

Supplementary Material to “Good Night – Good Day?”**Bidirectional Links Between Daily Sleep Quality and Aspects of Negative Affect in Old Age”**

In this supplement we present equations for the main models (Supplement S1) and report results from the additional analyses including between-person associations with sleep quality (Table S1), the time of day, and the self-reported number of illnesses (Tables S2 to Table S5).

SUPPLEMENT: SLEEP AND AFFECTIVE REACTIVITY

Supplement S1: Multilevel and Mixed Model Equations for the Main Models**Model 1: Sleep Quality Predicting Reactivity and NA**

Within Day, Within Person – Level 1

$$NA_{ijk} = \pi_{0jk} + \pi_{1jk} Stress_{ijk} + \varepsilon_{ijk}$$

Between Day, Within Person – Level 2

$$\pi_{0jk} = \beta_{00k} + \beta_{01k} SQ_{jk} + r_{0jk}$$

$$\pi_{1jk} = \beta_{10k} + \beta_{11k} SQ_{jk} + r_{1jk}$$

Between Person – Level 3

$$\beta_{00k} = \gamma_{000} + \gamma_{001} Age_k + \gamma_{002} Sample_k + u_{00k}$$

$$\beta_{01k} = \gamma_{010} + \gamma_{011} Age_k + \gamma_{012} Sample_k + u_{01k}$$

$$\beta_{10k} = \gamma_{100} + \gamma_{101} Age_k + \gamma_{102} Sample_k + u_{10k}$$

$$\beta_{11k} = \gamma_{110} + \gamma_{111} Age_k + \gamma_{112} Sample_k + u_{11k}$$

Mixed Model Equation

$$NA_{ijk} = \gamma_{000} + \gamma_{100} Stress_{ijk} + \gamma_{010} (SQ_{jk} - \overline{SQ_k}) + \gamma_{001} Age_k + \gamma_{002} Sample_k + \gamma_{110} (SQ_{jk} - \overline{SQ_k})$$

$$Stress_{ijk} + \gamma_{101} Age_k Stress_{ijk} + \gamma_{102} Sample_k Stress_{ijk} + \gamma_{011} Age_k (SQ_{jk} - \overline{SQ_k}) + \gamma_{012} Sample_k (SQ_{jk} - \overline{SQ_k})$$

$$+ \gamma_{111} Age_k (SQ_{jk} - \overline{SQ_k}) Stress_{ijk} + \gamma_{112} Sample_k (SQ_{jk} - \overline{SQ_k}) Stress_{ijk} + r_{1jk} Stress_{ijk} +$$

$$u_{10k} Stress_{ijk} + u_{01k} (SQ_{jk} - \overline{SQ_k}) + u_{11k} (SQ_{jk} - \overline{SQ_k}) Stress_{ijk} + r_{0jk} + u_{00k} + \varepsilon_{ijk}$$

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Model 2 - Step 1a: Exporting Reactivity and NA

Within Day, Within Person – Level 1

$$NA_{ijk} = \pi_{0jk} + \pi_{1jk} \text{Stress}_{ijk} + \varepsilon_{ijk}$$

Between Day, Within Person – Level 2

$$\pi_{0jk} = \beta_{00k} + r_{0jk} = NA_{jk}$$

$$\pi_{1jk} = \beta_{10k} + r_{1jk} = \text{Reactivity}_{jk}$$

Between Person – Level 3

$$\beta_{00k} = \gamma_{000} + u_{00k}$$

$$\beta_{10k} = \gamma_{100} + u_{10k}$$

Model 2 - Step 1b: Exporting Stressor Occurrence

Within Day, Within Person – Level 1

$$\text{Stress}_{ijk} = \pi_{0jk} + \varepsilon_{ijk}$$

Between Day, Within Person – Level 2

$$\pi_{0jk} = \beta_{00k} + r_{0jk} = \text{Stress}_{jk}$$

Between Person – Level 3

$$\beta_{00k} = \gamma_{000} + u_{00k}$$

Model 2 – Step 2: NA, Reactivity and Stress Predicting Sleep Quality

Between Day, Within Person – Level 2

$$SQ_{jk} = \delta_{00k} + \delta_{01k} NA_{jk} + \delta_{02k} \text{Stress}_{jk} + \delta_{03k} \text{Reactivity}_{jk} + s_{0jk}$$

$$SQ_{jk} = \delta_{00k} + \delta_{01k} \pi_{0jk} + \delta_{02k} \text{Stress}_{jk} + \delta_{03k} \pi_{1jk} + s_{0jk}$$

Between Person – Level 3

$$\delta_{00k} = \vartheta_{000} + \vartheta_{001} \text{Age}_k + \vartheta_{002} \text{Sample}_k + t_{00k}$$

$$\delta_{01k} = \vartheta_{010} + \vartheta_{011} \text{Age}_k + \vartheta_{012} \text{Sample}_k + t_{01k}$$

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$$\delta_{02k} = \vartheta_{020} + \vartheta_{021}Age_k + \vartheta_{022}Sample_k + t_{02k}$$

$$\delta_{03k} = \vartheta_{030} + \vartheta_{031}Age_k + \vartheta_{032}Sample_k + t_{03k}$$

Mixed Model Equation

$$SQ_{jk} = \vartheta_{000} + \vartheta_{010}NA_{jk} + \vartheta_{020}Stress_{jk} + \vartheta_{030}Reactivity_{jk} + \vartheta_{001}Age_k + \vartheta_{002}Sample_k + \vartheta_{011}Age_k NA_{jk} + \vartheta_{012}Sample_k NA_{jk} + \vartheta_{021}Age_k Stress_{jk} + \vartheta_{022}Sample_k Stress_{jk} + \vartheta_{031}Age_k Reactivity_{jk} + \vartheta_{032}Sample_k Reactivity_{jk} + t_{01k}NA + t_{02k}Stress_{jk} + t_{03k}Reactivity_{jk} + s_{0jk} + t_{00k}$$

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Table S1

Results from Three-Level Models: Sleep Quality (SQ) Predicting Reactivity and Baseline NA Negative Affect (NA) Including Between-Person Associations With Mean SQ.

	Estimate	95% CI
Fixed effects		
Intercept NA	9.575	[8.422, 10.719]
Reactivity (NA predicted by stress)	9.204	[8.137, 10.27]
Reactivity predicted by SQ ^a (within-person)	-0.013	[-0.053, 0.03]
NA predicted by SQ ^a (within-person)	-0.029	[-0.049, -0.01]
Reactivity predicted by Mean SQ (between-person)	-0.019	[0.084, 0.046]
NA predicted by Mean SQ (between-person)	-0.223	[-0.294, -0.153]
<i>Age and Sample as Moderators</i>		
Intercept NA predicted by age	0.383	[0.229, 0.538]
Intercept NA predicted by sample	2.664	[0.358, 4.989]
Reactivity predicted by age	-0.089	[-0.231, 0.054]
Reactivity predicted by sample	1.856	[-0.278, 4.022]
Reactivity predicted by SQ x age	0.000	[-0.006, 0.005]
Reactivity predicted by SQ x sample	0.051	[-0.034, 0.133]
NA predicted by SQ x age	0.000	[-0.003, 0.002]
NA predicted by SQ x sample	0.020	[-0.018, 0.059]
Random effects (Variances)		
<i>Within Person, Within Days</i>		
NA residual variance	72.779	[70.669, 74.988]
<i>Within Person, Between Days</i>		
NA residual variance	5.054	[3.617, 6.602]
Reactivity residual variance	81.282	[70.083, 93.936]
<i>Between Person</i>		
NA residual variance	104.326	[88.91, 123.66]
Reactivity residual variance	46.631	[33.688, 63.002]
Reactivity predicted by SQ residual variance	0.004	[0.001, 0.013]
NA predicted by SQ residual variance	0.007	[0.004, 0.012]
R ² Level 1	0.263	

Note. SQ = sleep quality. NA = negative affect. CI = credibility interval. N_{Level1}= 11773, N_{Level2}= 2224, N_{Level3}=325.

^aSleep quality was person-mean centered.

Bold faced estimates indicate that the 95% CI does not cover 0. Because variances can never be estimated at or below zero in Bayesian analysis in Mplus we did not bold face variance estimates. R²s indicating the explained total variance on the lowest level (i.e., Ω^2 , Xu, 2003; corresponding to $R_t^{2(fvm)}$) as suggested by Rights & Sterba, 2019)

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Table S2

Results From Three-Level Models: Sleep Quality (SQ) Predicting Reactivity and Negative Affect (NA) Including Time of Day.

	Estimate	95% CI
Fixed effects		
Intercept NA	9.651	[8.411, 10.883]
Reactivity (NA predicted by stress)	9.223	[8.082, 10.439]
Time trend in NA	-0.012	[-0.054, 0.028]
NA predicted by time x stress	-0.025	[-0.155, 0.101]
Reactivity predicted by SQ	0.019	[-0.04, 0.073]
NA predicted by SQ	-0.029	[-0.05, -0.004]
Time trend predicted by SQ	0.000	[-0.004, 0.005]
NA predicted by time x stress x SQ	-0.005	[-0.015, 0.004]
<i>Moderations^a</i>		
Intercept NA predicted by age	0.401	[0.235, 0.563]
Intercept NA predicted by study	2.121	[-0.321, 4.574]
Reactivity predicted by age	-0.021	[-0.175, 0.131]
Reactivity predicted by study	1.441	[-0.973, 3.832]
Time trend predicted by age	-0.001	[-0.006, 0.004]
Time trend predicted by study	-0.034	[-0.115, 0.046]
NA predicted by time x stress x age	-0.017	[-0.032, -0.001]
NA predicted by time x stress x study	0.077	[-0.201, 0.341]
Reactivity predicted by SQ x age	-0.004	[-0.011, 0.003]
Reactivity predicted by SQ x study	0.034	[-0.099, 0.136]
NA predicted by SQ x age	0.000	[-0.003, 0.003]
NA predicted by SQ x study	0.046	[0.001, 0.095]
Time trend predicted by SQ x age	-0.001	[-0.006, 0.004]
Time trend predicted by SQ x study	-0.034	[-0.115, 0.046]
NA predicted by time x stress x SQ x age	0.001	[0, 0.002]
NA predicted by time x stress x SQ x study	0.001	[-0.017, 0.019]
Random effects (Variances)		
<i>Within Person, Within Days</i>		
Intercept NA residual variance	67.545	[65.476, 69.758]
<i>Within Person, Between Days</i>		
Intercept NA residual variance	5.654	[4.264, 7.4]
Reactivity residual variance	72.526	[60.724, 85.21]
Time trend in NA residual variance	0.003	[0.001, 0.01]
NA on time x stress residual variance	0.807	[0.619, 1.042]
<i>Between Person</i>		
Intercept NA residual variance	117.634	[100.212, 139.01]
Reactivity residual variance	43.808	[30.966, 60.188]
Time trend in NA residual variance	0.004	[0.001, 0.012]
NA predicted by time x stress residual variance	0.070	[0.003, 0.198]
Reactivity predicted by SQ residual variance	0.005	[0.001, 0.019]
NA predicted by SQ residual variance	0.005	[0.002, 0.009]

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	Estimate	95% CI
Time trend predicted by SQ residual variance	0.001	[0, 0.001]
NA predicted by time x stress x SQ residual variance	0.001	[0.001, 0.001]
R ² Level 1	0.316	

Note. SQ = sleep quality. NA = negative affect. CI = credibility interval.

^aYoung-old -0.261; Old-old 0.739.

Bold faced estimates indicate that the CI does not cover 0. Because variances can never be estimated at or below zero in Bayesian analysis in Mplus we did not bold variance estimates.

R²s indicating the explained total variance on the lowest level (i.e., Ω^2 , Xu, 2003; corresponding to $R_t^{2(fvm)}$ as suggested by Rights & Sterba, 2019)

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Table S3

Results From Two-Level Models: Reactivity and Negative Affect (NA) Predicting Sleep Quality (SQ) Including Time of Day.

	Estimate	95% CI
Fixed effects		
Intercept SQ	70.168	[68.38, 72.018]
SQ predicted by reactivity ^a	-0.243	[-0.483, -0.001]
SQ predicted by NA ^a	0.055	[-0.681, 0.784]
SQ predicted by stress ^a	-0.007	[-0.174, 0.163]
SQ predicted by time trend in NA ^a	12.674	[33.092, 7.589]
SQ predicted by 'NA on time x stress' ^a	1.172	[-0.929, 3.372]
<i>Age group differences^b</i>		
Intercept SQ predicted by age		
Intercept SQ predicted by study		
SQ predicted by reactivity x age	0.013	[-0.019, 0.045]
SQ predicted by reactivity x study	0.238	[-0.258, 0.757]
SQ predicted by NA x age	-0.076	[-0.184, 0.017]
SQ predicted by NA x study	0.940	[-0.713, 2.285]
SQ predicted by stress x age	0.030	[0.007, 0.055]
SQ predicted by stress x study	0.100	[-0.227, 0.454]
SQ predicted by time trend x age	-0.014	[-2.637, 2.397]
SQ predicted by time trend x study	8.141	[33.498, 0.469]
SQ predicted by 'NA on time x stress x age	-0.027	[-0.279, 0.245]
SQ predicted by 'NA on time x stress x study	-1.240	[-5.425, 3.001]
Random Effects (Variances)		
<i>Within Person, Between Days</i>		
SQ residual variance	244.258	[225.404, 264.784]
<i>Between Person</i>		
SQ residual variance	236.028	[197.002, 284.854]
SQ predicted by reactivity residual variance	0.637	[0.238, 1.286]
SQ predicted by NA residual variance	1.470	[0.047, 5.267]
SQ predicted by stress residual variance	0.105	[0.007, 0.366]
SQ predicted by time trend residual variance	196.290	[517.852, 4898.148]
SQ predicted by 'NA on time x stress'	17.723	[2.238, 57.412]
R ² Level 2	0.119	

Note. SQ = sleep quality. NA = negative affect. CI = credibility interval.

^aAll predictors were Level 2 estimates from separate three-level models and are de facto person-mean centered. ^bYoung-old -0.261; Old-old 0.739.

Bold faced estimates indicate that the CI does not cover 0. Because variances can never be estimated at or below zero in Bayesian analysis in Mplus we did not bold variance estimates.

R²s indicating the explained total variance on the lowest level (i.e., Ω^2 , Xu, 2003; corresponding to $R_t^{2(fvm)}$ as suggested by Rights & Sterba, 2019)

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Table S4

Results From Three-Level Models: Sleep Quality (SQ) Predicting Reactivity and Negative Affect (NA) When Controlling for Illness.

	Estimate	95% CI
Fixed effects		
Intercept NA	9.573	[8.37, 10.774]
Reactivity	9.213	[8.148, 10.287]
Reactivity predicted by SQ	-0.014	[-0.055, 0.029]
NA predicted by SQ	-0.030	[-0.049, -0.011]
<i>Moderations^a</i>		
Intercept NA predicted by age	0.373	[0.193, 0.552]
Intercept NA predicted by illness	0.209	[-0.548, 0.942]
Intercept NA predicted by study	1.919	[-0.489, 4.301]
Reactivity predicted by age	-0.092	[-0.246, 0.066]
Reactivity predicted by illness	-0.016	[-0.688, 0.65]
Reactivity predicted by study	1.825	[-0.292, 3.99]
Reactivity predicted by SQ x age	0.000	[-0.006, 0.006]
Reactivity predicted by SQ x illness	0.001	[-0.024, 0.027]
Reactivity predicted by SQ x study	0.058	[-0.038, 0.144]
NA predicted by SQ x age	-0.001	[-0.004, 0.001]
NA predicted by SQ x illness	0.008	[-0.002, 0.02]
NA predicted by SQ x study	0.022	[-0.016, 0.061]
Random effects		
<i>Within Person, Within Days</i>		
NA residual variance	72.736	[70.64, 74.923]
<i>Within Person, Between Days</i>		
NA residual variance	5.035	[3.623, 6.742]
Reactivity residual variance	81.315	[70.393, 93.873]
<i>Between Person</i>		
NA residual variance	117.806	[100.186, 139.003]
Reactivity residual variance	47.057	[34.415, 63.132]
Reactivity predicted by SQ residual variance	0.003	[0.001, 0.012]
NA predicted by SQ residual variance	0.007	[0.004, 0.012]
R ² Level 1	0.263	

Note. SQ = sleep quality. NA = negative affect. CI = credibility interval.

^aYoung-old -0.261; Old-old 0.739.

Bold faced estimates indicate that the CI does not cover 0. Because variances can never be estimated at or below zero in Bayesian analysis in Mplus we did not bold variance estimates.

R²s indicating the explained total variance on the lowest level (i.e., Ω^2 , Xu, 2003; corresponding to $R_t^{2(fvm)}$ as suggested by Rights & Sterba, 2019)

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Table S5

Results From Two-Level Models: Reactivity and Negative Affect (NA) Predicting Sleep Quality (SQ) When Controlling for Illness.

	Estimate	95% CI
Fixed effects		
Intercept SQ	70.159	[68.363, 71.982]
SQ predicted by reactivity	-0.299	[-0.494, -0.101]
SQ predicted by NA	0.640	[-0.104, 1.414]
SQ predicted by stress	-0.022	[-0.199, 0.143]
<i>Moderations^a</i>		
Intercept SQ predicted by age	0.071	[-0.205, 0.342]
Intercept SQ predicted by illness	-0.850	[-1.985, 0.303]
Intercept SQ predicted by study	2.726	[-0.94, 6.37]
SQ predicted by reactivity x age	0.006	[-0.022, 0.035]
SQ predicted by reactivity x illness	0.088	[-0.034, 0.206]
SQ predicted by reactivity x study	0.353	[-0.05, 0.747]
SQ predicted by NA x age	-0.078	[-0.177, 0.02]
SQ predicted by NA x illness	-0.272	[-0.699, 0.116]
SQ predicted by NA x study	0.025	[-1.514, 1.523]
SQ predicted by stress x age	0.029	[0.003, 0.054]
SQ predicted by stress x illness	0.018	[-0.091, 0.125]
SQ predicted by stress x study	0.165	[-0.153, 0.536]
Random Effects (Variances)		
<i>Within Person, Between Days</i>		
Intercept SQ residual variance	246.679	[228.308, 266.471]
<i>Between Person</i>		
Intercept SQ residual variance	234.331	[195.198, 282.474]
SQ predicted by reactivity residual variance	0.613	[0.3, 1.033]
SQ predicted by NA residual variance	3.577	[0.397, 9.013]
SQ predicted by stress residual variance	0.104	[0.008, 0.35]
R ² Level 2	0.110	

Note. SQ = sleep quality. NA = negative affect. CI = credibility interval.

^aYoung-old -0.261; Old-old 0.739.

Bold face indicates that the CI does not cover 0. Because variances can never be estimated at or below zero in Bayesian analysis in Mplus we did not bold variance estimates.

R²s indicating the explained total variance on the lowest level (i.e., Ω^2 , Xu, 2003; corresponding to $R_t^{2(fvm)}$ as suggested by Rights & Sterba, 2019)