD_TIM slope, u2	0.02872	0.00082	40	83.26716	0.000
level-1, r	0.13835	0.01914			

Statistics for the current model

Deviance = -117.374177
 Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 0.98319
 Degrees of freedom = 2
 P-value = >.500

Model 11

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CDI_TOTA) + u0 \\ B1 &= G10 + G11*(CDI_TOTA) \\ B2 &= G20 + G21*(CDI_TOTA) + u2 \\ B3 &= G30 + G31*(CDI_TOTA) \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*CDI_TOTA \\ &+ G10*TIME + G11*CDI_TOTA*TIME \\ &+ G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM \end{aligned}$$

+ G30*LG_SAA + G31*CDI_TOTA*LG_SAA
+ G40*SAAXTIME
+ G50*SAAXQ_TI
+ u0 + u2*QUAD_TIM + r

sigma^2 = 0.01911

Standard error of sigma^2 = 0.00241

tau

INTRCPT1,B0	0.03048	-0.00246
QUAD_TIM,B2	-0.00246	0.00083

Standard errors of tau

INTRCPT1,B0	0.00759	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.490
QUAD_TIM,B2	-0.490	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.875
QUAD_TIM, G2	0.494

The value of the log-likelihood function at iteration 13 = 5.869653E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Standard Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.449972	0.029649	15.177	40	0.000
CDI_TOTA, G01	0.003317	0.005032	0.659	40	0.514
For TIME slope, B1					
INTRCPT2, G10	-0.004705	0.008996	-0.523	119	0.602
CDI_TOTA, G11	-0.001633	0.001788	-0.913	119	0.363
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012654	0.007398	1.711	40	0.095
CDI_TOTA, G21	-0.000708	0.001237	-0.573	40	0.570
For LG_SAA slope, B3					

INTRCPT2, G30	-0.051002	0.125140	-0.408	119	0.684
CDI_TOTA, G31	-0.002178	0.015568	-0.140	119	0.889
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.052837	0.063870	-0.827	119	0.410
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.015418	0.049973	-0.309	119	0.758

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.17458	0.03048	40	350.96008	0.000
QUAD_TIM slope, u2	0.02882	0.00083	40	83.61745	0.000
level-1, r	0.13824	0.01911			

Statistics for the current model

Deviance = -117.393070
Number of estimated parameters = 14

Model comparison test

Chi-square statistic = 0.01889
Degrees of freedom = 1
P-value = >.500

Model 12

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CDI_TOTA) + u0 \\ B1 &= G10 + G11*(CDI_TOTA) \\ B2 &= G20 + G21*(CDI_TOTA) + u2 \\ B3 &= G30 + G31*(CDI_TOTA) \\ B4 &= G40 + G41*(CDI_TOTA) \\ B5 &= G50 + G51*(CDI_TOTA) \end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned}
 \text{LG_CORT} = & G00 + G01*CDI_TOTA \\
 & + G10*TIME + G11*CDI_TOTA*TIME \\
 & + G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM \\
 & + G30*LG_SAA + G31*CDI_TOTA*LG_SAA \\
 & + G40*SAAXTIME + G41*CDI_TOTA*SAAXTIME \\
 & + G50*SAAXQ_TI + G51*CDI_TOTA*SAAXQ_TI \\
 & + u0 + u2*QUAD_TIM + r
 \end{aligned}$$

$$\text{sigma}^2 = 0.01843$$

$$\text{Standard error of sigma}^2 = 0.00233$$

tau

INTRCPT1,B0	0.03009	-0.00249
QUAD_TIM,B2	-0.00249	0.00086

Standard errors of tau

INTRCPT1,B0	0.00747	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.490
QUAD_TIM,B2	-0.490	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.877
QUAD_TIM, G2	0.511

The value of the log-likelihood function at iteration 13 = 6.137541E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect		Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0						
INTRCPT2, G00		0.443110	0.029591	14.974	40	0.000
CDI_TOTA, G01		0.000143	0.005196	0.028	40	0.978
For TIME slope, B1						
INTRCPT2, G10		-0.007351	0.008986	-0.818	117	0.415

CDI_TOTA, G11	-0.002950	0.001915	-1.541	117	0.126
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.009575	0.007493	1.278	40	0.209
CDI_TOTA, G21	-0.002095	0.001371	-1.528	40	0.134
For LG_SAA slope, B3					
INTRCPT2, G30	0.035312	0.129246	0.273	117	0.785
CDI_TOTA, G31	0.037616	0.023245	1.618	117	0.108
For SAAXTIME slope, B4					
INTRCPT2, G40	0.001502	0.067597	0.022	117	0.982
CDI_TOTA, G41	0.023342	0.011502	2.029	117	0.045
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.013971	0.050404	-0.277	117	0.782
CDI_TOTA, G51	-0.002090	0.007537	-0.277	117	0.782

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17347	0.03009	40	358.35600	0.000
QUAD_TIM slope, u2	0.02931	0.00086	40	86.78991	0.000
level-1, r	0.13577	0.01843			

Statistics for the current model

Deviance = -122.750812
Number of estimated parameters = 16

Model comparison test

Chi-square statistic = 5.35774
Degrees of freedom = 2
P-value = 0.067

Model 13

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$B1 = G10 + G11*(CDI_TOTA)$$

$$B2 = G20 + G21*(CDI_TOTA) + u2$$

$$B3 = G30 + G31*(CDI_TOTA)$$

$$B4 = G40 + G41*(CDI_TOTA)$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 + G01*CDI_TOTA \\ & + G10*TIME + G11*CDI_TOTA*TIME \\ & + G20*QUAD_TIM + G21*CDI_TOTA*QUAD_TIM \\ & + G30*LG_SAA + G31*CDI_TOTA*LG_SAA \\ & + G40*SAAXTIME + G41*CDI_TOTA*SAAXTIME \\ & + u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01842$$

$$\text{Standard error of } \sigma^2 = 0.00232$$

tau

INTRCPT1,B0	0.03008	-0.00244
QUAD_TIM,B2	-0.00244	0.00086

Standard errors of tau

INTRCPT1,B0	0.00747	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.479
QUAD_TIM,B2	-0.479	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.877
QUAD_TIM, G2	0.513

The value of the log-likelihood function at iteration 9 = 6.131260E+001
The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Approx. Error	T-ratio	d.f.	P-value

For INTRCPT1, B0						
INTRCPT2, G00	0.443948	0.029493	15.053	40	0.000	
CDI_TOTA, G01	0.000366	0.005153	0.071	40	0.944	
For TIME slope, B1						
INTRCPT2, G10	-0.007746	0.008909	-0.869	119	0.386	
CDI_TOTA, G11	-0.003126	0.001846	-1.693	119	0.093	
For QUAD_TIM slope, B2						
INTRCPT2, G20	0.009619	0.007479	1.286	40	0.206	
CDI_TOTA, G21	-0.002130	0.001368	-1.557	40	0.127	
For LG_SAA slope, B3						
INTRCPT2, G30	0.039368	0.128318	0.307	119	0.760	
CDI_TOTA, G31	0.038031	0.023283	1.633	119	0.105	
For SAAXTIME slope, B4						
INTRCPT2, G40	0.010962	0.057375	0.191	119	0.849	
CDI_TOTA, G41	0.024689	0.010618	2.325	119	0.022	

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17343	0.03008	40	358.47538	0.000
QUAD_TIM slope, u2	0.02941	0.00086	40	87.09009	0.000
level-1, r	0.13571	0.01842			

Statistics for the current model

Deviance = -122.625198
Number of estimated parameters = 14

Model comparison test

Chi-square statistic = 5.23213
Degrees of freedom = 0
P-value = >.500

Model 14

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$\begin{aligned}
B1 &= G10 + G11*(CDI_TOTA) \\
B2 &= G20 + u2 \\
B3 &= G30 + G31*(CDI_TOTA) \\
B4 &= G40
\end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned}
LG_CORT &= G00 + G01*CDI_TOTA \\
&+ G10*TIME + G11*CDI_TOTA*TIME \\
&+ G20*QUAD_TIM \\
&+ G30*LG_SAA + G31*CDI_TOTA*LG_SAA \\
&+ G40*SAAXTIME \\
&+ u0 + u2*QUAD_TIM + r
\end{aligned}$$

$$\sigma^2 = 0.01906$$

$$\text{Standard error of } \sigma^2 = 0.00241$$

tau

INTRCPT1,B0	0.03043	-0.00240
QUAD_TIM,B2	-0.00240	0.00086

Standard errors of tau

INTRCPT1,B0	0.00757	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.470
QUAD_TIM,B2	-0.470	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.875
QUAD_TIM, G2	0.502

The value of the log-likelihood function at iteration 8 = 5.847700E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Standard Approx.

Fixed Effect	Coefficient	Error	T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.450427	0.029582	15.226	40	0.000
CDI_TOTA, G01	0.002472	0.004759	0.519	40	0.606
For TIME slope, B1					
INTRCPT2, G10	-0.004739	0.008973	-0.528	120	0.598
CDI_TOTA, G11	-0.001227	0.001572	-0.781	120	0.436
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.013051	0.007408	1.762	41	0.086
For LG_SAA slope, B3					
INTRCPT2, G30	-0.052970	0.124109	-0.427	120	0.670
CDI_TOTA, G31	-0.001982	0.015552	-0.127	120	0.899
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.046091	0.053032	-0.869	120	0.387

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.17444	0.03043	40	351.19453	0.000
QUAD_TIM slope, u2	0.02928	0.00086	41	85.07683	0.000
level-1, r	0.13806	0.01906			

Statistics for the current model

Deviance = -116.953998
Number of estimated parameters = 12

Model comparison test

Chi-square statistic = 0.43907
Degrees of freedom = 2
P-value = >.500

Model 15

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$\begin{aligned}
B1 &= G10 + G11*(CDI_TOTA) \\
B2 &= G20 + u2 \\
B3 &= G30 + G31*(CDI_TOTA) \\
B4 &= G40 + G41*(CDI_TOTA)
\end{aligned}$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned}
LG_CORT &= G00 + G01*CDI_TOTA \\
&+ G10*TIME + G11*CDI_TOTA*TIME \\
&+ G20*QUAD_TIM \\
&+ G30*LG_SAA + G31*CDI_TOTA*LG_SAA \\
&+ G40*SAAXTIME + G41*CDI_TOTA*SAAXTIME \\
&+ u0 + u2*QUAD_TIM + r
\end{aligned}$$

$$\sigma^2 = 0.01857$$

$$\text{Standard error of } \sigma^2 = 0.00234$$

tau

INTRCPT1,B0	0.02996	-0.00251
QUAD_TIM,B2	-0.00251	0.00092

Standard errors of tau

INTRCPT1,B0	0.00745	0.00123
QUAD_TIM,B2	0.00123	0.00039

tau (as correlations)

INTRCPT1,B0	1.000	-0.478
QUAD_TIM,B2	-0.478	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.876
QUAD_TIM, G2	0.526

The value of the log-likelihood function at iteration 9 = 6.011621E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.445658	0.029448	15.134	40	0.000
CDI_TOTA, G01	-0.001018	0.005072	-0.201	40	0.842
For TIME slope, B1					
INTRCPT2, G10	-0.006662	0.008919	-0.747	119	0.457
CDI_TOTA, G11	-0.001619	0.001575	-1.028	119	0.306
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.011043	0.007532	1.466	41	0.150
For LG_SAA slope, B3					
INTRCPT2, G30	-0.000627	0.127035	-0.005	119	0.996
CDI_TOTA, G31	0.027745	0.022477	1.234	119	0.219
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.012773	0.055805	-0.229	119	0.819
CDI_TOTA, G41	0.017577	0.009605	1.830	119	0.070

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.17308	0.02996	40	354.41128	0.000
QUAD_TIM slope, u2	0.03033	0.00092	41	89.51766	0.000
level-1, r	0.13629	0.01857			

Statistics for the current model

Deviance = -120.232413
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 3.27841
Degrees of freedom = 1
P-value = 0.067

Model 16

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$B1 = G10 + G11*(CDI_TOTA)$$

$$B2 = G20 + u2$$

$$B3 = G30 + G31*(CDI_TOTA)$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 + G01*CDI_TOTA \\ & + G10*TIME + G11*CDI_TOTA*TIME \\ & + G20*QUAD_TIM \\ & + G30*LG_SAA + G31*CDI_TOTA*LG_SAA \\ & + u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01921$$

$$\text{Standard error of } \sigma^2 = 0.00242$$

tau

INTRCPT1,B0	0.03100	-0.00252
QUAD_TIM,B2	-0.00252	0.00083

Standard errors of tau

INTRCPT1,B0	0.00770	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.497
QUAD_TIM,B2	-0.497	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.876
QUAD_TIM, G2	0.491

The value of the log-likelihood function at iteration 12 = 5.811156E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448875	0.029778	15.074	40	0.000
CDI_TOTA, G01	0.002077	0.004763	0.436	40	0.665
For TIME slope, B1					
INTRCPT2, G10	-0.004799	0.009005	-0.533	121	0.595
CDI_TOTA, G11	-0.001304	0.001567	-0.832	121	0.407
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012380	0.007334	1.688	41	0.099
For LG_SAA slope, B3					
INTRCPT2, G30	0.006434	0.104114	0.062	121	0.951
CDI_TOTA, G31	-0.001690	0.015538	-0.109	121	0.914

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.17606	0.03100	40	354.64899	0.000
QUAD_TIM slope, u2	0.02874	0.00083	41	83.18240	0.000
level-1, r	0.13858	0.01921			

Statistics for the current model

Deviance = -116.223124
Number of estimated parameters = 11

Model 17

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$B0 = G00 + G01*(CDI_TOTA) + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

$$B3 = G30$$

LG_SAA has been centered around the group mean.

CDI_TOTA has been centered around the grand mean.

Mixed Model

$$\begin{aligned} \text{LG_CORT} = & G00 + G01*\text{CDI_TOTA} \\ & + G10*\text{TIME} \\ & + G20*\text{QUAD_TIM} \\ & + G30*\text{LG_SAA} \\ & + u0 + u2*\text{QUAD_TIM} + r \end{aligned}$$

$$\sigma^2 = 0.01942$$

$$\text{Standard error of } \sigma^2 = 0.00245$$

tau

INTRCPT1,B0	0.03094	-0.00250
QUAD_TIM,B2	-0.00250	0.00080

Standard errors of tau

INTRCPT1,B0	0.00770	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.504
QUAD_TIM,B2	-0.504	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.875
QUAD_TIM, G2	0.480

The value of the log-likelihood function at iteration 8 = 5.767045E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448434	0.029745	15.076	40	0.000
CDI_TOTA, G01	0.001688	0.004687	0.360	40	0.721
For TIME slope, B1					
INTRCPT2, G10	-0.004251	0.008958	-0.475	123	0.636
For QUAD_TIM slope, B2					

INTRCPT2, G20	0.012297	0.007307	1.683	41	0.100
For LG_SAA slope, B3					
INTRCPT2, G30	0.022427	0.100915	0.222	123	0.825

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17589	0.03094	40	350.63349	0.000
QUAD_TIM slope, u2	0.02823	0.00080	41	81.26064	0.000
level-1, r	0.13935	0.01942			

Statistics for the current model

Deviance = -115.340903
Number of estimated parameters = 9

Model 18

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

$$B3 = G30$$

LG_SAA has been centered around the group mean.

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM$$

$$+ G30*LG_SAA$$

$$+ u0 + u2*QUAD_TIM + r$$

$$\sigma^2 = 0.01942$$

Standard error of $\sigma^2 = 0.00245$

tau

INTRCPT1,B0	0.03106	-0.00251
QUAD_TIM,B2	-0.00251	0.00080

Standard errors of tau

INTRCPT1,B0	0.00773	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.504
QUAD_TIM,B2	-0.504	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.875
QUAD_TIM, G2	0.479

The value of the log-likelihood function at iteration 8 = 5.760570E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448048	0.029773	15.049	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.004231	0.008958	-0.472	123	0.638
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012288	0.007306	1.682	41	0.100
For LG_SAA slope, B3					
INTRCPT2, G30	0.023959	0.100829	0.238	123	0.813

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.17623	0.03106	41	351.79917	0.000
QUAD_TIM slope, u2	0.02822	0.00080	41	81.23429	0.000

level-1, r 0.13935 0.01942

Statistics for the current model

Deviance = -115.211409

Number of estimated parameters = 8

Model comparison test

Chi-square statistic = 14.09680

Degrees of freedom = 2

P-value = 0.001

Model 19

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM + u0 + u2*QUAD_TIM + r$$

$$\sigma^2 = 0.02223$$

$$\text{Standard error of } \sigma^2 = 0.00232$$

tau

$$\text{INTRCPT1,B0} \quad 0.04582 \quad -0.00066$$

$$\text{QUAD_TIM,B2} \quad -0.00066 \quad 0.00021$$

Standard errors of tau

$$\text{INTRCPT1,B0} \quad 0.01033 \quad 0.00095$$

$$\text{QUAD_TIM,B2} \quad 0.00095 \quad 0.00018$$

tau (as correlations)

$$\text{INTRCPT1,B0} \quad 1.000 \quad -0.212$$

$$\text{QUAD_TIM,B2} \quad -0.212 \quad 1.000$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.925
 QUAD_TIM, G2 0.257

The value of the log-likelihood function at iteration 2 = 6.747734E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
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For INTRCPT1, B0
 INTRCPT2, G00 0.426568 0.033744 12.641 45 0.000

For TIME slope, B1
 INTRCPT2, G10 -0.000188 0.005254 -0.036 183 0.972

For QUAD_TIM slope, B2
 INTRCPT2, G20 0.014040 0.004248 3.305 45 0.002

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
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INTRCPT1, u0 0.21405 0.04582 45 614.85525 0.000

QUAD_TIM slope, u2 0.01460 0.00021 45 61.87902 0.048

level-1, r 0.14908 0.02223

Statistics for the current model

Deviance = -134.954687
 Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 19.74328
 Degrees of freedom = 1
 P-value = <0.001

Model 20 – covariates

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(CHILD_EA) + G02*(CHILD_WA) + G03*(CHILD_SE) + \\ &G04*(CHILD_AG) \\ &+ G05*(ETHNICIT) + G06*(TIME_GAP) + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \end{aligned}$$

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*CHILD_EA + G02*CHILD_WA + G03*CHILD_SE \\ &+ G04*CHILD_AG + G05*ETHNICIT + G06*TIME_GAP \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.02243$$

tau

$$\begin{array}{lll} INTRCPT1,B0 & 0.04323 & -0.00045 \\ QUAD_TIM,B2 & -0.00045 & 0.00029 \end{array}$$

tau (as correlations)

$$\begin{array}{lll} INTRCPT1,B0 & 1.000 & -0.127 \\ QUAD_TIM,B2 & -0.127 & 1.000 \end{array}$$

Random level-1 coefficient Reliability estimate

$$\begin{array}{ll} INTRCPT1, G0 & 0.920 \\ QUAD_TIM, G2 & 0.319 \end{array}$$

The value of the log-likelihood function at iteration 17 = 2.093882E+001

Final estimation of fixed effects:

		Standard	Approx.			
Fixed Effect		Coefficient	Error	T-ratio	d.f.	P-value

For	INTRCPT1, B0					
	INTRCPT2, G00	0.770612	0.572080	1.347	34	0.187
	CHILD EA, G01	0.000004	0.000010	0.436	34	0.666

CHILD_WA, G02	0.000000	0.000012	0.027	34	0.979
CHILD_SE, G03	0.023276	0.074102	0.314	34	0.755
CHILD_AG, G04	-0.049399	0.053201	-0.929	34	0.360
ETHNICIT, G05	-0.002131	0.014019	-0.152	34	0.880
TIME_GAP, G06	-0.030992	0.016097	-1.925	34	0.063
For TIME slope, B1					
INTRCPT2, G10	0.005461	0.005591	0.977	163	0.330
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.013332	0.004724	2.822	40	0.007

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>						
INTRCPT1, u0		0.20791	0.04323	34	427.44935	0.000
QUAD_TIM slope, u2		0.01709	0.00029	40	58.73594	0.028
level-1, r		0.14977	0.02243			

Statistics for current covariance components model

Deviance = -41.877641
Number of estimated parameters = 4

Model 21- Final model

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM + u0 + u2*QUAD_TIM + r$$

$$\sigma^2 = 0.02235$$

tau

INTRCPT1,B0	0.04690	-0.00068
QUAD_TIM,B2	-0.00068	0.00023

tau (as correlations)

INTRCPT1,B0	1.000	-0.207
QUAD_TIM,B2	-0.207	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.926
QUAD_TIM, G2	0.268

The value of the log-likelihood function at iteration 14 = 5.703277E+001

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
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For INTRCPT1, B0					
INTRCPT2, G00	0.426568	0.034102	12.509	45	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.000188	0.005269	-0.036	183	0.972
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.014040	0.004294	3.270	45	0.002

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
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INTRCPT1, u0	0.21656	0.04690	45	611.44721	0.000
QUAD_TIM slope, u2	0.01509	0.00023	45	61.53603	0.051
level-1, r	0.14950	0.02235			

Statistics for current covariance components model

Deviance = -114.065549
Number of estimated parameters = 4

Variance-Covariance components test

Chi-square statistic = 18.69304

Degrees of freedom = 1
P-value = <0.001

Appendix 4.4

Model Equations and Results: Maternal-Reported Internalizing in the Competition Challenge

Model 1

Level-1 Model

$$LG_CORT = B0 + r$$

Level-2 Model

$$B0 = G00 + u0$$

Mixed Model

$$LG_CORT = G00 + u0 + r$$

$$\sigma^2 = 0.02518$$

$$\text{Standard error of } \sigma^2 = 0.00235$$

tau

$$\text{INTRCPT1, } B0 = 0.04528$$

Standard error of tau

$$\text{INTRCPT1, } B0 = 0.01032$$

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.915

The value of the log-likelihood function at iteration 2 = 5.970427E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect		Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For	INTRCPT1, B0					
	INTRCPT2, G00	0.426754	0.032796	13.012	45	0.000

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, level-1,	u0 r	0.21279 0.15868	0.04528 0.02518	45	542.32638	0.000

Statistics for the current model

Deviance = -119.408532
Number of estimated parameters = 3

Model 2

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

Mixed Model

$$LG_CORT = G00 + G10*TIME + u0 + r$$

$$\sigma^2 = 0.02518$$

$$\text{Standard error of } \sigma^2 = 0.00235$$

tau

$$INTRCPT1, B0 = 0.04528$$

Standard error of tau

$$INTRCPT1, B0 = 0.01032$$

Random level-1 coefficient	Reliability estimate
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INTRCPT1, G0	0.915
--------------	-------

The value of the log-likelihood function at iteration 2 = 5.970483E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.427036	0.033852	12.615	45	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.000188	0.005593	-0.034	229	0.973

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.21279	0.04528	45	542.32904	0.000
level-1, r	0.15868	0.02518			

Statistics for the current model

Deviance = -119.409659
 Number of estimated parameters = 4

Model comparison test

Chi-square statistic = 0.00113
 Degrees of freedom = 1
 P-value = >.500

Model 3

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \end{aligned}$$

Mixed Model

$$LG_CORT = G00$$

+ G10*TIME
+ G20*QUAD_TIM + u0+ r

sigma^2 = 0.02376

Standard error of sigma^2 = 0.00222

tau

INTRCPT1,B0 0.04552

Standard error of tau

INTRCPT1,B0 0.01032

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.920

The value of the log-likelihood function at iteration 2 = 6.637930E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.426568	0.033794	12.623	45	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.000188	0.005433	-0.035	228	0.972
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.014040	0.003787	3.707	228	0.000

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.21335	0.04552	45	574.73653	0.000
level-1, r	0.15414	0.02376			

Statistics for the current model

 Deviance = -132.758591
 Number of estimated parameters = 5

Model comparison test

 Chi-square statistic = 13.34893
 Degrees of freedom = 1
 P-value = <0.001

Model 4

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 \\ B3 &= G30 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ u0 + r \end{aligned}$$

$$\sigma^2 = 0.02400$$

$$\text{Standard error of } \sigma^2 = 0.00263$$

tau

$$\text{INTRCPT1, B0} = 0.03355$$

Standard error of tau

$$\text{INTRCPT1, B0} = 0.00839$$

 Random level-1 coefficient Reliability estimate

 INTRCPT1, G0 0.874

The value of the log-likelihood function at iteration 4 = 5.055731E+001
The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.447353	0.031298	14.293	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.003697	0.009949	-0.372	164	0.711
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012138	0.006513	1.864	164	0.064
For LG_SAA slope, B3					
INTRCPT2, G30	0.069475	0.104917	0.662	164	0.509

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18317	0.03355	41	335.27577	0.000
level-1, r	0.15493	0.02400			

Statistics for the current model

Deviance = -101.114613
Number of estimated parameters = 6

Model comparison test

Chi-square statistic = 31.64398
Degrees of freedom = 1
P-value = <0.001

Model 5

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + u0$$

B1 = G10
 B2 = G20
 B3 = G30
 B4 = G40

LG_SAA has been centered around the group mean.

Mixed Model

LG_CORT = G00
 + G10*TIME
 + G20*QUAD_TIM
 + G30*LG_SAA
 + G40*SAAXQ_TI
 + u0+ r

sigma^2 = 0.02402

Standard error of sigma^2 = 0.00263

tau

INTRCPT1,B0 0.03338

Standard error of tau

INTRCPT1,B0 0.00835

```
-----
Random level-1 coefficient  Reliability estimate
-----
INTRCPT1, G0                0.874
-----
```

The value of the log-likelihood function at iteration 7 = 5.059164E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

```
-----
Fixed Effect      Standard      Approx.
                  Coefficient Error   T-ratio d.f.  P-value
-----
For  INTRCPT1, B0
  INTRCPT2, G00    0.447863  0.031295  14.311   41  0.000
For  TIME slope, B1
  INTRCPT2, G10   -0.003733  0.009953  -0.375  163  0.708
For QUAD_TIM slope, B2
  INTRCPT2, G20    0.012357  0.006568   1.881  163  0.062
```

For LG_SAA slope, B3

INTRCPT2, G30	0.066055	0.105757	0.625	163	0.533
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For SAAXQ_TI slope, B4

INTRCPT2, G40	0.010246	0.038970	0.263	163	0.793
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Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18269	0.03338	41	333.54901	0.000
level-1, r	0.15499	0.02402			

Statistics for the current model

Deviance = -101.183276

Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 0.06866

Degrees of freedom = 1

P-value = >.500

Model 6

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

$$B3 = G30$$

$$B4 = G40$$

LG_SAA has been centered around the group mean.

Mixed Model

$$LG_CORT = G00$$

$$+ G10*TIME$$

$$+ G20*QUAD_TIM$$

+ G30*LG_SAA
+ G40*SAAXTIME
+ u0+ r

sigma^2 = 0.02401

Standard error of sigma^2 = 0.00263

tau

INTRCPT1,B0 0.03292

Standard error of tau

INTRCPT1,B0 0.00826

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.872

The value of the log-likelihood function at iteration 7 = 5.087204E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.448626	0.031101	14.425	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.003568	0.009952	-0.358	163	0.720
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012747	0.006559	1.943	163	0.054
For LG_SAA slope, B3					
INTRCPT2, G30	0.021272	0.121117	0.176	163	0.861
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.042742	0.053627	-0.797	163	0.427

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18144	0.03292	41	329.66441	0.000

level-1, r 0.15496 0.02401

Statistics for the current model

Deviance = -101.744088

Number of estimated parameters = 7

Model comparison test

Chi-square statistic = 0.62948

Degrees of freedom = 1

P-value = >.500

Model 7

Level-1 Model

$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$

Level-2 Model

$B0 = G00 + u0$

$B1 = G10$

$B2 = G20$

$B3 = G30$

$B4 = G40$

$B5 = G50$

LG_SAA has been centered around the group mean.

Mixed Model

$LG_CORT = G00$

$+ G10*TIME$

$+ G20*QUAD_TIM$

$+ G30*LG_SAA$

$+ G40*SAAXTIME$

$+ G50*SAAXQ_TI$

$+ u0 + r$

$\sigma^2 = 0.02399$

Standard error of $\sigma^2 = 0.00263$

tau

INTRCPT1,B0 0.03298

Standard error of tau

INTRCPT1,B0 0.00827

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.872

The value of the log-likelihood function at iteration 7 = 5.092107E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Coefficient Error Approx. T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.448250 0.031144 14.393 41 0.000
For TIME slope, B1
INTRCPT2, G10 -0.003470 0.009952 -0.349 162 0.728
For QUAD_TIM slope, B2
INTRCPT2, G20 0.012606 0.006571 1.918 162 0.057
For LG_SAA slope, B3
INTRCPT2, G30 0.010942 0.125522 0.087 162 0.931
For SAAXTIME slope, B4
INTRCPT2, G40 -0.056589 0.069586 -0.813 162 0.417
For SAAXQ_TI slope, B5
INTRCPT2, G50 -0.015838 0.050548 -0.313 162 0.754

Final estimation of variance components:

Random Effect Standard Variance df Chi-square P-value
Deviation Component

INTRCPT1, u0 0.18161 0.03298 41 330.48039 0.000
level-1, r 0.15488 0.02399

Statistics for the current model

Deviance = -101.842139

Number of estimated parameters = 8

Model comparison test

Chi-square statistic = 0.09805
Degrees of freedom = 1
P-value = >.500

Model 7.1

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 + u1 \\ B2 &= G20 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u1*TIME + r \end{aligned}$$

$$\sigma^2 = 0.02128$$

$$\text{Standard error of } \sigma^2 = 0.00269$$

tau

INTRCPT1,B0	0.02679	0.00284
TIME,B1	0.00284	0.00109

Standard errors of tau

INTRCPT1,B0	0.00730	0.00163
TIME,B1	0.00163	0.00076

tau (as correlations)

INTRCPT1,B0 1.000 0.526

TIME,B1 0.526 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.804

TIME, G1 0.335

The value of the log-likelihood function at iteration 18 = 5.512945E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448832	0.028324	15.846	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.003913	0.010671	-0.367	41	0.716
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012734	0.006199	2.054	121	0.042
For LG_SAA slope, B3					
INTRCPT2, G30	-0.019857	0.124469	-0.160	121	0.874
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.051997	0.072871	-0.714	121	0.477
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.013151	0.048713	-0.270	121	0.788

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.16366	0.02679	41	218.48118	0.000
TIME slope, u1	0.03295	0.00109	41	63.83974	0.013
level-1, r	0.14587	0.02128			

Statistics for the current model

Deviance = -110.258891
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 8.41675
Degrees of freedom = 2
P-value = 0.015

Model 7.2

Level-1 Model

$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$

Level-2 Model

$B0 = G00 + u0$
 $B1 = G10$
 $B2 = G20 + u2$
 $B3 = G30$
 $B4 = G40$
 $B5 = G50$

LG_SAA has been centered around the group mean.

Mixed Model

$LG_CORT = G00$
 $+ G10*TIME$
 $+ G20*QUAD_TIM$
 $+ G30*LG_SAA$
 $+ G40*SAAXTIME$
 $+ G50*SAAXQ_TI$
 $+ u0 + u2*QUAD_TIM + r$

$\sigma^2 = 0.01932$

Standard error of $\sigma^2 = 0.00244$

tau

INTRCPT1,B0	0.03054	-0.00250
QUAD_TIM,B2	-0.00250	0.00081

Standard errors of tau

INTRCPT1,B0	0.00761	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0 1.000 -0.502

QUAD_TIM,B2 -0.502 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.874

QUAD_TIM, G2 0.485

The value of the log-likelihood function at iteration 13 = 5.810132E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.448835	0.029635	15.145	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.004024	0.008943	-0.450	121	0.654
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012700	0.007379	1.721	41	0.093
For LG_SAA slope, B3					
INTRCPT2, G30	-0.044759	0.122530	-0.365	121	0.716
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.062670	0.063017	-0.994	121	0.322
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.022977	0.049630	-0.463	121	0.644

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17476	0.03054	41	348.15708	0.000
QUAD_TIM slope, u2	0.02848	0.00081	41	82.19075	0.000
level-1, r	0.13901	0.01932			

Statistics for the current model

Deviance = -116.202640
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 14.36050
Degrees of freedom = 2
P-value = 0.001

Model 7.3

Level-1 Model

$$\text{LG_CORT} = B0 + B1*(\text{TIME}) + B2*(\text{QUAD_TIM}) + B3*(\text{LG_SAA}) + B4*(\text{SAAXTIME}) + B5*(\text{SAAXQ_TI}) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10$$

$$B2 = G20$$

$$B3 = G30 + u3$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\text{LG_CORT} = G00$$

$$+ G10*\text{TIME}$$

$$+ G20*\text{QUAD_TIM}$$

$$+ G30*\text{LG_SAA}$$

$$+ G40*\text{SAAXTIME}$$

$$+ G50*\text{SAAXQ_TI}$$

$$+ u0 + u3*\text{LG_SAA} + r$$

$$\text{sigma}^2 = 0.02142$$

$$\text{Standard error of } \text{sigma}^2 = 0.00257$$

tau

$$\text{INTRCPT1,B0} \quad 0.03410 \quad 0.01807$$

$$\text{LG_SAA,B3} \quad 0.01807 \quad 0.18271$$

Standard errors of tau

$$\text{INTRCPT1,B0} \quad 0.00840 \quad 0.02546$$

$$\text{LG_SAA,B3} \quad 0.02546 \quad 0.12942$$

tau (as correlations)

$$\text{INTRCPT1,B0} \quad 1.000 \quad 0.229$$

$$\text{LG_SAA,B3} \quad 0.229 \quad 1.000$$

Random level-1 coefficient Reliability estimate

$$\text{INTRCPT1, G0} \quad 0.888$$

$$\text{LG_SAA, G3} \quad 0.259$$

The value of the log-likelihood function at iteration 13 = 5.325547E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	0.447252	0.031322	14.279	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.002080	0.009676	-0.215	121	0.830
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.014770	0.006349	2.326	121	0.022
For LG_SAA slope, B3					
INTRCPT2, G30	0.088260	0.145581	0.606	41	0.548
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.017040	0.068470	-0.249	121	0.804
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.017504	0.049914	-0.351	121	0.726

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.18466	0.03410	41	376.10762	0.000
LG_SAA slope, u3	0.42744	0.18271	41	50.97844	0.137
level-1, r	0.14635	0.02142			

Statistics for the current model

Deviance = -106.510940
Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 4.66880
Degrees of freedom = 2
P-value = 0.095

Model 7.4

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + u0$$

$$B1 = G10 + u1$$

$$B2 = G20 + u2$$

$$B3 = G30$$

$$B4 = G40$$

$$B5 = G50$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 \\ & + G10*TIME \\ & + G20*QUAD_TIM \\ & + G30*LG_SAA \\ & + G40*SAAXTIME \\ & + G50*SAAXQ_TI \\ & + u0 + u1*TIME + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01858$$

$$\text{Standard error of } \sigma^2 = 0.00287$$

tau

INTRCPT1,B0	0.02869	0.00119	-0.00151
TIME,B1	0.00119	0.00030	-0.00038
QUAD_TIM,B2	-0.00151	-0.00038	0.00050

Standard errors of tau

INTRCPT1,B0	0.00759	0.00174	0.00128
TIME,B1	0.00174	0.00090	0.00047
QUAD_TIM,B2	0.00128	0.00047	0.00046

tau (as correlations)

INTRCPT1,B0	1.000	0.408	-0.399
TIME,B1	0.408	1.000	-0.990
QUAD_TIM,B2	-0.399	-0.990	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.826
TIME, G1	0.086
QUAD_TIM, G2	0.264

The value of the log-likelihood function at iteration 5844 = 5.928108E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
<hr/>					
For INTRCPT1, B0					
INTRCPT2, G00	0.449907	0.028798	15.623	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.004279	0.009169	-0.467	41	0.643
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.013109	0.006770	1.936	41	0.060
For LG_SAA slope, B3					
INTRCPT2, G30	-0.058451	0.124465	-0.470	80	0.640
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.058670	0.063753	-0.920	80	0.360
For SAAXQ TI slope, B5					
INTRCPT2, G50	-0.007257	0.048452	-0.150	80	0.881

The outcome variable is LG_CORT

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.16939	0.02869	41	250.16030	0.000
TIME slope, u1	0.01725	0.00030	41	40.37455	>.500
QUAD_TIM slope, u2	0.02237	0.00050	41	52.37501	0.110
level-1, r	0.13631	0.01858			

Statistics for the current model

Deviance = -118.562156
Number of estimated parameters = 13

Model comparison test

 Chi-square statistic = 16.72002
 Degrees of freedom = 5
 P-value = 0.005

Model 8

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01932$$

$$\text{Standard error of } \sigma^2 = 0.00244$$

tau

INTRCPT1,B0	0.03054	-0.00250
QUAD_TIM,B2	-0.00250	0.00081

Standard errors of tau

INTRCPT1,B0	0.00761	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.502
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QUAD_TIM,B2 -0.502 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.874
QUAD_TIM, G2 0.485

The value of the log-likelihood function at iteration 13 = 5.810132E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Coefficient Error Approx. T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.448835 0.029635 15.145 41 0.000
For TIME slope, B1
INTRCPT2, G10 -0.004024 0.008943 -0.450 121 0.654
For QUAD_TIM slope, B2
INTRCPT2, G20 0.012700 0.007379 1.721 41 0.093
For LG_SAA slope, B3
INTRCPT2, G30 -0.044759 0.122530 -0.365 121 0.716
For SAAXTIME slope, B4
INTRCPT2, G40 -0.062670 0.063017 -0.994 121 0.322
For SAAXQ_TI slope, B5
INTRCPT2, G50 -0.022977 0.049630 -0.463 121 0.644

-

Final estimation of variance components:

Random Effect Standard Variance df Chi-square P-value
Deviation Component

INTRCPT1, u0 0.17476 0.03054 41 348.15708 0.000
QUAD_TIM slope, u2 0.02848 0.00081 41 82.19075 0.000
level-1, r 0.13901 0.01932

Statistics for the current model

Deviance = -116.202640

Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 14.36050
Degrees of freedom = 2
P-value = 0.001

Model 9

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(INTERNAL) + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*INTERNAL \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01932$$

$$\text{Standard error of } \sigma^2 = 0.00244$$

tau

INTRCPT1,B0	0.03055	-0.00250
QUAD_TIM,B2	-0.00250	0.00081

Standard errors of tau

INTRCPT1,B0	0.00761	0.00121
QUAD_TIM,B2	0.00121	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.503
QUAD_TIM,B2	-0.503	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.874
QUAD_TIM, G2	0.485

The value of the log-likelihood function at iteration 13 = 5.810440E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value
<hr/>					
For INTRCPT1, B0					
INTRCPT2, G00	0.448960	0.029681	15.126	40	0.000
INTERNAL, G01	-0.000395	0.005031	-0.079	40	0.938
For TIME slope, B1					
INTRCPT2, G10	-0.004022	0.008943	-0.450	121	0.654
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012689	0.007379	1.720	41	0.093
For LG_SAA slope, B3					
INTRCPT2, G30	-0.044327	0.122640	-0.361	121	0.718
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.062228	0.063271	-0.984	121	0.327
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.022746	0.049745	-0.457	121	0.648

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
<hr/>					
INTRCPT1, u0	0.17477	0.03055	40	348.19485	0.000
QUAD_TIM slope, u2	0.02848	0.00081	41	82.18706	0.000
level-1, r	0.13901	0.01932			

Statistics for the current model

Deviance = -116.208801
Number of estimated parameters = 11

Model comparison test

Chi-square statistic = 0.18218
Degrees of freedom = 0
P-value = >.500

Model 10

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(INTERNAL) + u0 \\ B1 &= G10 + G11*(INTERNAL) \\ B2 &= G20 + G21*(INTERNAL) + u2 \\ B3 &= G30 \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*INTERNAL \\ &+ G10*TIME + G11*INTERNAL*TIME \\ &+ G20*QUAD_TIM + G21*INTERNAL*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$\sigma^2 = 0.01906$

Standard error of $\sigma^2 = 0.00240$

tau

INTRCPT1,B0	0.03079	-0.00250
QUAD_TIM,B2	-0.00250	0.00082

Standard errors of tau

INTRCPT1,B0	0.00765	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.496
QUAD_TIM,B2	-0.496	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.876
QUAD_TIM, G2	0.492

The value of the log-likelihood function at iteration 13 = 5.885410E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448384	0.029752	15.071	40	0.000
INTERNAL, G01	0.001245	0.005287	0.235	40	0.815
For TIME slope, B1					
INTRCPT2, G10	-0.003575	0.008889	-0.402	120	0.688
INTERNAL, G11	-0.002026	0.001686	-1.201	120	0.232
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.013038	0.007380	1.767	40	0.085
INTERNAL, G21	-0.001124	0.001354	-0.830	40	0.411
For LG_SAA slope, B3					
INTRCPT2, G30	-0.032218	0.122697	-0.263	120	0.793
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.033735	0.067154	-0.502	120	0.616
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.009592	0.050792	-0.189	120	0.851

Final estimation of variance components:

Random Effect	Standard	Variance	df	Chi-square	P-value
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		Deviation	Component				
INTRCPT1,	u0	0.17546	0.03079	40	355.18083	0.000	
QUAD_TIM slope,	u2	0.02869	0.00082	40	83.59468	0.000	
level-1,	r	0.13805	0.01906				

Statistics for the current model

Deviance = -117.708203
Number of estimated parameters = 13

Model comparison test

Chi-square statistic = 1.49940
Degrees of freedom = 2
P-value = >.500

Model 11

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(INTERNAL) + u0 \\ B1 &= G10 + G11*(INTERNAL) \\ B2 &= G20 + G21*(INTERNAL) + u2 \\ B3 &= G30 + G31*(INTERNAL) \\ B4 &= G40 \\ B5 &= G50 \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*INTERNAL \\ &+ G10*TIME + G11*INTERNAL*TIME \\ &+ G20*QUAD_TIM + G21*INTERNAL*QUAD_TIM \\ &+ G30*LG_SAA + G31*INTERNAL*LG_SAA \\ &+ G40*SAAXTIME \\ &+ G50*SAAXQ_TI \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

sigma^2 = 0.01867

Standard error of sigma^2 = 0.00236

tau

INTRCPT1,B0	0.03084	-0.00277
QUAD_TIM,B2	-0.00277	0.00082

Standard errors of tau

INTRCPT1,B0	0.00764	0.00122
QUAD_TIM,B2	0.00122	0.00037

tau (as correlations)

INTRCPT1,B0	1.000	-0.551
QUAD_TIM,B2	-0.551	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.879
QUAD_TIM, G2	0.496

The value of the log-likelihood function at iteration 13 = 6.093949E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.445692	0.029745	14.984	40	0.000
INTERNAL, G01	0.000538	0.005291	0.102	40	0.919
For TIME slope, B1					
INTRCPT2, G10	-0.000836	0.008895	-0.094	119	0.925
INTERNAL, G11	-0.001669	0.001678	-0.995	119	0.322
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.014052	0.007342	1.914	40	0.063
INTERNAL, G21	-0.001257	0.001344	-0.935	40	0.355
For LG_SAA slope, B3					
INTRCPT2, G30	-0.016914	0.121118	-0.140	119	0.889
INTERNAL, G31	0.043570	0.021039	2.071	119	0.041
For SAAXTIME slope, B4					
INTRCPT2, G40	-0.012456	0.067214	-0.185	119	0.853

For SAAXQ_TI slope, B5

INTRCPT2, G50	-0.010187	0.049992	-0.204	119	0.839
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Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17562	0.03084	40	361.98112	0.000
QUAD_TIM slope, u2	0.02862	0.00082	40	83.94589	0.000
level-1, r	0.13662	0.01867			

Statistics for the current model

Deviance = -121.878977

Number of estimated parameters = 14

Model comparison test

Chi-square statistic = 4.50480

Degrees of freedom = 1

P-value = 0.032

Model 12

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + B4*(SAAXTIME) + B5*(SAAXQ_TI) + r$$

Level-2 Model

$$B0 = G00 + G01*(INTERNAL) + u0$$

$$B1 = G10 + G11*(INTERNAL)$$

$$B2 = G20 + G21*(INTERNAL) + u2$$

$$B3 = G30 + G31*(INTERNAL)$$

$$B4 = G40 + G41*(INTERNAL)$$

$$B5 = G50 + G51*(INTERNAL)$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

```

LG_CORT = G00 + G01*INTERNAL
+ G10*TIME + G11*INTERNAL*TIME
+ G20*QUAD_TIM + G21*INTERNAL*QUAD_TIM
+ G30*LG_SAA + G31*INTERNAL*LG_SAA
+ G40*SAAXTIME + G41*INTERNAL*SAAXTIME
+ G50*SAAXQ_TI + G51*INTERNAL*SAAXQ_TI
+ u0 + u2*QUAD_TIM + r

```

sigma^2 = 0.01889

Standard error of sigma^2 = 0.00238

tau

```

INTRCPT1,B0 0.02959 -0.00266
QUAD_TIM,B2 -0.00266 0.00074

```

Standard errors of tau

```

INTRCPT1,B0 0.00738 0.00117
QUAD_TIM,B2 0.00117 0.00036

```

tau (as correlations)

```

INTRCPT1,B0 1.000 -0.570
QUAD_TIM,B2 -0.570 1.000

```

Random level-1 coefficient Reliability estimate

```

INTRCPT1, G0 0.873
QUAD_TIM, G2 0.467

```

The value of the log-likelihood function at iteration 13 = 6.180150E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

```

-----
Fixed Effect      Standard      Approx.
                  Coefficient Error   T-ratio d.f.  P-value
-----
For  INTRCPT1, B0
  INTRCPT2, G00    0.444012  0.029287  15.161   40  0.000
  INTERNAL, G01   -0.000218  0.005241  -0.042   40  0.967
For  TIME slope, B1
  INTRCPT2, G10   -0.004400  0.009912  -0.444  117  0.658
  INTERNAL, G11   -0.002409  0.001927  -1.250  117  0.214
For QUAD_TIM slope, B2

```

INTRCPT2, G20	0.013204	0.007497	1.761	40	0.086
INTERNAL, G21	-0.001491	0.001391	-1.072	40	0.290
For LG_SAA slope, B3					
INTRCPT2, G30	0.027382	0.125827	0.218	117	0.828
INTERNAL, G31	0.065522	0.027412	2.390	117	0.018
For SAAXTIME slope, B4					
INTRCPT2, G40	0.005236	0.070279	0.075	117	0.941
INTERNAL, G41	0.014429	0.016416	0.879	117	0.381
For SAAXQ_TI slope, B5					
INTRCPT2, G50	-0.015665	0.051783	-0.303	117	0.763
INTERNAL, G51	-0.002451	0.010865	-0.226	117	0.822

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17201	0.02959	40	345.46384	0.000
QUAD_TIM slope, u2	0.02716	0.00074	40	79.49760	0.000
level-1, r	0.13745	0.01889			

Statistics for the current model

Deviance = -123.602999
Number of estimated parameters = 16

Model comparison test

Chi-square statistic = 1.72402
Degrees of freedom = 2
P-value = >.500

Model 13

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \end{aligned}$$

LG_SAA has been centered around the group mean.

Mixed Model

LG_CORT = G00
+ G10*TIME
+ G20*QUAD_TIM
+ G30*LG_SAA
+ u0 + u2*QUAD_TIM + r

sigma^2 = 0.01942

Standard error of sigma^2 = 0.00245

tau

INTRCPT1,B0	0.03106	-0.00251
QUAD_TIM,B2	-0.00251	0.00080

Standard errors of tau

INTRCPT1,B0	0.00773	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.504
QUAD_TIM,B2	-0.504	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.875
QUAD_TIM, G2	0.479

The value of the log-likelihood function at iteration 8 = 5.760570E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448048	0.029773	15.049	41	0.000
For TIME slope, B1					
INTRCPT2, G10	-0.004231	0.008958	-0.472	123	0.638
For QUAD_TIM slope, B2					

INTRCPT2, G20	0.012288	0.007306	1.682	41	0.100
For LG_SAA slope, B3					
INTRCPT2, G30	0.023959	0.100829	0.238	123	0.813

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, u0	0.17623	0.03106	41	351.79917	0.000
QUAD_TIM slope, u2	0.02822	0.00080	41	81.23429	0.000
level-1, r	0.13935	0.01942			

Statistics for the current model

Deviance = -115.211409
Number of estimated parameters = 8

Model comparison test

Chi-square statistic = 14.09680
Degrees of freedom = 2
P-value = 0.001

Model 14

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(INTERNAL) + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*INTERNAL \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \end{aligned}$$

+ G30*LG_SAA
+ u0 + u2*QUAD_TIM + r

sigma^2 = 0.01942

Standard error of sigma^2 = 0.00245

tau

INTRCPT1,B0	0.03105	-0.00252
QUAD_TIM,B2	-0.00252	0.00080

Standard errors of tau

INTRCPT1,B0	0.00773	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.506
QUAD_TIM,B2	-0.506	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.875
QUAD_TIM, G2	0.479

The value of the log-likelihood function at iteration 8 = 5.761922E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.448315	0.029814	15.037	40	0.000
INTERNAL, G01	-0.000831	0.005046	-0.165	40	0.870
For TIME slope, B1					
INTRCPT2, G10	-0.004224	0.008959	-0.471	123	0.638
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012269	0.007306	1.679	41	0.101
For LG_SAA slope, B3					
INTRCPT2, G30	0.023906	0.100823	0.237	123	0.813

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1,	u0	0.17620	0.03105	40	351.67262	0.000
QUAD_TIM slope,	u2	0.02821	0.00080	41	81.22331	0.000
level-1,	r	0.13936	0.01942			

Statistics for the current model

Deviance = -115.238441
Number of estimated parameters = 9

Model comparison test

Chi-square statistic = 0.02703
Degrees of freedom = 1
P-value = >.500

Model 15

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(INTERNAL) + u0 \\ B1 &= G10 + G11*(INTERNAL) \\ B2 &= G20 + G21*(INTERNAL) + u2 \\ B3 &= G30 \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*INTERNAL \\ &+ G10*TIME + G11*INTERNAL*TIME \\ &+ G20*QUAD_TIM + G21*INTERNAL*QUAD_TIM \\ &+ G30*LG_SAA \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01908$$

Standard error of sigma^2 = 0.00241

tau

INTRCPT1,B0	0.03110	-0.00252
QUAD_TIM,B2	-0.00252	0.00081

Standard errors of tau

INTRCPT1,B0	0.00772	0.00122
QUAD_TIM,B2	0.00122	0.00038

tau (as correlations)

INTRCPT1,B0	1.000	-0.501
QUAD_TIM,B2	-0.501	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.877
QUAD_TIM, G2	0.489

The value of the log-likelihood function at iteration 8 = 5.872260E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.447878	0.029804	15.027	40	0.000
INTERNAL, G01	0.001223	0.005309	0.230	40	0.819
For TIME slope, B1					
INTRCPT2, G10	-0.003589	0.008890	-0.404	122	0.687
INTERNAL, G11	-0.002327	0.001579	-1.474	122	0.143
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.012807	0.007307	1.753	40	0.087
INTERNAL, G21	-0.001221	0.001321	-0.924	40	0.361
For LG_SAA slope, B3					
INTRCPT2, G30	0.003687	0.101013	0.037	122	0.971

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
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INTRCPT1,	u0	0.17634	0.03110	40	358.05121	0.000
QUAD_TIM slope,	u2	0.02854	0.00081	40	83.17319	0.000
level-1,	r	0.13812	0.01908			

Statistics for the current model

Deviance = -117.445210
Number of estimated parameters = 11

Model comparison test

Chi-square statistic = 2.20677
Degrees of freedom = 2
P-value = 0.332

Model 16

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$\begin{aligned} B0 &= G00 + G01*(INTERNAL) + u0 \\ B1 &= G10 \\ B2 &= G20 + u2 \\ B3 &= G30 + G31*(INTERNAL) \end{aligned}$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT &= G00 + G01*INTERNAL \\ &+ G10*TIME \\ &+ G20*QUAD_TIM \\ &+ G30*LG_SAA + G31*INTERNAL*LG_SAA \\ &+ u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01883$$

$$\text{Standard error of } \sigma^2 = 0.00238$$

tau

INTRCPT1,B0	0.03088	-0.00276
QUAD_TIM,B2	-0.00276	0.00082

Standard errors of tau

INTRCPT1,B0	0.00766	0.00122
QUAD_TIM,B2	0.00122	0.00037

tau (as correlations)

INTRCPT1,B0	1.000	-0.548
QUAD_TIM,B2	-0.548	1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0	0.878
QUAD_TIM, G2	0.495

The value of the log-likelihood function at iteration 8 = 6.014842E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect	Standard Coefficient	Error	Approx. T-ratio	d.f.	P-value

For INTRCPT1, B0					
INTRCPT2, G00	0.446369	0.029684	15.037	40	0.000
INTERNAL, G01	-0.001539	0.004988	-0.309	40	0.759
For TIME slope, B1					
INTRCPT2, G10	-0.001204	0.008923	-0.135	122	0.893
For QUAD_TIM slope, B2					
INTRCPT2, G20	0.013705	0.007305	1.876	41	0.068
For LG_SAA slope, B3					
INTRCPT2, G30	0.007410	0.099490	0.074	122	0.941
INTERNAL, G31	0.046367	0.020353	2.278	122	0.024

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value

INTRCPT1, u0	0.17573	0.03088	40	359.26699	0.000
QUAD_TIM slope, u2	0.02868	0.00082	41	83.55906	0.000
level-1, r	0.13724	0.01883			

Statistics for the current model

Deviance = -120.296842

Number of estimated parameters = 10

Model comparison test

Chi-square statistic = 5.05840

Degrees of freedom = 1

P-value = 0.023

Model 17

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$B0 = G00 + G01*(CHILD_EA) + G02*(CHILD_WA) + G03*(INTERNAL) + G04*(CHILD_SE)$$

$$+ G05*(CHILD_AG) + G06*(ETHNICIT) + G07*(TIME_GAP) + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

$$B3 = G30 + G31*(INTERNAL)$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 + G01*CHILD_EA + G02*CHILD_WA + G03*INTERNAL \\ & + G04*CHILD_SE + G05*CHILD_AG + G06*ETHNICIT + G07*TIME_GAP \\ & + G10*TIME \\ & + G20*QUAD_TIM \\ & + G30*LG_SAA + G31*INTERNAL*LG_SAA \\ & + u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01969$$

$$\text{Standard error of } \sigma^2 = 0.00265$$

tau

$$INTRCPT1,B0 \quad 0.02477 \quad -0.00225$$

QUAD_TIM,B2 -0.00225 0.00086

Standard errors of tau

INTRCPT1,B0 0.00679 0.00120
QUAD_TIM,B2 0.00120 0.00042

tau (as correlations)

INTRCPT1,B0 1.000 -0.487
QUAD_TIM,B2 -0.487 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.846
QUAD_TIM, G2 0.494

Final estimation of fixed effects:

Fixed Effect Standard Coefficient Error Approx. T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.427960 0.454704 0.941 29 0.354
CHILD_EA, G01 -0.000004 0.000008 -0.490 29 0.628
CHILD_WA, G02 0.000001 0.000010 0.127 29 0.900
INTERNAL, G03 -0.001577 0.005103 -0.309 29 0.759
CHILD_SE, G04 0.022687 0.063703 0.356 29 0.724
CHILD_AG, G05 0.004353 0.043411 0.100 29 0.921
ETHNICIT, G06 0.015153 0.015443 0.981 29 0.335
TIME_GAP, G07 0.009660 0.015230 0.634 29 0.531
For TIME slope, B1
INTRCPT2, G10 0.005723 0.009756 0.587 107 0.559
For QUAD_TIM slope, B2
INTRCPT2, G20 0.013398 0.007969 1.681 36 0.101
For LG_SAA slope, B3
INTRCPT2, G30 -0.051100 0.111433 -0.459 107 0.647
INTERNAL, G31 0.051912 0.023771 2.184 107 0.031

Final estimation of variance components:

Random Effect Standard Variance df Chi-square P-value
Deviation Component

INTRCPT1, u0 0.15739 0.02477 29 251.27389 0.000

QUAD_TIM slope, u2	0.02935	0.00086	36	73.54836	0.000
level-1, r	0.14033	0.01969			

Statistics for the current model

Deviance = -103.400096

Number of estimated parameters = 16

Model comparison test

Chi-square statistic = 16.89675

Degrees of freedom = 6

P-value = 0.010

Model 18- Final Model

Level-1 Model

$$LG_CORT = B0 + B1*(TIME) + B2*(QUAD_TIM) + B3*(LG_SAA) + r$$

Level-2 Model

$$B0 = G00 + G01*(INTERNAL) + u0$$

$$B1 = G10$$

$$B2 = G20 + u2$$

$$B3 = G30 + G31*(INTERNAL)$$

LG_SAA has been centered around the group mean.

INTERNAL has been centered around the grand mean.

Mixed Model

$$\begin{aligned} LG_CORT = & G00 + G01*INTERNAL \\ & + G10*TIME \\ & + G20*QUAD_TIM \\ & + G30*LG_SAA + G31*INTERNAL*LG_SAA \\ & + u0 + u2*QUAD_TIM + r \end{aligned}$$

$$\sigma^2 = 0.01923$$

tau

INTRCPT1,B0	0.03247	-0.00282
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QUAD_TIM,B2	-0.00282	0.00086
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tau (as correlations)

INTRCPT1,B0 1.000 -0.534
QUAD_TIM,B2 -0.534 1.000

Random level-1 coefficient Reliability estimate

INTRCPT1, G0 0.881
QUAD_TIM, G2 0.501

The value of the log-likelihood function at iteration 22 = 4.080686E+001

The outcome variable is LG_CORT

Final estimation of fixed effects:

Fixed Effect Standard Coefficient Error Approx. T-ratio d.f. P-value

For INTRCPT1, B0
INTRCPT2, G00 0.446374 0.030368 14.699 40 0.000
INTERNAL, G01 -0.001526 0.005112 -0.299 40 0.767
For TIME slope, B1
INTRCPT2, G10 -0.001211 0.009018 -0.134 122 0.893
For QUAD_TIM slope, B2
INTRCPT2, G20 0.013703 0.007415 1.848 41 0.072
For LG_SAA slope, B3
INTRCPT2, G30 0.007588 0.100725 0.075 122 0.940
INTERNAL, G31 0.046244 0.020603 2.244 122 0.027

Final estimation of variance components:

Random Effect Standard Deviation Variance Component df Chi-square P-value

INTRCPT1, u0 0.18020 0.03247 40 351.80944 0.000
QUAD_TIM slope, u2 0.02933 0.00086 41 81.81646 0.000
level-1, r 0.13868 0.01923

Statistics for current covariance components model

Deviance = -81.613716

Number of estimated parameters = 4

Variance-Covariance components test

Chi-square statistic = 38.68313

Degrees of freedom = 6

P-value = <0.001

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