Changing approaches to research synthesis affect social and intellectual structures of science
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ABSTRACT
Research synthesis methods, like collaboration and interdisciplinary research, comprise practices through which scholarly and scientific knowledge is integrated. The methods, which include meta-analysis and integrative or systematic review, are also arguably one of the most important contemporary methodological innovations in many social, medical, health, and perhaps other sciences. As an innovative research practice, research synthesis, like many innovations, may be associated with complex or unexpected consequences as it diffuses through the research system. This study examines the extent to which the diffusion of research synthesis methods has affected levels of collaboration and research use through comparison with literature reviews in five fields. In Social Work and Information and Library Science, more authors contributed to research syntheses than reviews. There was no difference in number of authors in the biological sciences examined: two to four authors typically contributed to both reviews and syntheses. Research syntheses were used more than reviews in Conservation Biology and Women’s Studies. In Social Work, research syntheses and reviews were cited at similar levels, but production of reviews decreased as syntheses increased, suggesting that research synthesis was becoming the predominant approach to review, while traditional reviews remained valuable to researchers though in an increasingly narrow range of contexts. In Information and Library Science, research reviews were used more than research syntheses, and trends suggest that research reviews are a relatively rare but highly prized - or at least frequently used - resource. No difference was found between use of research syntheses and reviews in Evolutionary Biology. Future research should investigate relationships between different approaches to knowledge integration in the context of science fields, which would lead to a better understanding of integration, or synthesis, in science overall.

Keywords
Research synthesis methods, knowledge integration, diffusion of innovations, literature review, disciplinary differences

INTRODUCTION
Research practices diffuse within (e.g., Leahey & Moody, 2014) and across (e.g., Kiss, Broom, Craze, & Rafols, 2010) science fields, and may lead to consequences that are the result of the complex and often unpredictable interactions between innovations and individuals embedded in social and cultural contexts (Rogers, 2003). Potential consequences of innovations include changes at the level of individuals or social systems as a result of the adoption or rejection of an innovation (Rogers, 2003; Wejnert, 2002). They can be framed in terms of effects within an innovation-diffusion process, for example, the consequences of additional adoptions of an innovation on other innovation adoption decisions; or in terms of how the adoption of an innovation affects other characteristics of the status quo - an innovation may displace, complement or otherwise contribute to reconfigurations in the patterns of use of existing ideas, technologies, practices, and so on. Further, diffusion of an innovation may have implications for how social actors relate and social structure more broadly (Rogers, 2003).

Research synthesis methods, which first rose to prominence under the label ‘meta-analysis’, (Glass, 1976; Shadish & Lecy, 2015) and later spread, at least in part in concert with the evidence-based practice (EBP) movement, is a methodological research innovation that has contributed to changes in the practice of research and use of research knowledge. Systematic review, and meta-analysis in particular, has played a critical role in the transformation of research-related practices in medicine, and also in psychology, education, and other fields. Development and adoption of research synthesis has occurred in tandem with the development of complementary statistical techniques; literature search, retrieval, reporting, and appraisal
methods; and adaptation or interpretation of research synthesis in the context of divergent research traditions (Chalmers, Hedges & Cooper, 2002; Strike & Posner, 1983).

In some fields, research synthesis may contribute to changes in collaboration practices. Collaboration is considered beneficial to research synthesis studies because it enables triangulation between researcher evaluations of the relevance and quality of research, due to needs for multiple types of expertise, and the large scale of some projects. Collaborative information behaviors in the context of research synthesis was studied by Blake and Pratt (2006), and is important in that this approach to review differs substantially from the traditional notion of reviews as a genre dominated by expert researchers using the sole authorship model to share perspective as well as research-informed expertise (Peters & van Raan, 1994; c.f., Cooper, 1986) to “shape the literature of a field into a story in order to enlist the support of readers to continue that story” (Myers, 1991, p. 45). Use of research synthesis may contribute to changes observed in patterns in the citation system (e.g., Wallace, Larivièrè, & Gingras, 2009), including trends towards increasing levels of co-authorship (e.g., Morris & Goldstein, 2007). Additionally, changes in publication guidelines and standards made in part to accommodate the needs of researchers who perform syntheses (e.g., APA Publications & Communications Board Working Group, 2008) or based on beliefs related to hierarchies of evidence, which often place systematic reviews at or near the top, suggest that research synthesis may indirectly impact citation patterns (Bhandari et al., 2004; Montori, Wilczynski, Morgan, Haynes, & the Hedges Team, 2003; Patsopoulos, Analatos, & Ioannidis, 2005).

**Purpose**

This study examines the extent to which the diffusion of research synthesis methods has affected research practices associated with collaboration and research use through comparison of research syntheses with literature reviews in five fields: Evolutionary Biology, Conservation Biology, Social Work, Women’s Studies, and Information and Library Science.

**Significance**

This study contributes to diffusion of innovations research in information science generally, and the consequences of the diffusion of research innovations more specifically. Through comparison of the consequences of diffusion across fields, this research contributes to our knowledge of disciplinary differences (e.g., Fry & Talja, 2007) in the context of research integration. Additionally, findings from this research may contribute to further development of information science as a meta-discipline (Bates, 1999); and complements previous contributions of information science to the development, study, and implementation of research synthesis methods, especially in the medical and health sciences (Sheble, 2016).

**LITERATURE REVIEW**

The literature reviewed provides a brief introduction to the process of a research synthesis study, summarizes past research on the functions of reviews and research syntheses, and discusses relationships between reviews and research syntheses suggested in the literature. Use of research synthesis methods is one of many approaches to knowledge integration in the context of science and scholarship. Therefore, research synthesis methods are briefly presented in the broader context of scientific synthesis and integration. Throughout this text, ‘research synthesis’ is used to refer to synthesis initiatives that draw on research synthesis methods such as meta-analysis and systematic review; and ‘scientific synthesis’ is used to refer to concerted efforts to integrate research more broadly.

**Integration through research synthesis methods**

Document-based research synthesis methods, which include systematic or integrative review and meta-analysis, have been promoted as an innovative approach to research that has the potential to mitigate weaknesses of traditional scientific review (e.g., Mulrow, 1994); and facilitate consensus formation and cumulation of scientific knowledge (e.g., Glass, 1976; Miller & Pollock, 1994). The process of research synthesis studies is analogous to other types of empirical research studies. Researcher(s) formulate a research problem, collect data (findings from previous studies), evaluate, analyze, and synthesize the data, and interpreting the results. The importance of presenting and disseminating findings is often emphasized in research synthesis, and therefore this is often identified as the concluding step (Cooper & Hedges, 1994).

**Functions of reviews and research syntheses**

Generally, research synthesis is regarded as a relatively new form and method for literature review. Noguchi (2006) suggests that review articles serve as bridges between different audiences. As this metaphor suggests, reviews and research syntheses may be used to integrate previously unconnected lines of research (Leitch, 1958); aggregate and summarize prior findings (Leitch, 1958); translate ideas across disciplinary boundaries (Altman & Goodman, 1994; Noguchi, 2006), across language barriers (Gordon & Santman, 1981), between generalists and specialists (Cooper, 1986; Noguchi, 2006), across time (Price, 1963), into interdisciplinary contexts (Dijkers, 2009) and for new comers to a field (Luck, 1981). Garfield, who often wrote about reviews and their functions, emphasized the role of reviews in literature discovery: “…every time an author makes a reference he is in effect indexing that work from his point of view. This is especially true of review articles…” (Garfield, 1955, p. 470).

**Relationships between reviews and research syntheses**

Research syntheses have displaced traditional methods of review in highly visible fields, including the clinical sciences and psychology (Barrios, Guilera, & Gómez-Benito, 2013; Patsopoulos, Analatos, & Ioannidis, 2005).
Whether, to what extent, and which components of research synthesis methods are adopted in different fields is influenced by research cultures, resource availability, and how research goals are framed (Bastian, Glasziou, & Chalmers, 2010; Sheble, 2014). Adoption of research synthesis as a method of research review has implications for research practice: Teams of researchers may work on the distillation of a large number of potentially relevant study reports; multiple coders may be needed to assess study relevance and extract data from primary study reports; and broader varieties of skill sets may be needed to perform research syntheses.

It is important to consider how use of research synthesis may be contributing to changes in how reviews are written and used more broadly. While it has long been recognized that reviews serve many purposes, it is possible that the development of research synthesis, in effect, represents the emergence of the codification of different types of reviews and their associated functions – at least in some fields that have made extensive use of research synthesis. Discussion in research synthesis methods texts (e.g., Cooper & Hedges, 1994) and on the roles and uses of traditional literature reviews and research syntheses (e.g., Dijkers, 2009), suggests that this process, though underway in the medical and health sciences, has yet to stabilize. In these fields, this may be especially true in relation to reestablishing the legitimacy of some functions of traditional literature reviews. In other fields, it is less clear whether distinctions between different types of research synthesis and reviews will be seen as helpful to achieving the goals of research and of research as it relates to practice and policy. It is also possible that in some contexts research syntheses simply displace traditional reviews, and other functions of reviews such as provision of expert perspectives, may primarily be represented in other types of publications such as commentaries and 'perspectives'.

Recent citation analyses in several health and medical science fields support the notion of different functions for different types of research syntheses and reviews. Though past research has shown that review articles tend to be more highly cited than other types of articles (e.g., Peters & van Raan, 1994), studies of health and medical literature indicate that systematic reviews (including meta-analyses) (Bhandari, et al., 2004; Montori, et al., 2003), and meta-analyses (Patsopoulos, et al., 2005) are more highly cited than other types of review. While this may be a reflection of (a) publishing recommendations for authors made available by journals or (b) beliefs about evidence hierarchies, differences do seem to exist.

Other approaches to synthesis in science

Broadly, scientific synthesis is the generation of new knowledge from integration of extant data, information, and knowledge (Sidlauskas, Ganapathy, Hazkani-Covo, Jenkins, Lapp, et al., 2009). Through scientific synthesis, diverse knowledge is integrated to increase the generality and applicability of results and yield novel insights or explanations (Carpenter, Armarbrust, Arzberger, et al., 2009). Knowledge integration complements and counter-balances specialization and knowledge diffusion (Liu, Rafols, & Rousseau, 2012). Insights and explanations developed through synthesis may be most relevant within the context of science, or in a variety of application contexts, including for use in policy or professional decision-making. Synthesis occurs both within (e.g., Leahey & Moody, 2014) and across disciplines (Abbott, 2001) and professional sectors (Palmer et al., 2016).

Knowledge integration and synthesis occurs through a number of mechanisms in science. Integration of scholarly and scientific knowledge occurs through collaboration (Sonnenswald, 2007), interdisciplinary research (Wagner et al., 2011), integration of findings (Cooper & Hedges, 1994) and data (Cooper & Patall, 2009) across studies, implementation of simultaneous, or multi-site studies, and through theory development. Consensus congresses (Ferguson, 1993; Solomon, 2007) and working groups, including at synthesis centers (e.g., Hampton & Parker, 2011; Palmer, Kramer, Boyd, & Hawthorne, 2016) are examples of institutional programs that have been established to sponsor, encourage, and support synthesis. In many cases, research and scholarship performed with the goal of knowledge integration may draw on multiple modes of synthesis (e.g., use of research synthesis methods in a collaborative project).

**STUDY CONTEXT**

The current study on the consequences of the diffusion of research synthesis methods was conducted in the context of a larger project that examined macro-level trends in the diffusion of research synthesis across science broadly; and at the meso-level in two biological and two social sciences as well as in information and library science. Research reported here continues investigation of these same fields: Evolutionary Biology, Conservation Biology, Social Work, Women’s Studies, and Information and Library Science. These fields complement each other in that two are generally considered more applied and two more pure in orientation (Table 1). Information and library science (ILS) complements the selected fields as well: as a ‘meta-discipline’ ILS is concerned with the informational characteristics of other fields (Bates, 1999) in addition to research that is more internal to the field.

Selection of fields in the biological and social sciences enables us to compare and contrast findings of this study with those of previous research. Such research has primarily been conducted in fields in which research synthesis methods have become the predominant approach to review, including in the health and medical sciences (e.g., Patsopoulos, Analatos & Ioannidis, 2005) and psychology (Barrios, Guiler, & Gomez-Benito, 2013). Moreover, research synthesis has been studied to a lesser extent in the selected fields despite the rise of synthesis...
centers in the biological sciences (e.g., Sidlauskas, et al., 2009); and the continuing development of the Campbell Collaboration (www.campbellcollaboration.org/), which is the Cochrane Collaboration’s counterpart in the social, behavioral, and educational sciences.

|                      | Pure                     | Applied                  |
|----------------------|--------------------------|--------------------------|
| Life Sciences        | Evolutionary Biology     | Biodiversity/Conservation |
| Social Sciences      | Women’s Studies          | Social Work              |

**Table 1. Complementary characteristics of fields**

Findings of the broader study indicated that the selected fields differed to varying extents along other criteria examined, including when research synthesis first appeared in the fields, the proportion of publications related to evidence-based practice (EBP), and in the proportion of field resources devoted to reviews (Table 2). The two biological sciences have engaged more with past research, as gauged by the proportion of publications categorized as Document Type (‘DT’) ‘review’ in the Web of Science. Lower levels of engagement with past research were observed in Social Work and ILS, and almost none in Women’s Studies (Table 2).

|                      | 1st RS Pub | RS per 10,000 | EBP pubs | EBP per 10,000 | Reviews (%) |
|----------------------|------------|---------------|----------|----------------|-------------|
| Evolutionary Biology | 1990       | 33.73         | 14       | 1.58           | 4.76        |
| Conservation Biology | 1994       | 54.16         | 45       | 9.85           | 5.67        |
| Social Work          | 1982       | 78.66         | 552      | 148.89         | 1.33        |
| Women’s Studies      | 1985       | 66.91         | 50       | 15.00          | 0.12        |
| Info & Lib Science   | 1985       | 17.43         | 320      | 16.01          | 0.88        |

**Table 2. Overview of field characteristics**

**DATA COLLECTION**

Bibliographic records associated with reviews of research literature and research syntheses published between 2006 and 2008 in Evolutionary Biology, Conservation Biology, Social Work, Women’s Studies, and Information and Library Science were obtained from the Thomson Reuters’ Web of Science Expanded Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) using the Web of Knowledge (v. 5.5) interface. A combination of keyword and cited reference searches were used to identify papers that potentially reported a research synthesis; and searches by document type (‘DT’) were used to find papers that were potentially reviews of research in the literatures of each field. Keywords used to identify research synthesis publications included variations of ‘research synthesis’, ‘systematic review’, and ‘meta-analysis’, as well as less common variants such as ‘qualitative meta-synthesis’ (Sheble, 2014). Publications that cited methods books and seminal papers for research synthesis were collected with cited reference searches. Seed publications for the cited reference search were identified through a historical review of the development of research synthesis methods and systematic searching of databases such as OCLC’s WorldCat (detailed in Sheble, 2014). Citation data were downloaded 10 February 2014.

Evolutionary Biology, Conservation Biology, Social Work, Women’s Studies, and Information and Library Science fields were delineated based on the Web of Science categories (‘WC’) ‘Evolutionary Biology’, ‘Biodiversity & Conservation’, ‘Social Work’, ‘Women’s Studies’, and ‘Information Science & Library Science’, respectively.

Publications identified via searches were categorized as traditional research reviews or research syntheses based on examination of full text and supplement files. Only reviews of research were categorized as “traditional research reviews”. Other types of reviews, including of policy, flora, fauna, and so on were excluded, as were social science papers focused on theory or model building, though these often draw extensively on literature review. Publications were categorized as research syntheses if a meta-analysis of findings or data across two or more publications was presented; or if the author met four of seven criteria: the publication incorporated any of the six steps of research synthesis specified by Cooper and Hedges (1994) and/or the publication was labeled or described by one of the search phrases used to define research synthesis methods or a close synonym (e.g., “synthesis of research”).

**ANALYSIS**

Items identified through bibliographic searches were subject to a shallow content analysis to ascertain whether publications associated with the records reported a study that used research synthesis methods or related to the methods in another way; and whether reviews were traditional narrative research literature reviews. This process primarily relied on abstracts. When an abstract was not available or when information provided in an abstract was not sufficient to categorize a publication, full text was retrieved and examined. A primary coder coded all items. For each field, an individual with domain area expertise coded 10% or 40 items (which ever was greater) across a broader set of documents. Coders agreed 87.95% of the time on whether items reported a research synthesis study (Cohen’s kappa (κ) = 0.758).

Levels of collaboration in and subsequent research use of research synthesis studies versus traditional research reviews were compared across items published between 2006 and 2008 for Conservation Biology, Social Work, Women’s Studies, and Information and Library Science. Only 2007 publications were examined in Evolutionary Biology due to the great number of publications and limited research resources. The number of authors contributing to each publication is used to measure collaboration, and the
number of citations received by a paper at five years post-publication, an indicator of subsequent research use. Van Elteren tests (1960) were applied to understand whether research syntheses were more collaborative and received more citations compared to traditional research reviews, while controlling for differences in publication year.

The van Elteren test, also called a stratified Wilcoxon test, is a non-parametric test for differences between two groups, controlling for another factor:

\[
u = \sum_{j=1}^{m} \frac{w_j}{n_{1j} + n_{2j} + 1},\]

Where \(w_j\) is the Wilcoxon rank-sum statistic for testing the null hypothesis of no difference in the \(j^{th}\) year, and \(n_{1j} + n_{2j}\) is the total number of papers in the \(j^{th}\) year across groups 1 (RS) and 2 (Reviews). Strata based on publication year were considered in the analysis to account for systematic changes in the publication system over time such as the general trend towards greater collaboration. As previously mentioned, number of citations to publications were calculated based on a five-year citation window. Though the van Elteren test has not been frequently used in bibliometric studies, the closely related Wilcoxon test is used regularly.

The Wilcoxon rank sum test was used in the case of Evolutionary Biology given that only one year was examined. A supplementary analysis of publication years of reviews and research syntheses in Social Work was performed to examine trends in the number of each type of publication, 2006-2010. Wilcoxon and van Elteren tests were performed using SAS 9.3 (SAS Institute, 2012).

**Limitations**

This study is subject to the standard limitations of bibliometric and document-based studies of science: the data source used presents a biased view of research, including of the fields examined here (see, e.g., Meho & Spurgin, 2005). Additional limitations include those related to the search strategy used to identify studies and the categorization of research within *Web of Science* categories (see, e.g., Leydesdorff & Bornmann, 2016). It should be noted that the query phrases used to operationalize the concept “research synthesis methods,” were examined and refined through iterative scanning of results and results subsets. However, the concept “research synthesis methods” is operationalized at a level that is a compromise between precision and recall, and does not capture all studies that use research synthesis methods. To and extent, this limitation was mitigated through the search for reviews as comparator papers. Through the process of identifying reviews, research synthesis publications that were not found with the initial research synthesis methods search but which were categorized as reviews were identified and included as research syntheses.

**RESULTS**

The number of reviews and research syntheses varied across the fields examined. More research syntheses (45) than reviews (30) were published in Social Work between 2006 and 2008. The reverse was true in all other fields except for Women’s Studies, in which an equal number of reviews and research syntheses were published (Table 3).

| Field                  | Type | 2006 | 2007 | 2008 | Total |
|------------------------|------|------|------|------|-------|
| Evolutionary Biology   | RS   | 17   | 19   | 9    | 45    |
| Review                 | NA   | 36   | 41   | 40   | 117   |
| Conservation Biology   | RS   | 16   | 37   | 31   | 84    |
| Review                 | NA   | 143  | 143  | NA   | 286   |
| Social Work            | RS   | 17   | 17   | 9    | 45    |
| Review                 | 8    | 13   | 9    | 30    |
| Women’s Studies        | RS   | 8    | 6    | 9    | 23    |
| Review                 | 10   | 10   | 4    | 23    |
| Info & Library Science | RS   | 17   | 21   | 16   | 54    |
| Review                 | 29   | 36   | 27   | 92    |

Table 3. Research syntheses and reviews by field, year

**Collaboration patterns**

Data analyzed to compare the number of authors who contribute to reviews versus syntheses indicated that one or two authors typically wrote reviews in Information and Library Science, one to three in Social Work and Women’s Studies, two to three in Evolutionary Biology, and two to four in Conservation Biology (Table 4). In two fields, Social Work and Information and Library Science, more authors contributed to research syntheses than reviews. The non-significant finding in Women’s Studies (\(U = 2.8137, df=1, p=0.0935\)) may be a reflection of the small number of publications, 23 research reviews and 23 research syntheses, identified in the years examined (2006-2008).

| Field              | RS Median (IQR) | Review Median (IQR) | van Elteren (U) or Wilcoxon |
|--------------------|-----------------|--------------------|-----------------------------|
| Evolutionary Biology | 2.5 (2:3)       | 2 (2:3)            | \(W = 1713.5, p=0.4505\)   |
| Conservation Biology | 3 (2:4,3)      | 3 (2:4)           | \(U = 1.0539, df=1, p=0.3046\) |
| Social Work         | 2 (2:4)         | 2 (1:3)           | \(U = 4.8306, df=1, p=0.0280\) |
| Women’s Studies     | 3 (2:3)         | 2 (1:3)           | \(U = 2.8137, df=1, p=0.0935\) |
| Info & Library Science | 2 (1:3.8)     | 2 (1:2)           | \(U = 22.5998, df=1, p=0.001\) |

Table 4. Collaboration patterns: Number of authors: research syntheses versus reviews, 2006-2008
In the biological sciences examined, there were no differences in the number of authors that contributed to reviews versus research syntheses. Differences in the number of authors who contribute to research syntheses versus reviews in Social Work and Information and Library Science suggests that adoption of research synthesis methods in a field can contribute to changes in research practices, especially in the case of fields in which few authors generally contribute to research reviews.

There are several reasons research synthesis studies may be associated with higher levels of collaboration compared to traditional research reviews in fields in which traditional reviews are typically written by one or two people, and therefore contribute to changes in collaboration patterns. First, methods texts generally advocate or specify that multiple people should contribute to the selection of studies and data extraction. For example, the first key point highlighted in the “Selecting studies and collecting data” chapter of the Cochrane Handbook specifies, “assessment of eligibility of studies, and extraction of data from study reports, should be done by at least two people, independently” (Higgins & Green, 2011). Similarly, the Centre for Evidence-Based Conservation recommends that at least a random sample of 25% of items identified be reviewed by a second person when judging whether studies should be included in a research synthesis and when extracting data from study reports (2009). Second, identification of studies for inclusion in a research synthesis generally involves filtering out hundreds or thousands of potentially relevant and usable studies (e.g., Côté, Curtis, Rothstein, & Stewart, 2013). Third, research syntheses may require a broader set of skills or specializations compared to traditional research reviews, for example to devise comprehensive search strategies, construct databases for extracted data, or conduct advanced statistical analyses.

**Research Use: Citation patterns**

Across fields, comparison of review versus research synthesis citations indicated that research syntheses were used more than reviews in Conservation Biology and Women’s Studies. In Social Work and Evolutionary Biology, no differences in citation of reviews versus research syntheses were found (Table 5). In contrast, traditional research reviews in Information and Library Science were produced and used at a higher rate compared to research syntheses (Tables 3 and 5). Given the small proportion of review publications in ILS (Table 2), this finding suggests that research reviews are a relatively rare but highly prized - or at least frequently used – resource in the field. Though research syntheses generally have a greater number of authors, which we might typically expect to be associated with higher levels of citation (Levitt & Thelwall, 2009), this was not the case.

Though no difference between use of research syntheses and research reviews was observed in Evolutionary Biology, examination at the field level indicated that research reviews might not be the most appropriate type of comparator publication. Research synthesis methods as defined in this study appear to be used sometimes in the context of research review publications, but more often in the context of primary research studies in Evolutionary Biology. This is congruent with general observations that research data is relatively frequently reused in Evolutionary Biology studies, especially in molecular research; and that statistical meta-analytic techniques appear to be the most salient aspect of research synthesis based on examination of topics and full text documents of research synthesis-related publications (Sheble, 2014).

| Table 5. Research use: Citation of reviews versus research syntheses produced 2006-2008, at 5 years |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| Evolutionary Biology | RS Median (IQR) | Review Median (IQR) | van Elteren/Wilcoxon |
|----------------------|-----------------|-----------------|-----------------|
| 60 (29.0:85.0) | 52 (24.0:93.8) | W= 1625.5, p=0.7611 |
| Conservation Biology | 42 (24.0:78.0) | 31 (14.0:51.0) | U= 9.1515, df=1, p=0.0025 |
| Social Work | 12 (5.0:29.0) | 10.5 (5.3:22.0) | U= 0.5007 df=1, p=0.4792 |
| Women’s Studies | 14 (10.5:21.5) | 9 (5.0:13.5) | U= 5.8146 df=1, p=0.0159 |
| Info & Lib Science | 23 (8.3:51.8) | 35 (15.7:85.5) | U= 5.9004, df=1, p=0.016 |

Content analysis of specific procedural steps reported in research syntheses, or systematic collection of data from researchers who perform research synthesis would provide stronger evidence to support this view. If consistent, this might suggest that an alternative comparator, such as papers from the same issue of the same journal, might be more appropriate to research practices in the field. Anecdotally, discussion with a small group of researchers involved in the development of meta-analytic methods in Evolutionary Biology and Ecology revealed that though the researchers recalled prior discussion of meta-analysis in the context of reviews, such contexts were not considered to be the primary application context. This observation is in contrast to other fields, in which research syntheses were compared to reviews.

**Social Work: Extended analysis**

Given the small number of reviews and research syntheses published in Social Work from 2006 to 2008, the observed difference in collaboration but not citation patterns, and that it was feasible to collect and categorize reviews and syntheses published in 2009 and 2010, we chose to extend the analysis of Social Work publications. A substantial number of research syntheses were identified for 2009 and
2010: Fifty-eight were added for a total of 103 syntheses across five years. Only 18 additional reviews were added, for a total of 48 reviews across five years (Figure 1). The primary goals of this extended analysis were to (a) learn whether the patterns observed for 2006 to 2008 would be observed through more recent years; and (b) examine whether there was a trend in the number of reviews versus research syntheses that were published across years. With continued diffusion of research synthesis, it would be expected that more research syntheses would be published in later years. If research synthesis methods, in at least some contexts, were used in lieu of traditional narrative review methods, we would expect the relative number of reviews to decrease as the number of research syntheses increased.

![Figure 1. Social Work reviews and research syntheses](image)

Tests confirmed that collaboration patterns observed in 2006 to 2008 continued through 2010. Testing with the Wilcoxon rank sum test, it was found that research syntheses were more likely to be published in later years (W=3036, p = 0.0105), suggesting a trend towards increased use of research synthesis methods and decreased use of traditional review approaches in later years. Taken together, the data indicate there has been a change in the practice of synthesizing research in Social Work overall. In some contexts, researchers are more likely to use research synthesis methods rather than traditional narrative reviews. Research synthesis is also likely to be a more collaborative process. Across the five-year period (2006-2010), the median number of authors for reviews was 2 (1:3), and the median number of authors for research syntheses was 3 (2:4), a significant difference (U=8.2159, df=1, p=.0039). There was not, however, a difference in subsequent use of reviews versus research syntheses. At three years, reviews were cited a median of 6 (3:11) times, and research syntheses, 6 (2:13) times. Results of the van Elteren test were not significant (U=0.5007, df=1, p=0.4792). Finally, though there has been a reduction in the number of narrative reviews over time, narrative reviews, from the perspective of the audience of researchers who reference them, have not become obsolete.

**DISCUSSION**

Engagement with new ways of doing research can have far-reaching implications for how research is practiced within science fields. As observed in this study, patterns associated with fundamental relationships such as collaboration in the production of knowledge and subsequent use of that knowledge in the research context may change. In Social Work and Information and Library Science, more authors contributed to research syntheses than reviews. Recently, Barrios, Guilera, and Gomez-Benito (2013) observed a similar pattern in Psychology: one to three authors wrote Psychology reviews (median 2 (1 : 3)), and two to four contributed to research synthesis studies (median 3 (2 : 4)).

The combination of these findings suggests that, at least in some fields in which reviews are typically written by one or a few researchers, use of research synthesis methods contributes to higher levels of collaboration. Such a trend supports assertions that research synthesis methods often require collaboration to accommodate triangulation of researcher observations, process large quantities of research information, and incorporate a broader set of technical skills. Though research synthesis studies did not have more contributing authors compared to traditional reviews in the biological science fields examined, the number of authors typically contributing to both types of publications would be sufficient to conduct a research synthesis study. Collaboration patterns appear to be more closely associated with broader topical areas than whether a research area is more ‘pure’ or applied in nature. On the surface, this study suggests adoption of research synthesis methods in the social sciences is accompanied by an increase in coordination costs, while the same is not necessarily true in the biological sciences. In-depth examination of research synthesis versus review collaborations could provide insight into actual and perceived coordination costs.

Comparison of citation counts indicated that research syntheses were used more than reviews in Conservation Biology and Women’s Studies. These findings echo past findings in other fields: Patsopoulos, Analatos and Ioannidis (2005) and Barrios, Guilera, and Gomez-Benito (2013) found that meta-analyses were more cited than reviews in clinical medicine and psychology. Further examination of Social Work indicated that though research syntheses and reviews were cited at similar levels, production of reviews has decreased over time and production of research syntheses has increased. These trends suggest that while research synthesis was becoming the predominant method of review, traditional reviews remained valuable to researchers, though in an increasingly narrow range of contexts. Arguments for different roles for different types of reviews have been advanced in the health sciences (e.g., Dijkers, 2009). Role differentiation across
fields, including Social Work and increasingly, Conservation Biology. This study contributes to our knowledge of the diffusion innovations in disciplinary research contexts. Changes - and lack thereof - in collaboration patterns associated with adoption of an innovation, and associated changes in subsequent use of research in Evolutionary Biology, Conservation Biology, Social Work, Women’s Studies, and Information and Library Science were identified.

Knowledge of levels of collaboration in these fields could inform design of systems and services for the fields since tendencies towards more independent versus more collaborative research designs have implications for how researchers engage with information resources and share data. Additionally, these findings contribute to Information Science research related to collaboration and research practices by providing an example of a specific research innovation associated with changes in collaboration practices in some fields but not others. On introduction of this research, it was noted that research synthesis methods, like collaboration and interdisciplinary scholarship, is a mode through which scientific and scholarly knowledge is integrated. Knowledge integration and is an important counter-balance to research specialization and diffusion. Future research should investigate relationships between different approaches to scientific synthesis broadly; and outcomes of programs designed to promote integration of science knowledge. A better understanding of how these approaches complement each other and differ would lead to a better understanding of integration, or synthesis, in science overall; and could inform design of research policy programs and selection of approaches to scientific synthesis.

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