

SUPPLEMENTARY INFORMATION

Positive memory specificity reduces adolescent vulnerability to depression

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Supplementary Results:

Confirmatory Factor Analysis of Morning Cortisol

The confirmatory factor analysis (CFA) of morning cortisol (see Supplementary Figure 1; $n = 479$) showed good model fit at baseline without any modifications (robust model fit indices: $\chi^2_2 = 1.213$, $P = .545$, CFI = 1, TLI = 1.006, RMSEA = 0[0.000-0.092], SRMR = 0.008). However, the CFA at follow-up did not show good model fit (robust model fit indices: $\chi^2_2 = 21.987$, $P < .001$, CFI = 0.947, TLI = 0.842, RMSEA = 0.166[0.108-0.232], SRMR = 0.037). The model was re-specified once (MI = 30.203), freeing the path between day one and two at follow-up (improved model fit, ANOVA: $\chi^2_2 = 28.685$, $P < .001$). The modified model showed good model fit (robust model fit indices: $\chi^2_1 = 0.407$, $P = .523$, CFI = 1, TLI = 1.012, RMSEA = 0[0.000-0.134], SRMR = 0.005). Strong longitudinal measurement invariance was established between baseline and follow-up (see Supplementary Table 2).

Comparison of Positive and Negative Memory Specificity

To examine whether the effects in the path model (Figure 1 and Table 1, main manuscript) were due to memory specificity in general (and also found for negative memory specificity), or specific to positive memory specificity, we ran an exploratory model where both negative and positive memory specificity predicted current and later morning cortisol and negative self-cognitions during low mood. In this model, there was a relation between positive memory specificity and negative self-cognitions/mood (Effect = -0.133, S.E. = 0.040, z -value = -3.332, $P = .001$) and morning cortisol at follow-up (Effect = -0.324, S.E. = 0.137, z -value = -2.357, $P = .018$). Negative memory specificity was unrelated to negative self-cognitions/mood (Effect = 0.016, S.E. = 0.041, z -value = -0.403, $P = .687$) and morning cortisol at follow-up (Effect = 0.013, S.E. = 0.143, z -value = 0.091, $P = .927$). Relationships between positive memory specificity and negative self-cognitions/mood (Effect = -0.047, S.E.

= 0.046, z -value = -1.041, $P = .298$) and morning cortisol were not significant at baseline (Effect = -0.283, S.E. = 0.172, z -value = -1.648, $P = .099$). Negative memory specificity was unrelated to negative self-cognitions/mood (Effect = -0.033, S.E. = 0.046, z -value = -0.709, $P = .479$) and morning cortisol at baseline (Effect = -0.092, S.E. = 0.161, z -value = -0.570, $P = .569$). Robust fit statistics indicated good fit ($\chi^2_2 = 1.094$, $P = .579$, CFI = 1, TLI = 1.054, RMSEA = 0[0.000-0.078], SRMR = 0.006). In this model, constraining the negative memory specificity paths to zero did not affect model fit, suggesting that negative memory specificity was not needed to explain our data (ANOVA: $\chi^2_4 = 1.311$, $P = .920$; robust fit statistics still indicated good fit: $\chi^2_4 = 1.280$, $P = .865$, CFI = 1, TLI = 1.079, RMSEA = 0[0.000-0.036], SRMR = 0.006). On the other hand, constraining the positive memory specificity paths to zero significantly lowered model fit (ANOVA: $\chi^2_4 = 18.179$, $P < .001$; robust fit statistics indicated poor model fit: $\chi^2_4 = 18.179$, $P = .001$, CFI = 0.947, TLI = 0.600, RMSEA = .086[0.049-0.128], SRMR = 0.019). Furthermore, the lack of an effect of negative memory specificity was not due to the inclusion of positive memory specificity in the same model. When negative memory specificity was constrained to zero, positive memory specificity was related to negative self-cognitions during low mood (Effect = -0.126, S.E. = 0.038, z -value = -3.326, $P = .001$) and morning cortisol at follow-up (Effect = -0.319, S.E. = 0.122, z -value = -2.603, $P = .009$). When positive memory specificity was constrained to zero, negative memory specificity was unrelated to negative self-cognitions/mood (Effect = -0.043, S.E. = 0.039, z -value = -1.077, $P = .282$) and morning cortisol at follow-up (Effect = -0.131, S.E. = 0.126, z -value = -1.040, $P = .298$).

Cross-Sectional Correlations in the Moderation and Moderated Mediation Models

Correlations between negative life events and other follow-up measures were small to moderate (negative self-cognitions: $r_{479} = .17$, $P < .001$; dysphoric mood: $r_{479} = .22$, $P < .001$;

depressive symptoms $r_{479} = .21, P < .001$; morning cortisol $r_{479} = .16, P < .001$). The correlation between negative self-cognitions and depressive symptoms was large ($r_{479} = .70, P < .001$).

Supplementary Methods:

Participant Recruitment

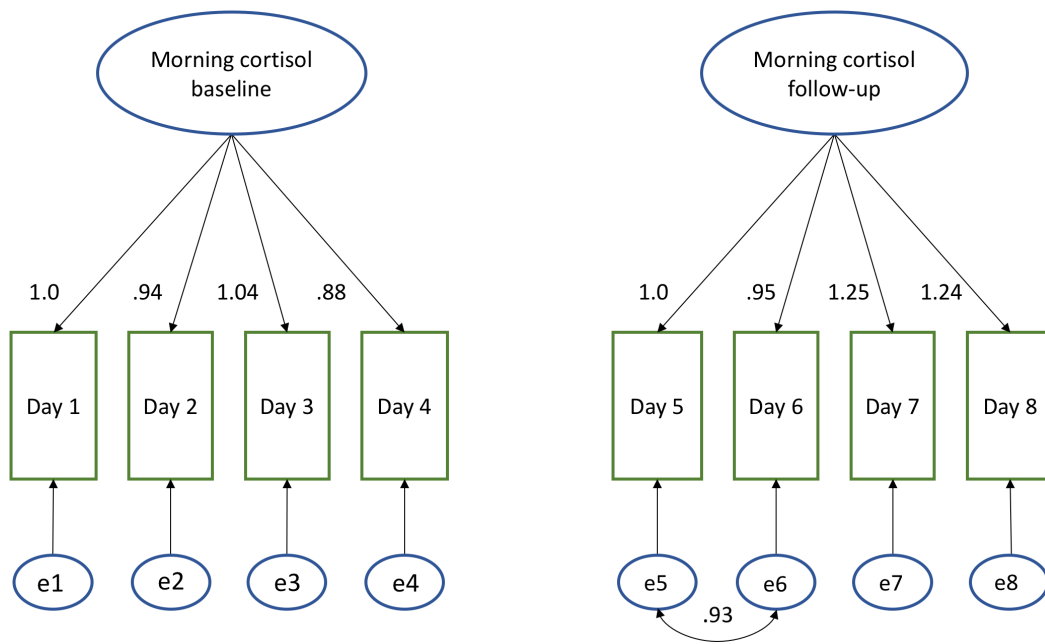
Uptake from the schools was generally high (about 1:2; 1707 invited, 990 consented, 937 did school interview, 905 remained after exclusion, 888 after dropout at baseline and 812 after dropout at follow-up). The main sample studied here with 479 adolescents were those who had data on all measures including cortisol, stemming from an overall cohort of 643 adolescents who had data on all measures excluding cortisol.

Types of Negative Life Events

1. Losses, involving only death or permanent separation from a valued other.
2. Disappointments, involving failure of previously held expectations and/or hopes, including breakdown of a romantic relationship or examination failure (affecting self), or loss of a job, new financial difficulties or an extramarital affair (affecting others).
3. Dangers to the self, involving a clear expectation or occurrence of a physical threat to the youth, including being affected by an illness or accident.
4. Dangers to others, similar events including an illness or accident affecting a parent, friend or significant other.

Cortisol Assay Specifications

Cortisol was measured by enzyme-linked immunosorbent assay (ELISA) on 20- μ L samples of saliva without extraction (antibody; Cambio). Intraassay variation was 5.7% and interassay variation was 5.6%.



Supplementary Figure 1. Confirmatory factor analysis of morning cortisol. Extraction of a stable factor of morning cortisol over four days at baseline and at one-year follow-up. Values are factor loadings on each indicator. The double-headed arrow between day 5 and day 6 indicates the modification to the model at follow-up.

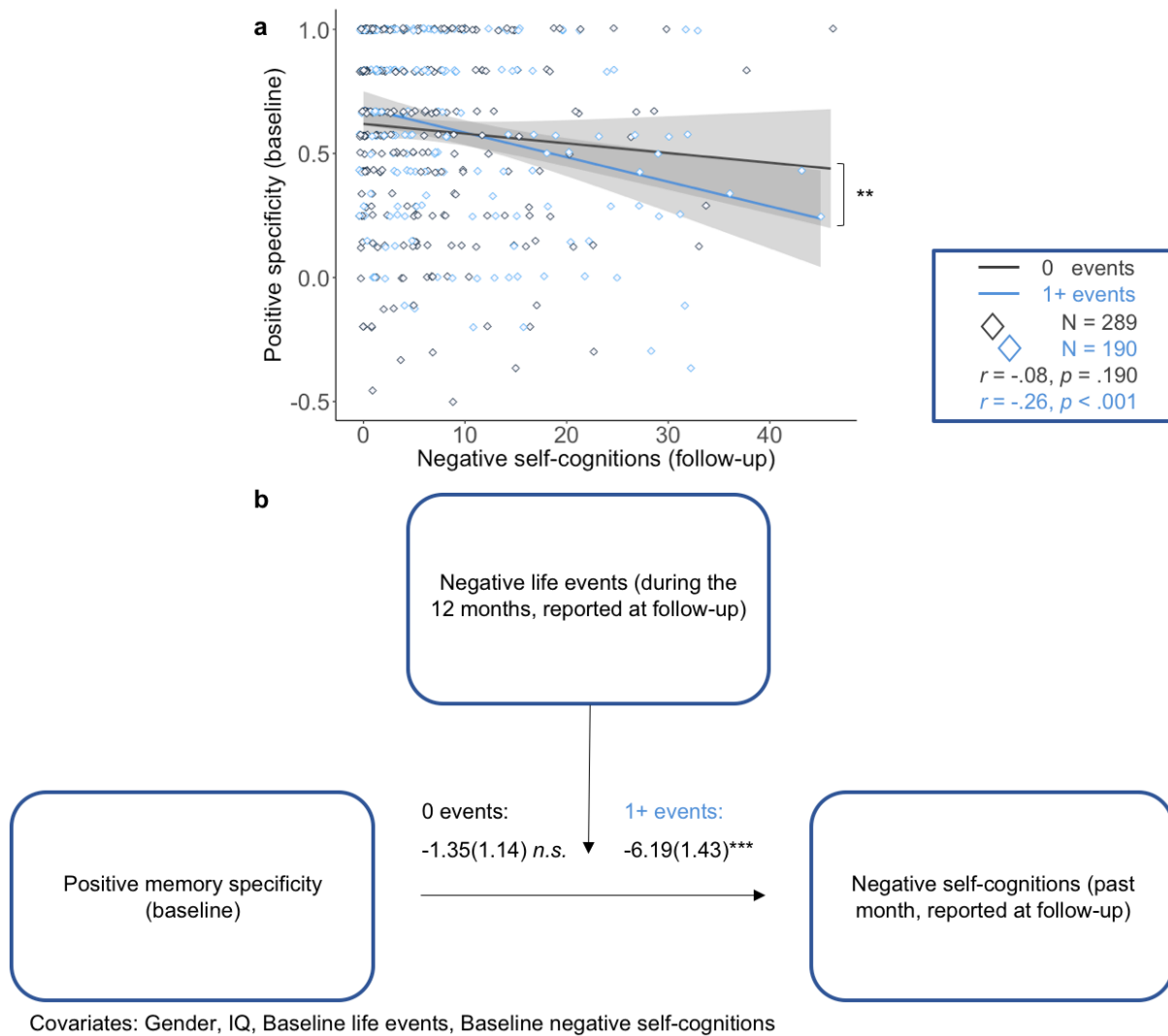


Figure 2. Positive memory specificity lowers negative self-cognitions after recent negative life events.

Plot **a** is showing a significant interaction where the effect of positive memory specificity on negative self-cognitions depends on exposure to recent negative life events. Specifically, positive memory specificity is related to lower negative self-cognitions in those exposed to one or more recent negative life events (during the 12 months following baseline of the study; blue line). The relationship is not significant in those not exposed to recent negative life events (black line). Lines show raw correlations, grey bands show confidence intervals. Figure **b** shows these results as a moderation model. Path values represent unstandardized coefficients and bootstrapped standard errors; * $P < .05$; ** $P < .01$; *** $P < .005$; *n.s.* not significant.

Supplementary Table 1. Descriptive statistics, and comparison of variable means between full sample (n = 643) and subsample (n = 479).

Variable	Subsample (n = 479)			Full sample (n = 643)			P
	M	SD	Min-max	M	SD	Min-max	
Age baseline	13.7	1.18	12-16	13.7	1.17	12-16	.848
Age follow-up	14.7	1.18	13-17	14.7	1.17	13-17	.759
Positive memory specificity	0.60	0.36	-0.5-1	0.59	0.37	-0.5-1	.773
IQ	103.56	16.77	59-151	102.54	16.46	59-151	.308
Depressive symptoms baseline	17.68	9.04	0-55	17.98	9.06	0-55	.585
Depressive symptoms follow-up	14.57	9.34	0-58	14.87	9.12	0-58	.601
Negative self-cognitions/mood ratio baseline	0.41	0.32	0-2.5	0.42	0.32	0-2.5	.575
Negative self-cognitions/mood ratio follow-up	0.34	0.31	0-1.6	0.34	0.30	0-1.6	.969
Negative life events baseline	0.89	1.07	0-4	0.89	1.11	0-4	.947
Negative life events follow-up	0.64	0.64	0-7	0.64	1.00	0-7	.968

M = mean, SD = standard deviation

Supplementary Table 2. Longitudinal measurement invariance of morning cortisol. The configural model is the baseline comparison model, in which all parameters are freely estimated. In the metric model, all parameters are freely estimated apart from factor loadings, which are constrained to be equal across time points. The scalar model constrains the mean of each observed variable over time. If this step is satisfied, strong measurement invariance can be established. The means model constrains the mean of the latent factor over time, indicating whether there are any significant mean differences across measurements.

Model	X^2	df	P	CFI	RMSEA	CFI delta	RMSEA delta
Configural	17.779	14	NA	0.997	0.024	NA	NA
Metric vs Configural	21.848	17	0.2542	0.996	0.024	0.001	0.001
Scalar vs Metric	22.004	20	0.9843	0.998	0.014	0.002	0.010
Means vs Scalar	23.533	21	0.2163	0.998	0.016	0.000	0.001

Model = four hierarchical (nested) steps of increasingly more strict equality constraints, X^2 = chi square difference, df = degrees of freedom, CFI = comparative fit index, RMSEA = the root mean squared error of approximation, CFI delta = difference in comparative fit index, RMSEA delta = difference in root mean squared error of approximation. Differences less than RMSEA delta = .015, or CFI delta = .01 are not considered significant, which indicates measurement invariance for that particular nested model comparison.

Supplementary Table 3. Positive memory specificity predicting negative self-cognitions and morning cortisol without outliers.

Outcome	Predictors	Estimate	S.E.	z-value	P(> z)
Morning cortisol (b)	Positive memory specificity (b)	-0.257	0.150	-1.712	.087
	Negative life events (b)	-0.041	0.045	-0.920	.358
	Gender (b)	0.736	0.108	6.846	.000
	IQ (b)	-0.001	0.003	-0.436	.663
Morning cortisol (f)	Morning cortisol (b)	0.228	0.038	5.988	.000
	Positive memory specificity (b)	-0.277	0.113	-2.463	.014
	Negative self-cognitions/mood (b)	0.164	0.139	1.180	.238
	Negative life events (b)	-0.006	0.042	-0.152	.879
	Negative life events (f)	0.142	0.049	2.893	.004
	Gender (b)	0.310	0.088	3.507	.000
	IQ (b)	0.008	0.002	3.249	.001
Negative self-cognitions/mood (b)	Positive memory specificity (b)	-0.063	0.037	-1.704	.088
	Negative life events (b)	0.026	0.015	1.779	.075
	Gender (b)	0.028	0.027	1.013	.311
	IQ (b)	-0.000	0.001	-0.158	.075
Negative self-cognitions/mood (f)	Negative self-cognitions/mood (b)	0.407	0.041	9.886	.000
	Positive memory specificity (b)	-0.099	0.033	-3.038	.002
	Morning cortisol (b)	-0.021	0.011	-1.910	.056
	Negative life events (b)	0.022	0.011	2.076	.038
	Negative life events (f)	0.026	0.015	1.712	.087
	Gender (b)	0.014	0.027	0.516	.606
	IQ (b)	0.000	0.001	0.371	.711
Morning cortisol (b) ~	Negative self-cognitions/mood (b)	-0.016	0.014	1.137	.256
Morning cortisol (f) ~	Negative self-cognitions/mood (f)	-0.012	0.009	-1.361	.173

n = 439. (b) = baseline, (f) = follow-up. Boys are coded as 1, girls as 2. Significant paths are bolded. Robust model fit indices: $\chi^2_2 = 3.184$, P = .204, CFI = 0.995, TLI = 0.932, RMSEA = 0.038[0.000-0.113], SRMR = 0.013. Estimate = unstandardised coefficient, S.E. = robust standard error, z-value = standardised coefficient.

Supplementary Table 4. To rule out selective attrition as an explanation for the results, we ran a structural equation model using the Full Information Maximum Likelihood method and a robust estimator to handle missing data. The model is penalised for all estimated parameters.

Outcome	Predictors	Estimate	S.E.	z-value	P(> z)
Morning cortisol (b)	Cortisol day 1 (b)	1.000			
	Cortisol day 2 (b)	1.048	0.077	13.651	.001
	Cortisol day 3 (b)	1.135	0.092	12.276	.001
	Cortisol day 4 (b)	0.984	0.083	11.877	.001
Morning cortisol (f)	Cortisol day 1 (f)	1.000			
	Cortisol day 2 (f)	0.931	0.107	8.718	.001
	Cortisol day 3 (f)	0.924	0.103	8.934	.001
	Cortisol day 4 (f)	0.924	0.103	8.939	.001
Morning cortisol (b)	Positive memory specificity (b)	-0.250	0.137	-1.833	.067
	Negative life events (b)	0.040	0.044	0.924	.356
	Gender (b)	0.770	0.103	7.508	.001
	IQ (b)	0.004	0.003	1.481	.138
Morning cortisol (f)	Morning cortisol (b)	0.637	0.120	5.308	.001
	Positive memory specificity (b)	-0.395	0.178	-2.217	.027
	Negative self-cognitions/mood (b)	0.335	0.202	1.661	.097
	Negative life events (b)	0.065	0.062	1.055	.291
	Negative life events (f)	0.001	0.057	0.025	.980
	Gender (b)	0.299	0.139	2.146	.032
	IQ (b)	0.008	0.004	2.283	.022
Negative self-cognitions/mood (b)	Positive memory specificity (b)	-0.067	0.034	-1.957	.050
	Negative life events (b)	0.022	0.010	2.097	.036
	Gender (b)	0.059	0.023	2.618	.009
	IQ (b)	-0.000	0.001	-0.727	.467
Negative self-cognitions/mood (f)	Negative self-cognitions/mood (b)	0.395	0.044	8.934	.001
	Positive memory specificity (b)	-0.090	0.031	-2.895	.004
	Morning cortisol (b)	-0.012	0.010	-1.208	.227
	Negative life events (b)	0.016	0.008	1.968	.049
	Negative life events (f)	0.021	0.009	2.224	.026
	Gender (b)	0.042	0.023	1.841	.066
	IQ (b)	-0.000	0.001	-0.827	.408
Morning cortisol (b) ~	Negative self-cognitions/mood (b)	0.001	0.015	0.075	.940
Morning cortisol (f) ~	Negative self-cognitions/mood (f)	-0.001	0.016	-0.078	.938

n = 479 with missing data estimated. (b) = baseline, (f) = follow-up. Boys are coded as 1, girls as 2. Significant paths are bolded. Robust model fit indices: $X^2_{63} = 91.907$, P = 0.01, CFI = 0.984, TLI = 0.976, RMSEA = 0.012[0.006-0.017], SRMR = 0.024. Estimate = unstandardised coefficient, S.E. = robust standard error, z-value = standardised coefficient.

Supplementary Table 5. Results of moderation and moderated mediation models without covariates and with outliers excluded. The index of the moderated mediation (ab) is significant for confidence intervals that do not include 0. All significant values are bolded.

Path	Predictor	Moderator	Mediator	Outcome	Effect	S.E.	df	t	95% CI	P(> z)
c1	Pos memory	0 events		Neg cognitions	-1.442	1.060	435	-1.360	[0.175; -3.525]	.642
c2	Pos memory	1+ events		Neg cognitions	-5.964	1.470	435	-4.058	[-8.852; -3.076]	.001
a1	Pos memory	0 events	Neg cognitions		-1.442	1.060	435	-1.360	[-3.525; 0.642]	.175
a2	Pos memory	1+ events	Neg cognitions		-5.619	1.470	435	-4.059	[-8.852; -3.076]	.001
b			Neg cognitions	Dep sympt	0.736	0.044	436	16.679	[0.650; 0.823]	.001
ab	Pos memory	Neg events	Neg cognitions	Dep sympt	-3.330	1.582	436		[-6.457; -0.329]	
c'	Pos memory	Neg events	Neg cognitions	Dep sympt	0.516	0.819	436	0.630	[-1.094; 2.125]	.529
a1	Pos memory	0 events	Dep sympt		-1.220	1.257	435	-0.971	[-3.690; 1.250]	.332
a2	Pos memory	1+ events	Dep sympt		-1.742	1.742	435	-1.487	[-5.524; 0.390]	.138
b			Dep sympt	Neg cognitions	0.529	0.032	436	16.679	[0.467; 0.591]	.001
ab	Pos memory	Neg events	Dep sympt	Neg cognitions	-0.725	1.262	436		[-3.181; 1.787]	
c'	Pos memory	Neg events	Dep sympt	Neg cognitions	-2.094	0.687	436	-3.048	[-3.444; -0.744]	.002

Predictor: baseline, moderator: between baseline and follow-up, mediator and outcome: follow-up. Pos memory = positive memory specificity, Neg events = negative life events, Neg cognitions = negative self-cognitions, Dep sympt = depressive symptoms. Levels of the moderator are 0 (no events) and 1+ (one or more events). Path a1/a2 = conditional effect of predictor on mediator, b = relationship between mediator and outcome, ab = indirect effect of predictor on outcome, through mediator, c' = direct effect of predictor on outcome controlling for the indirect effect, c1/c2 = conditional direct effect of predictor on outcome. Effect = standardised coefficient, S.E. = bootstrapped standard error, df = degrees of freedom, 95 % CI = 95 % bootstrapped confidence interval of the estimate.