Is learning in a conditioning procedure with valent targets unconscious?

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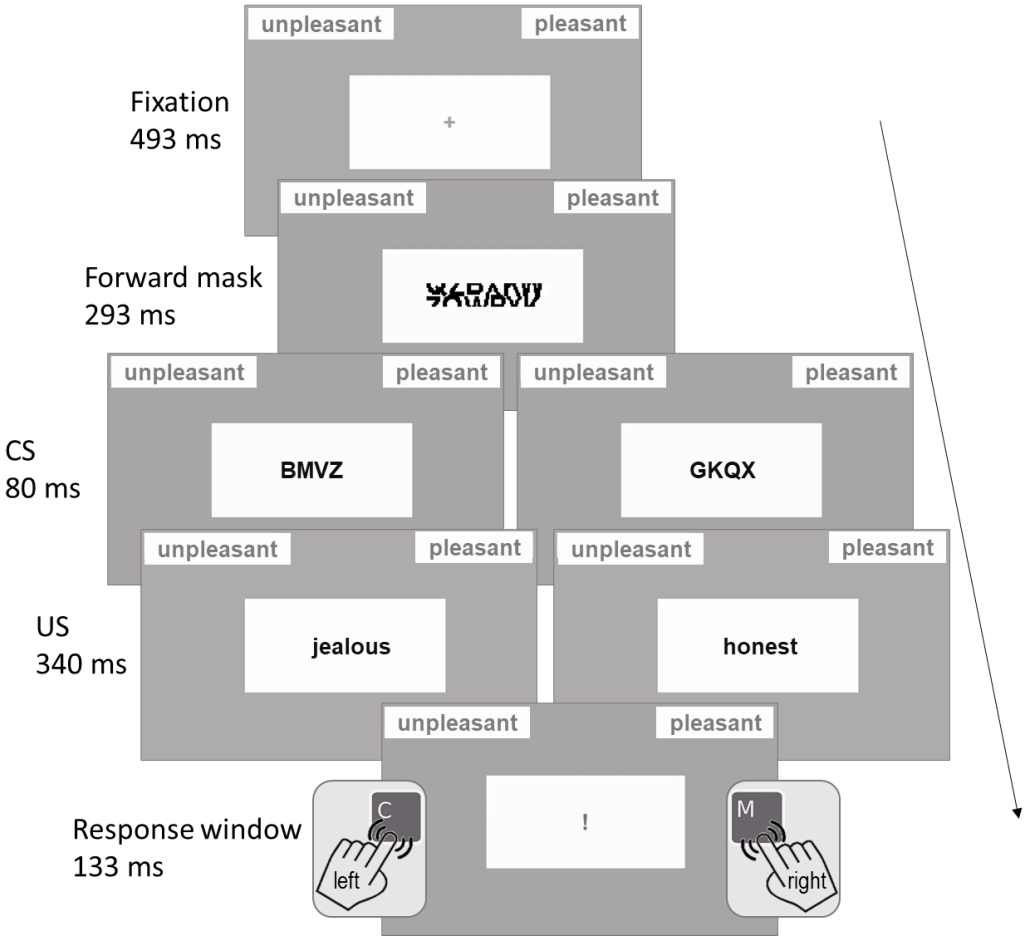
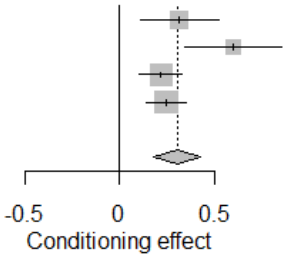
Learning phase and conditioning test



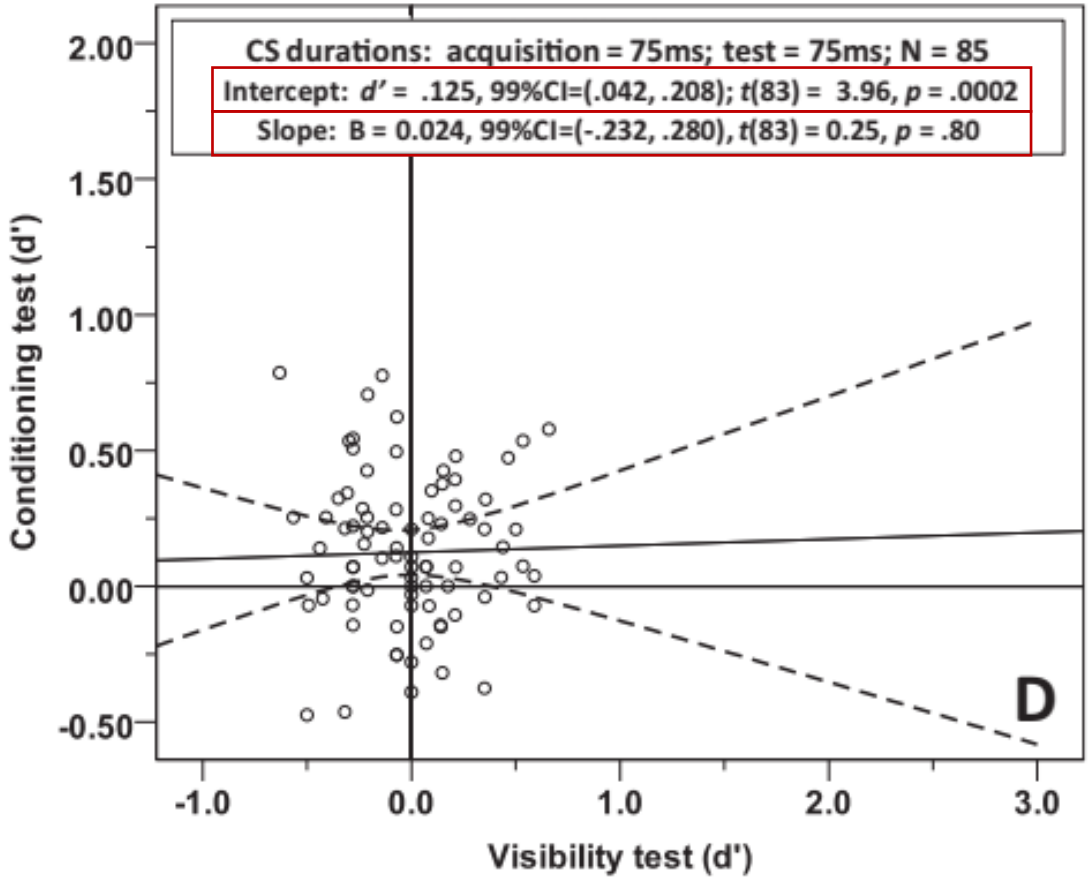
- Replication of Greenwald & De Houwer (2017)
- Learning phase:
  - Task: pleasant / unpleasant target? (2AFC)
  - Response window → fast responding
  - 100 % contingency between CS and US
- Conditioning test:
  - Same task
  - 50 % contingency
  - Better performance for congruent than for incongruent trials

Study	Cohen's d	95% CI
Exp.2, Masked, 70 ms	0.31	[0.11; 0.52]
Exp.2, Masked, 80 ms	0.59	[0.34; 0.85]
Exp.3, Masked, 80 ms	0.22	[0.10; 0.33]
Exp.4, Masked, 80 ms	0.24	[0.14; 0.35]
Random effects model	**0.30**	**[0.18; 0.42]**

Heterogeneity: I^2 = 61%, τ^2 = 0.0089, p = 0.05



Unconscious learning?
Data by Greenwald and De Houwer (2017)



- Visibility test:
  - Same sequence of stimuli as in the conditioning test
  - Task: Which CS was shown? (2AFC)
- Regressing the conditioning effect on visibility:
  - Zero slope: “conditioning independent of the visibility of the CS”
  - Positive intercept: “conditioning in the absence of visibility of the CS”

→ Double evidence for unconscious learning

Zero slope: Conditioning independent of the visibility of the CS?

No!

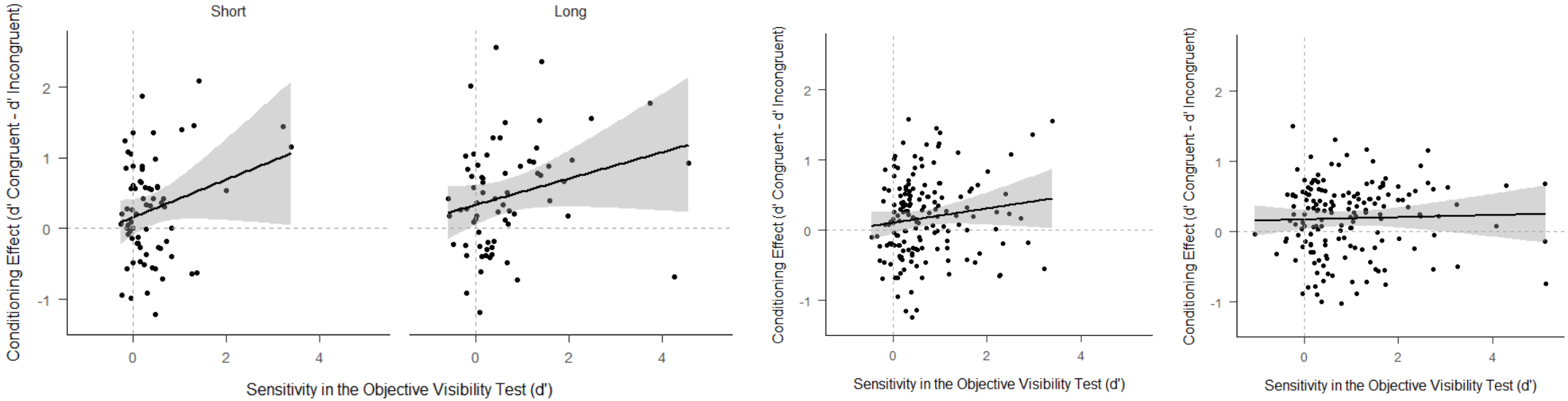
- G&DH: Only error variance in the predictor → under-estimation of the slope
  - Our study: Higher mean visibility → more systematic variance → unbiased estimation of the slope
- G&DH: Application of regression analysis despite measurement error in the predictor → under-estimation of the slope
  - Our study: Application of the Errors-in-variables correction (Klauer, Draine, & Greenwald, 1998) → unbiased estimation of the slope
- G&DH: Significantly positive slope in 1/9 studies (α=5%, one-sided), Meta-analysis with r = .10, 95% CI [0.04,∞], z = 2.70, p = .004, I^2=0.0%, τ^2_{SJ}=0.003
  - Our study: Significantly positive slope in 3/4 studies (α=5%, one-sided), Meta-analysis with r = .15, 95% CI [0.05,∞], z = 2.40, p = .008, I^2=18.5%,τ^2_{SJ}=0.006

r = .25, b = 0.28, 95% CI [0.07,∞], $t(68)$ = 2.16, p = .017

r = .25, b = 0.20, 95% CI [0.04,∞], $t(66)$ = 2.12, p = .019

r = .14, b = 0.10, 95% CI [−0.004,∞], $t(161)$ = 1.72, p = .044

r = .03, b = 0.02, 95% CI [−0.05, ∞], $t(161)$ = 0.48, p = .317



Positive intercept: Conditioning in the absence of visibility of the CS?

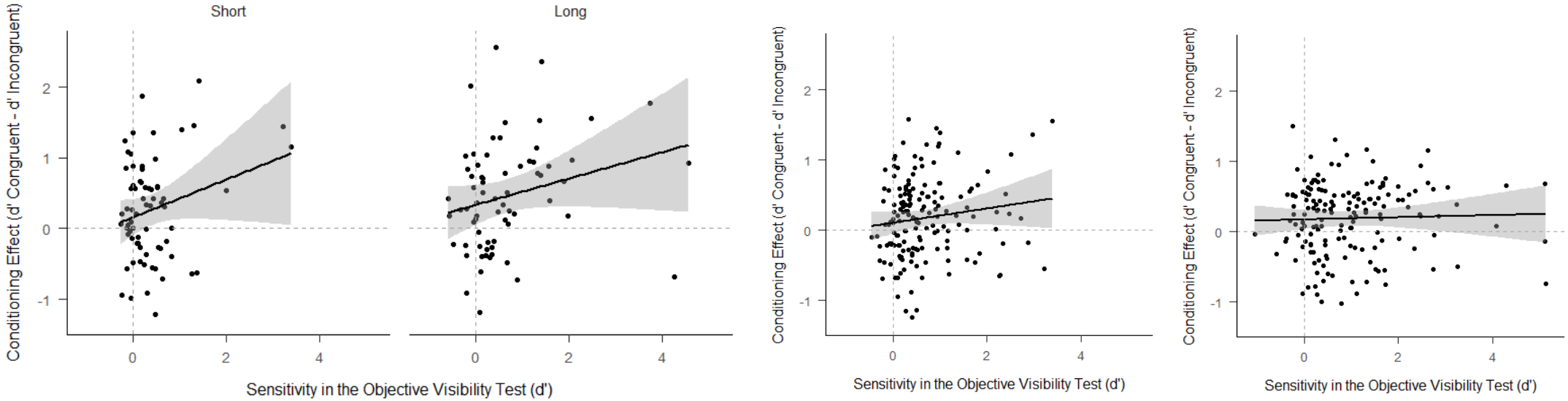
- G&DH: The objective visibility might be under-estimated due to a task-difficulty artifact (Pratte & Rouder, 2009) → over-estimation of the intercept
  - Our study: Insertion of easier trials between the difficult objective visibility trials → unbiased estimation of the intercept
- G&DH: Application of regression analysis despite measurement error in the predictor → over-estimation of the intercept
  - Our study: Application of the Errors-in-variables correction → unbiased estimation of the intercept
- G&DH: Significantly positive intercept in 8/9 studies (α=1%, two-sided)
  - Our study: Significantly positive intercept in 2/4 studies (α=1%, two-sided)

b = 0.16, 95% CI [-0.09, 0.41], *t*(68) = 1.71, *p* = .093

b = 0.33, 95% CI [0.06, 0.60], *t*(66) = 3.13, *p* = .003

b = 0.11, 95% CI [-0.05, 0.26], *t*(161) = 1.81, *p* = .072

b = 0.17, 95% CI [0.03, 0.31], *t*(161) = 3.15, *p* = .002



Positive intercept: Conditioning in the absence of visibility of the CS?

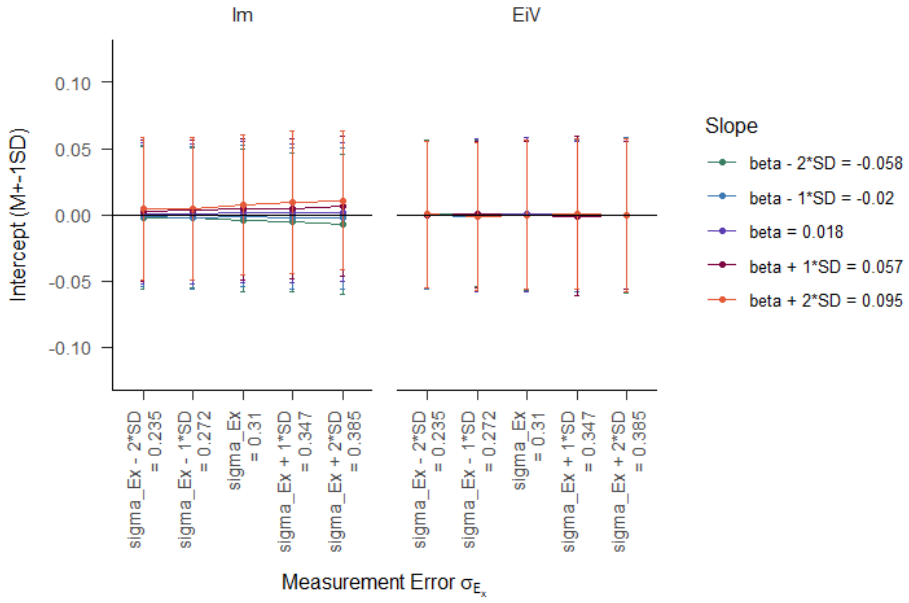
Is the Errors-in-variables correction a valid method to test unconscious learning?

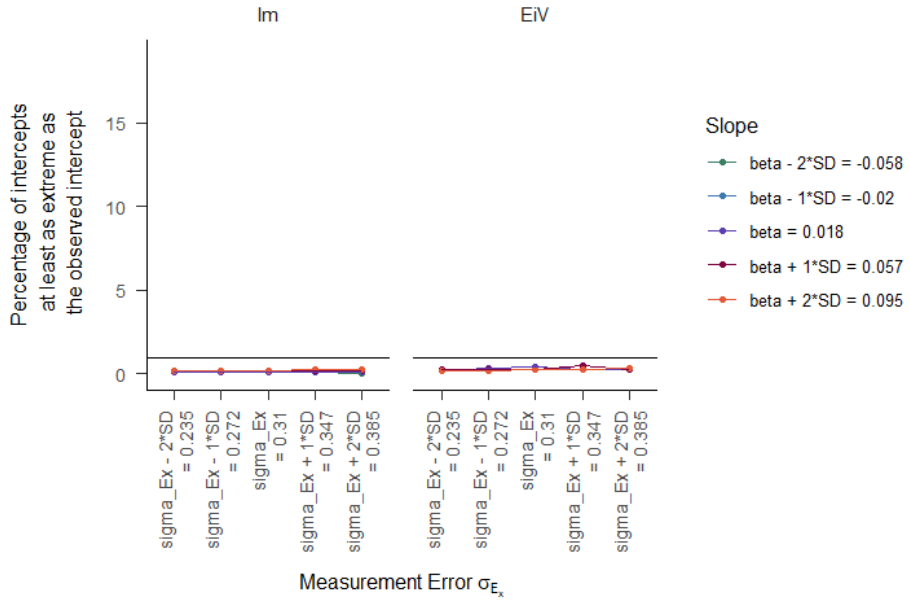
- The intercept is over-estimated by the Errors-in-variables correction…
  - For various distributions of the predictor (Miller, 2000)
  - Even for truncated normal distributed data (Malejka)
- The over-estimation might be less severe in our study
  - Simulation of huge samples by Miller (Klauer & Greenwald, 2000)
  - Simulation of steep slopes by Miller (Klauer & Greenwald, 2000)
  - Simulation of too few true zero predictor values by Miller (Klauer & Greenwald, 2000)

→ Simulations of realistic data that parallels our experimental data

Positive intercept: Conditioning in the absence of visibility of the CS?

- Simulations with truncated normal distributed data:
  - Unbiased estimation of the intercept with the Errors-in-variables correction
  - The observed intercept is very unlikely compared to the distribution of simulated intercepts (α=1%)

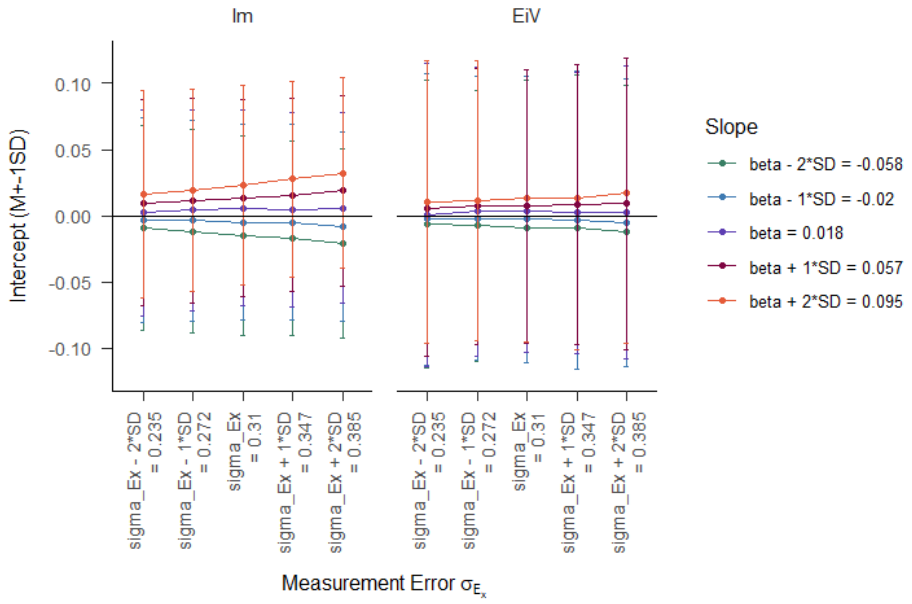


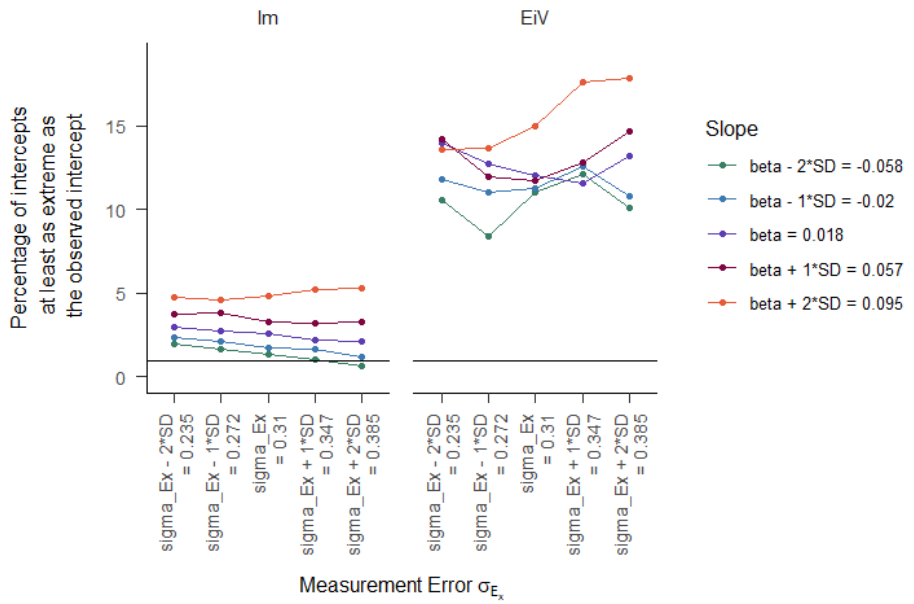


Positive intercept: Conditioning in the absence of visibility of the CS?

No

- What if the data is not truncated normal distributed?
- Simulations with bootstrapping from our experimental data:
  - (Slightly) biased estimation of the intercept even with the Errors-in-variables correction
  - The observed intercept is likely, compared to the distribution of simulated intercepts (α=1%)





Summary and Conclusion

- We replicated a conditioning effect in a speeded classification task with masked CSs and regressed the effect on the objective visibility of the CSs.
- G&DH: Zero slope → "Conditioning independent of the visibility of the CS"
  - Our study: Methodological and statistical improvements (more systematic variance, motivation trials, Errors-in-variables correction) revealed that the **conditioning effect is moderated by objective visibility**.
- G&DH: Positive intercept → "Conditioning in the absence of visibility of the CS"
  - Our study: Depending on the distribution **the intercept might be over-estimated**.
  - However, in some of G&DH's experiments objective visibility seems to be absent in the whole sample and still they observed a conditioning effect.
  - To interpret their data as conditioning in the absence of objective visibility, it needs to be ruled out that the objective visibility was under-estimated due to a task-difficulty artifact (Pratte & Rouder, 2009).

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- References

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