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Methodological quality of meta-analyses of single-case experimental studies

Laleh Jamshidi[a,b,*], Mieke Heyvaert[a], Lies Declercq[a,b], Belén Fernández-Castilla[a,b], John M. Ferron[c], Mariola Moeyaert[d], S. Natasha Beretvas[e], Patrick Onghena[a], Wim Van den Noortgate[a,b]

[a] Faculty of Psychology and Educational Sciences, KU Leuven, University of Leuven, Belgium
[b] IMEC-ITEC, KU Leuven, University of Leuven, Belgium
[c] University of South Florida, Tampa, Florida, USA
[d] State University of New York, Albany, NY, USA
[e] University of Texas at Austin, TX, USA

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ABSTRACT

Background: Methodological rigor is a fundamental factor in the validity and credibility of the results of a meta-analysis.
Aim: Following an increasing interest in single-case experimental design (SCED) meta-analyses, the current study investigates the methodological quality of SCED meta-analyses.
Methods and procedures: We assessed the methodological quality of 178 SCED meta-analyses published between 1985 and 2015 through the modified Revised-Assessment of Multiple Systematic Reviews (R-AMSTAR) checklist.
Outcomes and results: The main finding of the current review is that the methodological quality of the SCED meta-analyses has increased over time, but is still low according to the R-AMSTAR checklist. A remarkable percentage of the studies (93.80% of the included SCED meta-analyses) did not even reach the midpoint score (22, on a scale of 0–44). The mean and median methodological quality scores were 15.57 and 16, respectively. Relatively high scores were observed for "providing the characteristics of the included studies" and "doing comprehensive literature search". The key areas of deficiency were "reporting an assessment of the likelihood of publication bias" and "using the methods appropriately to combine the findings of studies".
Conclusions and implications: Although the results of the current review reveal that the methodological quality of the SCED meta-analyses has increased over time, still more efforts are needed to improve their methodological quality.

What this paper adds?

Through a comprehensive methodological quality assessment of SCED meta-analyses published between 1985 and 2015, this paper further clarifies important deficiencies in the validity and credibility of the results of these meta-analyses. Future SCED meta-analysts could avoid methodological flaws in the early stages of their studies by paying more attention to these methodological shortcomings.

* Corresponding author at: Faculty of Psychology and Educational Sciences, KU Leuven, Etienne Sabbelaan 53, 8500 Kortrijk, Belgium.
E-mail address: laleh.jamshidi@kuleuven.be (L. Jamshidi).

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1. Introduction

Systematic reviews (SRs) are an important and invaluable tool to combine the evidence about the effects of an intervention of interest in a systematic way and provide key summaries for clinical decision-making. An SR can include a meta-analysis (MA) that statistically combines the results of the individual studies and provides an overall estimate of the effect size, and possibly studies the moderating effect of study characteristics. SRs with high-ranked methodological standards can provide valid and appropriate conclusions. SRs can even be regarded as the most valid form of research aimed at providing evidence-based recommendations for clinical decision making (Faggion & Giannakopoulos, 2013; Hall, Lee, & Zurakowski, 2017; Rotta, Salgado, Silva, Correr, & Fernandez-Llimos, 2015; Wells, Kolt, Marshall, Hill, & Bialocerkowski, 2013). However, appropriate and proper systematic data collection and analytical methods should be used in SRs and MAs to reflect the current standards for evidence synthesis and to provide accurate evidence about the literature (Hall et al., 2017; Rice, Shrier, Kloda, Benedetti, & Thombs, 2016). This study explores the methodological quality of MAs of studies applying a single-case experimental design (SCED). Before discussing the methodology, we describe SCEDs, the meta-analysis of SCED studies and the issue of assessing the quality of MAs.

1.1. Single-case experimental design (SCED) characteristics and features

SCEDs are used to evaluate the effect of one or more treatments on one or more individual cases. The case may be a participant or another single entity that forms the research unit, such as a school or a family. This entity is repeatedly observed, over the levels of one or several manipulated independent variables (Onghena, 2005). An SCED is identified by three principal features: (a) data are gathered, analyzed, and interpreted for one or multiple cases (this “case” can be a participant, but also another unit, for example, a classroom); (b) the case(s) is/are observed repeatedly during at least two different conditions that are introduced/withdrawn by the researcher; and (c) outcomes are compared across conditions within a case (Beretvas & Chung, 2008a; Kratochwill et al., 2010; Moeyaert, Ugille, Ferron, Beretvas, & Van den Noortgate, 2014a; Rogers & Graham, 2008; Smith, 2012). This kind of design focuses on evaluating whether there is a causal or functional relationship between introducing a treatment as an independent variable and the change in a dependent variable. Because the cases in SCEDs are observed repeatedly over time, the time variable plays an important role in these designs. In the basic version of this design (AB design), the subject is measured repeatedly, before and during or after the treatment or intervention is introduced. The results of these designs can then be analyzed visually or statistically. There are more complex single case designs such as multiple-baseline designs (MBDs), reversal designs, and alternating designs (Barlow, Nock, & Hersen, 2009).

As Beretvas and Chung (2008b) pointed out, many outcomes of interest in social sciences have natural growth trends (increases or decreases over time) even without intervention/treatment. When a trend over time is present in temporally ordered data, treatment effect sizes that do not explicitly account for these trends may be under- or overestimating the effect (Campbell, 2004). The possibility of developmental trends is one of the main features of the SCED studies.

Another key feature of SCED data is that it is possible that sequential observations are more similar compared to observations that are more distant from each other because the same random factors may continue to influence the scores on multiple subsequent measurement occasions (Van den Noortgate & Onghena, 2008). This phenomenon is called serial dependency and it implies that residuals are not independently distributed, an assumption made by common statistical tests and analyses (Owens, 2011; Petit-Bois, Baek, Van den Noortgate, Beretvas, & Ferron, 2016).

1.2. SCED meta-analysis methods

SCEDs have been frequently applied in different disciplines to examine the effects of interventions or treatments (Schlosser, Lee, & Wendt, 2008; Shadish, 2014a, 2014b; Shadish & Rindskopf, 2007; Smith, 2012). One of the main issues of SCEDs is their limited generalizability and hence their limited usefulness for the development of evidence-based guidelines because of the small number of cases under investigation. To enhance generalizability, researchers replicate SCEDs across cases, across setting, or across behaviors. Meta-analytic procedures allow researchers to quantitatively synthesize the results of these replications and provide evidence for best practices (Beretvas & Chung, 2008a; Petit-Bois et al., 2016; Tincani & De Mers, 2016). Interest in the meta-analysis of SCEDs has increased in the past decade (Shadish, 2014a; Shadish, Hedges, & Pustejovsky, 2014) and many methodological advancements in the field of meta-analysis were made.

SCED meta-analysts can apply different methods and procedures for statistically analyzing the data from multiple SCED studies such as regression analyses of effect sizes, multilevel analyses of raw data or effect sizes, or the calculation of a simple average, median, or range of effect sizes (Owens, 2011; Petit-Bois et al., 2016).

The simplest method for calculating the overall effect is to combine the calculated effect sizes from individual studies by reporting the simple average, weighted average, median, or the range of effect sizes. Another method for providing an overall overview across studies is vote counting. Borenstein, Hedges, Higgins, and Rothstein (2009) considered this method as the process of counting the number of studies that found statistical significance and the number that do not, and then choosing the ‘winner’. An, advantage is that the method is still applicable if studies do not provide enough information to calculate an effect size estimate, but contain the information about the direction and the statistical significance of the results, or just the direction of the results (Bushman & Wang, 2009).

Combining p-values is another way of aggregating data from multiple studies. Borenstein et al. (2009) proposed this method for researchers who want to work directly with the p-values from each test instead of effect sizes in order to obtain an overall p-value.