Exploring the effects of daily hassles on eating behaviour in children: The role of cortisol reactivity

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Abstract

It is well established that stress is positively associated with unhealthy eating behaviours and that cortisol reactivity to stress has been found to influence the stress-eating relationship in adults. However, there is a paucity of research that has explored the daily stress-cortisol-eating relationship amongst children. Therefore, the current study aimed to explore whether the experience of daily stressors was associated with an increase in between-meal snack consumption in children over 7 days. Individual cortisol reactivity to stress in the laboratory was explored as a potential moderator of the stress-eating relationship in the real world. Twenty 8-11 year old children completed the Trier Social Stress Test (for children, TSST-C) during which 4 salivary cortisol samples were taken. Participants subsequently completed a 7-day diary that recorded daily hassles (stressors) and between-meal snack consumption. Using multi-level modelling, the results showed there were no effects of daily hassles or mood on snack consumption. However, there were cross-level interactions, such that individuals who had higher cortisol reactivity to stress in the laboratory were found to consume more total and unhealthy snacks in naturalistic settings on days with high hassles and more negative mood compared to those who exhibited low and moderate cortisol reactivity to stress. This exploratory study provides novel evidence that cortisol reactivity to stress is an important moderator of stress-eating relationship in children and that daily diary approaches are feasible in studies investigating stress and eating in children aged 8 to 11 years old.

Keywords: Stress, hassles, cortisol, children, snacking, eating behaviour, hypothalamic pituitary adrenal (HPA) axis.

1. Introduction

The number of obese children and adolescents in the world has risen tenfold over the past forty years, and prevalence is continuing to rise, thereby leading to serious implications for the sustainability of healthcare systems (NCD Risk Factor Collaboration, 2017). Research now shows that if a child is obese, the risk of them developing certain health conditions (e.g., non-alcoholic fatty liver disease) previously only seen amongst adults is increased (Daniels, 2006). Moreover, it has been found that children who are obese are more likely to be obese in adulthood, when compared with their normal weight counterparts (Daniels, 2006). Therefore, it is important to understand why the prevalence of childhood obesity is growing. The multi-dimensional nature of obesity makes identifying the causal factors difficult. However, it is well established that stress is positively associated with unhealthy food consumption and contributes to overweight and obesity in adults (Gibson, 2012; O'Connor, Jones, Conner, McMillan & Ferguson, 2008; O'Connor & Conner, 2011) and that individual differences in cortisol reactivity to stress play a role in stress-induced eating (Epel, Lapidus, McEwen & Brownell, 2001; Newman, Conner & O'Connor, 2007). However, relatively little is known about the effects of stress and cortisol reactivity on eating behaviour in children (Michels et al., 2013; O'Connor, 2018).

Therefore, this exploratory study aimed to explore the relationship between daily stressors (also known as daily hassles), daily mood and between-meal snacking in a sample of children and to investigate the feasibility of using a daily diary design in this age group. It was hypothesised that children who reported more daily hassles and more negative mood would also report eating more between-meal snacks on that day and these relationships will be moderated by cortisol reactivity to stress, such that children who exhibited greater cortisol reactivity to stress in the laboratory would report eating more between-meal snacks on days they encountered daily hassles and negative mood in naturalistic settings.

2. Method

2.1. Design and participants

This study used a repeated measures 7 day daily diary design. Ethical approval was obtained from the Departmental Research Ethics Committee (reference number: 17-0506). Twenty participants were recruited from a summer camp, an after-school club and by word of mouth (12 female, 8 male, *M*age: 9.45 years). Fifteen participants identified as being White, 2 participants identified as belonging to mixed/multiple ethnic groups and 3 participants identified as being Asian/Asian British. Seventeen children were identified as being healthy weight and three were identified as overweight. Neither participants nor their parents/caregivers were informed of the study aims prior to study commencement.

2.2. Study Materials and procedure

The study information pack contained: child and parent/caregiver information sheets, child and parent/caregiver consent forms, and a background questionnaire. The latter questionnaire included questions about demographics (e.g., age, weight, height) and medication use.

2.2.1. Study Day 1

Children's cortisol reactivity was individually tested in the laboratory in the afternoon, to control for the cortisol awakening response. After arriving in the laboratory, children were provided the opportunity to relax before taking part in the laboratory stress manipulation, the Trier Social Stress Test for Children (TSST-C; Buske-Kirschbaum et al., 1997). The TSST-C presents children with two tasks (one is a creative story task, the other is an arithmetic task) and was administered here as it was by Buske-Kirschbaum et al. (1997). During the TSST-C, participants were asked to give four saliva samples (to measure their cortisol levels) taken at: baseline, +10 minutes, +20 minutes and +30 minutes. Cortisol samples were collected from saliva using Salivettes (Sarstedt, UK) and were frozen at –20°C before being sent for assaying by Salimetrics. Cortisol levels were determined by using a competitive enzymelinked immunosorbent assay kit (ELISA) designed for analysing saliva. Intra-assay and weighted inter-assay coefficients of variation (CV) of the assay in the current study were 5.46% and 5.68% respectively.

2.2.2. Study Days 2-8

Participants were asked to complete one daily diary each evening fro 7 consecutive days before going to bed. Each daily diary asked about: the day's events, snacks consumed, their feelings and whether or not they took pictures of their snacks (with camera phones provided[1]). The events section contained 11 statements where participants had to specify whether that event had taken place. Ten statements were taken from the Children's Hassles Scale by Kanner, Feldman, Weinberger and Ford (1987), and one was created by the research team ('you could not do what you wanted to do').

Within the snacks question, 15 food/drink snacks were listed, and participants were asked to tick which had been consumed. The list contained 7 healthy (e.g., carrot or cucumber sticks) and 8 unhealthy snack items (e.g., chocolate) and had space to allow participants to report any snack (consumed) that had not been listed. Note both participants and parents/caregivers were informed that the snacks they needed to report were those that were consumed between meals and not during or immediately after.

In the feelings question, participants were asked how happy and sad they had been today (using a 5-point scale ranging from 'not at all' to 'extremely'). All participants that completed the study were given a £10 Love to Shop voucher.

2.3. Statistical Analysis

Data was analysed using the SPSS Statistics (Version 22) software and the Hierarchical Linear Modelling (HLM 7, Student Version 7) software. In HLM, the level 1 variables (e.g., daily hassles) were group mean centred and the level 2 variable (AUCg) was grand mean centred. Significant cross-level interactions were decomposed using Preacher and colleagues online simple slopes procedures (Preacher, Curran & Bauer, 2018). A small proportion of data was missing (4.87%), for which column mean values were used to replace missing data. All data were screened using boxplots and any outliers replaced using a truncation/winsorized method (whereby the outlier was replaced by the mean plus 3 standard deviations).

3. Results

3.1. Descriptive Statistics

Participants reported experiencing on average 2.75 (SD = 3.09) hassles per day and eating on average 5.21 healthy snacks (SD = 2.71) and 1.03 unhealthy snacks (SD = 0.83) per day. Participants' cortisol levels (operationalised as area under the curve with respect to the ground (AUCg); Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003) were within the normal range (baseline mean = 1.70 (SD = 0.75), +10 minutes mean = 1.60 (SD = 1.14), +20 minutes mean = 1.49 (SD = 1.14) and +30 minutes mean = 1.60 (SD = 1.22)) for similarly-aged healthy children (Michels et al., 2013). It is important to note there was a range in the total amount of cortisol secreted during the TSST-C (AUCg mean 47.36 (SD = 28.33) reflecting individual differences in cortisol reactivity to stress (cf., Newman et al., 2007).

3.2. Effects of daily hassles and mood on between-meal snacking

There were no significant effects of daily hassles, negative mood or positive mood on total snacks, healthy or unhealthy snacks consumed over the 7-day study period (see Table 1, β_{10}).

3.3. Moderating effects of cortisol reactivity to stress (AUCg) on the daily hassles/mood - between-meal snacking relationship

Four cross-level interactions were found suggesting that AUCg moderated the daily hassles/mood - snacking relationship (see Table 1, β_{11}). Specifically, AUCg was shown to influence the daily hassles – total snacks relationship (β = 0.008, p = 0.004) and the daily hassles – unhealthy snacking relationship (β = 0.004, *p* = 0.011). AUCg was also found to moderate the daily positive mood – unhealthy snacking relationship (β = -0.003, *p* = 0.046) and the daily negative mood – unhealthy snacking relationship (β = 0.002, *p* = 0.042).

The first interaction was decomposed using simple slopes analyses (see Figure 1, upper panel) and it was found that total hassles were positively related to snack consumption at low (β = 0.29, *p* = 0.04), moderate (β = 0.52, *p* = 0.02) and at high levels of AUCg (β = 0.74, *p* =0.02) with particularly strong relationships at high levels of daily stress.

[Insert Table 1 and Figure 1 about here]

When the second interaction for unhealthy snacks was decomposed, the results showed that total hassles were not significantly related to unhealthy snack consumption at low (β = 0.068, *p* = 0.17), moderate (β = 0.071, *p* = 0.16) or high (β = 0.074, *p* = 0.14) levels of AUCg. Similarly, decomposition of the third interaction found that daily positive mood was not significantly related to unhealthy snack consumption at low (β = -0.03, *p* = 0.45), moderate (β = -0.12, *p* = 0.13) or high (β = -0.20, *p* = 0.08) levels of AUCg. This suggests that these two interaction effects were only marginal because of a lack of significance following decomposition. Lastly, decomposition of the fourth interaction found that daily negative mood was significantly related to unhealthy snack consumption at low (β = 0.07, *p* = 0.03), moderate (β = 0.13, *p* = 0.01) and high (β = 0.18, p = 0.01) levels of AUCg, with stronger relationships apparent at higher levels of AUGg (see Figure 1, lower panel). This suggests that particularly children with high cortisol reactivity respond to their negative mood by consuming more unhealthy between-meal snacks compared to those with lower cortisol reactivity.

4. ***Discussion***

Three main findings emerged from the current study. First, there were no significant effects of daily stressors or mood on between-meal snacking when the sample was analysed as a whole. Second, cortisol reactivity to stress in the laboratory moderated the relationship between daily hassles and daily negative mood and snack intake in children in naturalistic settings. Third, daily diary design-based studies appear to be feasible and can be utilised in studies of children aged between 8 and 11 years old.

It was hypothesised that children who reported more daily hassles would also consume more snacks across the 7-day study period. However, the current findings did not support this hypothesis. Existing literature in adults suggests that the experience of daily hassles is associated with increased consumption of high fat, energy dense snacks as well as a reduction in vegetables and main meal consumption (Gibson, 2012; O'Connor et al., 2008; O'Connor & Conner, 2011). Moreover, in children, there is growing evidence to suggest that stress, more generally, is associated with unhealthy eating (Hill et al., 2018; Michels et al., 2013). Therefore, the current findings are surprising. A number of factors may account for the absence of the hypothesised relationships including the small sample size, the low frequency of daily hassles encountered by the children and the relatively short study time window (i.e., number of days examined). In addition, the observed null effects may also suggest that the effects of daily hassles may be more readily observable in some children than others (due to individual differences in past stress exposure, cortisol reactivity to stress, learned eating behaviours and the extent to which food/snack choices are under the control of parents/carers).

As hypothesised, we found that cortisol reactivity to stress in the laboratory moderated the relationship between daily hassles or daily negative mood and snack intake in children in naturalistic settings. This is a noteworthy finding as it confirms and extends earlier work which has shown that adults who exhibited larger cortisol responses to stress in the laboratory consumed significantly more between-meal snacks when they encountered stressors in the real world (Newman et al., 2007). The findings are also consistent with a previous laboratory-based study by Epel and colleagues, who showed that high cortisol reactors consumed more snacks during stress recovery than low reactors, especially high fat and sweet foods (Epel et al., 2001). The current findings also highlight the importance of daily negative mood (as well as daily hassles) in relation to between-meal snacking. Future research ought to investigate further the dynamics of the relationship between daily hassles and negative mood in the context of stress-eating processes. These results are also likely to have implications for future weight status. For example two studies of children and adolescents in the United States have provided evidence that greater cortisol reactivity to a laboratory stressor was linked to higher body mass index (BMI, Dockray et al., 2009) and greater energy intake soon after a stressor (Francis et al., 2013). However, it is unclear exactly how cortisol may influence food intake. O'Connor (2018) suggests a couple of possibilities. One is that cortisol initiates the release of neuropeptide Y, a known appetite stimulant. Another is that it is also conceivable that cortisol protects against the hypophagic effects of leptin. Moreover, it is also unknown why certain individuals (especially in children) are more reactive to stress in terms of cortisol output. Further research ought to attempt to replicate the current findings using a larger sample size and adopting a multi-level, longitudinal approach that explores the interplay between psychological, biological and environmental factors over time.

Finally, the current study also found that daily diary designs appear to be feasible for use in studies of children investigating stress and eating. However, we note that researchers ought to formally evaluate acceptability and feasibility in future studies using a larger sample. Nevertheless, past research has been criticised for its over-reliance on cross-sectional or laboratory-only methodologies (O'Connor & Conner, 2011). In contrast, the current study design provided initial support for using daily diaries in this age group. Future research ought to adopt approaches that allow researchers to identify momentary patterns and changes in stressors and behaviours in order to improve understanding of the causal relations between these important study variables.

Footnote

1. The reason that we decided to provide participants a camera phone was twofold. Firstly, we wanted the phone to act as a tool to help increase compliance to the study protocol. Secondly, providing participants with camera phones acted as a means of trying to retain the interest of participants because asking them to take photos using the phone in this way provided them with a fun and interesting task. Although we encouraged participants to take photos, we emphasised that it was more important for them to note down the between-meal snacks they consumed, and not to worry about any photographs that they may have forgotten to take. We understood that undertaking this study for 7 days would be challenging for participants.

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Author Contributions

RM, DO and MC identified a gap in the literature and designed this study. RM recruited participants and undertook data collection. RM conducted data analysis with supervision from DO and MC. RM, DO and MC wrote this manuscript and all authors are willing to be accountable for this piece.

References

Buske-Kirschbaum, A., Jobst, S., Wustmans, A., Kirschbaum, C., Rauh, W., Hellhammer, D., 1997. Attenuated free cortisol response to psychosocial stress in children with atopic dermatitis. *Psychosom. Med.,59(4),* 419-426.

Daniels, S.R., 2006. The consequences of childhood overweight and obesity. *The Future of Child., 16(1),* 47-67. https://doi.org/10.1353/foc.2006.0004

Dockray, S., Susman, E.J., Dorn, L.D., 2009. Depression, cortisol reactivity and obesity in childhood and adolescence. *J Adolesc Health*, 45, 344-350.

Epel, E., Lapidus, R., McEwen, B., Brownell, K., 2001. Stress may add bite to appetite in women: A laboratory study of stress-induced cortisol and eating behavior. *Psychoneuroendocrinology*, 26, 37-49.

Francis, L.A., Granger, D.A., Susman, E.J., 2013. Adrenocortical regulation, eating in the absence of hunger and BMI in young children. *Appetite*, 64, 32-38.

Gibson, E.L., 2012. The psychobiology of comfort eating: implications for neuropharmacological interventions. *Behav pharmacol, 23 (5 and 6),* 442-460. https://doi.org/10.1097/FBP.0b013e328357bd4e

Hill, D.C., Moss,R.H., Sykes-Muskett, B., Conner, M., O'Connor, D.B., 2018. Stress and eating behaviors in children and adolescents: Systematic review and meta-analysis. *Appetite, 123,* 14-22. https://doi.org/ 10.1016/j.appet.2017.11. 109

Kanner, A.D., Feldman, S.S., Weinberger, D.A., Ford, M. E., 1987. Uplifts, hassles, and adaptational outcomes in early adolescents. *J Early Adolesc, 7(4),* 371-394. https://doi.org/10.1177/0272431687074002

Michels, N., Sioen, I., Braet, C., Huybrechts, I., Vanaelst, B., Wolters, M., De Henauw, S., 2013. Relation between salivary cortisol as stress biomarker and dietary pattern in children. *Psychoneuroendocrinology, 38(9),* 1512-1520. https://doi.org/10.1016/j.psyneuen.2012.12.020

NCD Risk Factor Collaboration, 2017. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet, 390, 2627-42.

Newman, E., Conner, M., O'Connor, D.B., 2007. Daily hassles and eating behaviour: The role of cortisol reactivity status. *Psychoneuroendocrinology, 32, 2,* 125-132. https://doi.org /10.1016.jpsyneuen.2006.11.006

O'Connor, D.B., 2018. Effects of stress and cortisol on eating behaviour in children and adolescents. In P. N. Murphy (Eds.), *The Routledge International Handbook of Psychobiology* (pp. 179-192). Location: Psychology Press.

O'Connor, D.B., Conner, M., 2011. Effects of stress on eating behavior. Chapter in *Handbook of Stress Science: Psychology, Biology and Health*. Richard J. Contrada and Andrew Baum (Eds). New York: Springer Publishing Company. pp 275-286. ISBN 978-0-8261-1471-6

O'Connor, D.B., Jones, F., Conner, M., McMillan, B., Ferguson, E., 2008. Effects of daily hassles and eating style on eating behavior. *Health Psychol, 27(1).* https://doi.org/10.1037/0278-6133.27.1

Preacher, K.J., Curran, P.J., Bauer, D.J., 2018. Simple intercepts, simple slopes, and regions of significance in HLM 2-way interactions. Retrieved from http://www.quantpsy.org/interact/hlm2.htm

Pruessner, J.C., Kirschbaum, C., Meinlschmid, G., Hellhammer, D.H., 2003. Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology, 28(7),* 916-931. https://doi.org/10.1016/S0306-4530(02)00 108-7

Figure 1. The relationship between daily hassles and total snacking behaviours (upper panel) and daily negative mood and unhealthy snacking (lower panel) at different levels of cortisol reactivity (AUCg)

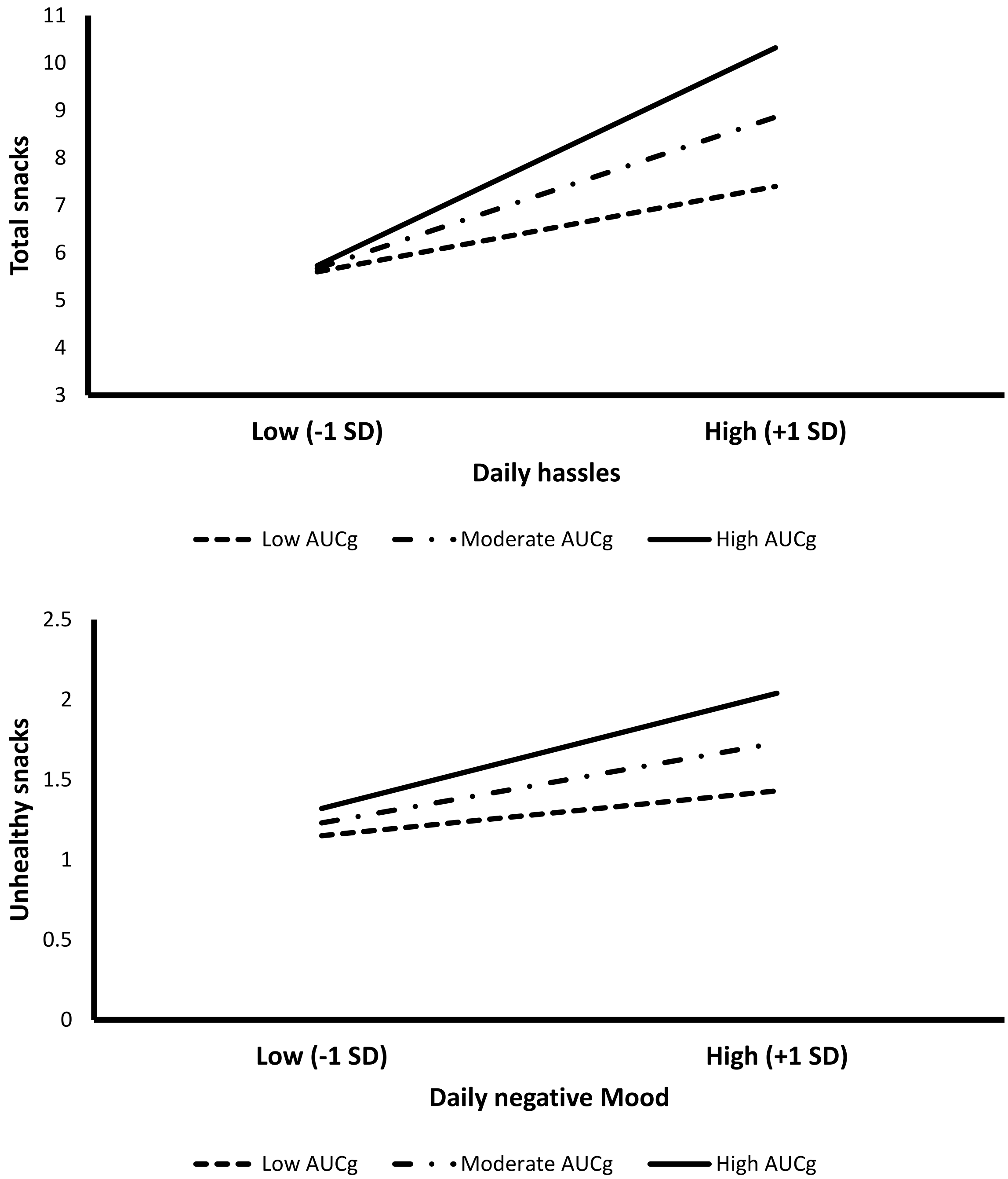

Table 1. Examining the moderating effects of AUCg on the daily stress/mood-eating relationships.

	Total snacks				Healthy snacks				Unhealthy snacks			
	Symbol	Coefficient	SE	P value	Symbol	Coefficient	SE	P value	Symbol	Coefficient	SE	P value
Intercept	β_{00}	5.607	0.618	<.001	β_{00}	5.214	0.505	<.001	β_{00}	1.029	0.125	<.001
AUCg	β_{01}	0.005	0.018	0.771	β_{01}	-0.004	0.014	0.807	β_{01}	-0.001	0.004	0.836
Level 1 slope: Total hassles	β_{10}	0.138	0.018	0.096	β_{10}	-0.051	0.043	0.247	β_{10}	0.067	0.004	0.178
Total hassles * AUCg	β_{11}	0.008	0.003	0.004	β_{11}	0.001	0.002	0.395	β_{11}	0.004	0.001	0.011
Intercept	β_{00}	5.607	0.618	<.001	β_{00}	5.214	0.505	<.001	β_{00}	1.029	0.125	<.001
AUCg	β_{01}	0.005	0.018	0.771	β_{01}	-0.004	0.014	0.807	β_{01}	-0.001	0.004	0.836
Level 1 slope: Positive mood	β_{10}	0.211	0.184	0.267	β_{10}	0.188	0.129	0.163	β_{10}	0.027	0.024	0.281
Positive mood * AUCg	β_{11}	-0.001	0.005	0.867	β_{11}	0.002	0.004	0.587	β_{11}	-0.003	0.001	0.046
Intercept	β_{00}	5.607	0.618	<.001	β_{00}	5.214	0.505	<.001	β_{00}	1.028	0.125	<.001
AUCg	β_{01}	0.005	0.018	0.771	β_{01}	-0.004	0.014	0.807	β_{01}	-0.001	0.004	0.836
Level 1 slope: Negative mood	β_{10}	-0.069	0.185	0.713	β_{10}	-0.127	0.114	0.280	β_{10}	0.033	0.023	0.179
Negative mood * AUCg	β_{11}	0.002	0.006	0.675	β_{11}	0.001	0.004	0.907	β_{11}	0.002	0.001	0.042