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Mood Dysregulation and Affective Instability in Emerging Adults with Childhood Maltreatment: An Ecological Momentary Assessment Study

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Abstract

Childhood maltreatment increases risk for mood, anxiety, substance use and personality disorders and is associated with alterations in structure, function and connectivity of brain regions involved in emotional regulation. We sought to assess whether maltreatment was specifically associated with disturbances in positive or negative mood regulation. Ecological momentary ratings were collected with a wristwatch-like device with joy-stick (Seiko ecolog) approximately six times per day over a week in 60 unmedicated participants (22 control, 38 maltreated, 18-25 years old). Forty-five percent of maltreated subjects had a history of major depression but all were currently euthymic. Principal component analysis with varimax rotation was used to provide orthogonal measures of positive and negative valence, which were analyzed for indices of variability,

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Conflict of Interest

Ann Polcari and Garrett M. Fitzmaurice report no conflicts of interest. Martin H. Teicher sits on the scientific advisory board and receives royalties (through an institutional licensing agreement) and consulting fees from BioBehavioral Diagnostic Company, which is now part of Pearson, for his role in developing the Quotient ADHD system, which is unrelated to the present work. Over a decade ago he served as a consultant to Copley Pharmaceuticals, Watson Pharmaceuticals, Sepracor and Sention. He also received funding from Copley, Sepracor, GlaxoSmithKline, Optax, Kodak, CNS Response, and The Litebook Company. Steven B. Lowen has received consulting fees from BioBehavioral Diagnostic Company, Brainpaint, Neurometrika and University of Pennsylvania, which are unrelated to the present work. Martin H. Teicher, Steven B. Lowen and Kyoko Ohashi hold US patents related to assessment of psychiatric disorders that are unrelated to the present work.

Contributors

Martin H. Teicher, Kyoko Ohashi and Ann Polcari *designed and performed research*. Martin H. Teicher, Kyoko Ohashi, Steven B. Lowen and Garrett M. Fitzmaurice *analyzed data or consulted on data analysis*. Martin H. Teicher, Kyoko Ohashi, Steven B. Lowen, Ann Polcari and Garrett M. Fitzmaurice *wrote or edited the paper*.

circadian rhythmicity and persistence, using linear and non-linear hierarchical modeling and Hurst analysis. Groups did not differ in mean levels of positive or negative affect. Maltreated subjects had increased variability and circadian and hemicircadian abnormalities in ratings of positive but not negative affect. Conversely, they had higher estimated Hurst exponents for negative but not positive affect ratings indicating a greater degree of persistence. Abnormalities in variability, rhythmicity and persistence were present in both maltreated subjects with and without histories of major depression. These findings suggest that both positive and negative valence systems may be dysregulated in individuals with childhood maltreatment. However the nature of the dysregulation appears to differ fundamentally in these domains, as positive mood ratings were more variable and negative ratings more persistent.

Graphical Abstract

Keywords

Abuse and neglect; maltreatment; mood; depression; anxiety; ecological momentary assessment; experience sampling

INTRODUCTION

Childhood maltreatment has been shown in meta-analyses to be a major risk factor for mood and anxiety disorders (Norman et al. , 2012, Teicher and Samson, 2013). According to the adverse childhood experiences study, maltreatment-related early adversity accounted for about 54% of the population attributable risk (**PAR**) for depression (Anda et al. , 2002) and 67% of the PAR for suicide attempts (Dube et al. , 2001). Similarly Green et al., (2010) reported that childhood adversity accounted for 32% of the PAR for anxiety disorders. Childhood maltreatment is also associated with alterations in structure, function, and connectivity of brain regions involved in emotional regulation, including the amygdala, hippocampus, ventromedial prefrontal cortex, dorsolateral prefrontal cortex, anterior insula and anterior cingulate (see Teicher and Samson (2013) for recent review). We recently reported in a large-scale cortical structural network analysis that the main consequence of maltreatment was a reduction in the centrality (central importance) of the anterior cingulate and temporal pole along with increased centrality of the anterior insula and precuneus. We hypothesized that alterations in centrality of anterior cingulate and insula would result in deficient emotional regulation (Stevens et al. , 2011). Further, alterations in centrality of temporal pole, insula and precuneus may affect the subject's ability to accurately interpret thoughts and intentions of others (Ross and Olson, 2010), their sensitivity to social rejection (Eisenberger, 2012), and their self-awareness (Cavanna and Trimble, 2006, Craig, 2009).

This in turn may play a role in reducing self-esteem and self-efficacy, resulting in distorted attribution and emotional response to daily events.

Curiously, relatively few studies have explored the association between childhood maltreatment and mood dysregulation or affective instability. In one of the better studies, Goodman and colleagues (2003) found a significant association between maltreatment history and measures of affective instability in patients with personality disorders using rating scales. Pietrek et al (2012), in a laboratory study, found that subjects with depression or borderline personality disorder had an impaired ability to down regulate response to emotional pictures, as assessed using magnetoencephalography. This deficit was observed in the subgroup of subjects with, but not without, high exposure to childhood maltreatment.

An alternative technique for evaluating emotional regulation is ecological momentary assessment (**EMA**) or experience sampling (Csikszentmihalyi and Larson, 1987, Shiffman et al. , 2008). This is a method for repeatedly acquiring self-reported information about an individual's subjective state at the moment of recording to provide a time series of instantaneous status reports collected without recall bias during the course of their daily life (Csikszentmihalyi and Larson, 1987, Shiffman, Stone, 2008). Theoretically, EMA has numerous advantages over rating scales as subjects record their mood state at the moment rather than endeavoring to recall how it was and how it fluctuated over days to weeks (Ebner-Priemer and Trull, 2009, Shiffman, Stone, 2008). Further, multiple records collected over an extended time series can be analyzed in a variety of ways to assess dynamic change (Ebner-Priemer and Trull, 2009, Shiffman, Stone, 2008).

Wonderlich et al (2007) used EMA to assess the potential effects of childhood abuse on affective stability in subjects with bulimia nervosa. They found that emotional abuse was significantly associated with higher variability in anger–hostility ratings and higher levels of negative affect (Wonderlich, Rosenfeldt, 2007), but physical and sexual abuse were not.

The aim of the present study was to assess the potential impact of childhood maltreatment on mood regulation in maltreated individuals selected from the community without regard to psychopathology. Studies that recruit maltreated subjects with psychopathology may overestimate the consequences of maltreatment by selecting the most adversely affected individuals. Conversely, studies that specifically select maltreated individuals without psychopathology may bias results in the opposite direction. Our goal was to select a sample based on exposure history that would contain both susceptible subjects with histories of psychopathology as well as more resilient subjects without psychiatric histories to provide a more balanced assessment of the overall consequences of maltreatment.

MATERIAL AND METHODS

Subjects

This study was approved by the McLean Hospital IRB. All subjects provided informed written consent. Methods for recruitment have been described in detail (Teicher et al. , 2012). Briefly, we recruited unmedicated 18-25 years olds from the community through advertisements. Potentially interested subjects were given access to a HIPAA-compliant

online enrollment system that collected extensive information about their developmental and medical history and degree of exposure to various forms of childhood maltreatment. Subjects with premature birth or birth complications, maternal substance abuse during pregnancy, or medical disorders that could affect brain development were excluded as were those who had experienced multiple unrelated forms of adversity such as natural disasters or motor vehicle accidents. Subjects were required to be free from neurological disease or significant head trauma. Subjects selected for interview either had no history of childhood maltreatment, reported exposure to a specific type of maltreatment (e.g., parental verbal abuse) or had exposure to one or more maltreatment-related events that fulfilled the DSM-IV A1 and A2 criteria for a traumatic experience. Sixty subjects meeting criteria underwent EMA as per protocol. All subjects tested negative for drug use by urinalysis and for recent alcohol consumption by breath test. Subjects were paid \$20 for completing the online assessment, \$50 per interview and assessment session (typically two 4-hour sessions) and \$25 for EMA.

Assessments

Structured Clinical Interviews for DSM-IV Axis I and II psychiatric disorders (SCID) (First et al. , 1997) were used for diagnoses. Maltreatment was assessed using the 100-item semi-structured Traumatic Antecedents Interview (TAI) (1989), which evaluates exposure to physical or sexual abuse, witnessing violence, physical or emotional neglect, significant separations or losses, verbal abuse, or parental discord (Roy and Perry, 2004). Subjects were also evaluated using both self-report and interview versions of the Conflict-Tactic Scales (CTS) (Straus et al. , 1998). Information from the TAI and CTS were used to determine their ACE score (Anda et al. , 2006, Felitti et al. , 1998) based on criteria delineated in Anda et al (2007). Degree of exposure to maltreatment was also quantified using the childhood trauma questionnaire (CTQ) (Bernstein et al. , 1997, Bernstein et al. , 1994), which is a 28-item self-report inventory that provides a brief, reliable, and valid screen for histories of abuse and neglect.

Kellner's symptom questionnaire (SQ) was used to provide self-report ratings of psychiatric symptom severity, during the current week, in four domains (depression, anxiety, anger-hostility, somatization) (Kellner, 1987). The symptom subscales have excellent test-retest reliability and correlate well with Hamilton depression rating scale (Kellner, 1987). We have previously found that SQ scores were substantially increased in individuals reporting exposure to physical, sexual and emotional abuse (Teicher et al. , 2006) as well as peer verbal abuse (Teicher et al. , 2010).

Symptoms of 'limbic irritability', were assessed using the limbic system checklist (LSCL-33) (Teicher et al. , 1993), which was created to evaluate the frequency with which subjects experience symptoms often encountered as ictal temporal lobe epilepsy phenomena, as described by Spiers et al. (1985). Limbic irritability' is the symptom cluster most strongly affected by exposure to childhood maltreatment in our studies (Teicher and Parigger, 2015, Teicher, Samson, 2006, Teicher, Samson, 2010, Teicher and Vitaliano, 2011), and limbic irritability was found, in one study, to mediate the risk between childhood maltreatment and symptoms of depression and dissociation (Dackis et al. , 2012).

Dissociation was assessed using the Dissociative Experience Scale (DES) (Bernstein and Putnam, 1986), which consists of 28 questions and Likert lines assessing the frequency of occurrence of various dissociative experiences in an individual's daily life. DES scores are also strongly associated with exposure to multiple forms of abuse (Teicher, Samson, 2006) as well as peer verbal abuse (Teicher, Samson, 2010).

Low income and poverty may be important developmental risk factors. Young adult subjects were often uncertain about parental income while they were growing up. However, they were well aware of the degree of *perceived financial sufficiency*, or stress they experienced during this time. This was rated from 1 (much less than enough money for our needs) to 5 (much more than enough money for our needs). Perceived financial stress and parental education were used as indices of socioeconomic status as studies suggest that separate factors may provide more meaningful covariates than a composite score (Duncan and Magnuson, 2003). Certified mental health clinicians (Ph.D. psychologists, clinical nurse specialists) conducted the assessment and evaluation interviews.

Ecological Momentary Assessment

Mood ratings were collected using a watch-type computer (Ruputer, ECOLOG, 42 g; Seiko Instruments Inc., Tokyo, Japan), with 20 mm × 30 mm LCD screen and joystick and buttons as input devices, plus a built in actigraph, that was a forerunner to current sport fitness watches (Kim et al. , 2013a, Kim et al. , 2013b). Subjects were provided with appropriate instructions and practiced using the device in the laboratory. The device was set up to collect four signaled recordings per day at semi-random, roughly equispaced times, programmed to occur between their individual wake and sleep times. They were prompted by the device to complete the questionnaires by a beep signal. If they could not enter the recordings when the device signaled, they were allowed to postpone the recordings twice for 15 min each time. Subjects were also instructed to initiate entries at the time of awakening and at bedtime by selecting these items from the menu. Subjects could also add additional ratings if a noteworthy event occurred.

Subjects used the joystick to provide Likert-like responses to 10 items from the PANAS (Watson et al. , 1988) (i.e., Positive Affect: alert, determined, enthusiastic, excited, inspired; Negative Affect: afraid, distressed, nervous, scared, upset), plus six negative somatic states (dizzy-lightheaded, face flushed, hard to breathe, heart racing, hot, wobbly knees) that are important clinical symptoms of negative affect omitted in the PANAS and PANAS-X. As is customary (Watson, Clark, 1988), principal component analysis (**PCA**) with varimax rotation was used to provide rotated measures of positive and negative affect from the 1469 recorded ratings of the 16 individual items. PCA z-scores were rescaled across all subjects to mean 50 and standard deviation 10 for convenience.

Statistical Analyses

Data analyses were conducted in R (R Development Core Team, 2013) and made use of the following specific packages (*car* (Fox and Weisberg, 2011), *ggplot2* (Wickham, 2009), *nlme* (Pinheiro et al. , 2015) and *psych* (Revelle, 2015)). Differences between maltreatment groups were assessed using analysis of covariance or mixed effects models. As the two

groups differed modestly, but significantly, in age and financial sufficiency during childhood, these were including as potential confounding factors in analyses.

Analysis of EMA ratings is complex as they consist of repeated measures nested within subjects that are acquired at semi-random times with occasional missing values. Mixed effects models (also called Hierarchical or Multi-Level models) provide an appealing strategy for analyzing these measures as this method can readily accommodate repeated measures collected at different times and with missing values (Bolger et al. , 2003, Jahng et al. , 2008, Schwartz and Stone, 2007). Further, this approach also facilitates modeling of the within group covariance structure as mood ratings are likely autoregressive with adjacent ratings correlating to a greater degree than more distal ratings. Mixed effects models also allow a direct assessment of whether variability is heterogeneous across groups.

Linear mixed effects models were used to determine whether maltreated and unexposed subjects differed in mean levels of positive and negative affect, and whether subjects in these groups differed in the variability of their ratings (i.e., was the model better fit by using separate variance structure for the two groups). In secondary/exploratory analyses, we also examined whether the effects of maltreatment differed by gender, whether there were differential effects of exposure to specific types of abuse and whether there were differences between maltreated subjects with and without histories of major depression.

Non-linear mixed effects models were used to analyze the potential effects of childhood maltreatment on circadian fluctuations in positive and negative affect. A 2-oscillator cosinor model was used that included 24-hour circadian and 12-hour hemicircadian amplitude and phase components (Mikulich et al. , 2003, Teicher and Barber, 1990).

The Hurst exponent (**H**) provides an index of dependence or “long-term memory” in a time series. Hurst developed this metric to help determine the optimum size for the Aswan Dam given the dramatic changes that occur across time in Nile river levels (Hurst, 1951), and this has become a widely used metric in physical, biological and psychological sciences . Briefly, H ranges from 0 – 1. Completely random series have $H = 0.5$. Series with $H > 0.5$ show increasing degrees of persistence, which is indicative of a time series with long-term positive autocorrelation, meaning that a high value will likely be followed by another high value and that subsequent values will also tend to be high. Conversely, series with $H < 0.5$ show anti-persistence, which is indicative of switching between high and low values in adjacent pairs.

To calculate H we created a program that binned each subject's positive and negative affect time series into equispaced intervals. The program determined, for each subject, the optimal start time and interval duration that provide, on balance, the maximum number of bins with single EMA measures and the fewest number of vacant bins. H was then calculated by combining two techniques for estimating H on short time series. The method of Flynn and Pereira (2013), provided an increased number of points for determination of Hurst's rescaled range, which was then calculated using a non-linear formula from Hamed (2007), with bias adjustment for series length, that provides estimates of H that are remarkably similar to values obtained on longer series using wavelets.

Hypotheses

We predicted that individuals with histories of maltreatment would have lower mean levels of positive affect, higher mean levels of negative affect, increased variability in ratings of both positive and negative affect, and greater persistence of negative mood states.

RESULTS

The sample population consisted of 22 unexposed controls and 38 maltreated individuals who were all healthy and unmedicated. The subjects were predominantly white (91% unexposed group, 80% maltreated group, $\chi^2 = 4.1$, $df=2$, $p>0.13$) and middle class. As indicated in Table 1, male / female ratios were nearly identical, and the groups did not differ significantly in the socioeconomic metric of parental education, but differed slightly in their degree of perceived financial sufficiency during childhood. Unexposed subjects were, on average, 1.6 years younger than the maltreated subjects. As expected, maltreated subjects had greater exposure to childhood adversity (ACE score), and elevated ratings of emotional abuse, physical abuse, and emotional neglect on the CTQ. Maltreated subjects also reported greater exposure to parental verbal abuse and less frequent exposure to parental verbal affection (Polcari et al. , 2014).

Overall, 45% of the maltreated subjects had a history of major depressive disorder (**MDD**) and 35% had a history of one or more anxiety disorders versus 5% of unexposed subjects (Fisher exact, $p < 0.002$ and $p < 0.03$, respectively). Nevertheless, at the time of assessment maltreated subjects had relatively few clinical symptoms, and did not differ significantly from unexposed controls in ratings of depression, anxiety, somatization, anger-hostility or dissociation (Table 2). Further, maltreated subjects were essentially euthymic at the time of assessment as none of the maltreated subjects had clinically-significant ratings on the SQ (Kellner, 1987), DES (Tutkun et al. , 1998) or LSCL33 (Teicher and Vitaliano, 2011). Maltreated subjects and unexposed controls were equally compliant with the EMA procedure, completing $79.1\% \pm 11.5\%$ and $78.7\% \pm 10.6\%$ ($F_{1,56} = 0.62$, $p > 0.4$) of the ratings, respectively.

Positive affect ratings were best fit by a linear mixed effects model with heteroscedastic variance and an autoregressive correlation structure. The variability in positive affect scores was heterogeneous across groups and was 26.3% greater in the maltreated subjects than controls (likelihood ratio (LR) test = 36.28, $df = 2$, $p < 10^{-8}$). However, there were no differences between groups in levels of positive affect ($F_{1,56} = 0.02$, $p > 0.8$). Figure 1 provides an illustration of mean group differences in variability of EMA ratings of positive affect in maltreated versus unexposed subjects.

Overall, variability in positive affect was increased by 20% in individuals exposed to single types of maltreatment and by 45% in those exposed to multiple types of maltreatment that fulfilled A1 and A2 criteria for a traumatic experience. Both the single and multiple exposure groups differed significantly from unexposed controls and from each other in variability of positive affect

Negative affect ratings were also best fit by a linear mixed effects model with an autoregressive correlation structure. Variability in negative affect scores was 8.7% greater for the maltreated group, but including additional terms in the model to account for group differences in variability did not significantly improve the fit (LR test = 4.58, $df = 2$, $p < 0.07$), so the null hypothesis of equal variance between groups could not be rejected. Maltreated and unexposed subjects did not differ significantly in mean levels of negative affect ($F_{1,56} = 2.29$, $p > 0.13$).

Interestingly, subjects who were exposed specifically to emotional maltreatment had a 14% increase in variability of negative affect ratings versus only a 2% increase in subjects exposed to other types of maltreatment including A1 traumatic events (emotional maltreatment versus all others LR Test = 9.37, $df = 2$, $p < 0.005$).

Non-linear mixed effects models showed that ratings of positive affect had a significant circadian pattern ($F_{1,1375} = 45.43$, $p < 10^{-10}$). There were no significant group differences in mesor (mean 24 hour activity; $F_{1,58} = 0.45$, $p > 0.5$) or circadian amplitude ($F_{1,1375} = 0.5748$, $p > 0.4$). However, the 12 hour hemicircadian amplitude was significantly increased in maltreated subjects ($F_{1,1375} = 8.25$, $p < 0.005$). Non-linear mixed effects cosinor models of negative affect did not show evidence of significant circadian ($F_{1,1374} = 0.68$, $p > 0.4$) or hemicircadian ($F_{1,1374} = 2.15$, $p > 0.14$) components, and there were no group differences in mesor, circadian amplitude or hemicircadian amplitude.

Hurst rescaled range analyses indicated that mood ratings had positive persistence. Maltreatment was associated with a 45% increase in persistence of negative affect ($F_{1,56} = 9.54$, $p < 0.004$), but no difference in persistence of positive affect ($F_{1,56} = 0.09$, $p > 0.7$). Figure 2 provides an illustration of how group differences in persistence of EMA ratings of negative affect may appear based on the most representative cases.

Exploratory analyses did not reveal any significant interactive effects between gender and maltreatment in terms of levels of positive affect ($F_{1,56} = 0.09$, $p > 0.7$), levels of negative affect ($F_{1,56} = 3.27$, $p < 0.08$) or persistence of negative affect ($F_{1,52} = 1.24$, $p > 0.2$). Overall, differences between maltreated and unexposed subjects appeared as discernible in males as in females in this modest size sample.

An exploratory analysis was also conducted to provide a preliminary test of the hypothesis that susceptible maltreated subjects who developed major depression following exposure (MAL_MDD+, $n = 17$) would show a greater degree of affective instability than more resilient (or less exposed) subjects who did not (MAL_MDD-, $n = 21$). Briefly, MAL_MDD+ subjects reported a greater degree of exposure to emotional and sexual abuse than MAL_MDD- subjects. Nevertheless, there were few statistically discernible differences between these subgroups. Variability in positive affect ratings were 23% and 30% greater than unexposed controls in MAL_MDD- and MAL_MDD+ groups, respectively. However, this difference between the two maltreated groups was not statistically significant (LR test = 1.46, $df = 2$, $p > 0.4$). The Hurst exponent for persistence of negative affect was also increased by 45% and 38% in MAL_MDD- and MAL_MDD+, respectively, and this difference was not significant (LR test = 0.55, $df = 2$, $p > 0.8$).

There were however some differences between MAL_MDD– and MAL_MDD+ in circadian regulation of positive affect. Compared to unexposed controls MAL_MDD– subject had a significant increase in hemicircadian amplitude ($t_{1371} = 3.57$, $p < 0.004$), and alterations in phase angle of both the circadian ($t_{1371} = 253.47$, $p < 10^{-16}$) and hemicircadian ($t_{1371} = -10.77$, $p < 10^{-16}$) components. MAL_MDD+ subjects had significant alterations in hemicircadian phase ($t_{1371} = 8.17$, $p < 10^{-14}$). Figure 3 illustrates the difference between groups in their circadian and hemicircadian composite waveforms. Note that MAL_MDD– had a higher morning than evening pattern of diurnal mood fluctuations whereas MAL_MDD+ subjects had reduced levels of positive affect midday and a higher evening than morning diurnal mood pattern.

DISCUSSION

Childhood maltreatment was associated with increased variability and abnormal circadian fluctuations in positive affect and increased persistence of negative affect. These findings are interesting in several ways. First, there were relatively robust differences between maltreated subjects and unexposed controls in regulation of positive and negative affect (e.g., Cohen's $d = 0.84$ for Hurst analysis of negative affect) even though there were no significant differences between these two groups in current symptoms of anxiety, depression, somatization or anger-hostility. Lack of group differences in symptoms of depression and anxiety are consistent with the absence of group differences in mean levels of positive or negative affect. These findings suggest that abnormalities in mood regulation and affective stability are discernible in maltreated individuals even when they appear to be relatively euthymic.

Second, results of exploratory analyses indicated that MAL_MDD– and MAL_MDD+ groups had comparable disturbance in their regulation of positive and negative affect. If regulatory abnormalities were significantly stronger in MAL_MDD+ then we would have suggested that they could be trait markers for MDD. The present findings suggest instead that they are sequelae of exposure to childhood maltreatment.

This finding fits with recent observations that childhood maltreatment is associated with enduring alterations in brain morphology and function in individuals with and without psychopathology. For example, we reported an inverse relationship between severity of exposure to childhood maltreatment and hippocampal subfield volumes, but this relationship was not mediated by history or symptoms of MDD or post-traumatic stress (Teicher, Anderson, 2012). Similarly, Opel and colleagues (2014) observed a nearly identical association between severity of childhood maltreatment and degree of hippocampal volume reduction in subjects with MDD and subjects without psychopathology. Maltreatment-related alterations in amygdala response to affective stimuli have also been observed to occur to children (McCrory et al. , 2011) and adults (Dannlowski et al. , 2012, van Harmelen et al. , 2012) without psychopathology.

Hence, these findings suggest that childhood maltreatment may impact the structural and functional development of the limbic system even in the absence of diagnosable psychopathology. Sixty-five percent of the participants in this studied were neuroimaged

and included along with other subjects in the previously discussed study of maltreatment and reduced hippocampal subfield volume (Teicher, Anderson, 2012). One possibility is that compensatory alterations enable resilient and recovered subjects to maintain a reasonable degree of mental health. However, this may be a fix not a cure, and abnormalities in their capacity to regulate positive and negative affect may be a subtle indication of compensation. It will be important in future studies to evaluate positive and negative affect regulation in maltreated individuals who are more symptomatic.

These findings are also interesting as they indicate that positive and negative affects were dysregulated in distinctly different ways in maltreated individuals. This is consonant with our awareness that positive and negative valence systems involve distinct but overlapping neural circuits (Dillon et al. , 2014). Understanding how these circuits are dysregulated may help us discern how the different components of these circuits interact in healthy, impaired and recovered individuals.

Key limitations of this study include modest sample size, absence of maltreated subjects who were currently anxious or depressed and relatively brief monitoring period. Longer time series provide more accurate estimates of H, and our observation of increased persistence of negative affect is a novel finding that requires replication.

Although we've interpreted differences in mood variability and persistence as signs of affective instability we cannot rule out the possibility that situational differences played a role, as victims of abuse are more likely to be re-victimized (Finkelhor et al. , 2007). However, we do not expect that there were major between group differences in degree of exposure to negative versus positive events during the monitoring period as there were no group differences in mean levels of positive or negative affect.

Reliance on retrospective self-report of maltreatment is also a limitation, though this needs to be put into perspective. Concerns about the veracity of self-report stem largely from the false/recovered memory debate (Berger, 2002, Brown, 1995, Porter et al. , 1999), which does not deny that abuse occurs but disputes the capacity of individuals to fully repress then recover seminal memories. Interestingly, recent research suggests that discontinuous memories of sexual abuse may be as verifiable as continuous memories, but only if the discontinuous memories were recalled unexpectedly outside of therapy (Geraerts et al. , 2007). This is not a relevant issue as all participants had persistent memories. Additional concerns include memory impairment associated with psychopathology, and mood-congruent memory biases. Brewin et al (1993), in their comprehensive review, found scant evidence to support these criticisms. Adults tend to minimize exposure on retrospective report (Shaffer et al. , 2008, Williams, 1994). Hence, retrospective exposure rates are lower than prospective rates, suggesting a problem with false negative but not false positive reports. Modern instruments for assessing maltreatment focus on the occurrence of specific events rather than attitude towards events, show impressive test-retest reliability and absence of negative attribution bias (Teicher and Parigger, 2015). Indeed, self-reported exposure to maltreatment has been found to be consistent over years even in psychotic individuals and not significantly influenced by the severity of psychotic or depressive symptoms (Fisher et al. , 2011).

Neurobiology also provides convergent support, as unbiased whole brain analyses delineate alteration in visual cortex (Tomoda et al. , 2012) and visual-limbic pathway (Choi et al. , 2012) in adults witnessing domestic violence, in auditory cortex (Tomoda, Polcari, 2012) and auditory pathways (Choi, Jeong, 2012) in adults reporting exposure to parental verbal abuse, and in genital representation area of somatosensory cortex in women reporting childhood sexual abuse (Heim et al. , 2013). Hence, there is forensic/anatomical evidence at the group level supporting the veracity of self-report regarding type of maltreatment experienced.

Overall, the present study identified significant abnormalities in the regulation of positive and negative affect in maltreated subjects selected from the community who were unaware of our entry requirements, and who were at the time of assessment relatively asymptomatic. These findings lend credence to neurobiological studies showing morphometric and functional abnormalities in maltreated individuals without psychopathology and suggest that even relatively resilient and recovered individuals with histories of childhood maltreatment have significant affective regulatory sequelae that likely place them at risk for future episodes of anxiety and depression.

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Highlights

- Maltreated young adults had increased variability in positive affect ratings
- Maltreated young adults had increased persistence in negative affect ratings
- Maltreated participants with or without depressive histories had comparable abnormalities

1.

Illustration of group differences in variability of positive affect in unexposed and maltreated subjects. Magnitude and timing of fluctuations was derived from the two subjects who most closely represented their respective group means for degree of variability in positive affect and scaled to accurately convey mean group values for overall levels of positive affect.

2.

Illustration of group differences in degree of persistence (Hurst exponent) in negative affect in unexposed and maltreated subjects. Magnitude and timing of fluctuations was derived from the two subjects who most closely represented their respective group means for degree of persistence in negative affect and scaled to accurately convey mean group values for overall levels of negative affect.

Diurnal Fluctuations

3.

Composite waveforms showing circadian and diurnal variations in positive affect ratings in unexposed controls and maltreated subjects with (MAL MDD+) and without (MAL MDD-) histories of major depression based on fit to a cosinor model with 24-hour circadian and 12-hour hemicircadian components.

Table I

Comparison between unexposed controls and subjects with childhood maltreatment in demographics and severity of exposure to early adversity. Group values are expressed as mean {95% confidence intervals}.

Measure	Unexposed Group	Maltreated Group	F	Probability	Effect Size d'
Sex	13M/25F	8M/14F		0.99	
Age	21.2 {20.3–22.0}	22.8 {22.1–23.4}	8.51	p<0.006	0.81
Parental Education	16.8 {15.8–17.8}	16.2 {15.4–17.0}	0.82	p>0.3	–0.26
Financial Sufficiency	3.6 {3.3–4.0}	3.1 {2.8–3.4}	4.70	p<0.04	–0.61
ACE Score	0.1 {–0.6–0.7}	2.4 {1.9–2.9}	28.87	p<10 ^{–5}	1.49
CTQ Sum	29.9 {22.6–37.2}	44.0 {39.7–48.3}	10.6	p<0.003	1.21
Emotional Abuse	6.1 {3.7–8.5}	10.6 {9.1–12.1}	10.31	p<0.003	1.15
Physical Abuse	5.1 {3.7–6.6}	8.2 {7.3–9.0}	13.05	p<0.001	1.29
Sexual Abuse	4.9 {3.5–6.4}	6.3 {5.4–7.2}	2.51	p>0.1	0.57
Emotional Neglect	6.5 {3.8–9.2}	11.9 {10.2–13.5}	11.62	p<0.002	1.22
Physical Neglect	5.2 {3.6–6.9}	7.8 {6.8–8.8}	7.53	p<0.01	0.98
Minimizing	0.6 {0.3–1.0}	0.0 {–0.2–0.2}	10.66	p<0.003	–1.17
Parental Verbal Aggression	13.8 {7.5–20.2}	36.8 {32.0–41.5}	31.71	p<10 ^{–6}	1.56
Peer Verbal Aggression	18.7 {10.4–27.0}	24.1 {17.9–30.3}	1.05	p>0.3	0.28
Parental Verbal Affection	67.9 {60.8–75.0}	51.7 {46.3–57.0}	12.59	p<0.0008	–0.98

ACE – Adverse Childhood Experiences, CTQ - Childhood Trauma Questionnaire.

Table 2

Comparison between unexposed controls and subjects with childhood maltreatment in current clinical symptoms. Group values are expressed as mean {95% confidence intervals}.

Measure	Unexposed Group	Maltreated Group	F	Probability	Effect Size d'
SQ – Anxiety	5.7 {3.4–8.0}	7.0 {5.4–8.6}	0.73	p>0.3	–0.25
SQ – Depression	4.5 {2.6–6.5}	5.9 {4.5–7.3}	1.15	p>0.2	–0.31
SQ – Somatization	5.2 {3.6–6.9}	5.4 {4.1–6.6}	0.01	p>0.9	–0.03
SQ – Anger Hostility	5.1 {3.1–7.1}	5.7 {4.3–7.1}	0.23	p>0.6	–0.14
Dissociative Experience Scale	5.7 {1.8– 9.6}	8.0 {5.2–10.7}	0.82	p>0.3	–0.27
Limbic System Checklist 33	11.3 {6.9–15.8}	17.8 {14.5–21.1}	4.95	p<0.04	–0.64

SQ – Symptom Questionnaire