A Meta-Analysis of Relations between Self-Regulation and Autonomic Flexibility: Executive Functioning, Effortful Control, and Emotion Regulation

Jacob B. Holzman, Alison Krauss, Taylor Koegel, Lauren E. Boddy, & David J. Bridgett
Northern Illinois University

Northern Illinois University

Introduction

- There is growing interest in potential biomarkers of self-regulatory capacity[1]
- Cardiac vagal tone is believed to reflect self-regulatory capacity due to the influence of prefrontal cortical structures [2,3,4]
- The goal of the current investigation was to conduct a meta-analysis on the relationship between cardiac vagal tone and several aspects of self-regulation, including executive functioning (EF), emotion regulation (ER), and effortful control (EC).
- A significant, positive relationship between self-regulation and cardiac vagal tone was expected
- Moderating variables were taken into consideration, including:
  - Type of self-regulation (i.e., ER vs. EF and EC)
  - Measurement of self-regulation (i.e., behavioral observation vs. report)
  - Measurement of cardiac vagal tone (i.e., baseline vs. task. vs. change)

Method

- A broad literature search was conducting using several databases (i.e., PsycInfo, Pubmed, ProQuest, Google Scholar, and Web of Science) using related key words (i.e., EF, EC, ER, heart-rate variability, respiratory sinus arrhythmia, and cardiac vagal tone)
- 6,728 titles and relevant abstracts were reviewed which led to 286 studies reviewed in full-text
- Studies were excluded if:
  - no measurement of self-regulation
  - no measurement or computation of cardiac vagal tone
  - written in a language other than English
  - experimental studies manipulating self-regulation without baseline measurements of self-regulation
  - data previously reported
  - statistics necessary to compute effect size not reported
- Correlation coefficients were adjusted (i.e., Fisher's R Transformation) to estimate the effect size

Contact Information

Corresponding Authors: Jacob B. Holzman (jacob.b.holzman@gmail.com)
David Bridgett (dbridgett1@niu.edu).

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Methods ctd.

- 139 effect sizes across 27 studies representing a Total N of 3,399 were identified
- Within study effect sizes were averaged to maintain independence
- A fixed-effects model was used with the assumption that potential moderators could explain heterogeneity within effect sizes [5, 6]
- Homogeneity tests were conducted using the Q statistic and the potential for publication bias was examined using the Fail Safe N [7]

Table 1

First Author	Year	*k*	*n*	*r**	*w'*
Beauchaine	2013	4	80	.0270	2.080
Becker	2012	3	126	.1106	13.660
Bell	2012	6	43	-.1427	-5.747
Blair	2003	3	42	.0432	1.686
Blandon	2008	6	239	.0470	11.100
Blankson	2012	12	263	.0738	19.223
Borger	1999	2	37	.2661	9.271
Conradt	2014	24	705	.0014	0.983
Feldman	2006	1	71	.3447	23.442
Gentzler	2009	6	65	.0688	4.272
Hannesdotir	2010	2	18	.0612	0.919
Hastings	2008	4	94	.0204	1.857
Hessler	2007	1	72	.2769	19.618
Hollenstein	2011	4	99	-.0662	-6.365
Kidwell	2007	2	56	.0701	3.721
Liew	2010	16	224	-.0100	-2.210
Liew	2011	1	36	.5101	18.575
Marcovitch	2010	8	220	.0850	18.490
Perry	2011	2	197	.1158	22.566
Pickens	1995	3	84	.6782	66.888
Porter	2003	1	56	.1409	7.518
Santucci	2007	3	54	.1075	5.483
Scott	2014	2	80	.2770	21.901
Skowron	2014	4	128	.1802	22.774
Slobodskaya	2001	2	65	.1727	10.816
Sulik	2013	5	101	.1132	11.141
Utendale	2014	12	144	-.010	-1.410

Note: *k* = # effects. *w'* = weighted effect size. * = Fisher's Transformed R.

Results

- A significant effect size (*r* = .09) was observed, albeit small based on Cohen's criteria [8]
- The Fail Safe N = 325 and a significant homogeneity test occurred
- Moderator analyses revealed the following results:
  - EC/EF vs. ER (Q_B = 1.89, p > .05)
  - Behavioral Observation vs. Report (Q_B = 0.39, p > .05)
  - Baseline CVT vs. Task CVT (Q_B = 2.19, p > .05)
  - Baseline CVT vs. CVT Change (Q_B = 1.02, p > .05)
  - Task CVT vs. CVT Change (Q_B = 4.40, p < .05)

Table 2

Unit of Analysis	EC Source	*k*	Mean ES	Std. Error
All Studies	Single ES	26	.0911	.0174
Type of Self-Regulation	EF/EC	16	.0694	.0216
	ER	13	.1153	.0259
Self-Regulation Measurement	Behavioral	16	.0967	.0203
	Report	15	.0769	.0260
Measurement of CVT	Baseline	24	.0772	.0182
	Task	10	.1283	.0330
	Change	17	.0477	.0194

Discussion

- Results validate CVT as a biomarker of self-regulation, as seen by effect sizes (including overall and across all moderator levels) being significantly different than zero, albeit with the caveat that these effect sizes were small in magnitude
- Moderator analyses were interpreted as:
  - No difference was found regarding the relationships between ER and CVT and EF/EC and CVT
  - The relationship between Self-regulation and CVT did not differ across different methods for measuring Self-regulation (i.e., behavioral observation compared to report)
  - No difference was found regarding the relationships between Baseline CVT and Self-regulation and Task CVT and Self-regulation
  - No difference was found regarding the relationships between Baseline CVT and Self-regulation and CVT change and Self-regulation
  - Task CVT demonstrated a stronger relationship with Self-regulation than CVT change
- Findings suggest that considering CVT as a broad marker of self-regulation as opposed to a specific aspect of self-regulation (e.g., emotion regulation) may be appropriate
- Future studies may examine gender as a moderator[9]

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* = Study contributed an effect size.

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