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All in a Day’s Laugh: A Replication and Extension of the Stress-Buffering Model of Positive Affect

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A Replication and Extension of the Stress-Buffering Model of Positive Affect

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Abstract

Positive affect, which is known to evoke pleasurable engagement with one's environment, has well-established potential to reduce the negative effects of stress (Fredrickson, 1998). Although there are various facets of positive affect, we principally examined the alleviating effect of laughter—a common operational definition of positive affect—on mental and physiological stress responses (Herring et al., 2011). We did so by conducting a replication and extension of a study published by Zander-Schellenberg et al. (2020), who affirmed the stress-buffering effect of laughter frequency in daily life. In our replication, we attempted to reproduce the findings of the original study, conducted a residual analysis of the statistical models used, and assessed laughter-stress interplay across individual participants. In our extension, we assessed the *cumulative* stress-buffering effect of laughter frequency in daily life by determining whether the original findings apply to populations of varying daily aggregate laughter frequencies. Our replication results are consistent with the original findings, suggesting that laughter indeed attenuates negative consequences of stress. Interestingly, our extension results only showed this stress-buffering effect at play on days characterized by low daily aggregate laughter frequency. Possible implications of these results are discussed.

Introduction

Positive affect is typically defined as the subjective experience of such positive moods as happiness, joy, excitement, enthusiasm, and satisfaction (Pressman & Cohen, 2005). Previous research on the physiological correlates of positive effect has established its role in broadening attention and restoring the body to mid-range levels of cardiovascular activity (Fredrickson, 2001). By contrast, stress is known to have negative impacts on short- and long-term physical health, which can contribute to the development of cardiovascular disease, immunodeficiency virus, inflammation, and other severe illnesses (Schneiderman et al., 2005). Examining these differing physiological effects in conjunction with each other may explain why such forms of positive affect as laughter and humour are correlated with a greater ability to cope with stressful situations (Fredrickson, 1998). In fact, positive affect has been found to reduce recovery time from stress (Pressman et al., 2019) and even improve physiological resilience in the presence of negative emotions (Papousek et al., 2010). In the long term, recurring instances of positive affect have been associated with lower mortality risk (Okely et al., 2017) and improved overall health, especially cardiovascular function (Pressman & Cohen, 2005).

It is important to note that the prevalence of positive affect across individuals can vary with personality type, gender, age, and cultural factors. For instance, a higher frequency of daily laughter has been observed in both men with greater Type A characteristics and women with greater Type B characteristics. Type A individuals are more competitive and aggressive than the more relaxed Type B individuals, which partially accounts for increased physical health problems (Martin & Kuiper, 1999). In addition, women of all ages generally smile and laugh more than men of all ages, a phenomenon which may be moderated by the presence of social tension (LaFrance et al., 2003). Precise laughter frequency and intensity generally depends on where and how one lives, however. Various cross-cultural studies have documented lower rates of smiling in East Asian students than American ones, which may relate to lower life satisfaction or simply less value attributed to public displays of positive affect (Talhelm & Zhang, 2019).

For those struggling with exceptionally stressful lifestyles or circumstances, laughter can be used as a form of treatment in clinical settings. Therapeutic laughter therapy has been shown to effectively reduce anxiety, depression, and stress in breast cancer patients after as little as one session (Kim et al., 2015). Similar effects have been observed in studies examining the use of Laughter Yoga intervention for depressed older women and male nursing students (Bressington et al., 2018). These studies indicate that positive affect, despite its variance across individuals, can alleviate the physiological correlates of stressful or otherwise negative experiences. As an instance of positive affect, laughter has had a similar impact in a wide range of stress-inducing circumstances.

The objective of this study was to evaluate the so-called “stress-buffering model of positive effect” by means of a replication and extension. Specifically, we attempted to reproduce the results published by Zander-Schellenberg and colleagues using various datasets. The first dataset was that of the original researchers, which included each ecological momentary assessment (EMA) for each participant throughout the course of the study. This dataset was used to conduct our replication, which we supplemented with an assessment of linear mixed model residuals and an investigation of laughter-stress interplay across individual participants. The second and third datasets were subsets of the first: the former included each EMA for each participant on days characterized by high cumulative (e.g., daily aggregate) laughter frequency, while the latter included each EMA for each participant on days characterized by low cumulative laughter frequency. These datasets were used to conduct our extension, thereby providing insight into whether laughter frequency has a notable cumulative effect on the association between stressful events and experienced stress. Our replication results revealed a significant moderating effect of laughter frequency on the association of interest, thereby supporting the stress-buffering model of positive affect and confirming the validity of the statistical analysis utilized by the original researchers. Meanwhile, our extension results revealed a significant moderating effect of laughter frequency on the association of interest on days characterized by low cumulative laughter frequency.

Methods/Materials

Experiment 1: Replication

The aim of this experiment was threefold: 1) to replicate the analysis of the original study, 2) to observe the stress-buffering effect of laughter frequency across individual participants, and 3) to assess the suitability of a linear mixed model analysis in the original study.

We completed a replication of the analysis in an attempt to validate the sole hypothesis that the original study could confirm—namely, that frequency of laughter has a moderating effect on the association between a stressful experience and the subsequent experience of stress symptoms. This sub-experiment mirrored the statistical analysis methodology delineated by the original study, which we supplemented with aesthetic adjustments and an additional moderation term that represents a close-to-baseline level of laughter frequency. Our observation of the laughter-stress interplay across individual participants aimed to illuminate whether many linear regression analyses would yield results consistent with the hypothesis that laughter frequency weakens the association between a stressful event and subsequent stress symptoms. To do so, we used the ESM data collected in the original study to plot linear regressions for each participant ID. These linear regressions model the relationship between person-mean-centered stressful events and experienced stress symptoms (as moderated by laughter frequency) and do not account for such random effects as the number of elapsed EMAs. Finally, we ran a diagnostic assessment of the linear mixed model analysis conducted by Zander-Schellenberg and colleagues to ensure it accurately represents their ESM data. This involved generating a normal quantile-quantile (Q-Q) plot of residuals from the linear mixed models used in the original study. We used this plot to observe whether the residuals follow normal distributions, which constitutes a critical assumption for this mode of statistical analysis.

Experiment 2: Extension

Our extension supplements the original study by examining the following question: Does frequency of laughter have a *cumulative effect* on the association between a stressful experience and the subsequent onset of stress symptoms? We assessed cumulative laughter frequency by identifying the days in which each participant exhibited a relatively high or low frequency of laughter: First, we calculated the mean laughter frequency for each participant on each day. Then, we identified all the days in which a given participant had a mean laughter frequency that was greater than the whole participant pool's mean laughter frequency. These days were categorized as “frequent laughter” days, and the remaining days were categorized as “infrequent laughter” days.

To begin to answer our question, we determined whether days of frequent laughter were characterized by fewer stress symptoms relative to days of infrequent laughter. This involved running a two-sided Wilcoxon rank-sum test, which accounted for the asymmetric distribution of our data. In addition, we assessed whether the moderating effects of laughter frequency on the association between stressful experiences and the onset of stress symptoms was stronger on days of frequent laughter relative to days of infrequent laughter. This involved conducting two linear mixed models: one using data from the former set of days, and one using data from the latter. Models were generated using the same methodology described in Experiment 1.

All analyses for both experiments were conducted in RStudio (Version 1.3.1093) and utilized packages cited by the original study, with the addition of the ggthemr package to make aesthetic adjustments to line plots and the dplyr package to manipulate the dataset.

Results

Replication

In line with the original study, we found that the association between stressful events and experienced stress was moderated by the effect of laughter frequency. As laughter frequency levels increased, there was a negative association between stressful events and experienced stress levels; thus, frequent laughter was associated with lower stress symptoms for stressful events. This association was found for both global and combined measures of stress as did the original models, further validating the stress-buffering effect of positive affect. We also incorporated an additional moderator value intermediate to the minimum and maximum laughter frequency levels of -3 and 4, respectively. As shown in Figure 1, the additional moderator value of 0.4 demonstrates a moderating effect intermediate to the values of -3 and 4. Excluding the additional moderator value, our plot matches that of the original study, thereby validating the analysis conducted by the original researchers.

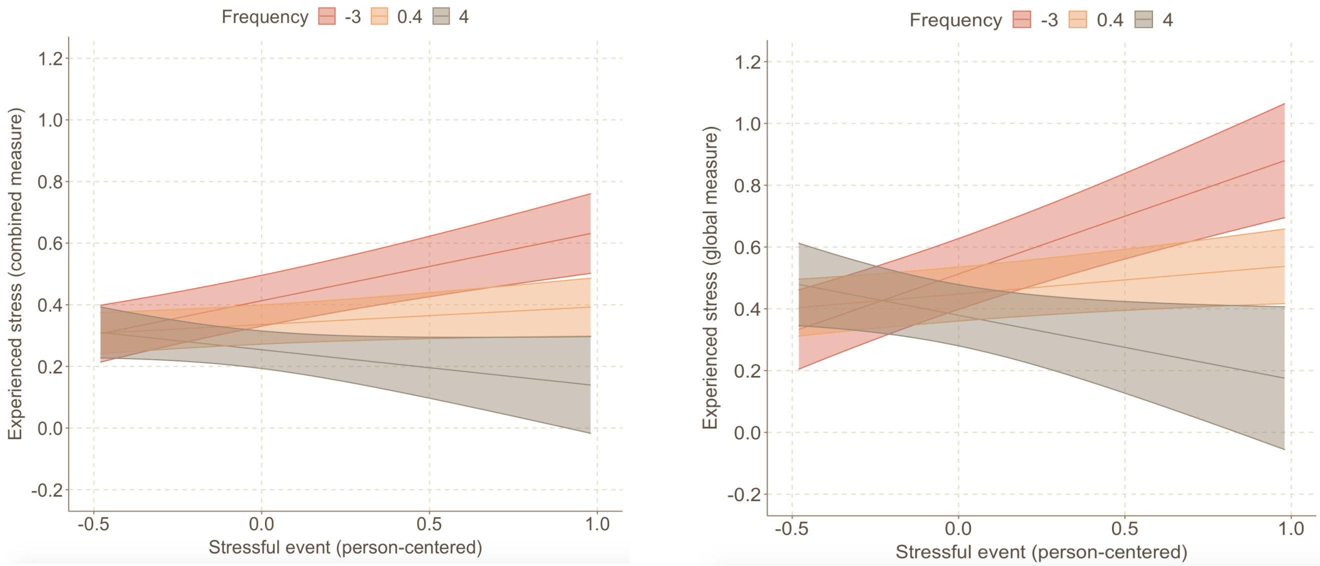

Fig 1. *Laughter frequency moderating experienced stress.* Extreme values of laughter frequency (-3, 4) moderate the association between a stressful event at time T and experienced stress symptoms (combined self-report on the right, global self-report on the left) at time T+1. A baseline level of laughter frequency (0.4) demonstrates an intermediate effect.

	Experience of stressful symptoms (combined measure)					
Model variables	**usCOEF**	**95% CI**		**sCOEF**	**95% CI**	
(Intercept)	0.339	0.268	0.409			
Experience of stressful events	0.077	0.017	0.137	0.066	0.015	0.118
Frequency of laughter	-0.023	-0.033	-0.013	-0.085	-0.123	-0.047
Consecutive ema prompts	0.000	-0.001	0.001	0.011	-0.056	0.077
Sex (referent = female)	-0.002	-0.149	0.145	-0.002	-0.166	0.162
IA Experience * Frequency	**-0.048**	-0.077	-0.020	**-0.052**	-0.082	-0.021

Table 1. *Results: Frequency of laughter as moderator of the association between experience of stressful events and experience of stress symptoms (combined measure).* The association between a stressful event and experienced stress symptoms decreases by 0.048 when laughter frequency increases by one standard deviation.

	Experience of stressful symptoms (global measure)					
Model variables	**usCOEF**	**95% CI**		**sCOEF**	**95% CI**	
(Intercept)	0.477	0.387	0.568			
Experience of stressful events	0.125	0.053	0.197	0.072	0.031	0.114
Frequency of laughter	-0.019	-0.037	-0.001	-0.048	-0.093	-0.003
Consecutive ema prompts	0.000	-0.001	0.001	-0.012	-0.074	0.051
Sex (referent = female)	-0.069	-0.270	0.132	-0.052	-0.203	0.099
IA Experience * Frequency	**-0.083**	-0.128	-0.039	**-0.060**	-0.092	-0.028

Table 2. *Results: Frequency of laughter as moderator of the association between experience of stressful events and experience of stress symptoms (global measure).* The association between a stressful event and experienced stress symptoms decreases by 0.083 when laughter frequency increases by one standard deviation.

Regarding our supplementary data analysis, Q-Q plots of residuals from the above linear mixed models generally adhered to a normal distribution (Fig 2), though the model using combined measures of stress did so more closely. Further, laughter-stress interplay observed across individual participants was either consistent or inconsistent with the association estimated by our linear mixed model (Fig 3).

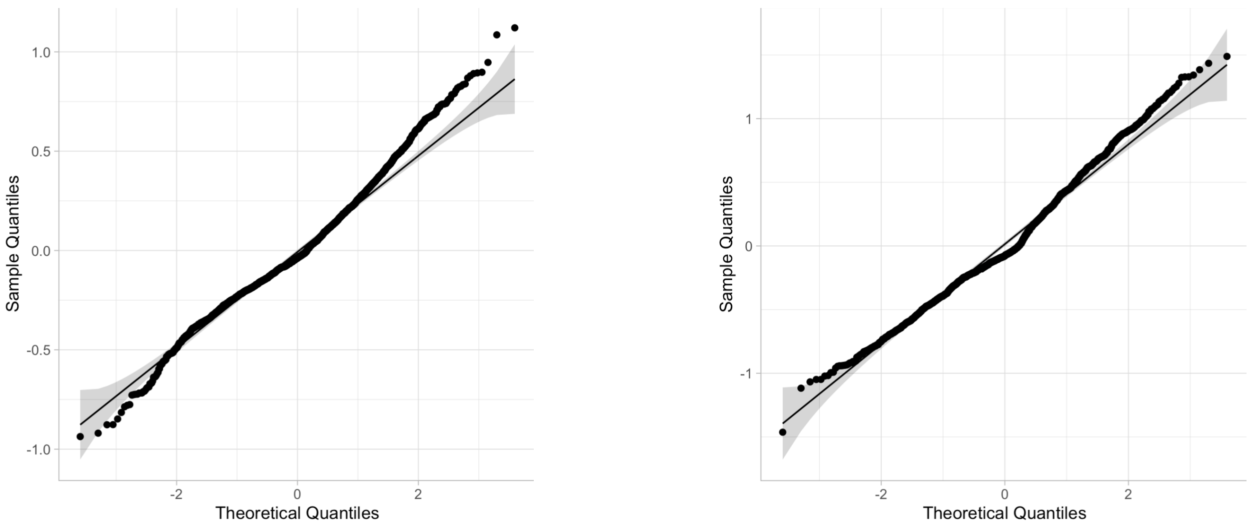

Fig 2. *Normal Q-Q Plots for Residuals.* The thin black line and gray region indicate a normal distribution and its 95% confidence interval. Relative to global measures (left), combined measures of stress (right) yielded a linear mixed model with residuals that are more fitted to a normal distribution.

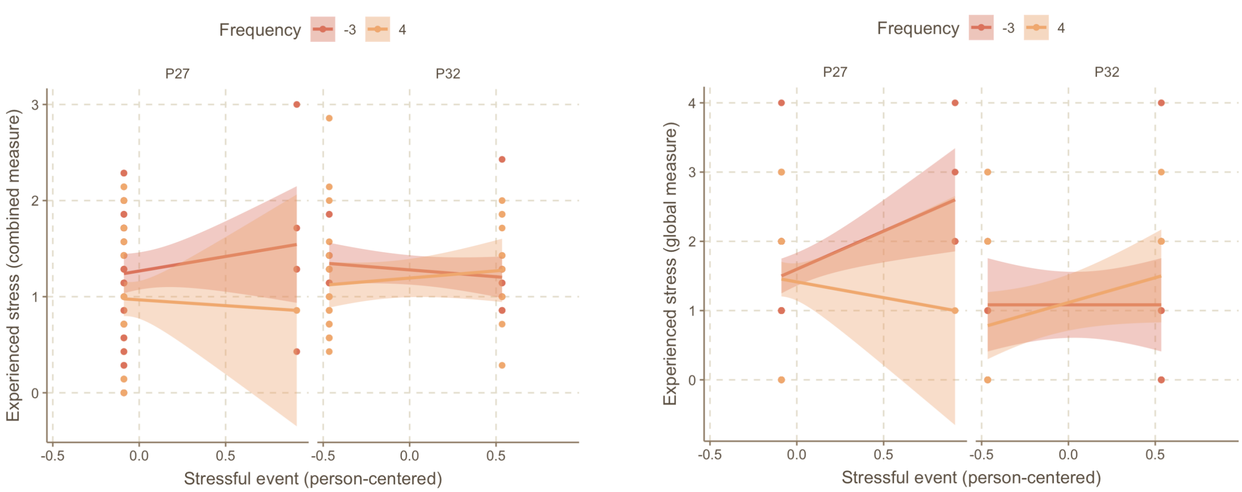

Fig 3. *Laughter frequency moderating experienced stress in individual participants.* Consistent with the effect of laughter frequency predicted in Fig 1, Participant 27 demonstrates a negative association between stressful events and subsequent stress symptoms. Participant 32 demonstrates a contrary effect, since there's a positive association between the aforementioned variables.

Extension

A Wilcoxon rank-sum test revealed a statistically significant difference (Z = 1753728, p < .001) in the experience of stressful events on "frequent laughter" days compared to "infrequent laughter" days, yet Cohen's effect size value (d = 0.08) suggested low practical significance. Similar results were found when assessing differences in the combined (Z = 1801046, p < .001) and global measure (Z = 1895385, p < .001) of experienced stress symptoms, though Cohen's effect size values in the former (d = 0.12) and latter (d = 0.08) analyses also suggested low practical significance.

Linear mixed models reveal that laughter frequency did not moderate the association between stressful events and experienced stress symptoms on "frequent laughter" days (**Fig 4**), especially given that 95% confidence intervals for the interaction coefficients relating laughter frequency and both experienced stress symptoms in this group included zero (**Tables 3-4**). Interestingly, the same went for the interaction coefficients relating stressful events and both experienced stress symptoms **(Tables 3-4)**. Our models also reveal that frequency of laughter did indeed moderate the association between experience of stressful events and experience of stress symptoms on "infrequent laughter" days (**Fig 5**). Thus, as frequency of laughter increased, the association between experiences of stressful events and subsequent experiences of stress symptoms decreased only on days characterized by low daily aggregate laughter frequency.

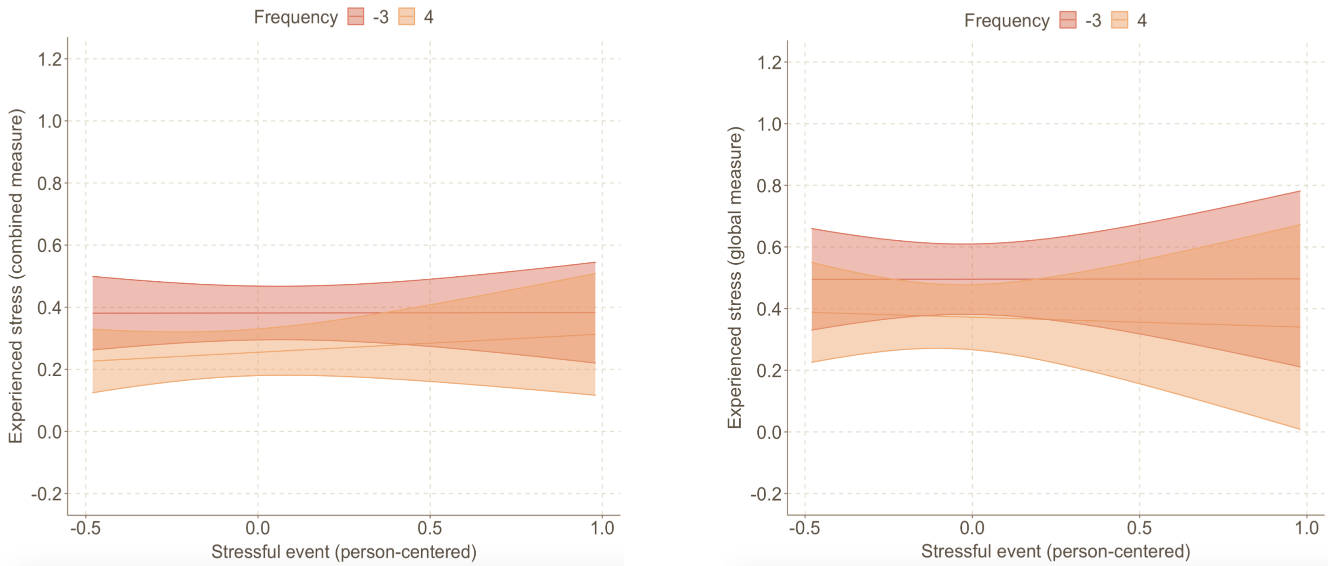

Fig 4. *Laughter frequency moderating experienced stress in "frequent laughers"*. Inconsistent with Fig 1, values of laughter frequency (-3, 4) do not appear to moderate the association between a stressful event at time T and experienced stress symptoms (combined self-report on the right, global self-report on the left) at time T+1.

	Experience of stressful symptoms (combined measure)					
Model variables	**usCOEF**	**95% CI**		**sCOEF**	**95% CI**	
(Intercept)	0.356	0.279	0.433			
Experience of stressful events	0.026	-0.043	0.095	0.022	-0.037	0.081
Frequency of laughter	-0.018	-0.031	-0.005	-0.070	-0.121	-0.019
Consecutive ema prompts	0.000	-0.001	0.000	-0.054	-0.127	0.019
Sex (referent = female)	-0.005	-0.172	0.161	-0.006	-0.209	0.196
IA Experience * Frequency	**0.008**	-0.034	0.050	**-0.009**	-0.035	0.053

Table 3. *Results: Frequency of laughter as moderator of the association between experience of stressful events and experience of stress symptoms in frequent laughers (combined measure).* The association between a stressful event and experienced stress symptoms increases 0.008 when laughter frequency increases by one standard deviation.

	Experience of stressful symptoms (global measure)					
Model variables	**usCOEF**	**95% CI**		**sCOEF**	**95% CI**	
(Intercept)	0.522	0.417	0.626			
Experience of stressful events	-0.013	-0.131	0.104	-0.007	-0.072	0.057
Frequency of laughter	-0.018	-0.037	0.001	-0.044	-0.091	0.003
Consecutive ema prompts	-0.001	-0.002	0.000	-0.082	-0.161	-0.003
Sex (referent = female)	-0.079	-0.299	0.140	-0.062	-0.234	0.110
IA Experience * Frequency	**-0.005**	-0.078	0.068	**-0.003**	-0.053	0.046

Table 4. *Results: Frequency of laughter as moderator of the association between experience of stressful events and experience of stress symptoms in frequent laughers (global measure).* The association between a stressful event and experienced stress symptoms decreases by 0.005 when laughter frequency increases by one standard deviation.

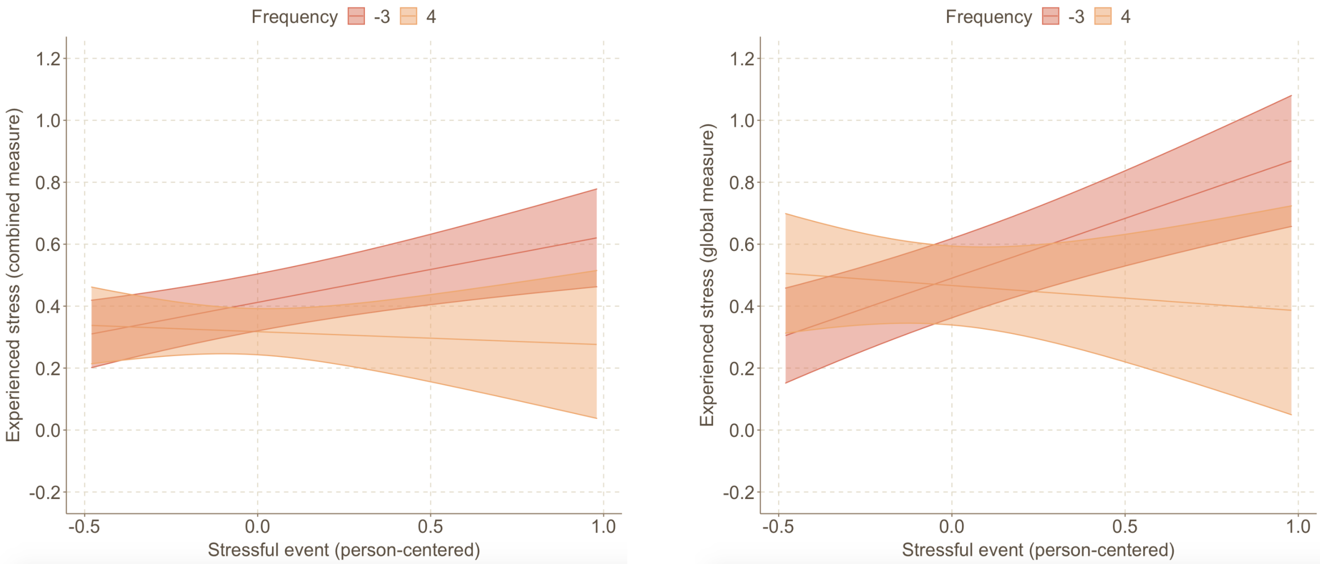

Fig 5. *Laughing frequency moderating experienced stress in "infrequent laughers".* Consistent with Fig 1, extreme values of laughter frequency (-3, 4) appear to moderate the association between a stressful event at time T and experienced stress symptoms (combined self-report on the right, global self-report on the left) at time T+1.

	Experience of stressful symptoms (combined measure)					
Model variables	**usCOEF**	**95% CI**		**sCOEF**	**95% CI**	
(Intercept)	0.362	0.285	0.439			
Experience of stressful events	0.103	0.024	0.183	0.090	0.021	0.159
Frequency of laughter	-0.014	-0.029	0.002	-0.043	-0.093	0.008
Consecutive ema prompts	0.000	-0.001	0.001	0.037	-0.048	0.121
Sex (referent = female)	-0.088	-0.238	0.063	-0.092	-0.250	0.066
IA Experience * Frequency	**-0.036**	-0.082	0.009	**-0.039**	-0.088	0.010

Table 5. *Results: Frequency of laughter as moderator of the association between experience of stressful events and experience of stress symptoms in infrequent laughers (combined measure).* The association between a stressful event and experienced stress symptoms decreases by 0.036 when laughter frequency increases by one standard deviation.

	Experience of stressful symptoms (global measure)					
Model variables	**usCOEF**	**95% CI**		**sCOEF**	**95% CI**	
(Intercept)	0.463	0.343	0.582			
Experience of stressful events	0.186	0.097	0.274	0.112	0.059	0.166
Frequency of laughter	-0.003	-0.029	0.022	-0.007	-0.063	0.048
Consecutive ema prompts	0.001	-0.001	0.002	0.032	-0.045	0.109
Sex (referent = female)	-0.083	-0.323	0.157	-0.060	-0.235	0.115
IA Experience * Frequency	**-0.067**	-0.132	-0.001	**-0.050**	-0.100	-0.001

Table 6. *Results: Frequency of laughter as moderator of the association between experience of stressful events and experience of stress symptoms in infrequent laughers (global measure).* The association between a stressful event and experienced stress symptoms decreases by 0.067 when laughter frequency increases by one standard deviation.

Discussion

Replication

The linear mixed models we generated using the dataset compiled by Zander-Schellenberg and colleagues mirrored those of the original analysis; notably, the line plots demonstrating the moderating effect of laughter frequency on experienced stress clearly indicate that increased laughter frequency decreases experienced stress following a stressful event. The added moderator value demonstrated an effect intermediate to the extreme frequencies for both global and combined measures of experienced stress, thereby implying that laughing as frequently as one typically does neither increases nor decreases the degree of stress one would typically experience after a stressful event.

The Q-Q plots we generated for the aforementioned linear mixed models confirm that their residuals largely adhere to a normal distribution; however, there were slight differences in distribution that depended on whether the model was generated with global or combined measures of experienced stress. Because the combined measure represents an aggregated self-report, it may reflect the abstract concept of experienced stress more accurately than the global (e.g., single-item) measure, thereby demonstrating a narrower variety of outcomes. This account would explain why the former measure yielded a linear mixed model with residuals that are more fitted to a normal distribution, while the latter measure yielded a model with residuals that begin to resemble a light-tailed distribution.

Based on the linear regressions we plotted for each participant, we observed various moderating effects of laughter frequency on experienced stress. Several plots demonstrated a laughter-stress interplay consistent with the original hypothesis, while others were contrary to it. This is likely because we plotted raw data from the original data set, which means that such random effects as gender and elapsed assessments were not taken into consideration. Since such data may be clustered according to various random effects, we can't make a sound conclusion regarding whether the apparent laughter-stress interplay across individual participants validates or invalidates the original hypothesis.

Altogether, our replication validates the use of LMM for assessing the stress-buffering effect of laughter in daily life, as well as the importance of accounting for random effects while observing laughter-stress interplay as a general phenomenon.

Extension

We determined that laughter frequency only moderated the association between stressful events and experienced stress symptoms on days of “infrequent laughter”. Thus, the cumulative stress-buffering effect of laughter frequency on experienced stress appears to be limited: On days where participants don’t laugh as frequently as the “average participant,” instances of greater laughter frequency throughout the day make participants more resilient to stress. No such effect appears to be at play on days where participants laugh more frequently than the “average participant”. These results were unexpected, since our replication analysis of the entire EMA dataset demonstrated a significant moderating effect of frequency of laughter on experienced stress symptoms. With that said: If a fraction of the dataset (e.g., “frequent laughter” days) demonstrated an insignificant moderating effect, then the rest of it (e.g., “frequent laughter days”) should demonstrate an effect more vigorous than that of our replication analyses. Such was not the case, however.

It is worth noting that the insignificant moderating effect of laughter frequency observed in our analysis of “frequent laughter” days likely occurred because there was no relation observed between stressful events and experienced stress in this group to begin with. This lack of relation and subsequent lack of moderating effect for “frequent laughter” days could not have occurred as a result of few data points, since our analyses revealed similarities in stressful events and stress symptoms between “frequent laughter” and “infrequent laughter” groups. Instead, it may be explained by a deficiency in our analysis: We measured the association between stressful events and subsequent stress symptoms by defining T as the time when a stressful event was experienced and T+1 as the time when stress symptoms were experienced. For stress symptoms that may take a longer time to surface after a stressful event, this choice of lagged variables may not have revealed those associations. A varied investigation relating subsequent stress symptoms to stressful events with a greater lag, such as at time T+2, may have revealed more relevant insights into the stress-buffering effect of laughter frequency. In addition, a potential limitation pertaining to the nature of data collection itself was that the original study did not measure physiological stress measures in addition to participants' self-evaluation of stress levels. These self-reports may have been prone to biases or unexpected variance, thereby compromising the accuracy of the resulting linear mixed models.

Conclusion

Our replication results are consistent with existing literature on the stress-buffering model of positive affect, suggesting that laughter attenuates negative consequences of stress in daily life. This finding serves as a meaningful contribution to existing literature on this effect, as it addresses instances where stressful events and positive affect occur in close proximity under naturalistic conditions. Other investigations, by comparison, largely occurred in controlled laboratory settings. Our extension results propose an avenue of future exploration, notably with regards to the cumulative effect of positive affect in daily life. Whether high aggregate laughter frequency further delays the onset of stress symptoms following a stressful event has yet to be determined. With that said, future studies may employ LMM with various lagged variable schemes to investigate the aforementioned cumulative effect.

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