Unity and Diversity of Metacognition – Supplementary Materials

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Domain-generality vs. Domain-specificity: Validation analyses

In the following, we present validation analyses concerning the inter-correlation of metacognitive efficiency scores per task, including Spearman's rank correlations (Supplementary Table 1) as an alternative to log-transformation to deal with the non-normality of several metacognitive efficiency variables in the present analysis, and partial Pearson's correlations controlling for age (Supplementary Table 2), which could not be accommodated within the hierarchical Bayesian estimation of correlation coefficients presented in Table 4 of the manuscript. Overall, the validation analyses broadly support the majority of findings reported in the manuscript. Due to conservative Bonferroni correction, there was no significant intra-domain correlation between AS-T and EA-T in the partial correlations (Supplementary Table 2), but the values were not substantially different from the main analysis. In both analyses, there is circumstantial evidence for correlations between metacognitive efficiency in the EA-T and the RW-T, which might partially compensate for the lack of correlation between the AS-T and the two episodic memory paradigms (which were significant in the hierarchical Bayesian correlations, as discussed below) and thereby provide a potential link between the attention-to-action domain and the memory domain. Likewise, correlations of metacognitive efficiency in the EA-T and the MP-T as well as (indicated by the partial correlations) between MP-T and RF-T are discernible; however, due to Bonferroni correction, these correlations failed to reach significance.

As for the absence of significant correlations between metacognitive efficiency in the AS-T and the episodic memory paradigms in the two validation analyses presented below, when compared to the hierarchical Bayesian estimation of correlation coefficients (see manuscript, Table 4), one might first point out several specific advantages of the hierarchical approach over simple correlations. Most notably, it allows for incorporation of uncertainties in the model's estimate of meta-d', which is particularly relevant for the assessment of inter-domain correlations and which is naturally accommodated in hierarchical estimation of the correlation coefficient (Fleming, 2017). As elaborated on in the manuscript, a possible limitation of the present study concerns the limited integrability of the EA-T, which could also potentially prove problematic here, as correlations between metacognitive efficiency scores in the EA-T with point estimates of metacognitive efficiency in the other five tasks are more strongly influenced by factors such as the varying number of trials between tasks than the Bayesian estimation of covariance matrices employed for the other between-task comparisons. Importantly, a log-transformation was applied to deal with non-normality of parameters entered as indicators in the confirmatory factor analyses, which was the case for the three tasks in question (AS-T, RW-T, RF-T). However, this transformation was not applied to and hence did not affect the input parameters for the hierarchical estimation of the correlation coefficients, which is why a less biased and thus arguably more precise result could be obtained by this method (Fleming, 2017).

Still, a cautionary note seems in place, as the 95% highest-density intervals presented in Table 4 of the manuscript are rather wide and the lower ends close to zero for the AS-T/RW-T and AS-T/RF-T hierarchical correlations. The possibility should hence not be ignored that the validation analyses bear incremental informational value about the relationship between metacognitive efficiency in the AS-T and the two episodic memory paradigms that cannot be accounted for by the hierarchical model: The inclusion of the covariate age (Supplementary Table 2) reduced the magnitude of correlation; moreover, Spearman's rank correlations represent an alternative approach to deal with non-normality of the variables of interest, but here, the inter-correlations of AS-T/RW-T and AS-T/RF-T were not present (Supplementary Table 1).

Rank correlations

Supplementary Table 1. Spearman's correlation coefficients and 95% confidence intervals for correlations between metacognitive efficiency estimates of all task pairings. Bonferroni-corrected α=.003.

	EA-T	MP-T	DD-T	RW-T	RF-T
AS-T	***r*=.28***	*r*=.09	*r*=.07	*r*=.13	*r*=.01
	[.08, .48]	[-.10, .28]	[-.13, .27]	[-.06, .31]	[-.16, .18]
EA-T	-	*r*=.18	*r*=.15	*r*=.23	*r*=.01
		[.02, .34]	[-.07, .34]	[.06, .37]	[-.21, .22]
MP-T		-	***r*=.30***	*r*=.16	*r*=.08
			[.13, .48]	[-.03, .32]	[-.13, .29]
DD-T			-	*r*=.12	*r*=.08
				[-.07, .31]	[-.11, .26]
RW-T				-	*r*=.15
					[-.04, .33]

Note: AS-T, Antisaccade Task, EA-T, Error Awareness Task, MP-T, Motion Perception Task, DD-T, Dot Discrimination Task, RW-T, Retrieving Words Task, RF-T, Retrieving Faces Task. *significant at p<.003.

Partial Pearson's correlations

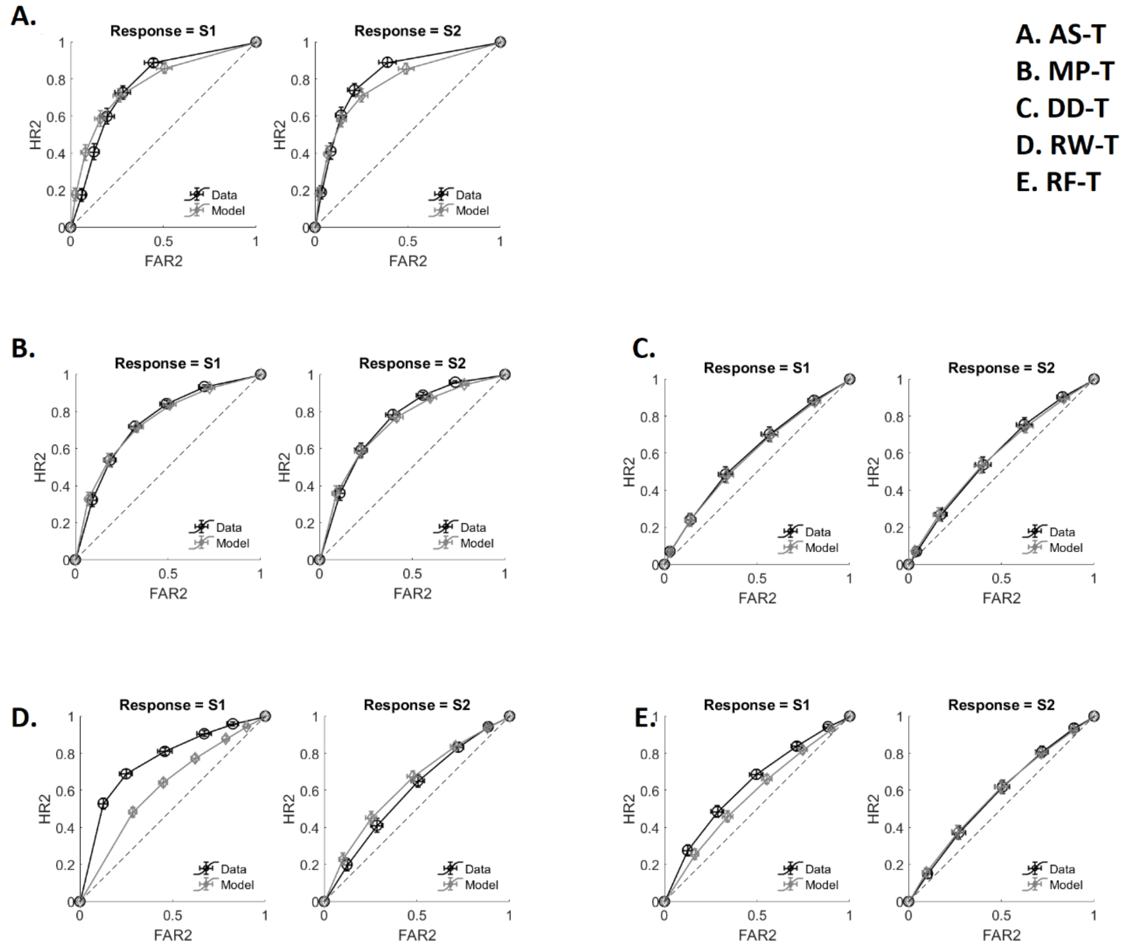
Supplementary Table 2. Partial Pearson's correlation coefficients and 95% confidence intervals for correlations between metacognitive efficiency estimates of all task pairings, controlling for age. Bonferroni-corrected α=.003.

	EA-T	MP-T	DD-T	RW-T	RF-T
AS-T	*r*=.26*	*r*=.05	*r*=.05	*r*=.14	*r*=.05
	[.10, .48]	[-.15, .22]	[-.11, .20]	[-.05, .34]	[-.10, .18]
EA-T	-	*r*=.21	*r*=.14	*r*=.24	*r*=.02
		[.03, .09]	[-.05, .33]	[.08, .40]	[-.20, .22]
MP-T		-	***r*=.35***	*r*=.12	*r*=.21
			[.18, .50]	[-.07, .29]	[-.02, .42]
DD-T			-	*r*=.14	*r*=.11
				[-.03, .31]	[-.13, .34]
RW-T				-	*r*=.18
					[-.00, .34]

Note: AS-T, Antisaccade Task, EA-T, Error Awareness Task, MP-T, Motion Perception Task, DD-T, Dot Discrimination Task, RW-T, Retrieving Words Task, RF-T, Retrieving Faces Task. *significant at *p*<.003.

Evaluation of meta-d' model fit

Group-level observed and predicted Type 2 receiver-operating-characteristic (ROC) curves can be inspected and compared to evaluate the meta-d' model fit, as the meta-d' framework is explicitly model-based (Maniscalco & Lau, 2012). There is a noticeably larger area-under-the-curve for "Old" responses in the memory domain, in particular in the RW-T (Supplementary Figure 1, Panel D) than for "No" responses, due to the Yes/No response format, which is known to be a methodological constraint in studying the structure of metacognition (Rouault *et al.*, 2018a; further discussion below). Meanwhile, it is noteworthy that a good fit of the meta-d' model is present in the AS-T, the MP-T, and the DD-T. Nevertheless, the Bi-factor model with isolated memory domain is not superior to its competing models, so in this case, no domain-specific noise (e.g., in the underlying metric) should be assumed to negatively affect the outcome of the CFAs by grouping together domains measured with greater precision than a different domain, although the extent of this argument is limited due to the lack of comparison between observed and predicted Type 2 receiver-operating-characteristics for the EA-T.



Supplementary Figure 1. **A.)** Group-level observed and predicted type 2 receiver-operating-characteristic (ROC) curves for responses to stimulus category 1 (S1, left) and stimulus category 2 (S2, right) in the AS-T. **B.)** Observed and predicted type 2 ROCs for responses to stimulus category 1 (S1, left) and stimulus category 2 (S2, right) in the MP-T. **C.)** Observed and predicted type 2 ROCs for responses to stimulus category 1 (S1, left) and stimulus category 2 (S2, right) in the DD-T. **D.)** Observed and predicted type 2 ROCs for responses to stimulus category 1 (S1, old) and stimulus category 2 (S2, new) in the RW-T. **E.)** Observed and predicted type 2 ROCs for responses to stimulus category 1 (S1, old) and stimulus category 2 (S2, new) in the RF-T. Figures generated by the metad_group_visualise function included in HMeta-d toolbox (Fleming, 2017).

Online and Offline metacognition: Validation analyses

Evaluation of G-factor model fit for metacognitive bias

We suggested that an optimally concise investigation of our second study goal, the online-offline comparison of metacognition, could be achieved in a hierarchical regression analysis on G-factor values of metacognitive efficiency and bias, with sequential inclusion of confound variables (age and sex) and predictors of interest (scales of self-report measures with minimal internal consistency). The fit of the metacognitive efficiency G-factor model is described in the manuscript; the fit indices for the metacognitive bias G-factor model are reported below.

Overall, the G-factor model estimated directly from the average confidence level parameters of the five paradigms employing confidence rating reports, from which individual G-factor scores were extracted for further use in the hierarchical regression analysis reported in the manuscript, yielded an acceptable fit with regard to the Comparative Fit Index (CFI, .92) and the Standardized Root Mean Square Residual (.05). Standardized factor loadings and error variances were highly significant (all $P<.01$) for all indicators of the latent G-factor. However, a significant χ^2 user model test ($\chi^2=23.36$, $df=5$, $p<.001$) and Root Mean Square Error of Approximation (RMSEA=.15, $p=.003$) cast doubt on whether the latent variable extracted from indicators appropriately converged for extraction of meaningful G-factor values. This is surprising given the highly significant correlations of average reported confidence levels for eight out of ten task pairings (see manuscript, Table 6) and the repeated finding of previous studies that average confidence levels remain quite stable across different situations and tasks (Ais *et al.*, 2016; Schraw, 1996; West & Stanovich, 1997). One contributing factor to this might be the discernibly weaker correlation of metacognitive bias in the AS-T and in the DD-T. Overall, we argue that the regression analysis on metacognitive bias presented in the manuscript (Table 9) retains substantive value, but its results should be treated with a cautionary note and further attention should be given to the hierarchical regressions with the original behavioral outcome variables entered as criterion variables in Supplementary Tables 11-15 as well as to the correlation matrix presented in Supplementary Table 4 to allow for an overall appropriate interpretation of the findings.

Predictor-criterion inter-correlations

Partial Pearson's correlations are presented in Supplementary Table 3, serving as a validation of Tables 7 and 8 (see manuscript) and thereby adding onto the preregistered correlation analyses for the online-offline comparison by controlling for the confounding influence of age, whereas the influence of sex could not be accounted for by correlational methods due to the variable's nominal level of measurement. Supplementary Table 4 provides an overview of Pearson's correlations between self-report measures of metacognition and average confidence levels reported in the laboratory, serving as a validation of the hierarchical regression analysis on metacognitive bias G-factor scores presented in Table 9 of the manuscript. For both Supplementary Tables 3 and 4, we also report correlations of self-report measures with the respective G-factor score used as criterion variables in the corresponding regression model (see manuscript, Tables 8 and 9).

Metacognitive Efficiency

Overall, the pattern of correlations was almost identical to the ones reported in the manuscript (Table 7). When controlling for age and after correcting for multiple comparisons, the only reliable association between self-report measures of metacognition and metacognitive efficiency scores used as criterion variables in the various hierarchical regression analyses remained the correlation between metacognitive efficiency in the EA-T and the MCQ-30 scale "Positive Beliefs about Worry". Here, a significant correlation between metacognitive efficiency in the AS-T and the BCIS scale "Self-Certainty" also became discernible; however, this correlation was not significant at a Bonferroni-corrected α=.001.

Supplementary Table 3. Partial Pearson's correlation coefficients and 95% confidence intervals for correlations between self-report measures of metacognition used as predictors and metacognitive efficiency scores used as criterion variables in hierarchical regression analyses, controlling for age.

	g	AS-T	EA-T	MP-T	DD-T	RW-T	RF-T
MCQ-CC	*r*=.04	*r*=.08	*r*=-.03	*r*=.04	*r*=.04	*r*=-.03	*r*=.01
	[-.15, .24]	[-.13, .25]	[-.21, .16]	[-.17, .25]	[-.10, .18]	[-.21, .15]	[-.15, .18]
MCQ-	*r*=-.02	*r*=.12	***r*=.34****	*r*=-.15	*r*=.02	*r*=-.14	*r*=-.13
PB	[-.18, .14]	[-.08, .30]	**[.18, .49]**	[-.33, .02]	[-.14, .21]	[-.32, .07]	[-.29, .05]
MCQ-	*r*=-.09	*r*=-.12	*r*=-.08	*r*=.01	*r*=-.16	*r*=-.00	*r*=-.00
CSC	[-.27, .09]	[-.28, .06]	[-.26, .15]	[-.15, .16]	[-.30, -.00]	[-.20, .20]	[-.18, .17]
MCQ-NB	*r*=-.03	*r*=.09	*r*=.05	*r*=-.08	*r*=-.16	*r*=.11	*r*=.09
	[-.25, .18]	[-.09, .28]	[-.13, .24]	[-.29, .13]	[-.33, .05]	[-.10, .29]	[-.14, .30]
MCQ-NC	*r*=.01	*r*=.07	*r*=.13	*r*=-.03	*r*=-.10	*r*=.10	*r*=-.03
	[-.15, .16]	[-.11, .24]	[-.00, .25]	[-.21, .14]	[-.25, .05]	[-.07, .25]	[-.20, .16]
MAI-KC	*r*=-.08	*r*=-.07	*r*=.01	*r*=-.10	*r*=-.07	*r*=-.01	*r*=.06
	[-.25, .10]	[-.24, .10]	[-.16, .20]	[-.27, .08]	[-.27, .10]	[-.18, .18]	[-.13, .25]
MAI-RC	*r*=-.03	*r*=-.17	*r*=.14	*r*=-.11	*r*=.04	*r*=-.01	*r*=.10
	[-.26, .20]	[-.33, .00]	[-.07, .32]	[-.31, .09]	[-.17, .23]	[-.19, .17]	[-.15, .32]
BCIS-SC	*r*=-.02	***r*=.19***	*r*=.10	*r*=-.09	*r*=-.05	*r*=.04	*r*=-.08
	[-.16, .14]	**[.01, .37]**	[-.12, .28]	[-.25, .09]	[-.23, .12]	[-.18, .24]	[-.26, .12]
BCIS-CI	*r*=.03	*r*=-.17	*r*=-.05	*r*=.09	*r*=.03	*r*=.04	*r*=.06
	[-.15, .22]	[-.34, .01]	[-.24, .15]	[-.10, .28]	[-.20, .27]	[-.18, .26]	[-.14, .25]

Note: g, G-factor value, AS-T, Antisaccade Task, EA-T, Error Awareness Task, MP-T, Motion Perception Task, DD-T, Dot Discrimination Task, RW-T, Retrieving Words Task, RF-T, Retrieving Faces Task, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty, BCIS-CI, Cognitive Insight. $^{**}p<.001$ (significant after Bonferroni correction), $^{*}p<.05$.

Metacognitive Bias

As can be inferred from Supplementary Table 4, there was no overwhelming evidence for strong associations between offline measures of metacognition and online measures of metacognitive bias; quantitatively, a slightly higher number of correlations could be observed than between self-report measures and metacognitive efficiency, as the MCQ-30 scale "Cognitive Confidence" showed associations with bias in both episodic memory paradigms and "Cognitive Self-Consciousness" (also

MCQ-30) with average confidence in the DD-T. Importantly, “Cognitive Confidence” was also significantly correlated with the obtained G-factor for metacognitive bias, which helps explain the significant model fit as well as the significant predictor contribution of “Cognitive Confidence” in the hierarchical regression analysis on metacognitive bias (see manuscript, Table 9). However, none of the reported correlations survived the application of conservative Bonferroni corrections.

Supplementary Table 4. Pearson’s correlation coefficients and 95% confidence intervals for correlations between self-report measures of metacognition used as predictors and metacognitive bias scores used as criterion variables in hierarchical regression analyses.

	g	AS-T	MP-T	DD-T	RW-T	RF-T
MCQ-CC	***r*=-.21***	*r*=-.12	*r*=-.17	*r*=-.10	***r*=-.25***	***r*=-.23***
	[-.37, -.04]	[-.32, .09]	[-.39, .05]	[-.33, .13]	**[-.45, -.01]**	**[-.45, -.02]**
MCQ-PB	*r*=.09	*r*=-.02	*r*=-.02	*r*=.10	*r*=.10	*r*=-.02
	[-.10, .26]	[-.23, .22]	[-.25, .21]	[-.09, .28]	[-.09, .26]	[-.26, .19]
MCQ-CSC	*r*=.10	*r*=-.05	*r*=.03	***r*=.20***	*r*=.13	*r*=.01
	[-.05, .24]	[-.24, .14]	[-.14, .20]	**[.02, .36]**	[-.06, .29]	[-.17, .18]
MCQ-NB	*r*=-.08	*r*=-.09	*r*=-.02	*r*=-.07	*r*=-.03	*r*=-.07
	[-.22, .07]	[-.24, .06]	[-.20, .17]	[-.24, .12]	[-.17, .23]	[-.23, .08]
MCQ-NC	*r*=.09	*r*=-.03	*r*=.06	*r*=-.03	*r*=.15	*r*=.07
	[-.07, .26]	[-.22, .19]	[-.15, .28]	[-.23, .16]	[-.05, .32]	[-.13, .25]
MAI-KC	*r*=.08	*r*=.09	*r*=.06	*r*=-.04	*r*=.09	*r*=.03
	[-.09, .23]	[-.06, .25]	[-.09, .21]	[-.24, .16]	[-.09, .27]	[-.14, .23]
MAI-RC	*r*=-.01	*r*=-.12	*r*=.02	*r*=-.00	*r*=.01	*r*=-.01
	[-.16, .16]	[-.29, .06]	[-.15, .20]	[-.19, .21]	[-.17, .17]	[-.18, .15]
BCIS-SC	*r*=.12	*r*=.01	*r*=.03	*r*=.07	*r*=.05	*r*=.19
	[-.05, .29]	[-.15, .20]	[-.13, .20]	[-.12, .23]	[-.14, .24]	[.00, .36]
BCIS-CI	*r*=-.07	*r*=.08	*r*=.04	*r*=-.03	*r*=.04	*r*=-.13
	[-.24, .12]	[-.09, .26]	[-.13, .22]	[-.22, .16]	[-.17, .25]	[-.33, .08]

Note: g, G-factor value, The five paradigms with confidence rating reports: AS-T, Antisaccade Task, MP-T, Motion Perception Task, DD-T, Dot Discrimination Task, RW-T, Retrieving Words Task, RF-T, Retrieving Faces Task, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty, BCIS-CI, Cognitive Insight. $^{**}p$<.001 (significant after Bonferroni correction), $^{*}p$<.05.

Regression analyses on original behavioral outcome variables

Metacognitive Efficiency

Supplementary Table 5 conveys a detailed representation of the hierarchical regression analysis for prediction of metacognitive efficiency in the AS-T. Neither Model 1 with confound variables age and sex (F(2,127)=.55, p=.581, R^2=.01, corrected R^2=-.01) nor Model 2 (F(10,119)=1.11, p=.361, R^2=.09, corrected R^2<.01) were able to significantly predict metacognitive performance in the AS-T; the incremental variance clarification of Model 2 was non-significant (F(8,119)=1.25, p=.278, ΔR^2=.08). Interestingly, "Self-Certainty" significantly predicted metacognitive efficiency in the AS-T.

Supplementary Table 5. Prediction of metacognitive efficiency in the AS-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.01	.01
Age	-.09 [-.01, .02]	.00	-.09	.376		
Sex	-.01 [-.04, -.13]	.01	-.05	.542		
Model 2					.09	.08
Age	-.00 [-.01, .00]	.00	-.05	.640		
Sex	-.00 [-.03, .03]	.01	-.02	.815		
MCQ-CC	.00 [-.00, .01]	.00	.06	.518		
MCQ-PB	.00 [-.00, .01]	.00	.14	.200		
MCQ-CSC	-.00 [-.01, .00]	.00	-.16	.100		
MCQ-NB	.00 [-.00, .01]	.00	.08	.443		
MCQ-NC	-.00 [-.01, .00]	.00	-.00	.994		
MAI-KC	.00 [-.00, .01]	.00	.05	.642		
MAI-RC	-.00 [-.01, .00]	.00	-.09	.372		
BCIS-SC	.01 [.00, .01]	.00	.19*	.042		

Note: AS-T, Antisaccade Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. *p<.05.

Detailed results of hierarchical regression analysis for prediction of metacognitive performance in the EA-T are given in Supplementary Table 6. Importantly, the results of this analysis revealed a distinct pattern as compared to the hierarchical regression analysis on extracted G-factor values reported in the manuscript: No significant prediction by Model 1 (F(2,150)=1.24, p=.291, R^2=.02, corrected R^2<.01), but a significant prediction by Model 2 (F(10,142)=2.03, p=.034, R^2=.13, corrected R^2=.06), which predicted efficiency in the EA-T significantly better than Model 1 (F(8,142)=2.2, p=.03, ΔR^2=.11). Two MCQ-30 scales, "Positive Beliefs about Worry" (positively associated with metacognitive performance in the EA-T) as well as "Cognitive Self-Consciousness" (negatively associated with metacognitive performance in the EA-T) were identified as significant predictors.

Supplementary Table 6. Prediction of metacognitive efficiency in the EA-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.02	.02
Age	-.01 [-.03, .01]	.01	-.10	.273		
Sex	-.08 [-.21, .05]	.07	-.11	.217		
Model 2					.13*	.11*
Age	-.01 [-.02, .02]	.01	-.05	.558		
Sex	-.08 [-.21, .05]	.07	-.10	.266		
MCQ-CC	-.01 [-.03, .02]	.01	-.07	.480		
MCQ-PB	.03 [.01, .05]	.01	.33*	.002		
MCQ-CSC	-.02 [-.04, -.00]	.01	-.24*	.026		
MCQ-NB	.01 [-.01, .02]	.01	.09	.346		
MCQ-NC	.00 [-.02, .02]	.01	.01	.880		
MAI-KC	.00 [-.02, .03]	.01	.01	.870		
MAI-RC	.00 [-.01, .02]	.01	.04	.650		
BCIS-SC	.01 [-.02, .03]	.01	.05	.579		

Note: EA-T, Error Awareness Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. *p<.05.

Hierarchical regression analysis for prediction of metacognitive efficiency in the MP-T (Supplementary Table 7) revealed non-significant model fits for Model 1 (F(2,149)=.53, p=.591, R^2=.01, corrected R^2<.01) as well as Model 2 (F(10,141)=.95, p=.494, R^2=.06, corrected R^2<.01), with Model 2 hence being unable to provide a significantly better prediction than Model 1 (F(8,141)=1.05, p=.40, ΔR^2=.06). Remarkably, the MCQ-30 scale “Positive Beliefs”, identified as a positive predictor of metacognitive performance in the EA-T, was negatively associated with metacognitive performance in the MP-T.

Supplementary Table 7. Prediction of metacognitive efficiency in the MP-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.01	.01
Age	-.01 [-.02, .01]	.01	-.09	.265		
Sex	-.01 [-.10, .08]	.05	-.01	.910		
Model 2					.06	.06
Age	-.01 [-.02, .01]	.01	-.12	.172		
Sex	.00 [-.10, .10]	.05	-.00	.995		
MCQ-CC	.00 [-.01, .02]	.01	.03	.712		
MCQ-PB	-.02 [-.03, -.00]	.01	-.22*	.021		
MCQ-CSC	.00 [-.01, .01]	.01	.03	.717		
MCQ-NB	-.00 [-.02, .01]	.01	-.06	.603		
MCQ-NC	.01 [-.01, .02]	.01	.06	.503		
MAI-KC	-.01 [-.02, .01]	.01	-.05	.597		
MAI-RC	-.00 [-.02, .01]	.01	-.07	.520		
BCIS-SC	-.00 [-.02, .02]	.01	.00	.998		

Note: MP-T, Motion Perception Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. *p<.05.

In the DD-T (Supplementary Table 8), neither Model 1 (F(2,150)=1.36, p=.259, R^2=.02, corrected R^2=.01) nor Model 2 (F(10,142)=.72, p=.702, R^2=.05, corrected R^2=-.02) were able to predict metacognitive efficiency; furthermore, Model 2 did not provide a significantly better prediction than Model 1 (F(8,142)=.57, p=.801, ΔR^2=.03).

Supplementary Table 8. Prediction of metacognitive efficiency in the DD-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.02	.02
Age	-.02 [-.03, .00]	.01	-.14	.078		
Sex	-.03 [-.19, .13]	.08	-.04	.680		
Model 2					.05	.03
Age	-.02 [-.04, .00]	.01	-.16	.065		
Sex	-.02 [-.19, .14]	.09	-.03	.775		
MCQ-CC	.00 [-.02, .02]	.01	.01	.876		
MCQ-PB	.00 [-.02, .02]	.01	.00	.993		
MCQ-CSC	-.01 [-.03, .01]	.01	-.07	.478		
MCQ-NB	-.01 [-.03, .01]	.01	-.08	.423		
MCQ-NC	.00 [-.02, .02]	.01	.01	.904		
MAI-KC	-.02 [-.05, .00]	.01	-.14	.133		
MAI-RC	.01 [-.01, .03]	.01	.12	.199		
BCIS-SC	-.01 [-.04, .02]	.02	-.07	.479		

Note: DD-T, Dot Discrimination Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. **p*<.05.

Similarly, hierarchical regression analysis on metacognitive efficiency in the RW-T (Supplementary Table 9) revealed no significant model fits for either Model 1 (F(2,144)=.48, p=.621, R^2=.01, corrected R^2=-.01) or Model 2 (F(10,136)=.27, p=.986, R^2=.02, corrected R^2=-.05), with Model 2 failing to provide a prediction of significantly incremental value (F(8,136)=.23, p=.985, R^2=.02, ΔR^2=.01).

Supplementary Table 9. Prediction of metacognitive efficiency in the RW-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.01	.01
Age	-.00 [-.01, .00]	.00	-.06	.437		
Sex	-.02 [-.06, .02]	.02	-.07	.413		
Model 2					.02	.01
Age	-.00 [-.01, .00]	.00	-.08	.352		
Sex	-.02 [-.07, .02]	.02	-.10	.281		
MCQ-CC	-.00 [-.01, .00]	.00	-.08	.426		
MCQ-PB	-.00 [-.01, .01]	.00	-.07	.529		
MCQ-CSC	.00 [-.01, .01]	.00	.02	.830		
MCQ-NB	.00 [-.00, .01]	.00	.06	.564		
MCQ-NC	.00 [-.01, .01]	.00	.01	.950		
MAI-KC	-.00 [-.01, .01]	.00	-.03	.748		
MAI-RC	.00 [-.00, .01]	.00	.06	.493		
BCIS-SC	.00 [-.01, .01]	.00	.04	.688		

Note: RW-T, Retrieving Words Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. **p*<.05.

Hierarchical regression analysis for prediction of metacognitive efficiency in the RF-T revealed a similar pattern (Supplementary Table 10): Model 1 could not significantly predict the outcome ($F(2,144)=1.04$, $p=.358$, $R^2=.01$, corrected $R^2<.01$), and neither could Model 2 ($F(10,136)=.67$, $p=.751$, $R^2=.05$, corrected $R^2=-.02$), hence being unable to predict the data significantly better than Model 1 ($F(8,136)=.58$, $p=.79$, $\Delta R^2=.03$).

Supplementary Table 10. Prediction of metacognitive efficiency in the RF-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.01	.01
Age	-.00 [-.01, .00]	.00	-.12	.083		
Sex	-.02 [-.06, .03]	.02	-.06	.452		
Model 2					.05	.03
Age	-.00 [-.01, .00]	.00	-.13	.085		
Sex	-.03 [-.08, .02]	.03	-.11	.283		
MCQ-CC	.00 [-.01, .00]	.00	-.01	.863		
MCQ-PB	-.00 [-.01, .01]	.00	-.06	.518		
MCQ-CSC	.00 [-.01, .01]	.00	.01	.899		
MCQ-NB	.01 [-.00, .01]	.00	.17	.118		
MCQ-NC	-.00 [-.01, .01]	.00	-.08	.538		
MAI-KC	-.00 [-.01, .01]	.00	-.03	.740		
MAI-RC	.00 [-.00, .01]	.00	.08	.540		
BCIS-SC	-.00 [-.01, .01]	.00	-.05	.527		

Note: RF-T, Retrieving Faces Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. **p*<.05.

Metacognitive Bias

Detailed results of exploratory hierarchical regression analysis for prediction of metacognitive bias in the AS-T are given in Supplementary Table 11. Model 1 with confound variables age and sex was able to significantly predict the average confidence level reported in the AS-T ($F(2,149)=3.91$, $p=.022$, $R^2=.05$, corrected $R^2=.04$), as average confidence ratings were observed to be higher in male participants. The model of interest, Model 2, however, was unable to significantly predict bias ($F(10,141)=1.04$, $p=.414$, $R^2=.07$, corrected $R^2<.01$) and therefore failed to provide a significantly better explanation for the data than Model 1 ($F(8,141)=.36$, $p=.94$, $\Delta R^2=.02$).

Supplementary Table 11. Prediction of metacognitive bias in the AS-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.05*	.05
Age	-.03 [-.08, .02]	.02	-.11	.163		
Sex	-.46 [-.77, -.13]	.17	-.22*	.014		
Model 2					.07	.02
Age	-.02 [-.08, .02]	.02	-.09	.324		
Sex	-.41 [-.75, -.09]	.19	-.20*	.034		
MCQ-CC	.00 [-.04, .06]	.02	.01	.938		
MCQ-PB	.01 [-.03, .05]	.02	.04	.682		
MCQ-CSC	.02 [-.04, .07]	.03	.07	.541		
MCQ-NB	-.01 [-.05, .03]	.02	-.05	.601		
MCQ-NC	.00 [-.05, .05]	.03	.00	.980		
MAI-KC	.03 [-.03, .10]	.03	.09	.247		
MAI-RC	-.03 [-.07, .02]	.02	-.13	.193		
BCIS-SC	.01 [-.04, .07]	.03	.03	.620		

Note: AS-T, Antisaccade Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. *$p<.05$.

Hierarchical regression analysis for prediction of metacognitive bias in the MP-T revealed a similar pattern as for the AS-T (Supplementary Table 12): Model 1 was able to provide a significant prediction ($F(2,151)=4.10$, $p=.018$, $R^2=.05$, corrected $R^2=.04$), Model 2 was not ($F(10,143)=1.10$, $p=.368$, $R^2=.07$, corrected $R^2=.01$) and hence unable to predict the empirical data significantly better than Model 1 ($F(8,143)=.38$, $p=.93$, $\Delta R^2=.02$). The significance of Model 1 was caused by the predictor sex, with male participants reporting higher average levels of confidence.

Supplementary Table 12. Prediction of metacognitive bias in the MP-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.05*	.05
Age	.03 [-.01, .06]	.02	.13	.105		
Sex	-.24 [-.46, -.04]	.11	-.16*	.028		
Model 2					.07	.02
Age	.03 [-.01, .06]	.02	.13	.110		
Sex	-.24 [-.47, -.01]	.12	-.16	.051		
MCQ-CC	-.02 [-.06, .01]	.02	-.13	.181		
MCQ-PB	.01 [-.03, .04]	.02	.05	.592		
MCQ-CSC	.01 [-.01, .04]	.01	.08	.359		
MCQ-NB	-.00 [-.04, .03]	.02	-.02	.891		
MCQ-NC	.01 [-.03, .04]	.02	.02	.818		
MAI-KC	.00 [-.04, .04]	.02	.00	.984		
MAI-RC	-.00 [-.03, .03]	.01	-.02	.852		
BCIS-SC	.00 [-.04, .05]	.02	.01	.859		

Note: MP-T, Motion Perception Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. **p*<.05.

As shown in Supplementary Table 13, Model 1 was also able to significantly predict metacognitive bias in the DD-T ($F(2,150)=3.57$, $p=.031$, $R^2=.05$, corrected $R^2=.03$), as was Model 2 ($F(10,142)=2.24$, $p=.019$, $R^2=.14$, corrected $R^2=.08$), which did, however, narrowly fail to provide a significantly better prediction ($F(8,142)=1.86$, $p=.07$, $\Delta R^2=.09$). The average confidence level reported in the DD-T was higher for males; the MCQ-30 scale Cognitive Self-Consciousness furthermore significantly predicted metacognitive bias in the DD-T.

Supplementary Table 13. Prediction of metacognitive bias in the DD-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.05*	.05
Age	.01 [-.02, .06]	.02	.06	.509		
Sex	-.34 [-.61, -.05]	.14	-.19*	.014		
Model 2					.14*	.09
Age	.01 [-.02, .06]	.02	.06	.480		
Sex	-.33 [-.59, -.02]	.14	-.19*	.024		
MCQ-CC	-.03 [-.07, .03]	.02	-.12	.231		
MCQ-PB	.04 [-.00, .09]	.02	.18	.079		
MCQ-CSC	.05 [.01, .08]	.02	.23*	.016		
MCQ-NB	-.03 [-.06, .01]	.02	-.13	.115		
MCQ-NC	-.04 [-.09, .00]	.02	-.17	.084		
MAI-KC	-.02 [-.08, .04]	.03	-.06	.489		
MAI-RC	-.01 [-.04, .03]	.02	-.05	.618		
BCIS-SC	.02 [-.03, .08]	.03	.06	.442		

Note: DD-T, Dot Discrimination Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. **p*<.05.

Importantly, hierarchical regression analysis for prediction of metacognitive bias in the RW-T revealed a distinct pattern (Supplementary Table 14): No significant prediction by Model 1 ($F(2,150)=2.29$, $p=.104$, $R^2=.03$, corrected $R^2=.02$), but a significant prediction by Model 2 ($F(10,142)=2.41$, $p=.011$, $R^2=.15$, corrected $R^2=.09$), which predicted metacognitive bias in the RW-T significantly better than Model 1 ($F(8,142)=2.40$, $p=.019$, $\Delta R^2=.12$). Again, sex was found to be a predictor, but so was the MCQ-30 Cognitive Confidence scale.

Supplementary Table 14. Prediction of metacognitive bias in the RW-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.03	.03
Age	-.01 [-.04, .01]	.02	-.08	.412		
Sex	-.22 [-.41, -.04]	.10	-.17*	.031		
Model 2					.15*	.12*
Age	-.01 [-.05, .02]	.02	-.07	.488		
Sex	-.21 [-.41, -.03]	.10	-.17*	.047		
MCQ-CC	-.05 [-.09, -.02]	.02	-.34*	.002		
MCQ-PB	.01 [-.02, .04]	.01	.08	.341		
MCQ-CSC	.02 [-.01, .05]	.01	.15	.106		
MCQ-NB	-.01 [-.03, .02]	.01	-.03	.721		
MCQ-NC	.02 [-.02, .05]	.02	.09	.353		
MAI-KC	.00 [-.04, .05]	.02	.02	.829		
MAI-RC	-.01 [-.03, .02]	.01	-.04	.633		
BCIS-SC	.01 [-.03, .05]	.02	.03	.742		

Note: RW-T, Retrieving Words Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. *$p<.05$.

In the RF-T (Supplementary Table 15), neither Model 1 ($F(2,150)=2.87$, $p=.06$, $R^2=.04$, corrected $R^2=.02$) nor Model 2 were able to predict metacognitive bias significantly, although Model 2 only narrowly missed out on significance ($F(10,142)=1.90$, $p=.05$, $R^2=.12$, corrected $R^2=.06$). It did not provide a significantly better prediction than Model 1 ($F(8,142)=1.63$, $p=.121$, $\Delta R^2=.08$). Sex and Cognitive Confidence were found to be significant predictors of metacognitive bias in the RF-T.

Supplementary Table 15. Prediction of metacognitive bias in the RF-T.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.04	.04
Age	.01 [-.02, .04]	.02	.05	.570		
Sex	-.25 [-.46, -.05]	.11	-.18*	.022		
Model 2					.12	.08
Age	.01 [-.02, .04]	.02	.04	.590		
Sex	-.24 [-.46, -.04]	.11	-.17*	.033		
MCQ-CC	-.04 [-.07, -.01]	.02	-.24*	.018		
MCQ-PB	.01 [-.02, .03]	.02	.04	.702		
MCQ-CSC	.02 [-.01, .05]	.01	.14	.135		
MCQ-NB	-.01 [-.04, .02]	.01	-.08	.416		
MCQ-NC	.01 [-.02, .04]	.02	.06	.512		
MAI-KC	-.00 [-.04, .04]	.02	-.01	.877		
MAI-RC	-.01 [-.03, .02]	.01	-.04	.632		
BCIS-SC	.04 [-.00, .08]	.02	.14	.083		

Note: RF-T, Retrieving Faces Task, CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. *p<.05.

General Discussion

Overall, regression analyses on original behavioral metacognitive efficiency and bias scores (Supplementary Tables 5-15) mostly revealed similar patterns as the hierarchical regression analyses on extracted G-factor values reported in the manuscript. Significant fits of the model of interest were obtained in 1 of 6 regressions on metacognitive efficiency and in 2 of 5 regressions on metacognitive bias. Broadly, this confirms the pattern of findings reported in the manuscript, but calls for a cautionary note regarding the association of offline self-report instruments with the online laboratory measure of metacognitive bias, as the G-factor approach to prediction of metacognitive bias might overstate the overall predictive value of self-report instruments. Furthermore, and probably unsurprisingly, a very similar pattern of findings emerged (see Supplementary Tables 3 and 4) as in the aforementioned regression analyses. Convergent evidence from correlation and regression analyses thus indicates there is a certain risk that the hierarchical regression analysis on metacognitive bias G-factor scores presented in Table 9 of the manuscript produced a relative over-fit of the regression model with a predictor combination of self-report measures of metacognition. As evident from Supplementary Table 4, indications for correlations could primarily be observed between the MCQ-30 “Cognitive Confidence” scale and average confidence levels reported in the RW-T and RF-T, as confirmed by significant predictor contributions within the hierarchical regression analysis on individual G-factor scores for metacognitive bias and the correlation of “Cognitive Confidence” with the metacognitive bias G-factor, which was, however, uncorrelated with any other self-report scale. Another correlation, albeit also non-significant after Bonferroni correction, could be conceived between “Cognitive Self-Consciousness” and average confidence levels reported in the DD-T.

With regard to the validation analyses concerning prediction of metacognitive efficiency, the hierarchical regression analysis on the EA-T (where metacognitive efficiency could not be quantified via the meta-d' framework) confirmed the significant positive association between the "Positive Beliefs about Worry" scale with metacognitive performance in the EA-T presented in Table 7 of the manuscript; moreover, a negative correlation of the outcome with "Cognitive Self-Consciousness" was observed. Since high values on the former scale in particular (e.g. item 10: “Worrying helps me to get things sorted out in my mind”) are associated with pathological "meta-worries" and the metacognitive model of generalized anxiety disorder (Wells, 1995), an interesting link to Rouault *et al.* (2018b) can be drawn. They found that participants scoring high on a dimension characterizing self-reported anxiety and depression also displayed high scores of metacognitive efficiency and had lower overall confidence; with respect to the analysis on metacognitive bias, such a connection could not be made here for the “Positive Beliefs about Worry” scale. However, it is unclear why high responses on the "Cognitive Self-Consciousness" scale would then be associated with lower metacognitive efficiency, since its items are phrased in a way (e.g. item 30: “I constantly examine my thoughts”) pointing to similar self-observant behavior. Notably, the latter association was not obtained by the correlations presented in Table 7 (see manuscript) and Supplementary Table 3. Similarly, it is not obvious why "Positive Beliefs about Worry" served as a negative predictor of metacognitive efficiency in the MP-T (Supplementary Table 7), although the corresponding model fit was not significant. Essentially, this pattern of findings is another indication of fundamental differences between the attention-to-action and the perception domains, with the same predictor ("Positive Beliefs about Worry") exerting diverging effects on metacognitive efficiency in an attention-to-action task (EA-T) and a perceptual task (MP-T), which might cancel each other out in the G-factor approach. It should furthermore be noted that there was a significant positive association between the BCIS scale "Self-Certainty" and metacognitive efficiency in the AS-T, although the corresponding model fit did not reach significance. Overall, associations with questionnaire measures seem to be present especially in the attention-to-action domain, perhaps due to the fact that the motor act itself (e.g. a keypress) is what manifests performance in that domain, whereas in memory and perception tasks, the critical act consists in the computation of a decision, with motor processes merely acting out and reporting that decision. However, the reported predictor contributions are only small to medium in range, and a fair amount of variance cannot be accounted for by the linear combination of predictors.

In summary, the selected analysis in the main manuscript may be insensitive to small associations between scales of two self-report instruments (MCQ-30 and BCIS) and metacognitive performance in specific paradigms. Nonetheless, in consideration of the various validation analyses, it does not seem appropriate to straightforwardly assume a relevant under-fit of the regression model on G-factor scores of metacognitive efficiency (manuscript, Table 8). Thus, the reported pattern of results implies that if anything, questionnaire self-report measures are associated with metacognitive bias and not with genuine metacognitive performance.

Further analyses for the memory domain

As the investigation of levels of processing (LoP) for the episodic memory domain was not connected to the research goals pursued in this study, the respective analyses are first reported below and subsequently discussed, along with possible interpretations concerning the absence of a significant intra-domain correlation for memory and other implications for the metamemory literature. Finally, a validation analysis with alternative computation of metacognitive performance parameters in the memory domain was conducted to ensure the integrity of the result structure presented in the manuscript, as reported below.

Levels of Processing (LoP) effects: Results

Appropriate descriptive statistics for Levels of Processing (LoP) effects are provided in Supplementary Table 16. Alpha-level was Bonferroni-corrected for multiple testing ($\alpha = .05/6 \approx .008$). As described in detail in the manuscript, deep encoding was achieved in the RW-T by pleasantness ratings of words and in the RF-T by likeableness ratings of faces. Counting syllables of words led to shallow encoding in the RW-T, whereas in the RF-T, shallow encoding was targeted by requesting participants to determine the sex of the depicted person.

There were significant LoP effects for Type 1 performance (d') in both tasks: Higher retrieval performance for deeply encoded than for shallowly encoded words in the RW-T ($t(123)=22.73$, $p<.001$, $d=1.94$) and for deeply encoded than for shallowly encoded faces in the RF-T ($t(123)=16.59$, $p<.001$, $d=1.47$). Furthermore, we observed significant LoP effects on metacognitive bias (average confidence level) both in the RW-T ($t(123)=18.5$, $p<.001$, $d=1.7$) as well as in the RF-T ($t(123)=10.78$, $p<.001$, $d=.5$) – higher confidence level for deeply encoded items. Importantly, however, for metacognitive efficiency (meta-d'/d'), we found a significant LoP effect only in the RW-T ($t(123)=6.63$, $p<.001$, $d=.68$), but not in the RF-T ($t(123)=.39$, $p=.699$, $d=.04$).

Supplementary Table 16. Descriptive statistics of Type 1 sensitivity (d'), metacognitive bias (average confidence level from 1-6) and Type 2 efficiency (meta-d'/d') by paradigm. *N*=155.

Measure	RW-T		RF-T	
	M	*SD*	*M*	*SD*
Type 1 performance				
Deep vs. New	1.81	0.65	0.81	0.41
Shallow vs. New	0.72	0.44	0.34	0.30
Metacognitive Bias				
Deep vs. New	4.85	0.65	4.05	0.66
Shallow vs. New	3.89	0.65	3.73	0.69
Type 2 efficiency				
Deep vs. New	1.22	0.57	1.13	0.80
Shallow vs. New	0.75	0.77	1.16	1.40

Note: RW-T, Retrieving Words Task, RF-T, Retrieving Faces Task, M, Mean, SD, Standard Deviation.

Implications for metamemory literature

We replicated findings from our previous study (Lehmann *et al.*, 2021) which revealed LoP effects on retrieval performance, (performance-corrected) bias and metacognitive efficiency using the same LoP manipulation in the RW-T. We furthermore show that the targeted LoP manipulation in the RF-T, as modified from Bower and Karlin (1974), was successful: retrieval performance was significantly higher for faces which had been encoded by making likeableness ratings. Also, we found average confidence levels to be significantly influenced by LoP; however, there was no LoP effect on metacognitive efficiency in the RF-T. Not only the absence of an effect is noteworthy; numerically, metacognitive efficiency was indeed higher for shallowly encoded faces. This selective LoP effect only on metacognitive efficiency in the RW-T, but not in the RF-T provides further evidence for our following interpretation regarding the absence on an intra-domain correlation between metacognitive performance scores in the two episodic memory paradigms, and corroborates the notion that metacognition regarding faces may constitute an exceptional case which should be investigated in further detail.

In more general terms, a number of arguments can be made that metamnestic evaluations for words and faces may have less in common than typically assumed, which is corroborated by the selective LoP effects only on metacognitive efficiency in the RW-T, not in the RF-T. In line with previous findings (Hancock *et al.*, 2000; Klatzky & Forrest, 1984; Megreya & Burton, 2008), it is noticeable that recognition performance for unfamiliar faces was particularly low; an effect potentially amplified by the use of face stimuli of several age groups in a predominantly young sample, as individuals show better recognition performance for their own age group (Bäckman, 1991). Hence, the strength of the memory trace for face stimuli may be lower than for words, as words may evoke semantic associations that facilitate recognition (Pexman *et al.*, 2007, 2008). Another difference is that in evolutionary terms, face recognition represents a considerably older ability than word recognition, which only became relevant with the development of orthographies (Plaut & Behrmann, 2011). Consequently, one can discriminate different neural substrates for word and face recognition: the fusiform face area (Axelrod & Yovel, 2015; Kanwisher *et al.*, 1997), which is highly specialized for the encoding and recognition of faces, and the visual word form area (Cohen *et al.*, 2000; Dehaene *et al.*, 2001; Dehaene & Cohen, 2011), which plays a role in word memory, may differ in their connectivity to brain regions associated with metacognition (Baird *et al.*, 2013), which could imply that metacognitive performance in the two paradigms is not based on the same neural information exchange. Finally, it should be recognized that the Yes/No choice format may complicate detecting cross-task correlations, especially in the memory domain: metacognitive performance has been found to be lower for "No" responses, as the Yes/No response requires a given stimulus to be compared with a mental image in the absence of sensory evidence, which impedes the process of confidence formation (Ruby *et al.*, 2017).

Taken together, before considering one kind of stimulus as representative for an entire domain, future studies should seek to first establish whether a relationship between metacognitive performance across different types of mnestic stimuli can at all be assumed. In any case, it seems constructive to employ several stimulus types per domain in order to achieve the most thorough representation possible.

Alternative efficiency indices for the memory domain: Validation analyses

Domain-generality vs. Domain-specificity

Following a reviewer's comment, we conducted an additional validation analysis of the outcome structure regarding metacognitive efficiency for both major study goals. Here, metacognitive efficiency in the memory domain (i.e., for RW-T and RF-T) was not computed collapsing over both levels of processing employed in the encoding tasks (EW-T and EF-T), but calculated as the average of the two separate two processing level estimates. The rationale for this validation analysis was to ensure that the result pattern presented in the manuscript is not adversely affected by the pooling of different difficulty levels in the formation of metacognitive efficiency in the memory domain. Specifically, similar to the mixing of different levels of stimulus variability in the perceptual domain when using adaptive staircase procedures, the employment of more than one difficulty level – in this case, deep and shallow processing of the encoded stimuli – may lead to an inflation in the metacognitive efficiency estimate (Rahnev & Fleming, 2019). However, because overall stimulus variability was still constant across participants, and to avoid increasing method variance across domains, which in itself could distort results (Rouault *et al.*, 2018a), this procedure is only considered as a means of validation to the main analysis reported in the manuscript.

Consequently, in the analyses reported below, identical parameters for metacognitive performance were employed as in the main analysis in the manuscript for the attention-to-action and perception domains; meanwhile, for the memory domain, new efficiency indices were computed for both paradigms, representing the average of the Type 2 efficiency scores for Deep vs. New and Shallow vs. New presented in Supplementary Table 16. The average efficiency score was 0.95 (*SD*=0.66) in the RW-T (*n*=150), and 1.22 (*SD*=1.24) in the RF-T (*n*=143). Due to non-normality, efficiency scores in both paradigms were transformed [log(10)], which led to an overall improvement in data quality; however, the normality assumption remained violated subsequent to transformation.

Despite the employment of an alternative quantification method for metacognitive efficiency, there was again no significant intra-domain Pearson's correlation within the memory domain (*r*=.09 [-.08, .24], *p*=.315) and no correlation between efficiency scores in the EA-T and RF-T (*r*=.07 [-.11, .26], *p*=.44). Notably, however, the correlation between efficiency in the EA-T and RW-T did reach significance (*r*=.24 [.10, .37], *p*=.003) even after correcting for multiple comparisons, consistent with the association of metacognitive performance in the domains of attention-to-action and memory.

Confirmatory factor analyses:

The fit indices for the adapted models are presented in Supplementary Table 17. As the observation of invalid estimates for the Specificity model was replicated in this analysis, an illustration of the estimated factor loadings is given in Supplementary Figure 2 only for the G-factor model, the Three-factor model and the three Bi-factor models.

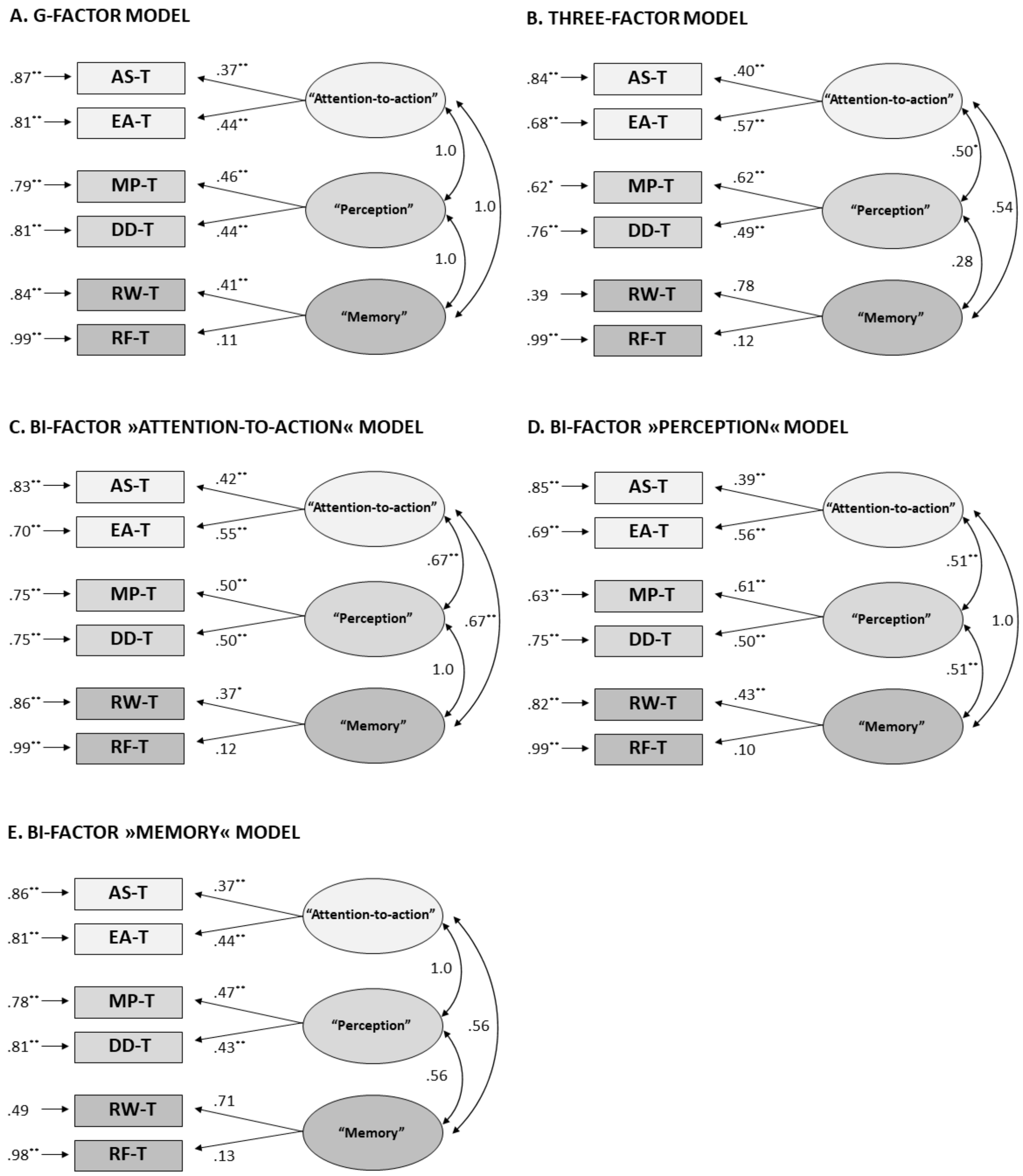
Supplementary Table 17. Overview of CFA model fits. *N*=155.

	χ^2	*df*	RMSEA	SRMR	CFI	AIC	BIC (adj.)
G-factor model	11.57	9	.04	.05	.92	-612.98	-615.17
Specificity model†	23.23*	9	.10*	.09	.56	-601.33	-603.52
Three-factor model	4.65	6	.00	.03	1.00	-613.90	-616.46
Bi-factor models							
Isolated Attention-to-action	9.99	8	.04	.04	.94	-612.57	-614.88
Isolated Perception	5.13	8	.00	.03	1.00	-617.43	-619.74
Isolated Memory	11.04	8	.05	.05	.91	-611.51	-613.83

Note: χ^2, χ^2-model test statistic, *df*, degrees of freedom, RMSEA, Root Mean Square Error of Approximation (≤.05 good fit, <.08 acceptable fit), SRMR, Standardized Root Mean Square Residual (≤.05 good fit, <.08 acceptable fit), CFI, Comparative Fit Index (≥.95 good fit, ≥.90 acceptable fit), AIC, Akaike Information Criterion, BIC (adj.), sample-size adjusted Bayesian Information Criterion. **p*<.05, † invalid model estimates (negative variances, eigenvalues).

The non-estimability and clearly inferior fit of the Specificity model compared to all other models corroborates the notion that a purely modular structure of metacognition seems altogether inappropriate. The least restrictive Three-factor model yielded an excellent fit; however, the memory domain was still inadequately represented. This should also explain why the numerically highest inter-domain correlation in the Three-factor model between the domains of attention-to-action and memory failed to reach significance (*r*=.54, *p*=.365). Overall, the CFAs point to an emergent pattern that despite the employment of alternative metacognitive performance parameters, the memory domain could only be modeled with insufficient precision. As in the main analysis, the Bi-factor model with isolated perception was found to be strongest model and consistently yielded the best fit indices. In line with the aforementioned significant Pearson's correlation between metacognitive efficiency in EA-T and RW-T, the association with the attention-to-action domain seemed reasonably adequate for the RW-T, whereas metacognitive efficiency in the RF-T could neither be explained by the extracted latent variable in this nor in any other of the five estimable models. The Bi-factor model with isolated memory domain again yielded the weakest of the Bi-factor model fits and was the only more restrictive model found to be inferior to the Three-factor model (χ^2_{diff}=6.39, *p*=.04).

Importantly, according to χ^2-difference tests, the Bi-factor model with isolated perceptual domain represented the data significantly better than the more restrictive G-factor model (χ^2_{diff}=6.44, *p*=.011) and would thus qualify for a formal model decision in this validation analysis. This is also supported when considering the AIC/BIC decision criteria (difference >2 compared to the second strongest model). However, to facilitate comparison with the main analysis and to comply with the principle of parsimony, factor scores for subsequent regression analyses on the online-offline associations of metacognition are derived from the G-factor model, which yielded a slightly better fit than in the main analysis, with an acceptable CFI (.92).



Supplementary Figure 2. Illustration of estimated parameters for the five estimable models when using the alternative efficiency indices in the memory domain: **(A) G-factor model** with all inter-domain correlations fixed to 1.0, signifying that all indicators essentially tap the same underlying construct. (**B) Three-factor model** with freely estimated inter-domain correlations, allowing for the coexistence of domain-generality and domain-specificity. (**C) Bi-factor model with isolated attention-to-action domain**, in which one of the three inter-domain correlations (Perception with Memory) is set to 1.0 and the other two inter-domain correlations are allowed to vary freely. (**D) Bi-factor model with isolated perceptual domain**, with one inter-domain correlation (Attention-to-action with Memory) fixed to 1.0 and the other two freely estimated. (**E) Bi-factor model with isolated memory domain**, with one inter-domain correlation (Attention-to-action with Perception) fixed to 1.0 and the other two freely estimated. Manifest variables (tasks) are provided in rectangles, whereas ellipses represent latent variables (domains). Single-headed arrows from latent variables to manifest indicators represent standardized factor loadings. The numbers at the ends of the smaller single-headed arrows directed towards manifest indicators depict error variances. The numbers next to the curved, double-headed arrows represent correlation coefficients for inter-domain correlations. AS-T: Antisaccade Task. EA-T: Error Awareness Task. MP-T: Motion Perception Task. DD-T: Dot Discrimination Task. RW-T: Retrieving Words Task. RF-T: Retrieving Faces Task. $^{**}p<.01$, $^{*}p<.05$.

Online and Offline metacognition

According to Pearson's correlations, there were no significant associations between "offline" self-report measures of metacognition and modified "online" metacognitive efficiency scores in the memory domain: After correcting for multiple comparisons, the correlation between "Negative Beliefs about Worry" (MCQ-30) and metacognitive efficiency in the RF-T (r=.20 [.05, .35], p=.022) did not reach significance (all other P>.05).

Hierarchical regression analysis for prediction of modified metacognitive efficiency G-factor scores (as per the inclusion of alternative efficiency indices in the memory domain) yielded convergent results. Neither Model 1 with age and sex as regressors of no interest (F(2,152)=2.72, p=.069, R^2=.03, corrected R^2=.02) nor Model 2 with questionnaire measures of metacognition (F(10,144)=.88, p=.551, R^2=.06, corrected R^2=-.01) significantly predicted efficiency, with Model 2 not providing a significantly superior prediction than Model 1 (F(8,144)=.44, p=.892, ΔR^2=.02). As can be inferred from Supplementary Table 18, age once again emerged as a significant negative predictor of metacognitive efficiency.

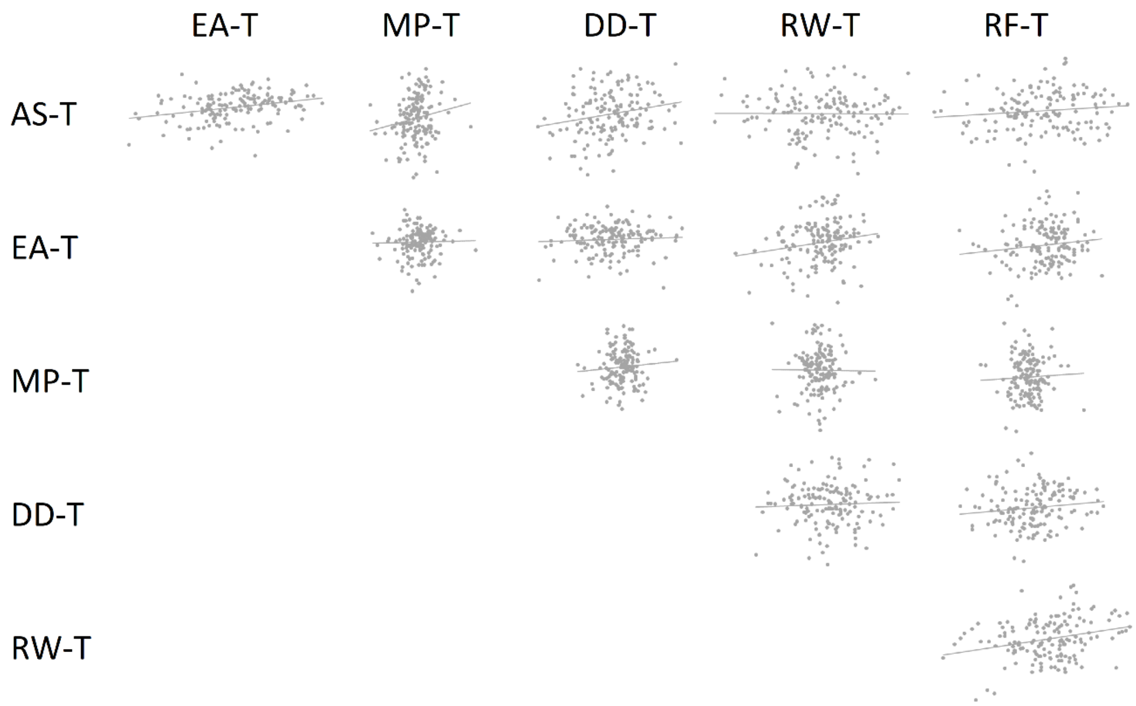
Supplementary Table 18. Prediction of modified G-factor scores for metacognitive efficiency.

	B [95 % CI]	*SE B*	β	*p*	R^2	ΔR^2
Model 1					.03	.03
Age	-.04 [-.07, -.01]	.02	-.18*	.024		
Sex	-.16 [-.41, .08]	.12	-.10	.201		
Model 2					.06	.02
Age	-.04 [-.07, -.00]	.02	-.18*	.037		
Sex	-.15 [-.41, .12]	.13	-.09	.271		
MCQ-CC	-.01 [-.04, .03]	.02	-.02	.795		
MCQ-PB	.01 [-.03, .06]	.02	.06	.552		
MCQ-CSC	-.02 [-.06, .01]	.02	-.14	.199		
MCQ-NB	.01 [-.02, .05]	.02	.05	.598		
MCQ-NC	.01 [-.03, .05]	.02	.05	.549		
MAI-KC	-.01 [-.06, .03]	.02	-.05	.546		
MAI-RC	.00 [-.03, .04]	.02	.03	.816		
BCIS-SC	.02 [-.04, .07]	.03	.06	.527		

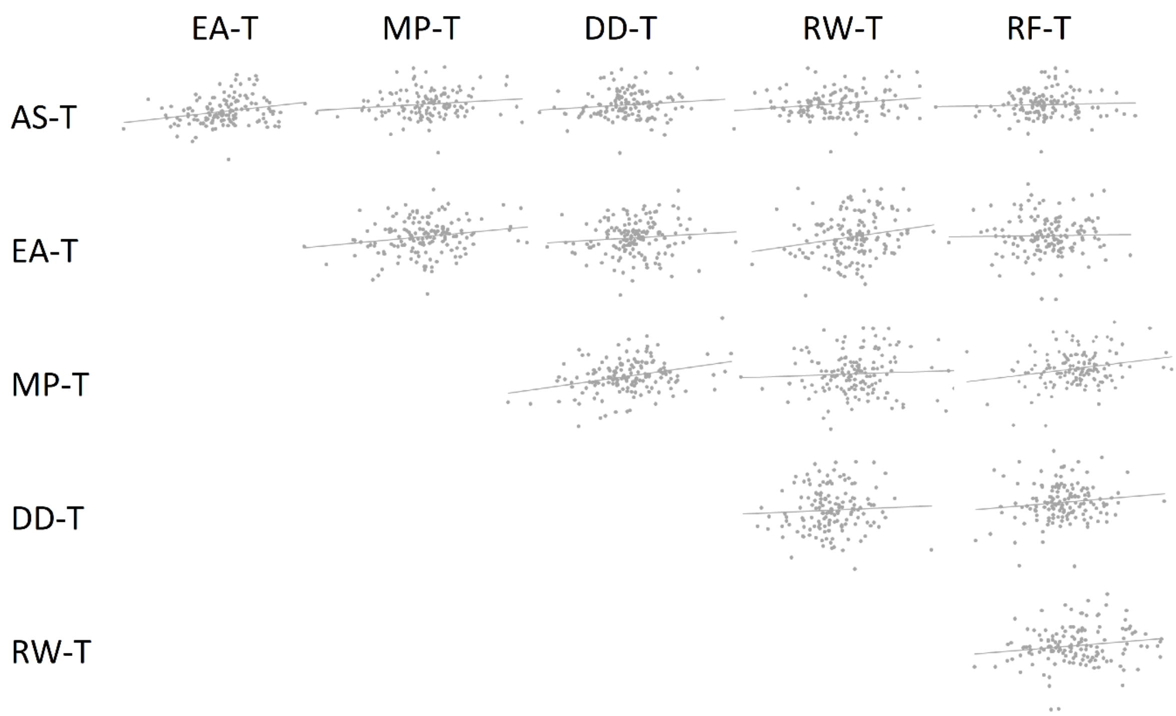
Note: CI, Confidence Interval, SE, Standard Error, MCQ-CC, Cognitive Confidence, MCQ-PB, Positive Beliefs about Worry, MCQ-CSC, Cognitive Self-Consciousness, MCQ-NB, Negative Beliefs about Uncontrollability and Danger of Worry, MCQ-NC, Need for Control, MAI-KC, Knowledge about Cognition, MAI-RC, Regulation of Cognition, BCIS-SC, Self-Certainty. *p<.05.

Scatter plots for correlations

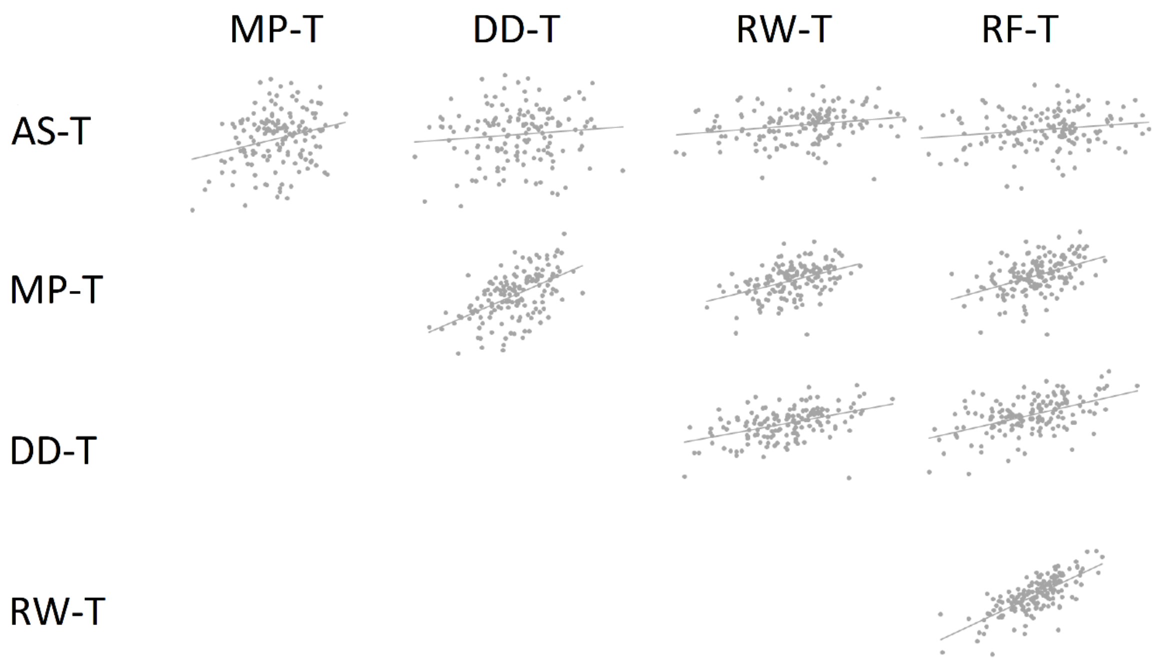
The following scatter plots serve as a visualization of results depicted in Tables 3, 4 and 6 of the manuscript.



Supplementary Figure 3. Scatter plots for Pearson's correlations in Type 1 performance (d') between all task pairings.



Supplementary Figure 4. Scatter plots for Pearson's correlations in Type 2 performance (meta-d'/d') between all task pairings.



Supplementary Figure 5. Scatter plots for Pearson's correlations in metacognitive bias (average confidence level) between the five paradigms with confidence rating reports.

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