Multiple Publication on a Single Research Study: Does It Pay? The Influence of Number of Research Articles on Total Citation Counts in Biomedicine

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Scientists may seek to report a single definable body of research in more than one publication, that is, in repeated reports of the same work or in fractional reports, in order to disseminate their research as widely as possible in the scientific community. Up to now, however, it has not been examined whether this strategy of "multiple publication" in fact leads to greater reception of the research. In the present study, we investigate the influence of number of articles reporting the results of a single study on reception in the scientific community (total citation counts of an article on a single study). Our data set consists of 96 applicants for a research fellowship from the Boehringer Ingelheim Fonds (BIF), an international foundation for the promotion of basic research in biomedicine. The applicants reported to us all articles that they had published within the framework of their doctoral research projects. On this single project, the applicants had published from 1 to 16 articles ($M = 4$; $Mdn = 3$). The results of a regression model with an interaction term show that the practice of multiple publication of research study results does in fact lead to greater reception of the research (higher total citation counts) in the scientific community. However, reception is dependent upon length of article: the longer the article, the more total citation counts increase with the number of articles. Thus, it pays for scientists to practice multiple publication of study results in the form of sizable reports.

Introduction

According to Frazzetto (2004) "authorship on scientific publications has become the currency of modern science and a measure of a scientist's participation in the international scientific community" (p. 446). In a competitive environment where appointments, promotions, and grant applications are strongly influenced by publication and citation records, scientists are under intense pressure to publish (Daniel, 2005; Giles, 2005). Undoubtedly, academic careers are to a great extent related to number of publications and citations (Breitling, 2005; Klamer & van Dalen, 2002). The "publish or perish" principle is as true as ever.

The need to produce a long list of publications (that are frequently cited) has contributed to the practice of reporting the results of a single definable body of research in more than one publication, that is, in repeated reports of the same work, or in fractional reports (Huth, 2000). In a cross-sectional survey of editors ($n = 71$) and authors ($n = 64$) from journals that publish clinical research, "there was consensus between both groups that redundant publications occur because authors feel the pressure to publish and journals do not do enough to publicize, criticize, and punish cases of overlapping and redundant publications" (Yank & Barnes, 2003, p. 109). In a broad-based ($n = 3{,}247$) survey on questionable scientific behaviors, approximately 5% of the scientists surveyed reported that they had published the same data or results in two or more publications within the previous three years (Martinson, Anderson, & de Vries, 2005; Wadman, 2005).

Various terms (e.g., double, dual, duplicate, or redundant publication) have been used to describe scientists' practice of publishing the same information multiple times (see Hammerschmidt, 1992; Hanke et al., 1990; Jefferson, 1998; Susser & Yankauer, 1993). Huth (2000) groups all of these under two overarching terms, *repetitive* and *divided publication*. *Repetitive publication* covers the republication of an entire paper or closely similar versions reporting the same body of research. Based on findings by Waldron (1992), Blancett, Flanagin, and Young (1995), and Egger,

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Zellweger-Zahner, Schneider, Junker, Lengeler, and Antes (1997), Huth (2000) estimates that the occurrence rate of repetitive papers in the clinical medical literature probably lies between 0.017 and 303 repetitive papers per 1,000 papers published (see also Schein & Paladugu, 2001). The term *divided publication* refers to the breaking down of findings from a single piece of research into a string of papers, each of which is the "Least Publishable Unit" (LPU) (see Lawrence, 2003; Waldron, 1992). Although the findings could probably have been reported in a single paper, scientists have been found to slice up data and interpretations into two, three, four, or more papers (Broad, 1981; Huth, 1986; Moed, 2005) (also called *salami slicing* or *salami style of publishing*).

While authors may profit from the practice of multiple publication of their research, it is suspected that the cost may fall on editors, reviewers, and readers (Huth, 1986). When five papers report findings that could have been reported in one, the editorial process, including peer review, has been turned on five times instead of once (Mojon-Azzi, Jiang, Wagner, & Mojon, 2004). Peer review is expensive in time and in money, for journal officers and for reviewers. For reviewers, it takes up time that could be used to evaluate studies that present new data (Huston & Moher, 1996); for readers, it wastes time that could be spent in reading about new research (Broad, 1981; Huth, 1986). Furthermore, the inadvertent inclusion of more than one publication on a single empirical study in a systematic review, for example, a meta-analysis, can distort the conclusions drawn (DeAngelis, 2004; Jefferson, 1998; Tramer, Reynolds, Moore, & McQuay, 1997; Yank, Rennie, & Bero, 2005).

Although it is assumed that multiple publication increases reception of study findings in the scientific community (see e.g. Huth, 2000), our search of the literature did not turn up any supporting evidence. The literature search using the terms *divided*, *double*, *dual*, *duplicate*, *fragmented*, *multiple*, *overlapping*, *redundant*, and *repetitive* in combination with *publication* as well as the terms *salami slicing*, *salami style*, and *salami science* revealed numerous editorials criticizing the practice, but little in the way of hard facts. We therefore set out to clarify whether multiple publication of a single research study really pays by analyzing the data from an evaluation study of selection procedures for research fellowships used by the Boehringer Ingelheim Fonds (BIF), a foundation for the promotion of basic research in biomedicine.

Methods

In the first part of our comprehensive evaluation study we analyzed the fellowship selection procedure followed by the BIF with regard to reliability, fairness, and predictive validity—the three quality criteria for professional evaluations. The results of these analyses are reported in Bornmann and Daniel (2005a, 2005b, 2005c, 2006a, 2006b, 2007). In the second part of our study we constructed comparison groups by matching BIF fellowship recipients as closely as possible on certain characteristics (e.g., applicant's gender or final grade) to applicants that were rejected by the BIF. According to Rossi, Freeman, and Lipsey (1999) this quasi-experimental comparison group design is most appropriately used when random assignment cannot be undertaken for professional evaluations. Classic studies by Baker, Robertson, and Toguchi (1996) and Cole and Zuckerman (1984) followed a similar research design.

For the present study, the data from the second part of our evaluation was used (data for 96 applicants) to test the extent to which the number of publications on a single research project affected reception of these publications in the scientific community. We asked the BIF research fellowship applicants to list all articles that they had published in the framework of the research project for which they had applied for a BIF grant. The research projects were comparable in that they all served to fulfill the requirements for a Ph.D. degree, addressed a topic in basic biomedical research, and were completed successfully.

As we were interested in reception of the study results in the scientific community, we included in the evaluations of the data only those publications that are listed as "articles" in the online databases Science Citation Index (SCI, provided by Thomson Scientific, Philadelphia) and Scopus (Elsevier Publisher, Amsterdam, Netherlands) (no "reviews," "corrections," "additions," etc., were included in the analyses). According to Thomson Scientific, only those publications that report original research are designated "article" in the databases.

To investigate our research question using multiple regression analysis, we created the dependent and independent variables described in the following sections.

The Dependent Variable: Reception of Articles

As there is broad support for citation counts of scientific articles as a measure of the impact of scientific research (Cole, 2000; Daniel, 2005; van Raan, 2004), in this study we used citation counts as a proxy for reception of articles by scientific peers. We determined the number of citations to articles by BIF fellowship applicants on their research projects in the three-year period after they were published. According to Glänzel, Schlemmer, and Thijs (2003), for research fields covered by the SCI the peak in the average citation counts occurs about three years after publication. We determined the citation counts by using the online database SCI. The total number of citations to all of the articles published on a single research project was entered into the data analysis as a dependent variable (total citation counts).

The Independent Variables

The independent variable in the analysis was the number of articles published on a single research project. In the case of multiple publication we were not able to distinguish between divided and repetitive publication, as we did not have information as to the extent to which the findings of the research projects were published multiply in one form or the other. We also did not attempt to categorize the

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publication as divided or repetitive later on, as Mojon-Azzi et al. (2004) showed, when determining the redundancy of publications in scientific ophthalmologic journals, that it is impracticable to detect all redundant publications.

In order to control for other factors, besides the number of BIF applicants' articles, that influence the citation frequency of scientific publications, we included in the multiple regression analyses further independent variables in addition to the variable of actual interest to us:

1) In the normative theory of citing behavior, citation counts reflect the quality of scientists' work (Merton, 1988). The more highly colleagues or peers rate the scientific quality of a research study, the more frequently it is cited. According to the "Matthew effect in science" (Merton, 1968) scientific contributions will have greater visibility in the scientific community when introduced by scientists of high rank than when introduced by scientists who have not yet made their mark. Because there is evidence that both the quality of the work (Baldi, 1998) and the reputation of the research unit that conducted the research (Hagstrom, 1971) increase the probability of citations, we included measures of both in our statistical analyses. In their decisions on awarding research fellowships, the BIF Board of Trustees assesses both the quality of the proposed research project and the reputation of the laboratory at which the research will be conducted. These assessments, recorded by the board in writing in the form of brief, standardized comments, were available to us for content analysis.[1] For each fellowship application, we determined the extent to which the quality of the research project and the scientific standard of the laboratory in question were rated as positive or negative in the comment or whether one of the criteria was not commented upon at all (neutral evaluation). The Board adds no formal comment on a criterion if the relevant information in the application does not make either a positive or negative impression.

2) Some bibliometric studies show that the citation frequency of an article is dependent upon (a) the Journal Citation Report (JCR) impact factor (provided by Thomson Scientific) of the journal in which it was published (Abt, 1991; van Dalen & Henkens, 2005); (b) the number of authors under whose names the paper appears (Beaver, 2004; Tregenza, 2002); and (c) the length (number of pages) of the article (Abt, 1993; Baldi, 1998; Laband, 1990; Stewart, 1990). Journals with high JCR impact factors[2] are in general more visible to the scientific community. This may influence the citation likelihood of the articles they publish. According to Baldi (1998) the greater the number of authors, the larger the network of colleagues that could cite the article. Bibliometric studies by Abt (1993), Baldi (1998), Laband (1990), and Stewart (1990) show unanimously that short articles are cited less frequently than long articles. Short articles provide other scientists with less substantive content than long papers.

This means that the citation frequency of published results of projects by the BIF applicants could be influenced by (a) the JCR impact factor of the journals in which they appeared; (b) the number of authors (or coauthors) of the articles; and (c) the number of pages in the article. In order to control these three factors, independently of the number of articles published on a research study, we entered into the multiple regression analyses the average number of authors, the average JCR impact factor of the journals, and the average number of pages of all the articles published on a single research project.

Results

Figure 1 shows the number of articles published by the BIF applicants on their research projects.

BIF applicants published from 1 to 16 articles on their research projects ($M = 4$ articles; $Mdn = 3$ articles). On about half of the research projects ($n = 51$) the applicants published from one to three articles (see Figure 1). Ten or more articles were published on five of the research projects. Figure 2 shows the relation between number of articles published on each project and number of total citations to these articles. The line in the figure (along with a 95% confidence interval) is the prediction for total citation counts based on a linear regression of *total citation counts* versus *number of articles* (StataCorp., 2005).

Figure 2 shows that a large part of the research projects (about 90%) were cited not more than 200 times (total citation counts). The line in the figure shows that there is a

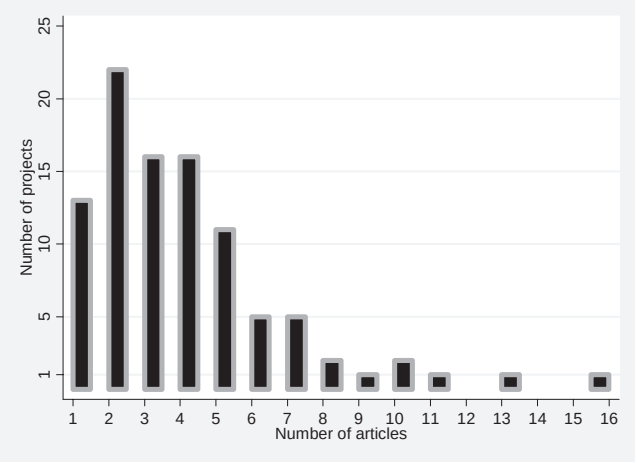

FIG. 1. Number of articles published on BIF applicants' research projects.

[1]For content analyses, it is customary for two persons to conduct the coding of text material for purposes of determining the interjudgmental reliability of the codings using measures of agreement. However, as the BIF board's comments were formulated in a standardized form, the coding of the positive and negative assessments for the data analysis was conducted by only one member of our research team in cooperation with the administrative office of the BIF.

[2]The JCR impact factor is a measure of the frequency with which the "average article" in a journal has been cited in a particular year or period, revealing a journal's importance relative to others in its field, and is commonly used as a measure of journal quality or visibility (Bott & Hargens, 1991). According to Ziman (1968), an article in a reputable journal does not merely represent the opinions of its authors; it bears the stamp of scientific authenticity, as given to it by the editor and the referees the editor may have consulted.

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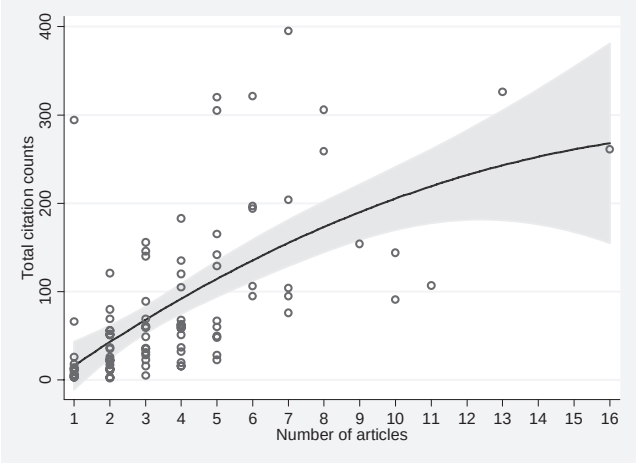

FIG. 2. Relation between number of articles published on each project and total citation counts. The line in the graph (along with 95% confidence interval) is the prediction for total citation counts based on a linear regression of total citation counts versus number of articles.

(curvi-)linear relation between total citation counts and number of articles published on a project: with each additional article published on a study, a (steady) increase in citations can be expected. The correlation between the variables is strong ($r_P = .67$) and statistically highly significant (total citation counts and number of articles published on a project are transformed logarithmically in order to fulfill the assumption necessary to calculate the product-moment correlation coefficient).

While the results in Figure 2 suggest that total citations to the articles by the BIF applicants on their research are influenced by the number of articles, other factors could in principle have been responsible for low or high citation counts. We mentioned above (see The Independent Variables section) five additional factors that bibliometric studies have demonstrated to have a general influence on citation counts. For this reason, we performed a multiple regression analysis that reveals the factors that exert a primary influence on a certain outcome. The coefficients in the regression model, called partial regression coefficients (Rabe-Hesketh & Everitt, 2004), represent the effects of each factor, controlling for all other factors in the model.

The total citation count to the articles that the BIF applicants published on their single research studies enters into the estimation of the regression model as a dependent variable (see Table 1). Since the distribution of citation counts suggests the use of a negative binomial specification (Glänzel & Schubert, 1993), we calculated a negative binomial regression model (NBRM; Long & Freese, 2003, section 7.3) provided in the statistical package Stata (StataCorp., 2005). As independent variables, in addition to the number of articles, the model takes into account the mean number of authors of the articles, the mean JCR impact factor of the journals that published the articles, the mean number of pages, and the assessments by the BIF Board of Trustees of both the quality of the proposed research project and the reputation of the laboratory in question (see the ranges of these variables in Table 1).

TABLE 1. The range of the dependent and independent variables included in the negative binomial regression model.

Variable	Range
Dependent variable	
Total citation counts	2–395
Independent variable	
Year of research project completion	1988–2001
Number of articles	1–16
Mean number of pages of articles	3–16.5
Mean number of authors of the articles	2–13.3
Mean JCR impact factor of the journals	1.3–29.8
Assessment of the quality of the research project by the BIF Board of Trustees	1 (positive) – 3 (negative)
Assessment of the reputation of the laboratory in question by the BIF Board of Trustees	1 (positive) – 3 (negative)

The year of completion of the applicants' research project was included in the model as exposure time (Long & Freese, 2003, pp. 264–266). Using the exposure option provided, the statistical package Stata (StataCorp., 2005) takes into account in the NBRM that the research projects were completed by the applicants at different points in time (from 1988 to 2001; see Table 1). Clearly, the amount of time between finishing the project and the date of the survey affects the number of publications and their total citation counts. By using the exposure option, the amount of time that research results are "at risk" of being published (and being cited) is considered.

Table 2 shows the results of the NBRM. Besides the regression coefficients, the bootstrap standard errors, and the *p* values, Table 2 shows the percent changes in the expected count for each independent variable, to facilitate interpretation of the coefficients. As statistical significance does not mean real-life importance, it is important to translate the data into an informed prediction that can be used in a more practical manner (Conroy, 2002). We performed bootstrapping to improve the estimations of the standard errors of the model (Cameron & Trivedi, 1998). As shown in Table 2, we estimated two models (A and B). Model B differs from model A through the inclusion of an interaction term. Interaction terms are commonly included in multiple regression models when the effect of an independent variable on the dependent variable is thought to depend on the value of another independent variable (Long & Freese, 2003). As we expect that the effect of the number of articles published on total citation counts increases with the number of pages of the articles, we created an interaction term between the number of articles and the average number of pages of the articles for model B.

Looking first at the results for model A (without interaction term; see Table 2), two coefficients are statistically significant: (a) number of articles and (b) mean JCR impact factor of the journals. The percent change in the values of these coefficients can be interpreted as follows: (a) For every additional article published by a project, the total citation counts of the project's publications increases by 30%, holding all other variables constant; (b) an increase by one unit in the JCR impact factor

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TABLE 2. Negative binomial regression models predicting total citation counts to articles published on the BIF applicants' research projects.

Independent variable	Coefficient	Bootstrap standard error	*p* value	Percent change in expected count
Model A (without interaction term)				
Year of research project completion	(exposure)			
Number of articles	.263	.047	.000	30
Mean number of pages of the articles	.024	.039	.535	2
Mean number of authors per article	.051	.039	.190	5
Mean JCR impact factor of the journals	.100	.018	.000	11
Assessment of the quality of the research project by the B.I.F. Board of Trustees	−.076	.084	.366	−7
Assessment of the reputation of the laboratory in question by the B.I.F. Board of Trustees	−.006	.134	.967	−1
Model B (with interaction term)				
Year of research project completion	(exposure)			
Number of articles	−.087	.188	.643	−8
Mean number of pages of the articles	−.097	.079	.218	−9
Interaction term: number of articles × mean number of pages of the articles	.044	.023	.049	5
Mean number of authors per article	.045	.039	.253	5
Mean JCR impact factor of the journals	.100	.018	.000	11
Assessment of the quality of the research project by the BIF Board of Trustees	−.043	.080	.592	−4
Assessment of the reputation of the laboratory in question by the B.I.F. Board of Trustees	.010	.132	.943	1

of the journals in which the articles are published leads to an 11% increase in the number of citations. The coefficients of the other dependent variables included in model A (mean number of pages of the articles, the mean number of authors per article, and assessments by the BIF Board of Trustees of both the quality of the proposed research project and the reputation of the laboratory in question) are not statistically significant.

When we included the interaction term in the model estimation, there was a clear change in the results of the NBRM. Model B (Table 2) shows that the number of articles coefficient is no longer significant. But in addition to the coefficient of the mean JCR impact factor, in model B the interaction term (number of articles × mean number of pages of the articles) is also statistically significant.

In order to clarify the effect of the interaction term in model B, following calculation of the NBRM, we graphed a conditional effect plot showing the linear relation between number of articles and predicted values of total citation counts with three levels of mean number of pages of the articles: lowest (3 pages), medium (8.8 pages), and highest (16.5 pages; see Figure 3) number of pages. Conditional effect plots help clarify the implications of an interaction model. Predicted values of a dependent variable are graphed against one independent variable, with the other independent variable held constant for several levels (Hamilton, 1992, pp. 158–161; Kohler & Kreuter, 2005, pp. 222–223). Figure 3 shows clearly that the number of articles has different influences on total citation counts for different levels of mean number of pages of the articles. The higher the mean number of pages, the more the total citation counts increase with number of articles. This finding suggests that the number of pages can increase the effect (statistically significantly) of the number of articles on total citation counts.

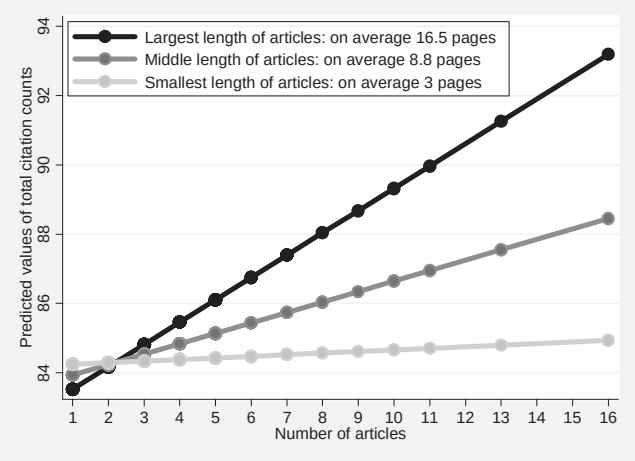

FIG. 3. Conditional effect plot showing linear relation between number of articles and predicted values of total citation counts with (on average) lowest (3 pages), medium (8.8 pages), and highest (16.5 pages) number of pages of the articles.

Discussion

Scientists may seek to find greater reception of their research in the scientific community by reporting a single definable body of research in more than one publication; that is, in repeated reports on the same work, or in fractional reports. However, up to now there has been little investigation

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of what effect the number of publications on a research study has on reception of the research in the scientific community. Our data set consisted of 96 applicants for a BIF research fellowship who reported to us all articles that they had published within the framework of their doctoral research projects. We analyzed the effect of the number of articles published by the applicants on their research studies on total citation counts—the indicator for reception of the publications by scientific peers.

Our results show that the BIF applicants published from 1 to 16 articles on their studies ($M = 4$ articles, $Mdn = 3$ articles). The results of bivariate (Figure 2) and multivariate analysis (Table 2, NBRM, model A) suggest that the number of articles has a clear effect on total citation counts. The results of a second NBRM (model B with interaction term) shows, moreover, that the influence of the number of articles on total citation counts is dependent on the mean number of pages of the articles: Citation counts for articles increase significantly with each additional article published only when the article is not too short. To put it another way, publishing more articles results in higher citation counts if the articles provide sufficient substantive content to other researchers (see in this context the differentiation of Moed, 2005, p. 268, between the "quantity publication strategy" and strategies that take the quality of the publications into account).

All in all, the results of our study suggest that the practice of multiple publication of sizable reports on a single research study leads to greater reception of the study findings in the scientific community. In other words, it pays for researchers to publish more than one paper per study. However, not all forms of multiple publication practices are held to be ethically acceptable. In the "Uniform Requirements for Manuscripts Submitted to Biomedical Journals" (International Committee of Medical Journal Editors, 2004) the authors, a group of general medical journal editors, "[state] the ethical principles in the conduct and reporting of research and provide recommendations relating to specific elements of editing and writing" (section I.C.). This document also lists the forms of multiple publication that are to be considered ethical and the forms considered unethical scientific behavior (see also Huth, 2000, pp. 115–116).

The section of the "Uniform Requirements for Manuscripts Submitted to Biomedical Journals" on Overlapping Publications (International Committee of Medical Journal Editors, 2004, section III.D.) finds "duplicate submission" (the simultaneous submission of the same paper to two or more journals) and "redundant publication" (publication of a paper that overlaps substantially with one already published in print or electronic media) to be a violation of ethical principles of research reporting. Section III.D.3 defines the following acceptable form of multiple publication:[3]

> Secondary publication for various other reasons, in the same or another language, especially in other countries, is justifiable, and can be beneficial, provided all of the following conditions are met.
>
> 1) The authors have received approval from the editors of both journals; the editor concerned with secondary publication must have a photocopy, reprint, or manuscript of the primary version.
> 2) The priority of the primary publication is respected by a publication interval of at least one week (unless specifically negotiated otherwise by both editors).
> 3) The paper for secondary publication is intended for a different group of readers; an abbreviated version could be sufficient.
> 4) The secondary version faithfully reflects the data and interpretations of the primary version.
> 5) The footnote on the title page of the secondary version informs readers, peers, and documenting agencies that the paper has been published in whole or in part and states the primary reference. A suitable footnote might read: 'This article is based on a study first reported in the [title of journal, with full reference].' Permission for such secondary publication should be free of charge.
> 6) The title of the secondary publication should indicate that it is a secondary publication (complete republication, abridged republication, complete translation, or abridged translation) of a primary publication. (p. 7)

We do not know what forms of secondary publication the BIF applicants chose for multiple publication of their doctoral research project results. Even though each applicant published all of the articles examined in the present study within the framework of his or her doctoral research project, this does not mean at all that the articles can be regarded as repeated reports of the same piece of work. It is possible that one single project covered several related research themes that all resulted in publications. A multiple publication strategy is not generally a violation of ethical principles of research reporting. Dividing up publications into smaller contributions or publishing almost the same work for different audiences can be a completely legitimate and wise strategy for effectively enhancing knowledge dissemination. Even editors or reviewers may ask an author of a submitted manuscript to consider dividing the manuscript for readability.

Because our data on the publications of the BIF applicants on their doctoral research projects do not contain information as to the extent of overlapping content in the different publications, it is essential that future research on the topic of multiple publication examine content overlap by means of content analysis. Further, it will be important to test the generalizability of the present findings by (a) investigating the phenomenon not only in biomedicine but also as practiced in other fields, and (b) investigating publications on research studies by groups having a different status than doctoral researchers (e.g., senior researchers).

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[3]See also Sorensen (2005); Taylor (2005).

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