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Simulation checks

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## Simulation checks

## Supplemental Material 2

- In order to insure the reliability of our calculation method, for all scenarios where  $G_1 = G_2 = 0$ , we compared empirical means and variances of all estimators (i.e. means and variances of all estimates) with theoretical means and variances (i.e. expected means and variances, computed based on equations in Tables 1, 2 and 3 in the main article). Because we can draw exactly the same conclusions for **biased** (Cohen's d, Glass's d using either  $S_1$ or  $S_2$  as standardizer, Shieh's d and Cohen's  $d^*$ ) and **unbiased** (Hedges' g, Glass's g using either  $S_1$  or  $S_2$  as standardizer, Shieh's g and Hedges'  $g^*$ ) estimators, we will simultaneously present results for both categories of estimators. Results will be subdivided into 4 conditions: - When population variances and sample sizes are equal across groups (condition a; 13 see Figures A2.1 and A2.5 for respectively biased and unbiased estimators); 14 - When population variances are equal across groups and sample sizes are unequal 15 (condition b; see Figures A2.2 and A2.6 for respectively biased and unbiased estimators); 16 - When population variances are unequal across groups and sample sizes are equal 17 (condition c; see Figures A2.3 and A2.7 for respectively biased and unbiased estimators); 18 - When population variances and sample sizes are unequal across groups (condition d; 19 see Figures A2.4 and A2.8 for respectively biased and unbiased estimators). 20
- Because the equations of theoretical means and variances of Cohen's *d* and Hedges' *g*rely on the assumption of normality and equality of population variances, we expect
  empirical and theoretical parameters to be very close only in conditions a and b. For all
  other estimators, the equations of theoretical means and variances rely solely on the
  assumption of normality and therefore, we expect empirical and theoretical parameters to
  be very close in all conditions.
  - On average, empirical means (and variances) of all estimators are very close to

SIMULATION CHECKS

theoretical expectations when population variances are equal across groups, with equal

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sample sizes (condition a; see Tables A2.1 and A2.5) or unequal sample sizes (condition b;
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   see Tables A2.2 and A2.6).
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         When population variances are unequal across groups (conditions c and d; see Tables
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   A2.3, A2.4, A2.7 and A2.8), empirical means (and variances) of Cohen's d^* (Hedges' q^*)
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   and Shieh's d (Shieh's g) are still very close to theoretical expectations. Regarding Glass's
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   d (Glass's q), on average, while empirical variances remain very close to theoretical
   expectations, one observes larger departures between empirical and theoretical means when
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   using S_2 as standardizer. However, when looking at details in results for each scenario (see
   "biased estimator_condition C.xlsx," "biased estimator_condition D.xlsx," "unbiased
   estimator_condition C.xlsx" and "unbiased estimator_condition C.xlsx" in Supplemental
   Material 2), one notices that the larger the population effect size, the larger the departure
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   between empirical and theoretical means, and that relative to the population effect size,
   departures between empirical and theoretical means are always very small. On the other
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   hand, both empirical bias and variance of Cohen's d (Hedges' q) highly depart from
   theoretical expectations, even when looking at relative departures to the population effect
   size, especially when sample sizes are unequal across groups (condition d; see Table A2.4
   and A2.8), which is not surprising, as Cohen's d (Hedges' q) relies on the equality of
   population variances assumption.
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Table A2.1.

Absolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for biased estimators,

when population variances and sample sizes are equal across groups (condition a).

Absolute deviation between empirical and theoretical means

Ratio between empirical and theoretical variances

	Estimator $(\widehat{\delta})$	Cohen's d	Glass's d <sub>1</sub>	Glass's d <sub>2</sub>	Cohen's d*	Shieh's d
	Max	0,012	0,022	0,023	0,012	0,006
	Min	0,000	0,000	0,000	0,000	0.000
$ E(\widehat{\delta})$ - $\mu_{\delta} $	Mean	0,002	0,004	0,005	0,002	0,001
	Standard deviation	0,003	0,006	0,007	0,003	0,002
	Max	1,006	1,006	1,005	1,006	1,006
	Min	0,910	0,897	0,889	0,910	0,910
$S^2_{\ \widehat{\delta}}/\sigma_{\delta}$	Mean	0,976	0,966	0,966	0,976	0,976
	Standard deviation	0,028	0,033	0,035	0,028	0,028

 Table A2.2

 Absolute deviation between empirical and theoretical means as well as rat

Absolute deviα	tion between er	npirical and t	heoretical mea	Absolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for biased estimators,	en empirical	and theoretic	al variances fo	r biased estimators,
when populatio	m variances ar	e equal acros.	s groups and su	when population variances are equal across groups and sample sizes are unequal (condition b),	(condition b)			
	Absolute de	eviation betwe	en empirical anc	Absolute deviation between empirical and theoretical means	Ratio	between empi	Ratio between empirical and theoretical variances	ical variances
		_ <b>-</b>	$ E(\widehat{\delta})$ - $\mu_{\delta} $				$S^2_{\widehat{\delta}}/\sigma_{\delta}$	
Estimator ( $\delta$ )	Мах	Min	Mean	Standard deviation	Мах	Min	Mean S	Standard deviation
Cohen's d	500'0	0,000	0,001	0,001	1,017	0,951	0,985	0,017
Glass's d1	0,019	0,000	0,004	900'0	1,006	0,891	996'0	0,037
Glass's d <sub>2</sub>	0,027	00000	500'0	0,007	1,015	0,881	896'0	980'0
Cohen's d*	0,010	000'0	0,003	0,002	1,007	0,902	996'0	0,034
Shieh's d	0,008	000'0	0,002	0,002	1,005	998'0	0,945	0,048

Table A2.3

when population variances are unequal across groups and sample sizes are equal (condition c). Absolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for biased estimators,

Absolute deviation between empirical and theoretical means

Ratio between empirical and theoretical variances

			Ε(δ)-μ <sub>δ</sub>				5 8/08	
Estimator $(\widehat{\delta})$	Max	Min	Mean	Standard deviation	Max	Min	Mean	Standard deviation
Cohen's d	0,080	0,000	0,010	0,015	1,753	1,005	1,175	0,208
Glass's $d_1$	0,037	0,000	0,005	0,007	1,004	0,888	0,973	0,030
Glass's d <sub>2</sub>	0,230	0,000	0,012	0,033	1,008	0,883	0,974	0,032
Cohen's d*	0,036	0,000	0,003	0,006	1,007	0,874	0,975	0,033
Shieh's d	0,018	0,000	0,002	0,003	1,007	0,874	0,975	0,033

Table A2.4

Absolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for biased estimators, whe

osouwe wevun ihen populatio	non verween er n variances an	npa reus una s sd sample size	neorencu med 15 are unequal c	osotute aertation verween empurcut and theoretical means as wen as ratio verween empurcat and theoretical variances for otasea estimators, hen population variances and sample sizes are unequal across groups (condition d).	an empiricae d).	7119 1091/1 1911	an variables for	oused estimators,
	Absolute de	eviation betwe	en empirical and $ E(\widehat{\delta}) - \mu_{\delta} $	Absolute deviation between empirical and theoretical means $ E(\widehat{\mathcal{S}}) - \mu_{\mathcal{S}} $	Ratio b	etween empi	Ratio between empirical and theoretical variances $S^2 \hat{\hat{s}}/\sigma_\delta$	al variances
stimator $(\delta)$	Max	Min	Mean	Standard deviation	Max	Min	Mean St	Standard deviation
Cohen's d	0,252	000'0	0,015	0,034	5,624	0,208	1,638	1,357
Glass's d1	0,026	000'0	900'0	0,006	1,009	0,881	0,972	0,033
Glass's d <sub>2</sub>	0,219	00000	0,012	0,031	1,011	0,872	0,973	0,036
Cohen's d*	0:030	00000	0,003	900'0	1,011	0,860	0,974	0,034
Shieh's d	600'0	0,000	0,001	0,002	1,011	0,867	0/6′0	9:0'0

Table A2.5

estimators, when population variances and sample sizes are equal across groups (condition a). Absolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for unbiased

Absolute deviation between empirical and theoretical means

Ratio between empirical and theoretical variances

			E(δ)-μ <sub>δ</sub>				3.6/08	
Estimator $(\widehat{\delta})$	Max	Min	Mean	Standard deviation	Max	Min	Mean	Standard deviation
Cohen's g	0,011	0,000	0,002	0,003	1,006	0,911	0,976	0,028
Glass's $g_1$	0,021	0,000	0,004	0,006	1,006	0,897	0,966	0,033
Glass's g <sub>2</sub>	0,022	0,000	0,004	0,007	1,005	0,889	0,966	0,035
Cohen's g*	0,015	0,000	0,003	0,004	1,006	0,908	0,975	0,029
Shieh's g	0,008	0,000	0,002	0,002	1,006	0,908	0,975	0,029

lbsolute deviat	tion between e	mpirical and t	theoretical me.	bsolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for unbiased	sen empirical	and theoretic	al variances for	unbiased
stimators, whe	n population	variances are	equal across <u>ş</u>	stimators, when population variances are equal across groups and sample sizes are unequal (condition b).	re unequal (	condition b).		
	Absolute de	eviation betwe	en empirical ar	Absolute deviation between empirical and theoretical means	Ratio	between empi	Ratio between empirical and theoretical variances	cal variances
			$ E(\widehat{\delta})$ - $\mu_{\delta} $				$S^{2}_{\ \widehat{\delta}}/\sigma_{\delta}$	
Estimator (δ)	Мах	Min	Mean	Standard deviation	Мах	Min	Mean Si	Standard deviation
Cohen's g	900'0	000'0	0,001	0,001	1,017	0,951	985	0,017
Glass's g1	0,018	000'0	0,004	0,005	1,006	0,891	996'0	0,037
Glass's g <sub>2</sub>	0,026	000'0	0,004	900'0	1,015	0,881	0,968	0,036
Cohen's g*	0,010	000'0	0,003	0,003	1,007	0,925	0,972	0,027
Shieh's g	0,007	0,000	0,002	0,002	1,007	006'0	6,959	0,037

estimators, when population variances are unequal across groups and sample sizes are equal (condition c). Absolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for unbiased

Absolute deviation between empirical and theoretical means

Ratio between empirical and theoretical variances

Table A2.7

1 008 0 890	טבטני טטעני דינעני
1,008 0,883	
0,974	0,974
0,032	0,032

lbsolute devia	tion between e.	mpirical and t	heoretical me	lbsolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for unbiased	en empirical	and theoretic	al variances for	. unbiased
stimators, whe	en population	variances and	sample sizes ı	stimators, when population variances and sample sizes are unequal across groups (condition d).	s (condition	Ŋ.		
	Absolute de	eviation betwe	en empirical ar	Absolute deviation between empirical and theoretical means	Ratio	between empi	Ratio between empirical and theoretical variances	ical variances
			$ E(\widehat{\delta})$ - $\mu_{\delta} $				$S^2_{\widehat{\delta}}/\sigma_{\delta}$	
Estimator (δ)	Мах	Min	Mean	Standard deviation	Мах	Min	Mean S	Standard deviation
Cohen's g	0,250	000'0	0,015	0,034	5,624	0,208	1,638	1,357
Glass's g1	0,025	00000	0,004	900'0	1,009	0,881	0,972	0,033
Glass's g <sub>2</sub>	0,210	00000	0,012	0,030	1,011	0,872	0,973	0,036
Cohen's g*	0,029	000'0	0,003	500'0	1,011	0,882	7.200	0,029
Shieh's g	800'0	000'0	0,001	0,002	1,011	0,881	6,973	0,032