1

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' d using either S_1 or S_2 as standardizer, Shieh's d and Cohen's d^*) and **unbiased** (Hedges' g, Glass' 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
- When population variances are unequal across groups and sample sizes are equal (condition c; see Figures A2.3 and A2.7 for respectively biased and unbiased estimators);
- When population variances and sample sizes are unequal across groups (condition d;
 see Figures A2.4 and A2.8 for respectively biased and unbiased estimators).
- 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

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theoretical expectations when population variances are equal across groups, with equal
   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' d
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   (Glass' 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
37
   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
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population variances assumption.

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' d ₁	Glass' d ₂	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
$S^2_{\ \delta}/\sigma_{\delta}$	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 ratio between en

bsolute devia	tion between er.	npirical and t	theoretical me	bsolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for biased estimators,	en empirica	l and theoreti	cal variances f	or biased estimators,
hen populatic	m variances ar	e equal acros	s groups and s	hen population variances are equal across groups and sample sizes are unequal (condition b).	(condition b	~		
	Absolute de	eviation betwe	en empirical ar	Absolute deviation between empirical and theoretical means	Ratio	between emp	irical and theore	Ratio between empirical and theoretical variances
			$ E(\widehat{\delta})$ - $\mu_{\delta} $				$S^2_{\widehat{\delta}}/\sigma_{\delta}$	
Estimator $(\widehat{\delta})$	Мах	Min	Mean	Standard deviation	Мах	Min	Mean	Standard deviation
Cohen's d	900'0	0,000	0,001	0,001	1,017	0,951	986'0	0,017
Glass' d ₁	0,019	0,000	0,004	900'0	1,006	0,891	996'0	0,037
Glass' d ₂	0,027	00000	900'0	0,007	1,015	0,881	896'0	0,036
Cohen's d*	0,010	000'0	6)003	0,002	1,007	0,902	596'0	0,034
Shieh's d	800'0	000'0	0,002	0,002	1,005	0,865	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(o)-με				0 6/06	
Estimator $(\widehat{\delta})$	Max	Min	Mean	Standard deviation	Max	Min	Mean	Standard deviation
Cohen's d	080,0	0,000	0,010	0,015	1,753	1,005	1,175	0,208
Glass' d_1	0,037	0,000	0,005	0,007	1,004	0,888	0,973	0,030
Glass' d ₂	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,

when populatio	n variances a	nd sample size	s are unequal	vhen population variances and sample sizes are unequal across groups (condition d).	d).			
	Absolute d	eviation betwe	en empirical ar $ E(\widehat{\delta})$ - $\mu_{\delta} $	Absolute deviation between empirical and theoretical means $ { m IE}(f \delta) \! + \! u_{m \delta} $	Ratio	between empi	Ratio between empirical and theoretical variances $S^2_{\hat{\delta}}/\sigma_{\hat{\delta}}$	cal variances
Estimator (δ)	Max	Mi	Mean	Standard deviation	Max	Min		Standard deviation
Cohen's d	0,252	00000	0,015	0,034	5,624	0,208	1,638	1,357
Glass'd ₁	0,026	00000	900'0	900'0	1,009	0,881	0,972	0,033
Glass'd ₂	0,219	000'0	0,012	0,031	1,011	0,872	0,973	0,036
Cohen's d*	0,030	000'0	00'003	900'0	1,011	0,860	0,974	0,034
Shieh's d	600'0	000'0	0,001	0,002	1,011	0,867	0,970	9:00'0

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

Shieh's g	Cohen's g*	Glass'g ₂	Glass'g ₁	Cohen's g	Estimator $(\widehat{\delta})$	
0,008	0,015	0,022	0,021	0,011	Max	Absolute dev
0,000	0,000	0,000	0,000	0,000	Min	iation betwe
0,002	0,003	0,004	0,004	0,002	Mean	en empirical a $ E(\widehat{\delta}) \cdot \mu_{\delta} $
0,002	0,004	0,007	0,006	0,003	Standard deviation	Absolute deviation between empirical and theoretical means $ { t E}(\widehat{\delta}) \!\!-\! \mu_{\widehat{\delta}} $
1,006	1,006	1,005	1,006	1,006	Max	Ratio
0,908	0,908	0,889	0,897	0,911	Min	between emp
0,975	0,975	0,966	0,966	0,976	Mean	oirical and theo $S^2\widehat{\delta}/\sigma_\delta$
0,029	0,029	0,035	0,033	0,028	Standard deviation	Ratio between empirical and theoretical variances $S^2\hat{_6}/\sigma_6$

bsolute devia stimators, whe	tion between ei m population v	mpirical and t variances are	heoretical mec equal across g	bsolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for unbiased stimators, when population variances are equal across groups and sample sizes are unequal (condition b).	en empirical re unequal (and theoretic condition b).	al variances for	unbiased
	Absolute de	eviation between	en empirical an	Absolute deviation between empirical and theoretical means	Ratio	between empi	Ratio between empirical and theoretical variances	cal variances
			Ε(δ̂)-μ _δ			-	$S^{2}_{\ \widehat{\delta}}/\sigma_{\delta}$	
stimator (δ)	Мах	Min	Mean	Standard deviation	Max	Min	Mean Si	Standard deviation
Cohen's g	900'0	0,000	0,001	0,001	1,017	0,951	0,985	0,017
Glass' g1	0,018	0,000	0,004	0,005	1,006	0,891	996'0	0,037
Glass' g ₂	0,026	000'0	0,004	900'0	1,015	0,881	0,968	9:00
Cohen's g*	0,010	000'0	0,003	00'00	1,007	0,925	0,972	0,027
Shieh's g	0,007	000'0	0,002	0,002	1,007	006'0	656'0	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

				ĺ		
Shieh's g	Cohen's g*	Glass'g ₂	Glass'g1	Cohen's g	Estimator $(\widehat{\delta})$	
0,017	0,034	0,221	0,036	0,079	Max	
0,000	0,000	0,000	0,000	0,000	Min	
0,002	0,003	0,012	0,005	0,010	Mean	$ E(\widehat{\delta})\!\!-\!\!\mu_{\delta} $
0,003	0,006	0,032	0,007	0,015	Standard deviation	
1,008	1,008	1,008	1,004	1,753	Max	
0,890	0,890	0,883	0,888	1,005	Min	
0,978	0,978	0,974	0,973	1,175	Mean	$S^2 \hat{_{ar{\delta}}}/\sigma_{\delta}$
0,029	0,029	0,032	0,030	0,208	Standard deviation	

Table A2.8

lbsolute deviai	ion between e	mpirical and t	heoretical me	bsolute deviation between empirical and theoretical means as well as ratio between empirical and theoretical variances for unbiased	een empirical	and theoreti	cal variances f	or unbiased
stimators, whe	ท population	variances and	sample sizes	stimators, when population variances and sample sizes are unequal across groups (condition d).	s (condition	d).		
	Absolute d	eviation betwe	en empirical a	Absolute deviation between empirical and theoretical means	Ratio	between empi	Ratio between empirical and theoretical variances	etical variances
			$ E(\widehat{\delta})$ - $\mu_{\delta} $				$\mathcal{S}^{2}_{\widehat{\delta}}/\sigma_{\delta}$	
Estimator (δ)	Мах	Min	Mean	Standard deviation	Мах	Min	Mean	Standard deviation
Cohen's g	0,250	000'0	0,015	0,034	5,624	0,208	1,638	1,357
Glass' g1	0,025	000'0	0,004	900'0	1,009	0,881	0,972	0,033
Glass' g2	0,210	00000	0,012	0,030	1,011	0,872	0,973	0,036
Cohen's g*	0,029	0,000	0,003	500'0	1,011	0,882	726'0	0,029
Shieh's g	0,008	0,000	0,001	0,002	1,011	0,881	0,973	0,032