clarify associations between ERN magnitude in adulthood and more severe stress occurring early in development. Similarly, our results did not identify significant associations between ERN magnitude and stress experienced during the past year, despite prior research suggesting that there are proximal effects of stress on performance monitoring (e.g., Meyer & Gawlowska, 2017; Riesel et al., 2012; Riesel et al., 2019). However, in this study, proximal stress included stressors experienced over the preceding 12 months, whereas other studies investigated effects of same-day or previous-day stress, which may explain the observed differences. Future experimental research examining the duration of the effects of laboratory stressors will be helpful to clarify the nature of these associations.

Limitations of this study point to directions for future research. First, our sample consisted of relatively few male participants, which did not allow us to investigate whether there are different stress-susceptible developmental periods for males versus females. Given prior research indicating possible sex differences in rates of neural maturation (Andersen, 2003; Lenroot et al., 2007; Lenroot & Giedd, 2010), future research should look closely at sex-specific sensitive periods. In particular, adolescence is thought to begin with puberty onset (Blakemore et al., 2010), which tends to be between the ages of 8 and 12 for females (Hayward, 2003). However, hormonal events involved in puberty typically occur 1 or 2 years later for males (Blakemore et al., 2010). Our stress severity time intervals classified early adolescence as 8 to 12 years old, which may be accurate for denoting the period of transition to puberty for females (Hayward, 2003) but may not effectively capture male transition to puberty (Blakemore et al., 2010). Additionally, a sample that consisted of 75% female participants may not have provided adequate statistical power to detect gender effects, or potential moderating effects of gender.

Second, our sample consisted of undergraduate students at the beginning of their college studies, who endorsed fewer, and less severe, stressors compared with other studies that have employed the STRAIN (Cazassa et al., 2020; Slavich & Shields, 2018; Sturmbauer et al., 2019). Our results may reflect experiences unique to those with higher-than-average socioeconomic status and education, limiting their generalizability. Indeed, prior research has found different patterns of error monitoring alterations among individuals reporting more extreme forms of stress—for instance, a blunted, as opposed to enhanced, ERN in early adolescents who experienced prolonged early institutionalization (Loman et al., 2013; Troller-Renfree et al., 2016). At a broader level, relative to most of the global population, our sample was Western, Educated, Industrialized, Rich, and Democratic (i.e., WEIRD; Henrich et al., 2010a), and findings in WEIRD samples do not always replicate in non-WEIRD samples (Henrich et al., 2010b). Future research should thus aim to replicate our findings in a more racially and socioeconomically diverse sample reporting more, and more severe, stressors. However, research has shown that experiencing even one major social stressor may substantially impact health (Slavich et al., 2009; Slavich et al., 2014), and consistent with such findings, we observed significant associations between social-evaluative stress exposure and the ERN even with a relatively limited range of stress severity. Furthermore, investigating effects of stressors in the mild-moderate range is important for elucidating how different levels of stress severity—not just the presence and absence of severe stress—may impact development (McLaughlin et al., 2020).

Third, although prior research indicates that social desirability and personality characteristics do not influence responding on the STRAIN (e.g., Slavich & Shields, 2018), we cannot rule out the possible influence of such biases in this study. Furthermore, as is the case with all retrospective self-report measures, recall of stressful events and severity may not have been completely accurate. For example, participant reports of childhood stress may not be as accurate as their reports on stressors that occurred more recently (Maughan & Rutter, 1997). However, we note that the STRAIN focuses on stressors that are moderate to severe in nature, which prior research has shown can be reliably recalled (Brown & Harris, 1978; Reuben et al., 2016). Moreover, validation studies using the STRAIN have shown very high test-retest reliability over time, suggesting that individuals are recalling the same stressors at different time points (Cazassa et al., 2020; Slavich & Shields, 2018). Additionally, because of the correlational nature of the study, it is also possible that individuals with a larger ERN have more biased recall. Yet a negative recall bias should result in global biases reflected across *all* stressor types and timing, and we did not find associations between ERN magnitude and stress experienced in every domain or developmental period, again suggesting minimal impact of recall biases. Nevertheless, future prospective studies documenting stress across time will be necessary to validate the results reported here, and, in particular, the present study should be replicated using contemporaneous assessments of life stress exposure.

Fourth, unlike traditional interview-based measure of life stress, such as the UCLA Life Stress Interview (Hammen, 1991) and Life Events and Difficulties Schedule (Brown & Harris, 1978), the STRAIN does not generate interviewer-rated life stress exposure or severity scores. A wealth of research has shown that perceptions of stress exposure and severity are strongly tied to biological and clinical health (Epel et al., 2018; Slavich & Cole, 2013), suggesting that it is important to investigate individuals' stressor appraisals and not just objective stress severity. However, future research should certainly employ other interview-based measures of life stress to examine the robustness of the effects described here.

Fifth, given the present study design, we cannot be certain whether the effects observed are due to adolescent-limited stress versus chronic stress that began in childhood and perhaps peaked in adolescence (Tottenham & Galván, 2016). Research suggests that interpersonal stress is highly continuous (Chapell et al., 2006), and the social stress reported by participants in the present sample during adolescence may have started earlier and continued past early adolescence. However, the results of our multiple regression analysis—in which stress across other periods was controlled for—are suggestive in this regard, in that social stress during early adolescence showed unique associations with the ERN. Nonetheless, prospective studies would be helpful for further disentangling the effects of stress experienced during different developmental periods on the ERN.

Finally, the effect sizes observed in the present sample are small to medium in magnitude (Cohen, 1988), and should be interpreted with caution. However, self-report data and psychophysiological variables share no method variance and thus are expected to moderately correlate with one another (Campbell & Fiske, 1959; Patrick et al., 2013). Consistent with this, similar effect sizes are common in the literature investigating associations between the ERN and important individual difference variables (Cavanagh & Shackman, 2015; Meyer et al., 2015a; Moser et al., 2013; Weinberg et al., 2016) and can have meaningful implications for real-world outcomes (Hajcak et al., 2019; Meyer et al., 2017a). For instance, the ERN has demonstrated incremental predictive ability for the later development of anxiety disorders over and above other common risk factors (Meyer et al., 2015a; Meyer et al., 2018) and appears to predict adolescents' tobacco use initiation (Anokhin & Golosheykin, 2015), effects that were in the small to medium range. These studies suggest that even relatively modest effects can improve prediction of important health-related outcomes.

Conclusions

The present findings indicate that greater total and social-evaluative stress severity during early adolescence is associated with increased error monitoring in emerging adulthood. These results provide support for the notion that early adolescence is a sensitive period during which stress may more significantly influence neural networks involved in performance monitoring. In a notable extension of prior work, the present results also indicate that it is important to consider both the developmental timing and type of stressors experienced over the lifespan. Specially, we found that social-evaluative stress occurring during early adolescence was associated with a larger ERN, whereas life-threatening stress severity during mid-adolescence was related to a *smaller* ERN. However, total stress severity in early adolescence was also associated with enhanced error monitoring, which suggests that there are both cumulative *and* specific effects of stressor type on performance monitoring across development. This research therefore lays the groundwork for future prospective studies seeking to understand the long-term effects of stress-induced neural adaptations to the environment.

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Open practices statement The experiment and analyses reported in this manuscript were not pre-registered. The data and SPSS syntax for the primary analyses reported are available on the Open Science Framework (OSF) website at the following links:

Data: https://mfr.ca-1.osf.io/render?url=https://osf.io/53k7q/?action=download%26mode=render

Syntax: https://mfr.ca-1.osf.io/render?url=https://osf.io/f42n7/?direct%26mode=render%26action=download%26mode=render

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Declarations

Declarations of interest None.

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