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Four ways in which data-free papers on animal personality fail to be impactful

Nicholas DiRienzo[1†] *and Pierre-Olivier Montiglio*[2*†]

[1] *Neurobiology, Physiology and Behavior, University of California, Davis, Davis, CA, USA,* [2] *Environmental Science and Policy, University of California, Davis, Davis, CA, USA*

The literature on animal personality is dominated by papers lacking any data. These papers, which we will call "data-free" papers, are cited and recognized twice as much as comparable empirical studies. In this data-free paper, we highlight 4 common data-free contributions that often fail to have an impact on the topic: (a) novel conceptual frameworks suggesting novel avenues of research or hypotheses, (b) papers prescribing novel terminologies, (c) syntheses revisiting older theories, and (d) papers introducing novel statistical methods. We argue that conceptual papers presenting a novel hypothesis probably could almost always be replaced by robust empirical studies actually testing the hypotheses of interest. We hope this paper will stimulate discussion on what makes a data-free paper on animal personality impactful, beyond simply being highly cited.

Keywords: animal personality, behavioral variation, Ecology, behavior, mixed models, evolution

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***Correspondence:**
Pierre-Olivier Montiglio, FQRNT post-doctoral fellow, Environmental Science and Policy, University of California at Davis, One Shields Avenue, Davis, CA 95616, USA
montiglio.pierre-olivier@courrier.uqam.ca

[†] *These authors have contributed equally to this work.*

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Introduction

Students of animal behavior recently switched from studying the average behavior of populations to the individual variation around this average (Wilson, 1998). This change lead to a huge increase in studies investigating animal personality (i.e., consistent behavioral differences among individuals of the same population, Dall et al., 2004; Sih et al., 2004a; Réale et al., 2007). As an example, the 10 leading papers in the field have now been cited collectively more than 4500 times, even though most of them were produced in the last decade (in order of decreasing number of citations: Verbeek et al., 1994; Golsing, 2001; Dingemanse et al., 2002; Bolnick et al., 2003; Dall et al., 2004; Sih et al., 2004a,b; Réale et al., 2007; Smith and Blumstein, 2008; Dingemanse et al., 2010). Most studies on animal personality were initially descriptive, quantifying the extent and structure of individual behavioral variation in various systems (Bell, 2005; Bell et al., 2009; Wilson et al., 2011). However, a number of formal theoretical models and conceptual syntheses, as well as revisiting classical ecological and evolutionary theories have helped this topic transition to a more predictive investigation of *a priori* hypotheses regarding the evolution, function, and consequences of animal personality (i.e., McElreath and Strimling, 2006; Wolf et al., 2007; Réale et al., 2010).

The literature on animal personality is dominated by papers lacking any data or empirical grounds *per se* (**Figure 1**). Such papers highlighted the links between animal personality and other aspects of ecology and evolution (e.g., McDougall et al., 2006; Sih et al., 2012), suggested novel terminology (Stamps and Groothuis, 2010a,b), or prescribed and introduced the use of a particular statistical machinery when investigating individual variation in behavior (Dingemanse et al., 2010). These papers, which we will call "data-free" papers, are cited and recognized

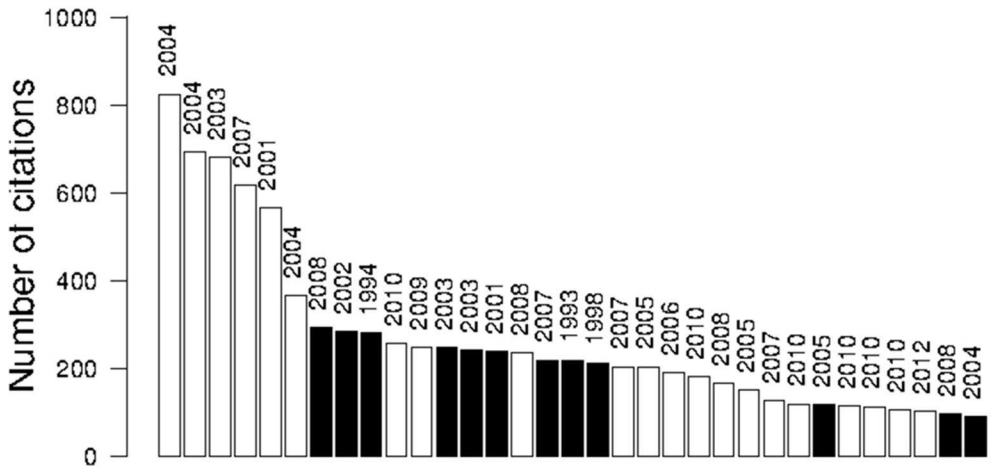

FIGURE 1 | The 35 most cited data-free (white) and empirical papers (black) discussing individual behavioral variation or animal personality as of December 12th 2014 on Web of Science. Year of publication of each paper is displayed on top of the bars. The list was created by searching web of science for "animal personality" or "individual behavioral variation." See Supplementary Material for the full references.

far more than empirical studies presenting similar ideas. As an illustration, data-free papers (e.g., Réale et al., 2010, cited 102 times, or Schuett et al., 2010 cited 112 times) collect roughly twice as many citations than empirical studies on similar topics published at the same time (e.g., Réale et al., 2009, cited 59 times, Schuett and Dall, 2009, cited 67 times). Obviously, data-free papers have received a lot of interest by researchers on the topic of animal personality. However, when discussing with those researchers, in laboratory meetings, conferences or workshops, we still noticed that there is far less consensus on whether those papers are useful or impactful in pushing the topic forward. Is the large number of citations associated with data-free papers truly reflecting progress in the topic?

Here we analyze and discuss the impact that recent data-free papers have exerted on the field. The overarching goal is to raise the question of what makes a data-free paper impactful, in the aim of sparking a discussing on what constitutes an advance without any empirical data, and what does not. Both authors are eager to push research on animal personality forward, and have written data-free papers themselves (Montiglio et al., 2013; DiRienzo and Hedrick, 2014; Montiglio and Royauté, 2014). Yet, we question if pushing the field forward would not be better done with empirical data. To spark the discussion, we chose to focus on presenting four common contributions of data-free papers that more often than not fail to have an impact on the topic. These include, (a) novel conceptual frameworks suggesting novel avenues of research or hypotheses, (b) papers prescribing novel terminologies or buzzwords, (c) syntheses failing to fully acknowledge, or simply revisiting, older theories, and (d) papers introducing novel statistical constructs and methods. We defend the idea that research on animal personality does not need more data-free papers, but rather conclusive empirical investigations. While these points may appear obvious to many researchers familiar with the literature, we have observed a complete lack of debate on the value of data-free papers. We hope this data-free paper will spark a true debate, and we genuinely encourage replies and rebuttals, especially ones that will outline a constructive alternative view on the papers we analyze here.

Verbal Conceptual Frameworks

An important role of data-free papers has been to outline how animal personality would have consequences for virtually every aspect of an animal ecology. We fully agree that it is very exciting, and we ourselves authored such papers. However, one can argue that outlining mere possibilities of effects and speculating about the links between animal personality and other research topics does not always represent a progress. It would be more effective to explore these links with data or formal models. One may argue that data-free papers generate better empirical work, by outlining a framework, providing a first comprehensive review of the evidence, or by focusing research interests on a particular topic to move it forward. Considering the number of such papers, we wonder how all these novel frameworks attract enough attention. To us, the truly influential frameworks were written before the explosion of data-free papers (e.g., Sih et al., 2004a), or before any of their derivatives (e.g., Dingemanse et al., 2010). In contrast, more recent data-free papers seem to have stirred relatively few empirical follow ups. As a quick example, Réale et al. (2010)'s presentation of the "pace-of-life syndrome" is currently cited by only 13 empirical studies actually investigating links between personality and either life history or physiology (excluding studies done by the authors themselves). In comparison, this paper has been cited 12 times by additional data-free papers (again excluding ones by the authors). Another important data-free paper, Schuett et al., 2010, shows similar patterns. Schuett et al. (2010) present how sexual selection could explain the extent of variation in males and females. It is cited by only 8 empirical studies testing this hypothesis. Four of them are

testing for personality differences between males and females, and 4 others investigated how animal personality affects mating preferences and patterns. During the same period, this paper has also been cited far more, 16 times, by additional data-free papers. These topics are both fascinating. To us, this lack of empirical follow up suggests that pushing these topic forward is swamped by the challenges of studying these topic empirically, rather than by a lack of proper framework. If this is indeed the case, the way to push these challenging topics forward would be to produce more exemplary empirical studies directly testing these particular hypotheses (Réale et al., 2009; Schuett and Dall, 2009), even if these are cited ∼50% less (see Introduction).

Ignoring or Revisiting Past Research

Some of the data-free papers do not only seem to lack proper empirical follow ups, but also seem to not fully synthesize the literature when revisiting classical theory from an individual perspective (but see Careau and Garland, 2012). Failure to acknowledge past research can result in researchers potentially repeating past errors. For example, many data-free papers pushed the idea that the general r and K selection theory is useful to understand how ecological conditions can generate animal personality. This lead to the idea that animal personality is associated with life history productivity (Stamps, 2007; Biro and Stamps, 2010) or that particular personality traits are consistent and correlated when they affect life history tradeoffs (Réale et al., 2010). The major advance is that this framework provides clear predictions on the particular patterns of personality one may find in a given environment. Yet, we run the risk of repeating the same mistake of r and K selection theory by failing to fully integrate this past literature. r and K selection theory represented a major advance because it provided a framework to investigate the role of ecological conditions in maintaining correlations among traits. Yet a lot of the empirical studies simply used it as an assumption, measuring one life history trait and using it to classify organisms along a r - K selection continuum (Reznick et al., 2002). Likewise, studies on animal personality may underutilize the predictive power if this framework and instead use r and K selection theory as an *ad-hoc* explanation for the patterns they report.

Similarly, we wonder if these papers need to be written in the first place. Revisiting classical theory taking into account individual behavioral variation is surely a necessary step. However, we question whether these need to be featured in papers without any data. One prime example is the study of role of animal personality in sexual selection. Sexual selection has a long history of studying which traits affect intra- and inter-sexual selection (Andersson, 1994). Indeed, an animal's personality is yet another aspect of an individual's phenotype that may be subject of sexual selection. Further, sexual selection already considers individual phenotypic variation and its effects on mating success (Maynard Smith, 1982; Gross, 1996). Considering animal personality as a sexually selected trait is exciting and relevant, but the inclusion of the words "individual variation" before keywords has not fundamentally changed the existing sexual selection framework. Thus, although data-free papers highlighting this matter have indeed been highly cited, we question if they have truly advanced the topic by providing genuinely new insights, or instead have made minimal extensions to existing theory.

Creating Terminology

In addition to lacking empirical follow ups, and failing to truly acknowledge older literature, some data-free papers have prescribed novel terminology. At this point, we strongly doubt that there is a need for new terms. Animal personality is simply consistent individual variation in behavior, and much of the terminology needed to study and report results on this topic is probably already available. Creating additional terms will likely do nothing more than further fragment the field. Operationally naming and defining an object of interest in order to discuss it in an empirical paper may be needed at times (e.g., social skill in Sih et al., 2014, or social responsiveness, Wolf et al., 2011), but we do not see why such terms each require their own conceptual paper. For example, Stamps and Groothuis (2010a,b), prescribed the use of terms typically used in developmental psychology to characterize different aspects of animal personality. Example of these terms are contextual generality, contextual specificity. Yet a query in web of science using those keywords failed to pull any empirical studies applying this terminology to animal personality. Similarly, the same authors used terms like "differential consistency," which is is essentially no different than the statistical definition of personality (consistent individual differences in behavior). This term also has yet to be cited on any studies on animal personality. Clearly, this terminology is not required to investigate this interesting topic.

Methodological Prescriptions

Some conceptual papers have presented statistical methods, ranging from less powerful but intuitive to more robust but more complex ones. For example, some papers have presented simple ways to quantify intra-individual variability (Stamps et al., 2012; note that this papers does include two empirical examples used to illustrate the method). This statistical approach is intuitive, and its presentation probably motivated further empirical developments on the implications and evolution of intra-individual variability. However, it has the common caveat of doing "stats on stats," and more robust methods are available. In particular, mixed model approaches have been extended to account for or quantify intra-individual variability (Cleasby et al., 2015), or even to assess its underlying mechanisms (Pinheiro and Bates, 2000). Research on animal personality appears to struggle in striking a balance between such intuitive and sophisticated methods, and sophisticated methods might also run the risk of obscuring the biological questions considered in this research area.However, as research questions on animal personality progress, we think thatmore robust and powerful mixed modeling approaches will be increasingly required.

Moving Forward: to Collect Data or Not to Collect Data?

We *discussed* four types of data-free contributions to the study of animal personality that are not, in our opinion, contributing to the progress of the topic. Conceptual papers presenting a novel hypothesis probably could almost always be replaced by robust empirical studies actually testing the hypotheses of interest. Papers revisiting older bodies of theory without properly acknowledging their whole literature will be much harder to publish as empirical paper as well, since they will be reviewed on the quality of the data, experimental soundness, and so on. Similarly, novel terminology and statistical methods will be put to test more effectively if they are directly applied to data. In order to spark debate, we intentionally aimed at presenting four negative aspects of data-free papers. Of course, we recognize that some data-free papers have been highly beneficial by structuring empirical efforts, helping achieve higher rigor, and enabling the study of animal personality to transition descriptive to predictive. We also recognize that quantifying precisely such positive impacts will be challenging. For example, mixed models, in particular random regressions, proposed by Dingemanse et al. (2010) have allowed us to tackle new questions, and provided statistical definitions of the core concepts in animal personality. Similarly, Jandt et al. (2014) drew useful predictions on the ecological and evolutionary role of animal personality by thoroughly revisiting past work behavioral variation within eusocial insect colonies (Seeley, 1982; Hölldobler and Wilson, 1990; Schulz et al., 1998). Time will tell whether this paper will generate the necessary empirical follow up. Nonetheless, such data-free papers have definitely helped the initial general interest in animal personality to become a rigorous research topic with predictive frameworks. Most of these still await to be put to test with data.

We do not intend to diminish the work of particular researchers, but instead to stimulate discussion on whether data-free papers are truly impactful. Clearly, data-free papers are highly cited compared to empirical studies on the same topic. But if your aim is to push the topic forward, should your next paper contain data or not? The study of animal personality is fascinating, but still lacks credibility in the eyes of many researchers. In our opinion data-free papers do little to increase this credibility. We think data and robust analyzes of effect sizes are more needed then additional concepts and syntheses. Unfortunately, it is a fact that empirical studies will enjoy fewer citations than a data-free paper on a similar topic. We attribute this trend to the volume of papers on animal personality: it may simply be easier to read data-free papers that synthesize the literature rather than attempt to sift through the abundance of empirical papers and acknowledge the outstanding ones.

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Supplementary Material

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