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An Evidence-Based Study of the Evolutionary Behavioral Sciences

Edouard Machery and Kara Cohen

ABSTRACT

The disagreement between philosophers about the scientific worth of the evolutionary behavioral sciences (evolutionary psychology, human behavioral ecology, etc.) is in part due to the fact that critics and advocates of these sciences characterize them very differently. In this article, by analyzing quantitatively the citations made in the articles published in *Evolution & Human Behavior* between January 2000 and December 2002, we provide some evidence that undermines the characterization of the evolutionary behavioral sciences put forward by their critics.

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The evolutionary approaches to human behavior and psychology (henceforth, 'evolutionary behavioral sciences') remain controversial in philosophy: While philosophers of science have extensively criticized them (e.g. Richardson [1996], [2007]; Lloyd [1999]; Dupré [2001]; Kaplan [2002]; Lloyd and Feldman [2002]; Woodward and Cowie [2004]; Buller [2005]; Davies [2009]), a few philosophers have challenged these criticisms (e.g. Carruthers [2006]; Machery [2007], [forthcoming]; Machery and Barrett [2006]). Given the growing influence of the evolutionary behavioral sciences within mainstream psychology, anthropology, sociology, and even law, it is important to resolve the controversy about the scientific worth of the evolutionary behavioral sciences.

This controversy has two distinct sources: While it is due in part to a disagreement about the epistemic value of the discovery heuristics—i.e. the methods for developing plausible hypotheses—and the confirmation strategies—i.e. the methods for providing empirical support for these hypotheses—used by evolutionary behavioral scientists, it also results from critics and proponents of the evolutionary behavioral sciences characterizing the current evolutionary behavioral sciences very differently. Our goal in this article is to address the disagreement about the proper characterization of the evolutionary behavioral sciences.

To do so, we will quantitatively analyze the citations found in the articles published by evolutionary behavioral scientists. Quantitative citation analysis has been used successfully in numerous studies of science (e.g. Robins and Craik [1993]; Fellows *et al.* [2005]; Webster [2007a]), although to our knowledge it has not yet been employed in philosophy (but see Hull [1990] and Wray [2010] for the use of related methods in philosophy). Analyzing the citations made by evolutionary behavioral scientists provides a distinct type of evidence that can be used to better characterize their field.

Here is how we will proceed. In Section 1, we will describe four claims made by the critics of the evolutionary behavioral sciences. In Section 2, we will describe the methodology used in this article—quantitative analysis of citations—and operationalize the four claims made by the critics of the evolutionary behavioral sciences. In Section 3, we will describe our methods and present two preliminary studies. In the remainder of this article, we will present our findings. In Section 4, we will examine whether evolutionary behavioral scientists can legitimately be blamed for being insufficiently acquainted with the biological sciences in general, and with evolutionary biology in particular. In Section 5, we will investigate whether they are unduly influenced by outdated theories in evolutionary biology. In Section 6, we will examine whether the contemporary evolutionary behavioral sciences are closely tied to classical sociobiology. In Section 7, we will investigate whether the contemporary evolutionary sciences divide into several distinct competing paradigms. In Section 8, we will conclude that our analyses have yielded a nuanced, often surprising characterization of the evolutionary behavioral sciences, and that this characterization is at odds with the mainstream characterization of these sciences within philosophy.

1 Four Claims about the Evolutionary Behavioral Sciences

1.1 The disparaging characterization

Most philosophers of science have a dim view of the evolutionary behavioral sciences—the area of research that includes evolutionary psychology, human behavioral ecology, and dual-inheritance theory (see below) and that is illustrated by the work of researchers such as, among many others, John Tooby, Leda Cosmides, David Buss, Martin Daly, Margo Wilson, Geoffrey Miller, Sarah Hrdy, Peter Todd, Dan Fessler, Rob Boyd, Pete Richerson, Kevin Laland, Joe Henrich, Clark Barrett, John Manning, Eric Alden Smith, Hillard Kaplan, Monique Borgerhoff Mulder, and Steven Gangestad. Evolutionary behavioral scientists are psychologists, anthropologists, or (more rarely) biologists or ecologists.

According to what we will call 'the disparaging characterization', evolutionary behavioral scientists are typically poorly acquainted with the biological sciences, and in particular with evolutionary biology; as a result, they rely on evidential standards that are inappropriate for biology, particularly when attempting to establish that psychological traits or behaviors are adaptations. To the extent that they are acquainted with evolutionary biology, they rely on largely outdated theories from the 1960s and 1970s. They have little knowledge of the more recent developments in evolutionary biology, such as the integration of development and evolution, or the study of non-genetic forms

of inheritance. Furthermore, and perhaps relatedly, most contemporary evolutionary approaches to human behavior and psychology are an outgrowth of the classical human sociobiology. Finally, these evolutionary approaches divide into several competing paradigms that have little in common. In the remainder of Section 1, we elaborate on the four claims just sketched.

1.2 Evolutionary behavioral scientists' acquaintance with the biological sciences and with evolutionary biology

We start with the first claim made by the proponents of the disparaging characterization: Evolutionary-minded psychologists and anthropologists often have little acquaintance with the biological sciences in general, and with evolutionary biology in particular. This poor acquaintance leads them to hold some mistaken assumptions about evolutionary processes and to rely on evidential norms that are largely rejected by biologists.[1]

One finds three distinct versions of this claim in the literature critical of the evolutionary behavioral sciences. First, some critics have claimed that evolutionary behavioral scientists are ignorant of the biological sciences in general, including animal behavior (or ethology) and evolutionary biology. For instance, Woodward and Cowie write ([2004], p. 35; emphasis added):

> Evolutionary psychologists *largely ignore the biological evidence that has the strongest scientific credentials* and is most directly relevant to their claims about psychological mechanisms. This includes not only evidence from neurobiology, *genetics*, and *developmental biology*, but *also any evidence from evolutionary biology, ethology and population genetics* that threatens to undermine their armchair adaptationism.

Second, and more commonly, critics hold that evolutionary behavioral scientists ignore evolutionary biology in particular rather than the biological sciences in general. Examples of this charge abound (e.g. Lickliter and Honeycutt [2003], p. 826). Lloyd ([1999], p. 226) blames Tooby and Cosmides for ignoring the kind of evidence required to show that some cognitive capacity is an adaptation (a claim endorsed by Downes [2001], p. 588), and she refers to 'a lack of awareness of the real standards of evidence in evolutionary biology' ([1999], p. 230; see also Richardson [2007]). Gray *et al*. ([2003], p. 248) write that '[. . .] the impoverished view of evolution and psychology adopted by many Evolutionary Psychologists, and the weakness of their empirical science, is frankly rather embarrassing'. We will address

[1] The charge of ignoring much of the biological sciences is sometimes pressed more strongly against one of the competing paradigms distinguished within the evolutionary behavioral sciences, namely evolutionary psychology (see Sections 1.5 and 7).

these two versions of the first claim made by the critics of the evolutionary behavioral sciences in Section 4.

Finally, a third version of the first claim should be noted here. Instead of claiming that evolutionary behavioral scientists have little knowledge of or acquaintance with evolutionary biology, critics sometimes hold that evolutionary behavioral scientists misunderstand the discovery heuristics and confirmation strategies (e.g. the methods used to test adaptationist claims about psychological traits) or fail to apply them properly. Since we will rely on a quantitative measure of the acquaintance of evolutionary behavioral scientists with various scientific fields (such as evolutionary biology or the behavioral sciences), we will not be able to address this third version of the first claim made by the proponents of the disparaging characterization. We will discuss this limitation of our analysis in the last section of this article.

1.3 Evolutionary behavioral scientists and the evolutionary biology of the 1960s and 1970s

Critics of the evolutionary behavioral sciences often insist that evolutionary-minded psychologists and anthropologists rely extensively on the evolutionary theories developed in the 1960s and 1970s, particularly the theories developed by George Williams ([1966]), William Hamilton, and Robert Trivers, and that they ignore more recent work in evolutionary biology. Evolutionary behavioral scientists are then blamed for developing hypotheses on the basis of theories that have been rejected or at least seriously qualified by contemporary biologists.

For instance, Lickliter and Honeycutt ([2003], p. 828; emphasis added) blame evolutionary psychologists for having ignored 'the empirical and conceptual *advances* that have taken place in the biological sciences *over the past several decades*', and they call for a new 'evolutionary perspective of human behavior that moves beyond *outdated* notions of genetically or environmentally determined development'. Downes ([2001], p. 592) writes that textbooks in evolutionary psychology are characterized by an 'over-emphasis on a small subset of evolutionary biology's conceptual toolkit [. . .]. Evolutionary biology is presented as starting with Darwin, receiving a jumpstart from Williams (1966) on its way to culminating in inclusive fitness theory as developed by Hamilton and Trivers.'

1.4 Evolutionary behavioral scientists and sociobiology

The third claim put forward by the proponents of the disparaging characterization concerns the relation between contemporary evolutionary approaches to human behavior and psychology and the sociobiology that flourished in the

1970s and early 1980s. One finds two versions of this criticism in the literature critical of the evolutionary behavioral sciences.[2]

First, proponents of the disparaging characterization sometimes hold that to a large extent contemporary evolutionary behavioral sciences are inspired by sociobiology (e.g. Caporael and Brewer [1995], pp. 32–3; Panksepp and Panksepp [2000], p. 108; Pigliucci and Kaplan [2000], p. 67; Gray *et al*. [2003], p. 247; Lickliter and Honeycutt [2003], pp. 820–1). Downes ([2001], p. 575) notes that '[s]ome have argued that Evolutionary Psychology takes over much of the research agenda of sociobiology (e.g. [. . .] Sterelny and Griffiths 1999) and some critics seem not to have noticed that Evolutionary Psychology is in any way distinct from sociobiology (e.g. some contributors to Rose and Rose 2000).'

Second, some critics hold that contemporary evolutionary behavioral scientists make the same mistakes as the sociobiologists of the 1970s and 1980s without being committed to the claim that the former are actually inspired by the latter. Kitcher ([2004], p. 4; emphasis added) refers to the 'low-budget ventures of pop sociobiology and their debased *recapitulations* in the work of David Buss, Randy Thornhill and Craig Palmer'. Dupré ([2001], p. 48), a vocal proponent of the disparaging characterization, refers to the theories developed in evolutionary psychology as 'contemporary versions of human sociobiology'. In Section 6, we will only examine the first version of the criticism discussed here since the second version cannot be properly addressed with the quantitative measure of acquaintance we will be relying on in this article. We will discuss this limitation of our analysis in the conclusion of this article.

1.5 The homogeneity of the evolutionary behavioral sciences

The last claim made by the proponents of the disparaging characterization that we will examine in this article concerns the homogeneity of the field dedicated to studying human behavior and psychology from an evolutionary point of view. Proponents of the disparaging characterization often argue that this field divides into several distinct and competing paradigms, which are hypothesized to have very little in common besides the common goal of understanding human behavior from an evolutionary point of view. Often, these proponents contrast three paradigms: evolutionary psychology, human behavioral ecology, and dual-inheritance theory (e.g. Foley [1996]; Downes [2001], [2009]; Buller [2005]; Ferguson [2007]).[3] Briefly, evolutionary

[2] Thanks to Luc Faucher for insisting on the need to distinguish these two versions.

[3] Downes's views on this question differ from Buller's (personal communication). For Downes, Buller's use of the term 'paradigm' overstates the distinctions between fields in this area, and Laudan's 'research tradition' terminology is much more apt.

psychologists (e.g. Tooby and Cosmides, Miller, Gangestad, and Nesse) attempt to identify the psychological adaptations that make up the mind using the methods of cognitive and social psychology, while human behavioral ecologists (e.g. Smith, Kaplan, and Borgerhoff Mulder) are more interested in the adapativeness of human behavior in different social and ecological contexts and tend to use anthropological methods. Dual-inheritance theorists (e.g. Boyd and Richerson, Feldman) focus on how culture may have interacted with organic evolution to shape human behavior and mind (for a more complete overview of these three research traditions, see, e.g. Laland and Brown [2002]). Downes ([2001], p. 583) concludes his review of the evolutionary approaches as follows:

> The current state of play briefly sketched here is that Evolutionary Psychologists and behavioral ecologists disagree about many key aspects of their respective approaches. At the same time there are attempts to play down differences and move towards a more collaborative approach [...]. The prospects for pluralism are not bright as the theoretical differences seem to run deep. If Evolutionary Psychologists continue to characterize their approach inflexibly in terms of the key theoretical principles discussed above, it is hard to see how they could find a place in a collaborative effort with behavioral ecologists.

The insistence that there are several distinct paradigms among the evolutionary approaches to human behavior and psychology often goes hand in hand with the charge that one of these paradigms, typically evolutionary psychology, is more guilty of ignoring evolutionary biology and other biological sciences, being inspired by outdated theories, and being closely connected with sociobiology than the other paradigms. Thus, Downes ([2001], p. 588) writes that 'behavioral ecologists' epistemic standards are more in line with those of philosophers of science who have examined Evolutionary Psychology.'

It would be silly to deny that there are differences between various groups within the evolutionary behavioral sciences. After all, some researchers call themselves 'evolutionary psychologists', while others call themselves 'human behavioral ecologists'. Furthermore, controversies between different approaches have marked the recent history of the evolutionary approaches to human behavior (see, e.g. the exchange between Daly and Wilson [1999], [2000]; Smith *et al*. [2000]; for discussion, see Gangestad and Simpson [2007]). However, acknowledging such differences is not tantamount to agreeing with the claim, made by some influential proponents of the disparaging characterization, that these groups endorse different paradigms that have little in common. Instead, these groups form different research traditions.

Although this is not the place to provide an extensive explication of these two notions, the distinction between paradigms and research traditions should

be clarified. Paradigms and research traditions have much in common: Just like a paradigm, a research tradition consists, roughly, of theories that share some methodological principles, that agree on the kind of explananda of interest, and that concur on the kind of explanations required to account for these explananda. For present purposes, there are two crucial differences between paradigms and research traditions. First, research traditions within a given scientific field (e.g. psychology of vision) share various commitments—they might agree on what the explananda are, they might share some methodological principles, or they might concur on what the characteristics of successful explanations are—while paradigms have little in common. Second, two hypotheses formulated within two distinct research traditions might both be correct, while the hypotheses formulated within two distinct paradigms tend to be incompatible.

Some examples might also be useful to clarify this distinction. In cognitive science, dynamic systems theory (e.g. Van Gelder [1995]) and classical computationalism form two competing paradigms since they have little in common and since they tend to develop incompatible explanatory hypotheses. In contrast, social and psychological explanations of racism form two distinct research traditions (for discussion, see Machery *et al.* [2010]). The hypotheses developed in each tradition are often compatible in that they focus on different phenomena or on different aspects of the same phenomena.

So, if evolutionary psychology and human behavioral ecology form two research traditions, then, first, some hypotheses developed within each tradition are likely to be compatible, and, second, one should expect many similarities between evolutionary psychology and human behavioral ecology. In Section 7, we will rely on this second idea, and we will attempt to show that evolutionary psychologists and human behavioral ecologists are influenced by the same sources.

Indeed, advocates of the evolutionary behavioral sciences typically hold that evolutionary psychology and human behavioral ecology have much in common. Thus, commenting on Buller's ([2005]) distinction between Evolutionary Psychology (with capital letters) and evolutionary psychology (the evolutionary approaches that do not commit the mistakes and fallacies allegedly made by Tooby, Cosmides, Buss, and others), Machery and Barrett write ([2006], p. 233):

> 'EP' and 'ep' do not in fact represent independent, isolated groups of people or schools of thought. Not only do evolutionary psychologists of all stripes share common professional meetings and publication outlets, they share a large number of theoretical commitments as well.

In addition, where Downes ([2001]) highlights evolutionary psychologists' and behavioral ecologists' commitment to incompatible positions, advocates

of the evolutionary behavioral sciences insist that the differences between these research traditions are eroding. Thus, Gangestad ([2007]) writes that 'there are signs that, at least tacitly, integration between perspectives is possible and, indeed, occurring' and refers to 'an integrative human behavioral science'. As evidence for a slow but real convergence between the research traditions mentioned above, the proponents of the positive view might point to textbooks that bring together the findings and perspectives from different research traditions,[4] the research projects involving researchers from different traditions and the resulting articles (e.g. Kaplan and Gangestad [2005]), and the meetings of the Human Behavior and Evolution Society, which bring together evolutionary psychologists, behavioral ecologists, dual-inheritance theorists, etc. We are also inclined to speculate that the controversies between different research traditions should be at least partly understood as a kind of academic territory marking (see also Gangestad and Simpson [2007]): Researchers exaggerate the theoretical and empirical differences between scientific programs in order to promote their own approach.

2 Quantitative Citation Analysis

To properly assess the scientific status of the evolutionary behavioral sciences, one needs to determine whether the disparaging characterization is accurate. This is naturally an empirical matter: What is at stake is the proper characterization of a scientific field. How should this empirical question be solved?

2.1 The usual philosophical method

To characterize this field, philosophers have typically relied on a qualitative (or content) analysis of the articles and books published by evolutionary behavioral scientists. For example, Lloyd's ([1999]) criticism of evolutionary psychology is based on an analysis of Cosmides's ([1989]) and Cosmides and Tooby's ([1992]) articles on the hypothesized cheater detection module. Philosophers have examined theoretical articles, which describe the commitments and methods of evolutionary-minded psychologists and anthropologists (e.g. Tooby and Cosmides [1992]). They have also analyzed empirical articles, which illustrate how these commitments and methods are put to use (e.g. Cosmides [1989]).

[4] In contrast, Downes ([2001], pp. 585–6) criticizes (among others) Cartwright's textbook *Evolution and Human Behavior: Darwinian Perspectives on Human Nature* for mixing together the findings from evolutionary psychology and human behavioral ecology. In an overall positive review of the second edition of this book, Braddock ([2009]) concurs.

Although philosophers have rarely explained on what grounds they single out some articles (books, etc.) but not others for consideration, it would seem that they typically focus on what they take to be the paradigmatic articles and books. That is, philosophers seem to focus on the articles they take to illustrate or characterize the tenets evolutionary behavioral scientists are expected to believe in, the methods they are expected to use, the evidential standards they are expect to abide by, and so on.

The undeniable virtues of this traditional philosophical method should not obfuscate its limitations. First, because content analysis is time and effort consuming, only a few articles are typically examined. As a result, this method is not optimally tailored to examine whether different subgroups within the evolutionary behavioral sciences (and *a fortiori* within evolutionary psychology or within human behavioral ecology) endorse different norms, methods, or assumptions. Second, it might also be problematic to extrapolate from these few alleged paradigmatic articles to a whole field since the research commonly done in a scientific field can substantially differ from the research done in the articles singled out by philosophers. Third, because philosophers intend to single out paradigmatic articles, they tend to focus on foundational articles and books—those that defined the relevant fields. Indeed, even in recent articles and books (e.g. Richardson [2007]), proponents of the disparaging characterization tend to focus on the articles published by central figures of evolutionary psychology, such as John Tooby, Leda Cosmides, or David Buss, at the end of the 1980s and in the early 1990s. As a result, philosophers of science remain largely impervious to the evolution of the evolutionary approaches to human behavior and psychology.

2.2 Quantitative citation analysis

Because of these limitations of content analysis, we examined whether quantitative citation analysis might help us assess the disparaging characterization of the evolutionary behavioral sciences.

Quantitative citation analysis consists in quantitatively analyzing the citations made by researchers. As Eugene Garfield, the inventor of the Science Citation Index, puts it (Garfield *et al.* [1978], p. 180), 'Citation analysis is a bibliometric method that uses reference citations found in scientific papers as the primary analytical tool.' Citations can be quantitatively analyzed for various purposes, including the evaluation of individual researchers', institutions', and countries' scientific outputs (e.g. Moed [2005]), the identification of specialties (e.g. Small and Griffith [1974]), science mapping (i.e. the identification of relations between specialties; e.g. Small [1999]), the analysis of scientific change (e.g. De Solla Price [1965]; Robins *et al.* [1999]), and the detection of biases in scientific fields (e.g. Robins and Craik [1993]).

An important assumption of quantitative citation analysis (which we will call 'the influence assumption') is that citation measures influence or 'intellectual heritage' (Kostoff [1998]; for discussion of this assumption, see Appendix A). As Cole and Cole put it ([1973], p. 220), 'a basic assumption of [citation] analysis is that the research that scientists cite in their own papers represents a roughly valid indicator of influence on their work'. That is, it is assumed, first, that when a researcher cites another article (book, etc.), she typically acknowledges the influence of this article (book, etc.) on her own work and, second, that when an article (book, etc.) influences a researcher's work, she typically cites it. Influence can take various forms. An article (book, etc.) can be the source of the methods used in the citing work; it can report some data used in the citing work; it can present a hypothesis or theory examined or developed in the citing work; and it can belong to the relevant literature for understanding the research reported in the citing work.

In what follows, we will use quantitative citation analysis to assess the disparaging characterization (for related work, see Webster [2007b], [2007c], [2007d]). Citation analysis seems to be a promising method for evaluating whether the disparaging characterization is accurate because it has been successfully used to answer descriptive questions about specific sciences (e.g. did psychology undergo a Kuhnian paradigm change? Is the field of behavior and decision making in psychology biased toward citing findings showing human irrationality?). Furthermore, it has also been used to examine issues that are similar to the controversies at hand (e.g. Webster [2007d] on the importance of *The Adapted Mind* for the development of evolutionary psychology). Finally, it is not affected by the limitations that bear on the kind of evidence usually used by philosophers (see above).

We will focus on the articles published in *Evolution & Human Behavior* (http://www.ehbonline.org/home). *Evolution & Human Behavior* is the official journal of the Human Behavior and Evolution Society (HBES), an interdisciplinary, international society founded in 1988 to bring together researchers working on human behavior and psychology from various perspectives. The society describes its mission in the following terms:

> The Society was formed to promote the exchange of ideas and research findings using evolutionary theory, including studies of animal behavior, to better understand human nature. HBES is highly eclectic, consisting of scholars from a great number of fields, including psychology, anthropology, psychiatry, economics, medicine, law, philosophy, literature, biology, sociology, business, artificial intelligence, political science, and art.

Evolution & Human Behavior replaced *Ethology and Sociobiology* (which was founded in 1979) in 1997. It is one of the leading journals in the

evolutionary behavioral sciences.[5] Its impact factor in 2007 was 2.5, compared to, e.g. 1.5 for *Human Nature* and 3.1 for *Evolutionary Anthropology*. This impact factor has increased in the period 1997–2005, and its rate of increase was higher than the mean increase for the American Psychological Associations journals (Webster [2007d]; Gangestad [2008]). Its mission is described as follows:

> *Evolution & Human Behavior* is an interdisciplinary journal, presenting research reports and theory in which evolutionary perspectives are brought to bear on the study of human behavior. It is primarily a scientific journal, but submissions from scholars in the humanities are also encouraged. Papers reporting on theoretical and empirical work on other species will be welcome if their relevance to the human animal is apparent.

During the period 2000–02 (examined in this study), the journal was edited by Margo Wilson and Martin Daly (who were the editors from 1997 to 2006).

2.3 Operationalizing the controversy

Earlier, we identified four claims made by the proponents of the disparaging characterization of the evolutionary behavioral sciences. Quantitative citation analysis can be used to assess this characterization only if these four claims make predictions as to what patterns of citations are to be expected if they are true. Here we provide such operationalizations in the form of four hypotheses.

Hypothesis 1: Acquaintance with the biological sciences/evolutionary biology
If the disparaging characterization is correct, then evolutionary behavioral scientists should cite fewer articles from the biological sciences in general (evolutionary biology, the literature on animal behavior, and the literature on the phylogeny of humans) or from evolutionary biology in particular than one would expect on the basis of the relative number of articles published in these disciplines.

Hypothesis 2: Influence of the evolutionary biology from the 1960s and 1970s
If the disparaging characterization is correct, then the ratio of the number of citations from the 1970s to the number of citations from the 1990s should be substantially higher in biology than in psychology or anthropology (i.e. in the non-evolutionary behavioral sciences).

Hypothesis 3: Relation to sociobiology
If the disparaging characterization is correct, then there should be more citations drawn from the evolutionary behavioral sciences of the 1970s and

[5] Other journals include *Evolutionary Psychology*, *Human Nature*, and *Evolutionary Anthropology*.

1980s than one would expect on the basis of the distribution by decade of citations from other fields (e.g. non-evolutionary behavioral sciences).

Hypothesis 4: Different competing paradigms
If the disparaging characterization is correct, then evolutionary psychologists, human behavioral ecologists, and dual-inheritance theorists should cite differently, and we should be able to identify different citation patterns in the articles published by these three groups of scientists. Furthermore, if the contrast between evolutionary psychology and human behavioral ecology drawn by philosophers stands up to examination, human behavioral ecologists should cite much more work from the biological sciences in general, and from evolutionary biology in particular, than evolutionary psychologists.

2.4 A plea for quantitative analyses

Before presenting our citation analyses, it is worth addressing a likely objection. We will analyze *quantitatively* the distribution of citations by fields, periods, and authors' disciplinary affiliations without examining either *how* the authors use the articles cited or *which* articles are cited.

One might object to this quantitative orientation on the grounds that the type of quantitative information we are looking for might be misleading since articles can be inappropriately cited: Scientists occasionally cite irrelevant articles; they also cite articles to support claims these articles explicitly deny; and they sometimes cite articles presenting discredited evidence (e.g. Thomasson and Stanley [1955]). These worries have been examined by bibliometrists, and research on the influence assumption shows in fact that scientists typically, though not always, cite appropriately (see Appendix A).

One might also object to this quantitative orientation on the grounds that the real issue is how evolutionary behavioral scientists understand biology (or, perhaps, evolutionary biology in particular), not whether they are acquainted with biology. Thus, Lloyd ([1999], pp. 225–6) argues that evolutionary psychologists' citation practices are disconnected from their methodological practices. She contends that evolutionary psychologists regularly discuss the objections against adaptationism (she even refers to a 'ritual recitation') without renouncing their adaptationist practices. Instead of the envisioned quantitative analysis, the objection continues, a qualitative analysis, which would examine which articles are cited and how they are used by evolutionary behavioral scientists, is required to assess the disparaging characterization of the evolutionary behavioral sciences.

We acknowledge that a quantitative citation analysis is limited in several important respects and that it should be complemented with other kinds of

analysis. In particular, as we noted above, quantitative citation analysis is of little help to address some claims made by the proponents of the disparaging characterization of the evolutionary behavioral sciences. It is of no use if one is interested in determining whether evolutionary behavioral scientists understand and apply properly the discovery heuristics and confirmation strategies that are common in the biological sciences and in evolutionary biology (the third version of the first claim made by the critics of the evolutionary behavioral scientists) or in determining whether evolutionary behavioral scientists make the same mistakes as sociobiologists (the second version of the third claim made by these critics).

However, it remains that such analysis does provide evidence bearing on the four hypotheses at hand (Section 2.3): The disparaging characterization of the evolutionary behavioral sciences makes clear predictions about the patterns of distribution of citations one would expect if it were correct, and, consequently, the presence or absence of these patterns provides relevant evidence to evaluate this characterization.

3 Methods and Preliminary Analyses

3.1 Methods

Our sample consisted of the articles published in *Evolution & Human Behavior* over a three-year period (January 2000 to December 2002) for a total of 18 issues. We excluded the book reviews, resulting in a total of 79 articles. For each article, we selected the citations mentioned in the bibliography, resulting in a sample of 3487 citations.

To classify our citations, we developed the following classificatory scheme:

Scheme 1: Classification of Citations by Field

(1) Evolutionary biology
(2) Animal behavior
(3) Evolution of hominins, archaeology, paleoanthropology
(4) Evolutionary approaches to human behavior (including sociobiology, human behavioral ecology, evolutionary psychology)
(5) Medicine, psychiatry, physiology (including hormonal studies of behavior)
(6) Behavioral sciences (including psychology, cultural anthropology, sociology, economics)
(7) Neuroscience
(8) Others

Under Category 1 (evolutionary biology), we classified articles, books, dissertations, etc.,[6] that theorize about evolutionary processes or that test hypotheses about them. Trivers's ([1971]) article 'The evolution of reciprocal altruism' and Møller and Swaddle's ([1997]) book *Asymmetry, Developmental Stability, and Evolution* are paradigmatic examples of Category 1. Under Category 2 (animal behavior), we classified articles, books, dissertations, etc., that examine animal behavior within particular species or taxa (either from an evolutionary or from a non-evolutionary point of view). Some articles, books, dissertations, etc., could have been classified under either category because they examine whether some hypothesis about evolutionary processes is true of some taxon. We decided to classify these ambiguous items under Category 1 if the main intent of their authors was to test a hypothesis about evolutionary processes; otherwise, articles were classified under Category 2. Thus, Thornhill and Alcock's ([1983]) book *The Evolution of Insect Mating Systems* was classified under the first category. Under Category 3 (phylogeny of humans and archaeology), we classified articles, books, dissertations, etc., that examine the historical and phylogenetic aspects of the evolution of humans. In contrast, Category 4 (evolutionary behavioral sciences) applied to the research that looks at human behavior and psychology from an evolutionary point of view without being concerned with the historical and phylogenetic aspects of their evolution. This research examines whether some behaviors or psychological traits are adaptations or by-products, what their function is, whether they are adaptive, etc. Works in sociobiology, evolutionary psychology, and human behavioral ecology illustrate this category. Category 5 (medicine, physiology, and psychiatry) was somewhat disparate: Under Category 5, we classified citations drawn from the medical disciplines (including psychiatry) and from disciplines focusing on human physiology. Under Category 6 (behavioral sciences), we classified articles, books, dissertations, etc., in the non-evolutionary behavioral sciences (particularly, psychology, sociology, cultural anthropology, and economics). Some articles could have been classified under either Category 5 or 6—particularly those articles that examine the causal relation between hormonal and behavioral variables (e.g. Mazur and Booth [1998]). We classified the latter articles under Category 5. Category 7 included research in neuroscience.

Each of us (E.M. and K.C.) then classified the 3487 citations under the eight categories of the disciplinary scheme. One of the two authors (K.C.) was not aware of the specific hypotheses considered, although she knew that the goal was to evaluate the common characterization of the evolutionary work on

[6] Most of the citations referred to articles (66%).

human behavior and psychology. Disagreements between the two resulting classifications were resolved by discussion.[7]

We also classified the publication date of each citation according to the following scheme:

Scheme 2: Classification of Citations by Publication Dates

(1) Before 1950
(2) 1950–59
(3) 1960–69
(4) 1970–79
(5) 1980–90
(6) After 1990

Finally, we noted the disciplinary affiliation of the authors of the 79 articles considered here. One of us (E.M.) classified their disciplinary affiliations according to the following scheme:

Scheme 3: Classification of Authors by Disciplinary Affiliation

(1) Evolutionary psychology
(2) Human behavioral ecology and evolutionary anthropology
(3) Dual-Inheritance theory
(4) Evolutionary biology and animal behavior
(5) Medicine and physiology
(6) Others

The main point of this third classificatory scheme was to examine Hypothesis 4: The evolutionary behavioral sciences divide into distinct, competing paradigms (Section 1). As noted in Section 1, it is common to distinguish three approaches: evolutionary psychology, human behavioral ecology, and dual-inheritance theory—whence the first three categories. Category 4 was added to these categories in order to examine whether biologists publish in the flagship journal of the evolutionary study of human behavior, while Category 5 was added to examine the contribution of researchers on human physiology. Articles were classified under one of these categories depending on the

[7] Because both coders missed several citations in their coding and because we did not realize our errors early enough, we are unable to report the intercoder reliability. Nonetheless, we estimate that we classified approximately one citation out of three differently. Although this is a low intercoder reliability (Tinsley and Weiss [2000]), we feel that it is sufficient for our purposes since our disagreements were due to a few systematic divergences in the application of scheme 1. For instance, one of us classified articles examining the causal relation between hormonal and behavioral variables under Category 5, while the other classified them under Category 6. With the exception of these systematic disagreements, which were resolved by discussion, our degree of agreement was high.

affiliation of their authors, which itself was determined by taking into consideration (1) the departments to which they belong, (2) their reputation (as evolutionary psychologists, behavioral ecologists, etc.), (3) the description of their research interests on their websites (evolutionary psychology, human ecology, etc.), and (4) their research projects (as illustrated by their CVs). Particularly, articles were classified as belonging to evolutionary psychology depending on whether their authors were psychologists, had an established reputation as evolutionary psychologists, described their own work as belonging to evolutionary psychology on their website, and worked on topics usually associated with evolutionary psychology. Articles written by scientists such as John Tooby and Leda Cosmides, John Manning (well known for his work on the 2D:4D ratio), David Perrett (well known for his work on facial symmetry), and Irwin Silverman (who, among other things, works on gender differences in spatial orientation) were thus included under Category 1. Articles written by scientists such as Monique Borgerhoff Mulder or Eric Alden Smith were classified under Category 2.[8]

Before presenting our analyses, it is worth considering a worry caused by the uncertainties in our classifications. Particularly, when we classified the citations under the first classificatory scheme, we found that some citations could have been classified under two or sometimes three possible categories. Because some analyses below depend on this classification, one might question the robustness of our analyses: One might object that they would not hold if we had decided to classify the ambiguous citations differently. In reply, we first note that this worry does not affect all the findings reported below since many analyses do not hang on the classification of citations in different fields. Second, although real, the uncertainty is small. Most articles were unambiguously classified.

3.2 Analysis by publication date

As Figure 1 shows, most articles cited by evolutionary psychologists were published after 1990, followed unsurprisingly by the 1980s and the 1970s.[9]

To analyze this finding further, we fitted an exponential curve to the number of citations per year between 1951 and 1998,[10] and we found that the best fitting exponential (number of citations in a given year $= 3.253e^{0.09(\text{year-}1950)}$) fitted the distribution extremely well since it accounted for 95% of the variance (Figure 2).

This exponential growth is typical of the distribution of citations across years (De Solla Price [1965]; Moed [2005]). It is partly explained by reference

[8] This classificatory scheme is further discussed in Section 7.

[9] In what follows, we use 'articles' as shorthand for 'articles, books, dissertations, etc.'.

[10] We chose 1998 as the endpoint of our analysis because the number of citations declined after this date. This is naturally due to the fact that the articles published in 2000 (the beginning of our sample) were written at the end of the 1990s and could not cite the research done after 1998.

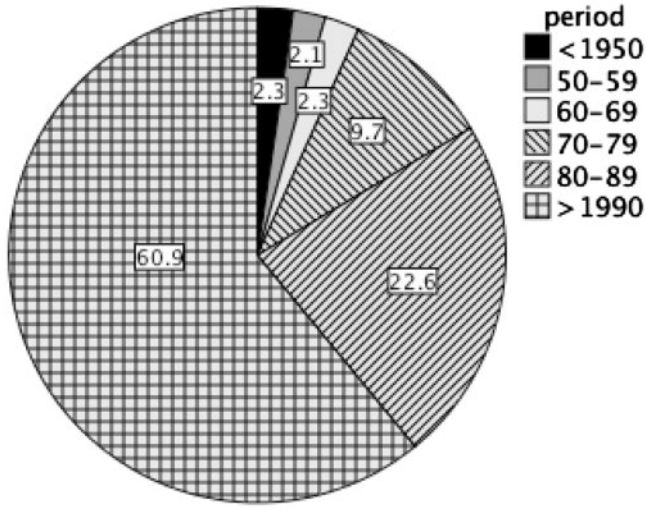

Figure 1. Distribution of citations across periods.

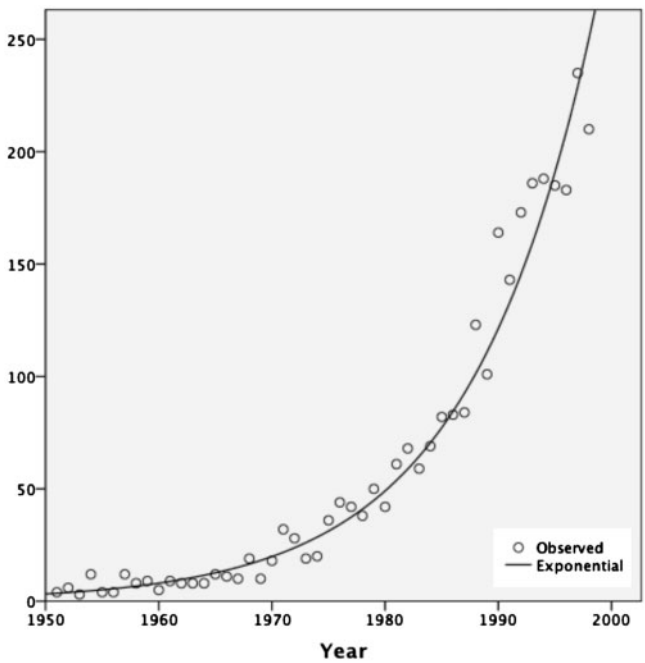

Figure 2. Best fitting exponential curve.

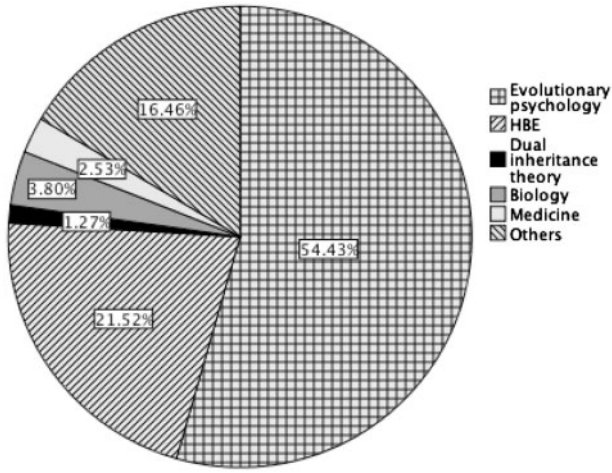

Figure 3. Authors' affiliation.

to the exponential growth of articles written across times: Because more articles are written, more are cited.

3.3 Analysis by authors' disciplinary affiliation

As Figure 3 shows, the articles published in *Evolution & Human Behavior* belong to several research traditions, which is in line with the description of the journal's goals (Section 2; for consistent empirical evidence, see Webster [2007d]; Gangestad [2008]).

Although most articles were written by evolutionary psychologists (54.4%), a substantial proportion of articles were written by human behavioral ecologists and evolutionary anthropologists (21.5%). Although only one article was written by a proponent of dual-inheritance theory, this does not indicate that *Evolution & Human Behavior* fails to be open to diverse research traditions. Rather, this low proportion is largely due to the fact that the main proponents of dual-inheritance theory, such as Peter Richerson and Robert Boyd, have trained few graduate students before 2000, and one would find a substantially larger proportion of articles written by dual-inheritance theorists in more recent volumes of this journal.

4 Hypothesis 1: Are Evolutionary Behavioral Scientists Sufficiently Influenced by Biology in General and by Evolutionary Biology in Particular?

In this section, we examine Hypothesis 1, which is derived from the first criticism made by the proponents of the disparaging characterization

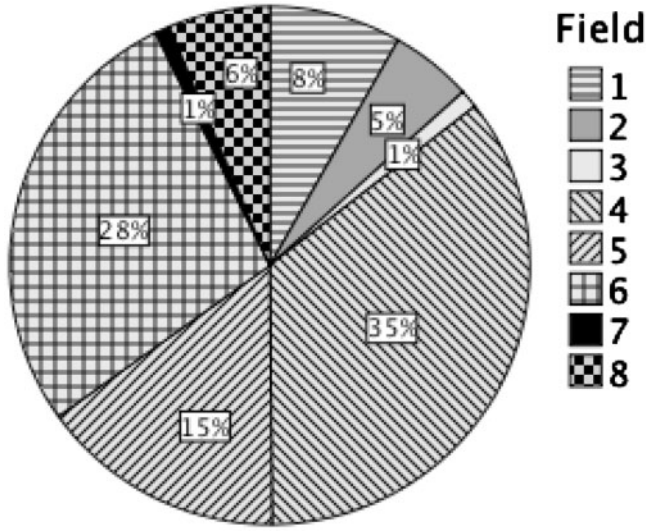

Figure 4. Distribution of citations across fields.

(Section 2.3). We focus first on the first version of this criticism, according to which evolutionary behavioral scientists ignore the biological sciences in general (see the quotation of Woodward and Cowie in Section 1.2), before turning to the most commonly held, second version, according to which evolutionary behavioral scientists ignore evolutionary biology in particular.

To examine Hypothesis 1, we looked at the distribution of citations by fields (Figure 4). Three groups of citations can be distinguished: 44% of citations belonged to disciplines studying humans from a contemporary, non-evolutionary perspective (psychology, medicine, physiology, anthropology, etc.: we will call them 'non-evolutionary human disciplines'); 35% of citations belonged to disciplines studying modern humans from an evolutionary perspective, including sociobiology, behavioral ecology, and evolutionary psychology; finally, 14% of citations derived from biological disciplines (evolutionary biology, animal behavior, and paleoanthropology).

What do we learn from Figure 4?[11] Since the evolutionary behavioral sciences are meant to form a field at the junction of biology and the social sciences (what Darden and Maull [1977] call an 'interfield'), one would expect evolutionary behavioral scientists to be influenced by both biological disciplines and non-evolutionary human disciplines, and indeed they cite works

[11] Although this is not the focus of the article, our results show that at the beginning of the 2000s the evolutionary behavioral sciences had little contact with neuroscience and neuropsychology, as some critics have noticed (Panksepp and Panksepp [2000]): There are 15 times more citations drawn from behavioral sciences than from fields studying the brain. Neuroscience may have a greater influence on the evolutionary behavioral sciences nowadays than in the early 2000s.

from both groups of disciplines. At the same time, because only 14% of the citations were drawn from the biological disciplines, one might be tempted to conclude from Figure 4 that biological disciplines do not have a large influence on the evolutionary behavioral sciences. If this conclusion were correct, Figure 4 would provide evidence for one of the claims made by the proponents of the disparaging characterization (Hypothesis 1 of Section 2.3): Evolutionary behavioral scientists are insufficiently influenced by biological disciplines. Before drawing this conclusion, it is important, however, to take into account the fact that more articles are published in the non-evolutionary human disciplines (particularly, psychology and medicine) than in the biological disciplines (particularly, evolutionary biology and animal behavior) since this disparity might explain at least in part why there are three times more citations drawn from non-evolutionary human disciplines than from biological disciplines.

To examine this issue, we examined whether the distribution of citations across Categories 1, 2, 5, and 6 differed from the distribution expected on the basis of the relative number of articles published in the biological disciplines, in medicine (physiology, etc.), and in the non-evolutionary behavioral sciences.[12] To estimate the relative number of articles published in these disciplines, we relied on impact factor since differences of impact factors across fields largely reflect differences in the number of articles published (Moed *et al.* [1985]; Bornmann *et al.* [2008]).[13] As a proxy for the mean impact factor in Categories 1, 2, 5, and 6, we used the impact factors of the five journals with the highest impact factors in evolutionary biology, animal behavior, medicine, and psychology.[14] According to ISI Web of Knowledge[SM], for 2007, the five journals with the highest impact factor in evolutionary biology are *Trends in Ecology and Evolution* (14.8), *The Annual Review of Ecology, Evolution, and Systematics* (10.3), *Systematic Biology* (8.8), *Molecular Biology and Evolution* (6.4), and *Molecular Ecology* (5.2) (mean impact factor = 9.1).[15] The five journals with the highest impact factor in psychology are *Behavioral and Brain Sciences* (17.5), *The Annual Review of Psychology* (13.4), *Psychological Bulletin* (10.9), *Trends in Cognitive Sciences* (9.4),

[12] We did not examine Field 7 because of the very small number of citations from this field.

[13] According to ISI Web of Knowledge[SM], <thomsonreuters.com/products_services/science/free/essays/impact_factor/>, the impact factor of a journal for a given year (e.g., 2010) is the average number of citations received in that year (2010) by the articles published in this journal in the two previous years (2008–9).

[14] The field of medicine was chosen as a proxy for Category 5, and the field of psychology was chosen as a proxy for Category 6.

[15] 'Evolutionary Biology' is a distinct category in the search engine of ISI Web of Knowledge[SM]. To identify the journals with the highest impact factors in medicine, we used the categories 'Medicine, General and Internal' and 'Medicine, Research and Experimental'. For psychology, we used the categories 'Psychology, Biological', 'Psychology, Developmental', 'Psychology, Experimental', 'Psychology, Mathematical', and 'Psychology, social'.

Table 1. Observed and expected distributions of citations by fields

Field	Observed *N*	Expected *N*
Evolutionary biology	287	325.9
Animal behavior	178	120.5
Medicine, etc.	532	1091.4
Behavioral sciences	966	424.0

Psychological Review (7.8) (mean impact factor = 11.8). The five journals with the highest impact factor in medicine were *The New England Journal of Medicine* (52.6), *Lancet* (28.6), *Nature Medicine* (28.4), *JAMA* (25.5), and *The Journal of Clinical Investigation* (16.9) (mean impact factor = 30.4). Because ISI Web of Knowledge[SM] does not have an animal behavior category, we examined the impact factors of five prominent journals in this field—viz. *American Naturalist* (4.5), *Journal of Animal Ecology* (3.7), *Behavioral Ecology* (3.0), *Behavioral Ecology and Sociobiology* (2.8), and *Animal Behaviour* (2.8) (mean impact factor = 3.36). An article published in a psychological journal has 130% greater chance and an article in medicine 330% greater chance to get cited than an article published in an evolutionary biology journal in the two years following its publication, while an article published in a psychological journal has 350% greater chance and an article in medicine 900% greater chance to get cited than an article published in an animal behavior journal.

We then compared the distribution of articles across Categories 1, 2, 5, and 6 with the distribution one would have expected if the proportion of articles in these four categories was a mere function of the mean impact factors of the journals in evolutionary biology, animal behavior, medicine, and psychology (Table 1).

The distribution of articles in these four fields is different from the distribution of articles one would have expected on the basis of the mean impact factors of the highest impact journals in these four fields.[16] However, a closer look at the difference between observed and expected numbers for the four categories provides little support for the first version of the first criticism put forward by the proponents of the disparaging characterization: Evolutionary behavioral scientists should cite fewer articles from the biological sciences than one would expect on the basis of the relative number of articles published in this field. While there are fewer citations drawn from evolutionary biology than one would have expected, there are more citations drawn from the literature on animal behavior than one would have expected, suggesting that overall the biological disciplines are not cited less than expected. There is thus little evidence that evolutionary behavioral scientists are insufficiently

[16] $\chi^2(3, N = 1963) = 101, p < 0.001$.

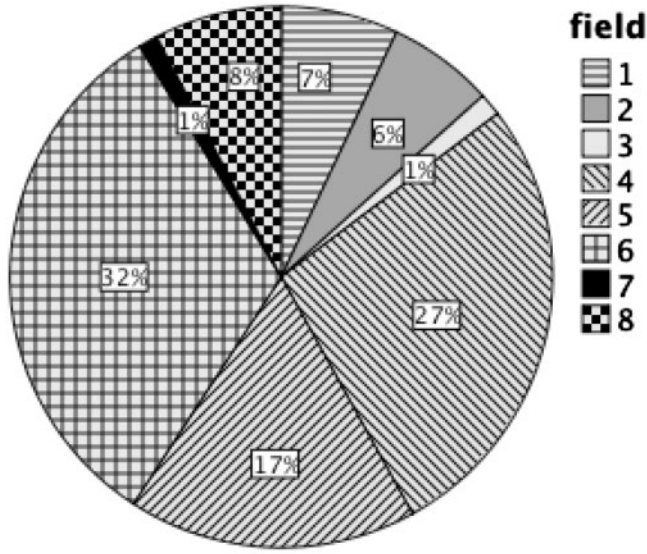

Figure 5. Distribution of unique citations across fields.

influenced by the research done in biology in general, as some proponents of the disparaging characterization (e.g., Woodward and Cowie) would have it.[17]

In response, a proponent of the disparaging characterization might object that the influence of the research in biology is inflated by the study just reported because we have not eliminated the repeated citations from our sample of citations. For instance, if Trivers's ([1971]) article 'The evolution of altruism' is cited by *n* articles, this counts for *n* citations drawn from evolutionary biology in our sample. A proponent of the disparaging characterization might speculate that evolutionary behavioral scientists cite a few citations, such as Trivers's ([1971]) article or Williams's ([1966]) *Adaptation and Natural Selection*, again and again. As a result, the proportion of articles drawn from the biological sciences reported in Figure 4 inflates the true influence of evolutionary biology and the literature on animal behavior on the evolutionary behavioral sciences.

To examine this objection, we reanalyzed the distribution of citations by field after having eliminated the repeated citations, resulting in a sample of 2621 citations (Figure 5).

[17] However, the evolutionary behavioral sciences do not seem to be greatly influenced by the disciplines that study the phylogeny of humans, such as paleoanthropology and archaeology: There are five times more citations drawn from the study of animal behavior than from these disciplines.

The proportion of citations drawn from the biological sciences remains almost unchanged. What changes is the proportion of citations drawn from the non-evolutionary behavioral sciences and from the evolutionary behavioral sciences. This is plausibly due to the conjunction of two phenomena—many articles cite classic works in the evolutionary behavioral sciences (thus many citations drawn from the evolutionary behavioral sciences are repeated, and the proportion of citations in Category 4 decreases when one looks at unique citations), and very few articles cite classic works in the non-evolutionary behavioral sciences (thus, few citations drawn from the non-evolutionary behavioral sciences are repeated, and the proportion of citations in Category 6 increases). For present purposes, what matters is that looking at unique citations does not alter the conclusion drawn above: In contrast to Hypothesis 1, which was inspired by the disparaging characterization, evolutionary behavioral scientists are influenced by the biological sciences.

Some proponents of the disparaging characterization might also object that our focus on the biological sciences in general (what we called 'the first version of the first claim made by critics of the evolutionary behavioral sciences' in Section 1.1) is misplaced since they object to evolutionary behavioral scientists' ignorance of evolutionary biology specifically (what we called 'the second version of the first claim made by critics of the evolutionary behavioral sciences' in Section 1.1). So, are evolutionary behavioral scientists poorly acquainted with evolutionary biology in particular?

To deal with this objection, we recoded the articles that were previously classified under Category 2 (animal behavior) since we needed to determine which of the 178 articles on animal behavior had been written from an evolutionary point of view. Articles on animal behavior written from an evolutionary point of view were reclassified under 1 (evolutionary biology), while articles on animal behavior written from a non-evolutionary point of view remained classified under 2 (animal behavior). An article previously classified under 2 was reclassified under 1 if the research hypothesis was derived from an evolutionary hypothesis or was formulated to test an evolutionary model.[18] Abstracts, introductions, and conclusions of articles as well as the tables of contents of books were examined. For instance, Kempenaers and Sheldon's ([1996]) article 'Why do male birds not discriminate between their own and extra-pair offspring?' published in *Animal Behaviour* was reclassified under 1 on the grounds that its abstract stated that a 'number of recent models of optimal paternal investment predict that males should alter their investment in offspring in response to changes in paternity or certainty of paternity'. In contrast, Whiten's ([1998]) article 'Imitation of the sequential structure

[18] E.M. reclassified these articles.

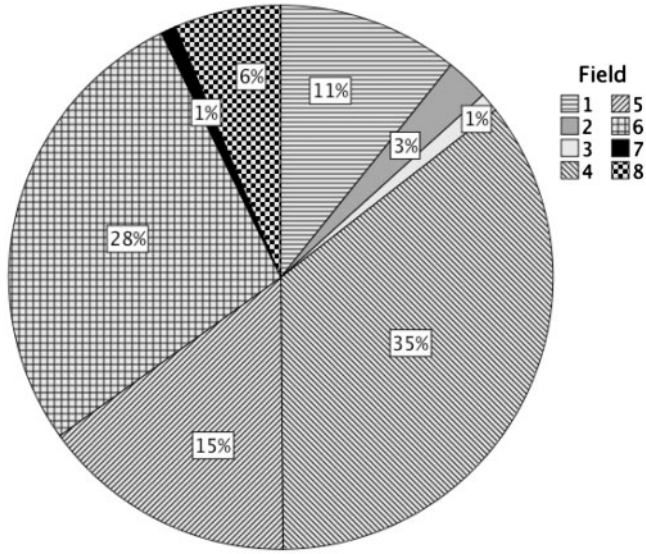

Figure 6. Distribution of citations across fields after reclassification.

of action by chimpanzees (Pan troglodytes)' in the *Journal of Comparative Psychology* remained classified under 2.

About half of the articles previously classified under 2 (49.4%) were reclassified under 1. This high proportion is unsurprising since evolutionary behavioral scientists are more likely to be interested in the study of animal behavior that is informed by evolutionary considerations. Figure 6 presents the distribution of citations across fields that results from this reclassification.

While 14% of our citations were drawn from biological science in our previous analysis (Figure 4), after reclassification, 10.7% are drawn from evolutionary biology in particular. To take into consideration the number of articles published in these different fields, we examined whether the distribution of citations across Categories 1, 5, and 6 differed from the distribution expected on the basis of the relative number of articles published in evolutionary biology, in medicine, and in the non-evolutionary behavioral sciences, using impact factor as a proxy, as we did above. Table 2 presents this analysis.

The assessment of the second version of the first claim made by the critics of the evolutionary behavioral sciences ('Evolutionary behavioral scientists are poorly acquainted with evolutionary biology') leads to a similar conclusion as the assessment of the first version ('Evolutionary behavioral scientists are poorly acquainted with the biological sciences') because much of the research on animal behavior evolutionary behavioral scientists cite is inspired by evolutionary considerations. In fact, Table 2 suggests that evolutionary

Table 2. Observed and expected distributions of citations by fields after reclassification

Field	Observed *N*	Expected *N*
Evolutionary biology	375	334
Medicine, etc.	532	1104
Behavioral sciences	966	435

behavioral scientists cite articles drawn from evolutionary biology slightly more often than one would expect based on the number of articles published in this discipline, the behavioral sciences, and medicine. There is thus little evidence that evolutionary behavioral scientists are poorly acquainted with evolutionary biology.

Finally, one may object that our discussion of Hypothesis 1 fails to address the concerns expressed by Downes, Griffiths, and others. They are not really concerned with the evolutionary behavioral sciences in general; rather, their criticisms are specifically addressed to evolutionary psychologists. However, as we shall see in Section 7, evolutionary psychologists are no less influenced by evolutionary biology than other evolutionary behavioral scientists, such as human behavioral ecologists, and they are equally acquainted with recent work in this discipline.

5 Hypothesis 2: Are Evolutionary Behavioral Scientists Unduly Influenced by the Evolutionary Biology of the 1970s?

To test Hypothesis 2, we examined whether the proportion of citations by periods varies across fields (Figure 7).

As can be seen on Figure 7 (see also Table B1 in Appendix B), several fields show a similar pattern of citation distribution across periods. Of particular interest are fields 1, 2, 5, and 6. Fields 1 and 2 provide the bulk of citations from biological disciplines, while fields 5 and 6 provide the bulk of citations from non-evolutionary human disciplines. The distribution of citations by periods is similar for these four fields, and contrasts with the distribution of citations for the fields of evolutionary behavioral sciences (Field 4) and neuroscience (Field 7).

This finding bears on the second claim made by the proponents of the disparaging characterization of the evolutionary behavioral sciences: Are evolutionary behavioral scientists influenced by out-dated theories in the biological sciences, and in evolutionary biology in particular? In Section 2.3, we operationalized this issue as follows: If the disparaging characterization is right, then the proportion of citations from the 1970s should be greater for

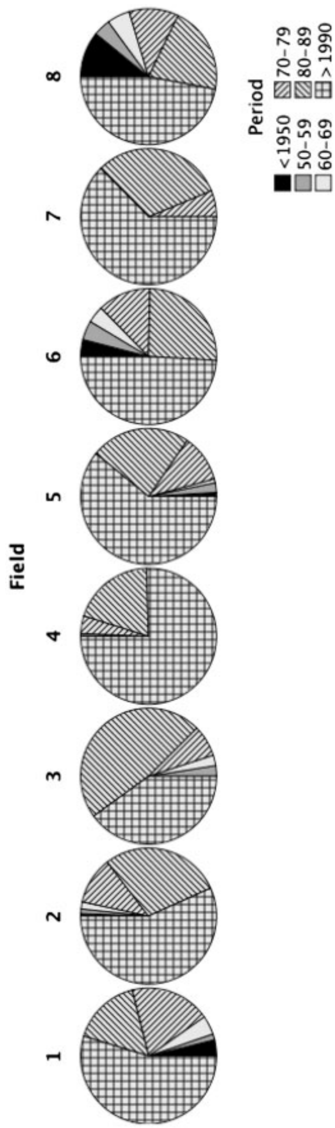

Figure 7. Distribution of citations by field × period.

Table 3. Observed and expected distributions of citations by decades for Field 1 on the basis of the distribution by decades of the citations in Field 6

Period	Observed *N*	Expected *N*
Before 1950	11	11.5
1950–50	4	3.2
1960–69	13	11.5
1970–79	55	36.4
1980–89	47	73.5
After 1990	157	140.9

the biological fields (particularly, fields 1 and 2) than for the fields dedicated to the non-evolutionary human sciences (particularly, fields 5 and 6). The similarity of the distribution of citations across periods for fields 1, 2, 5, and 6 suggests that evolutionary behavioral scientists' acquaintance with the biological sciences, particularly evolutionary biology, is not much more biased toward the 1970s than their acquaintance with psychology or with medicine (if it is biased at all). This is the evidence against the claim that evolutionary behavioral scientists are unduly influenced by the evolutionary theories developed in the 1970s—that is, that their knowledge of evolutionary biology is not up-to-date.

In order to refine this qualitative analysis, we examined quantitatively whether the distribution of citations by periods for evolutionary biology and animal behavior differs from the distribution one would expect if these distributions were identical to the distribution of citations by periods for the non-evolutionary behavioral sciences (Field 6). The distribution of citations in evolutionary biology was significantly different from the expected distribution (Table 3).[19] Similarly, the distribution of citations in animal behavior was significantly different from the distribution one would expect on the basis of the distribution of citations in the non-evolutionary behavioral sciences (Table 4).[20]

Thus, although the citations drawn from evolutionary biology and from the literature on animal behavior and the citations drawn from the human behavioral sciences are similarly distributed, they are not identically distributed. Table 3 reveals two main differences between the distributions of the citations drawn from evolutionary biology and from the non-evolutionary behavioral sciences. There are more citations drawn from evolutionary biology in the 1970s and from contemporary evolutionary biology (articles, books, etc., written after 1990) than expected if the distribution by period of the

[19] $\chi^2(5, N = 287) = 27.45, p < 0.001$.
[20] $\chi^2(5, N = 178) = 15.39, p < 0.01$.

Table 4. Observed and expected distributions of citations by decades for Field 2 on the basis of the distribution by decades of the citations in Field 6

Period	Observed *N*	Expected *N*
Before 1950	1	7.1
1950–50	2	8.2
1960–69	3	7.1
1970–79	20	22.6
1980–89	51	45.6
After 1990	101	87.4

citations drawn from evolutionary biology were identical to the distribution of the citations drawn from the non-evolutionary behavioral sciences. Thus, the citations in research articles in the evolutionary behavioral sciences are somewhat biased toward the 1970s (although not much, as observed above). However, Table 3 also shows that it would be incorrect to conclude from this small bias that evolutionary behavioral scientists are influenced by outdated theories in evolutionary biology or, equivalently, that they are not appropriately influenced by the recent developments in evolutionary biology. We found that the proportion of citations from the 1990s was higher than expected if the distribution of citations drawn from evolutionary biology were identical to the distribution of citations drawn from the non-evolutionary behavioral sciences. Table 4 provides further evidence inconsistent with the claim that evolutionary behavioral scientists are influenced by outdated biology. There are more citations from the literature on animal behavior in the 1990s than expected if the distribution by period of the citations drawn from the literature on animal behavior were identical to the distribution of the citations drawn from the non-evolutionary behavioral sciences.[21] Thus, if anything, evolutionary behavioral scientists seem to rely more on up-to-date information from the literature on animal behavior and from evolutionary biology than from the non-evolutionary behavioral sciences.

Perhaps one could object that it makes little sense to expect the citations from evolutionary biology or the literature on animal behavior to follow the same distribution by periods as the citations from the non-evolutionary behavioral sciences and that, as a consequence, deviations from the expected distribution of citations if it were identical to the distribution of the citations drawn from the non-evolutionary behavioral sciences are not informative. To address this objection, we compared the actual distribution of the citations drawn from evolutionary biology, from the literature on animal behavior,

[21] Keep in mind too that about half of the articles on animal behavior cited by evolutionary behavioral scientists are influenced by evolutionary considerations (Section 3).

from medicine (physiology, etc.: Field 5), and from the non-evolutionary behavioral sciences in the 1970s to the distributions expected for this period in each field on the basis of the exponential curves that best fit the distribution of citations by year in the period 1951–98 for each field. To do so, we plotted the number of citations drawn from evolutionary biology (Field 1), the literature on animal behavior (Field 2), medicine (physiology, etc.: Field 5), and the non-evolutionary behavioral sciences (Field 6) per year for the period 1951–98; we then fitted exponential curves to these plots (since the best fitting curve to the complete sample was exponential). This controls for the problem raised above because we do not derive the expected distribution of the citations in the 1970s for a given field from another field, but from the complete (1951–98) distribution by year of citations for this field. Figures 8–11 present these curves.[22]

The best fitting exponential curves explained 43% of the variance for the citations drawn from evolutionary biology per year, 51% for the citations drawn from the literature on animal behavior, 46% for the citations drawn from medicine, physiology, and psychiatry (Field 5), and 52.5% for the citations drawn from the non-evolutionary behavioral sciences. We then computed the sum of the residuals for the period 1970–79 (Table 5). This sum indicates the extent to which the actual distribution differs from the expected distribution. A positive sum shows that the number of citations for the period 1970–79 is higher than expected.

For the four fields of interest, more citations of articles written during the 1970–79 period were made than one would have expected on the basis of the exponential increase in citations. The deviation for the biological sciences (fields 1 and 2) is about the same as the deviation for the non-evolutionary human sciences (fields 5 and 6). The deviation is also larger for the citations drawn from evolutionary biology than it is for the citations drawn from the non-evolutionary behavioral sciences; on the other hand, it is about the same for the citations drawn from evolutionary biology and from medicine, physiology, and psychiatry; finally, the deviation is slightly smaller for the citations drawn from the literature on animal behavior than it is for the non-evolutionary behavioral sciences. This is consistent with our previous analysis. Evolutionary behavioral scientists are not unduly influenced by the work done in the biological sciences in the 1970s. They are somewhat more influenced by the work done in the 1970s in evolutionary biology than they are by the work done in the 1970s in the behavioral sciences, but they are not more influenced by the work done in the 1970s on animal behavior than by the work done in the 1970s on medicine, physiology, and psychiatry.

[22] For each field, linear curves fit the distribution by year of the number of citations better than exponential curves. However, these curves fail to capture the increasing rate of citations across time.

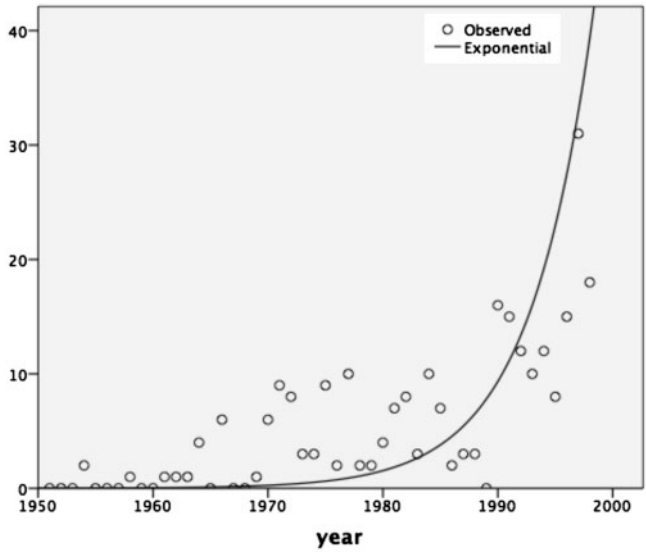

Figure 8. Distribution by year of the citations drawn from evolutionary biology.

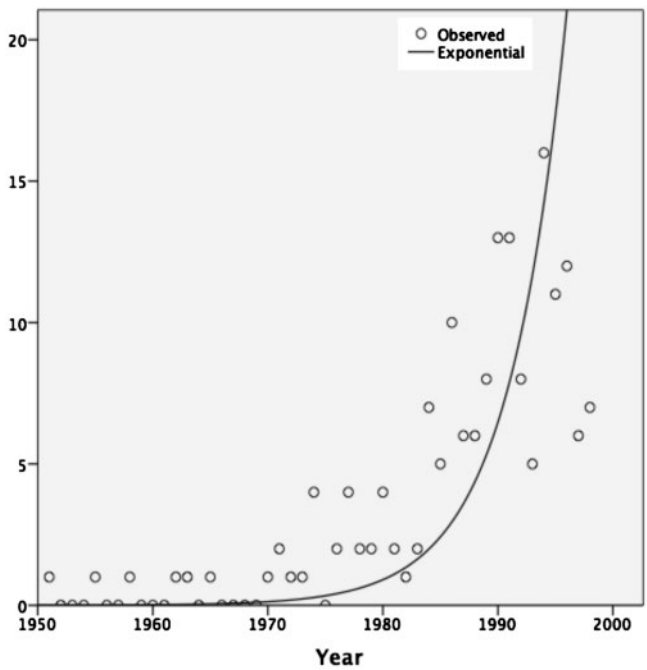

Figure 9. Distribution by year of the citations drawn from the literature on animal behavior.

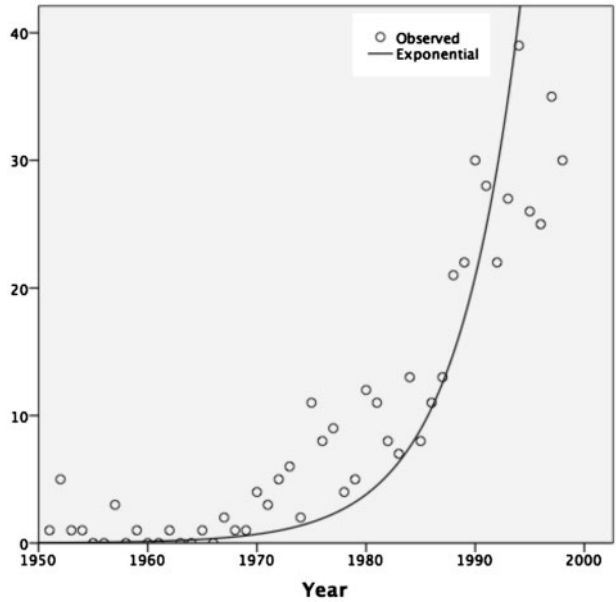

Figure 10. Distribution by year of the citations drawn from medicine, physiology, and psychiatry.

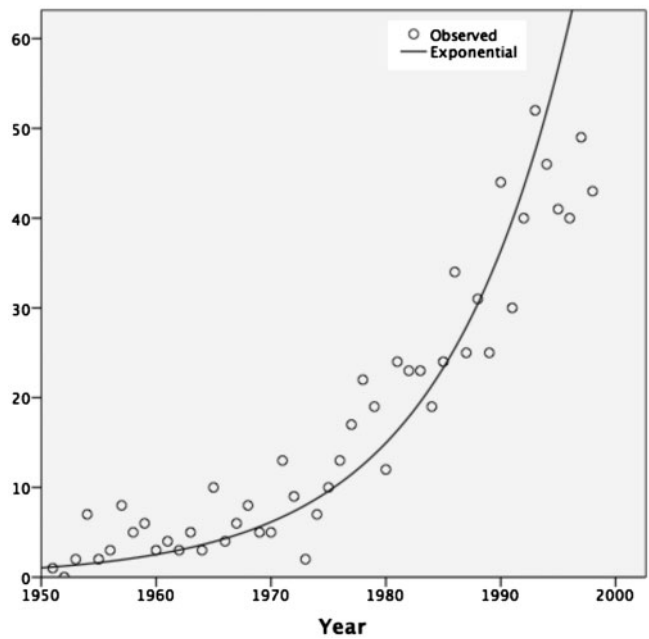

Figure 11. Distribution by year of the citations drawn from the non-evolutionary behavioral sciences.

Table 5. Sum of the residuals for the period 1970–79

	Field 1	Field 2	Field 5	Field 6
Sum	47.5	15.4	40.2	22.3

Finally, to control for the fact that some citations are repeated numerous times, we examined the distribution of unique citations by field × period, as we did in Section 4 (Figure 12).

The distribution represented in Figure 12 is similar to the distribution represented in Figure 7, suggesting that our findings are not due to evolutionary behavioral scientists citing the same articles from the 1970s, 1980s, or 1990s again and again.

To conclude, we found no evidence for a grossly distorted influence of the theories and findings in the evolutionary biology of the 1970s on the contemporary evolutionary behavioral sciences. The distributions by decades of the citations drawn from evolutionary biology and from the literature on animal behavior are by and large similar to the distribution of the citations drawn from the non-evolutionary behavioral sciences. It is true that evolutionary behavioral scientists tend to cite somewhat more, but not much more, articles from the evolutionary biology of the 1970s than one would expect on the basis of the citations drawn from the non-evolutionary behavioral sciences. On the other hand, they tend to cite fewer articles from the literature on animal behavior of the 1970s than one would expect, and they cite a greater number of recent articles from the contemporary evolutionary biology than one would expect.

6 Hypothesis 3: What is the Relation between Sociobiology and the Evolutionary Behavioral Sciences?

The relation between classical sociobiology and the evolutionary behavioral sciences remains a matter of controversy. In Section 2.3, we operationalized the stance of the proponents of the disparaging characterization as follows: If the contemporary evolutionary behavioral sciences are unduly influenced by classical sociobiology, then the proportion of citations from the 1970s and 1980s should be larger for the evolutionary behavioral sciences than what one would expect on the basis of the distribution by periods of the citations in other fields (e.g. non-evolutionary behavioral sciences). To test this prediction, we compared the observed distribution by periods for Field 4 with the expected distribution if the distributions for Field 4 were identical to the distributions for Field 5 (Table 6) and Field 6 (Table 7).

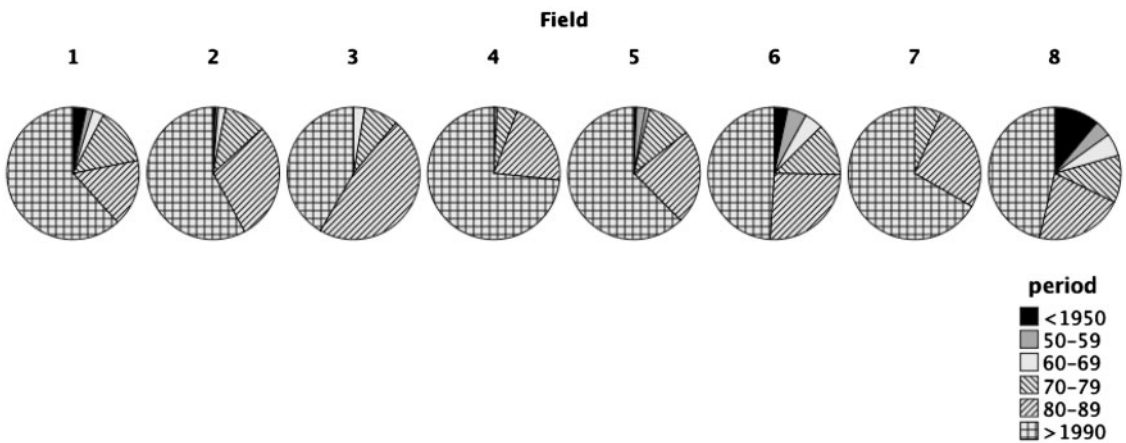

Figure 12. Distribution of unique citations by field × period.

Table 6. Observed and expected distributions by period of the citations drawn from the evolutionary behavioral sciences (based on Field 5)

Period	Observed *N*	Expected *N*
Before 1950	1	11.1
1950–50	1	28.4
1960–69	6	11.1
1970–79	52	139.4
1980–89	243	292.5
After 1990	931	750.3

Table 7. Observed and expected distributions by period of the citations drawn from the evolutionary behavioral sciences (based on Field 6)

Period	Observed *N*	Expected *N*
Before 1950	1	49.4
1950–50	1	56.8
1960–69	6	49.4
1970–79	52	156.7
1980–89	243	315.9
After 1990	931	650.9

The distribution by periods of the citations drawn from the evolutionary behavioral sciences was significantly different from what one would expect if it were identical to the distribution by periods of the citations drawn from medicine, physiology, and psychiatry (Field 5) and from the human behavioral sciences (Field 6).[23] Tables 6 and 7 reveal the same pattern: Evolutionary behavioral scientists cite much less research done in the evolutionary behavioral sciences before 1990 and much more research done after 1990 than expected. These findings provide evidence that the connection between the contemporary evolutionary behavioral sciences and classical sociobiology is more tenuous than what is often asserted (e.g. Sterelny and Griffiths [1999]): Evolutionary behavioral scientists do not seem to be very much influenced by classical sociobiology.

7 Hypothesis 4: Do the Evolutionary Behavioral Sciences Divide into Competing Paradigms?

Proponents of the disparaging characterization often assert that the evolutionary behavioral sciences divide into at least three competing paradigms.

[23] Comparison with the expected distribution based on Field 5: $\chi^2(5, N = 1234) = 401.5$, $p < 0.001$; comparison with the expected distribution based on Field 6: $\chi^2(5, N = 1234) = 144.6$, $p < 0.001$.

In Section 2.3, we operationalized this hypothesis as follows: If there are such paradigms, then it should be possible to identify different patterns of citation distribution in the articles written by evolutionary psychologists and by behavioral ecologists; particularly, one would expect the latter to cite more research from the biological sciences than the former. To test Hypothesis 4, we compared the distribution by fields of the citations found in the articles written by evolutionary behavioral ecologists and by evolutionary psychologists (Figure 13).[24]

As Figure 13 shows (see also Table B2 in Appendix B), the distribution of citations by fields is qualitatively similar for evolutionary psychologists (Authors' Field 1) and for human behavioral ecologists (Authors' Field 2).

To examine Hypothesis 4 quantitatively, we compared the observed distribution by field of the citations found in the articles written by evolutionary psychologists with the distribution one would expect if evolutionary psychologists and human behavioral ecologists cited identically (Table 8).

The observed distribution differs significantly from the expected distribution based on the distribution by field of the citations found in the articles written by human behavioral ecologists: Evolutionary psychologists and human behavioral ecologists cite differently.[25] However, this difference falls short of showing that they form the two incompatible paradigms that have been depicted by the disparaging characterization. Instead, it suggests that evolutionary psychology and human behavioral ecology form two distinct research traditions.

The reason is that the citation patterns in these two research traditions are fairly similar. When the fields are rank-ordered as a function of the number of citations, a common pattern is clearly apparent. The evolutionary behavioral sciences provide more citations than any other field for both traditions, followed by the non-evolutionary behavioral traditions. Medicine, physiology, and psychiatry is the third field for evolutionary psychology and the fourth for human behavioral ecology, while evolutionary biology is the third field for human behavioral ecology and the fourth one for evolutionary psychology. Finally, for both traditions, the literature on animal behavior is the fifth field in terms of the number of citations. Based on citation patterns, evolutionary psychology, and human behavioral ecology are thus more similar than one would expect if these were really two incompatible paradigms. Thus, in light of the distinction between paradigms and research traditions introduced in Section 1, evolutionary psychology and human behavioral ecology form two distinct research traditions rather than two competing paradigms.

[24] We set aside dual-inheritance theory because in the period examined only one relevant article was published in *Evolution & Human Behavior*.

[25] $\chi^2(7, N = 1814) = 491.8, p < 0.001$.

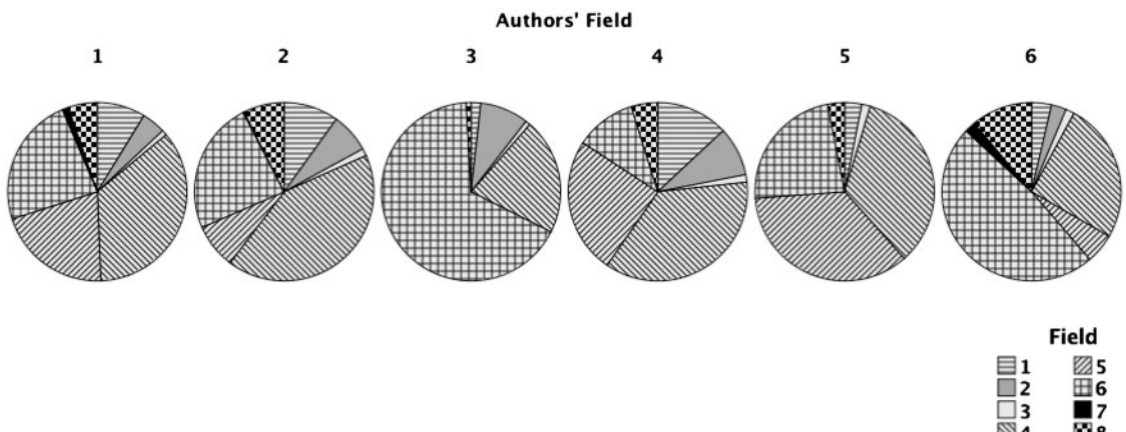

Figure 13. Distribution of citations by field × authors' discipline.

Table 8. Observed and expected distributions of citations per field in the evolutionary psychologists' articles

Field	Observed *N*	Expected *N*
Evolutionary biology	158	179.58
Animal behavior	78	128.79
Phylogeny of humans	17	23.58
Evol. behavioral sciences	643	761.88
Medicine, etc.	375	146.93
Behavioral sciences	427	435.36
Neuroscience	21	3.63
Others	95	134.24

It is also worth noting that the specific nature of the differences between the distributions by field of the citations found in the articles written by evolutionary psychologists and by human behavioral ecologists is at odds with the contrast drawn by philosophers between evolutionary psychology and human behavioral ecology (Section 1.5). While one might have expected evolutionary psychologists to cite much more often articles drawn from the non-evolutionary behavioral sciences than human behavioral ecologists, this is not the case. For instance, 23.5% of the citations in articles published by human behavioral ecologists are drawn from the non-evolutionary behavioral sciences, while the proportion is 24% for the articles published by evolutionary psychologists. Furthermore, one might have expected human behavioral ecologists to cite much more articles drawn from evolutionary biology than evolutionary psychologists, and this is not the case either: The respective proportions are 8.7 and 9.9%. Thus, the contrast drawn between evolutionary psychology and human behavioral ecology by the proponents of the disparaging characterization, according to which the former, but not the latter, ignore the biological sciences, is misguided.

What distinguishes these two research traditions is, surprisingly, the fact that evolutionary psychologists cite substantially more articles from medicine, physiology, and psychiatry than human behavioral ecologists, while human behavioral ecologists cite substantially more articles from the evolutionary behavioral sciences than evolutionary psychologists. One possible explanation of the latter finding is that human behavioral ecology is more influenced by animal and human sociobiology than evolutionary psychology. If this were the case, one would expect the difference between the number of citations drawn from the evolutionary behavioral sciences by human behavioral ecologists and evolutionary psychologists to be larger for the 1970s than for the 1990s. Figure 14 shows that this is indeed the case (see also Table B3 in Appendix B).

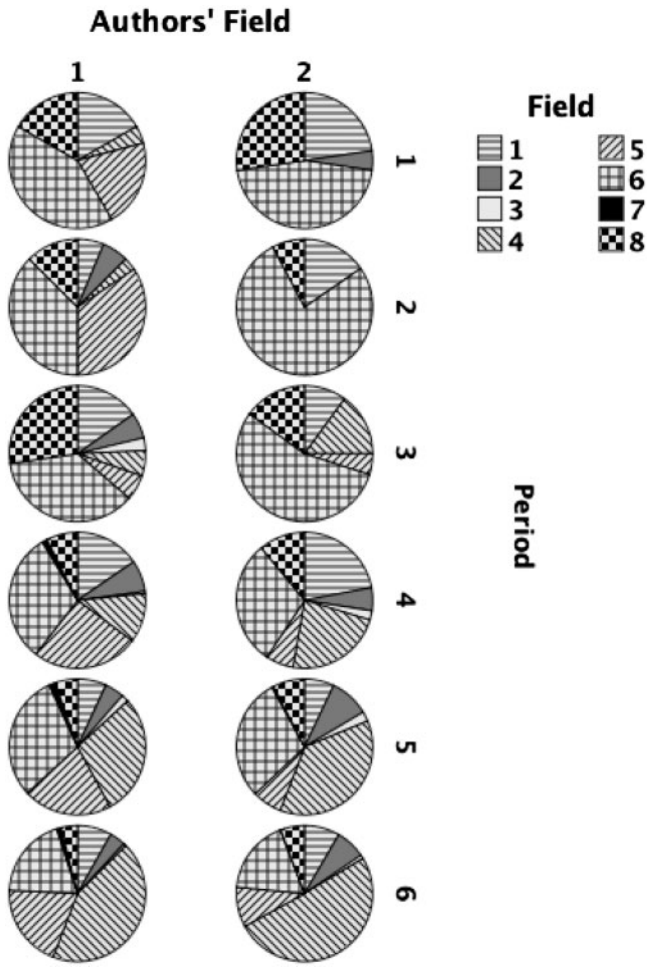

Figure 14. Distribution of citations by period × field for the articles written by evolutionary psychologists and human behavioral ecologists.

There are twice (1.97) as many citations from the evolutionary behavioral sciences of the 1970s in the articles written by human behavioral ecologists than in the articles written by evolutionary psychologists. This ratio becomes 1.28 for the citations drawn from the evolutionary behavioral sciences of the 1980s and 1.17 for the citations posterior to 1990.

One could perhaps object that we classified as evolutionary psychologists scientists that are committed to distinct scientific approaches. For example, one might criticize our decision to classify Manning and Silverman as evolutionary psychologists on the grounds that their work differs from Tooby and Cosmides's. In this spirit, Downes ([2005]) distinguishes 'evolutionary

psychology' (illustrated by Singh's work) from 'fluctuating asymmetry research' (illustrated, e.g. by Gangestad's work) and 'chemical signaling research' (illustrated, e.g. by Wedekind's work). One would then conclude that we have not really tested whether evolutionary psychology forms a distinct paradigm that is squarely different from the other paradigms that make up the evolutionary behavioral sciences.

In reply, we maintain that our classification is entirely appropriate.[26] First, we used the authors' characterization of their own work as belonging to evolutionary psychology to classify them as evolutionary psychologists. Second, Barkow, Cosmides, and Tooby's edited collection *The Adapted Mind*, which is often viewed as fundamental in the development of evolutionary psychology, includes a large range of authors, using a range of methodological tools, working on many different topics, and endorsing various assumptions about the nature of our cognitive processes. These authors included, e.g. Nesse, Profet, Silverman, and Shepard, a collection of scientists in no way more diverse than the scientists grouped under Category 1. Third, the works of the authors we classified as evolutionary psychologists are typically cited together, suggesting that the scientific community treats these authors as forming a single research community.

To summarize, our findings undermine the hypothesis that the evolutionary behavioral approaches to human behavior and psychology divide into distinct incompatible paradigms. Instead, they constitute distinct research traditions. Evolutionary psychologists and human behavioral ecologists cite differently: In particular, they do not appeal to the research in the evolutionary behavioral sciences and in medicine/psychiatry/physiology to the same extent. A possible explanation of this finding is that human behavioral ecologists may view the evolutionary behavioral sciences as being continuous with classical sociobiology and may thus be more likely to cite research in sociobiology. But the similarities between the citation patterns in both traditions are equally, if not more, striking. Particularly, evolutionary psychologists and human behavioral scientists appeal to evolutionary biology and non-evolutionary behavioral sciences in the same proportion—that is, they are influenced by these two fields to the same extent. Importantly, the fact that evolutionary psychologists and human behavioral ecologists cite articles drawn from evolutionary biology in the same proportion is evidence against the suggestion that evolutionary psychologists' acquaintance with biology is much weaker and more superficial than human behavioral ecologists'.

[26] In future work, we plan to use other, more objective methods to identify scientific groups within the evolutionary behavioral sciences. Particularly, we intend to examine the clusters of co-citations, a method successfully used to identify research communities and to describe their relations (Small and Griffith [1974]; Klavans and Boyack [2009]).

8 An Evidence-based Characterization of the Evolutionary Behavioral Sciences

The analyses we reported have yielded unexpected findings that bear on the assessment of the disparaging characterization of the evolutionary behavioral sciences. Before examining the significance of these findings, however, we would like to highlight some important limitations of our analyses. Not all claims made by the proponents of the disparaging characterization can be handled by examining quantitatively evolutionary behavioral scientists' acquaintance with particular scientific fields at particular times. In particular, this method is of no use to determine whether evolutionary behavioral scientists understand and apply properly the discovery heuristics and confirmation strategies that are common in evolutionary biology, whether evolutionary psychologists are more likely than human behavioral ecologists to make such mistakes, and whether evolutionary behavioral scientists are repeating the mistakes made by sociobiologists. Only a content analysis could answer such questions. As a result, our analyses do not provide a definitive assessment of the disparaging characterization, and critics of the evolutionary behavioral sciences still have grounds to find them wanting. That said, our analyses do bear on some important claims made by the proponents of the disparaging characterization. Let's now summarize what we have learned.

Evolutionary behavioral scientists are not ignorant of the biological sciences in general, since the respective influence of the biological (evolutionary biology and the literature on animal behavior) and of the non-evolutionary human sciences (medicine, physiology, anthropology, etc.) is approximately proportional to their scientific output. Furthermore, focusing on evolutionary biology in particular instead of the biological sciences in general, it is also not the case that evolutionary behavioral scientists ignore evolutionary biology.

Still, evolutionary behavioral scientists are somewhat less influenced by evolutionary biology than one might wish (only one citation out of nine is drawn from this discipline), and the non-evolutionary behavioral sciences have the largest influence on them. Thus, even though the evolutionary behavioral sciences are a true interfield, inspired by two different kinds of disciplines, they seem to be more closely aligned on the behavioral sciences. Another way to put this point is that the evolutionary behavioral sciences are behavioral sciences done from a particular perspective—viz. inspired by the biological sciences—rather than an evolutionary science focused on human behavior.

It is also not the case that the contemporary evolutionary behavioral sciences are unduly influenced by the biological sciences of the 1970s. Evolutionary behavioral scientists cite about the same proportion of articles from the biological sciences of the 1970s as from the non-evolutionary

behavioral sciences of the 1970s. Again, there is a small difference between evolutionary biology and the literature on animal behavior: The proportion of articles from the evolutionary biology of the 1970s (but not from the literature on animal behavior) cited by evolutionary behavioral scientists is larger than the proportion of articles from the non-evolutionary behavioral sciences of the 1970s. Furthermore, the deviation between the actual number of citations from the 1970s and the expected number based on the exponential growth of citations is larger for evolutionary biology than it is for the non-evolutionary behavioral sciences. On the other hand, the proportion of recent evolutionary biology articles (i.e. written after 1990) cited by evolutionary behavioral scientists is larger than the proportion of recent articles from the non-evolutionary behavioral sciences.

We found no evidence that the research done by contemporary evolutionary behavioral scientists is deeply rooted in classical sociobiology. Rather, evolutionary behavioral scientists cited a smaller proportion of articles from the evolutionary behavioral sciences of the 1970s than of articles from the non-evolutionary behavioral sciences of the same period and a larger proportion of recent articles from the evolutionary behavioral sciences than of articles from the non-evolutionary behavioral sciences of the same period. This suggests that evolutionary behavioral scientists are not very much influenced by classical sociobiologists and that they view their own field as recently developed (rather than as being continuous with the sociobiology of the 1970s or, say, the human ethology of the 1960s). This is more the case of evolutionary psychologists than of human behavioral ecologists, the latter being more influenced by classical sociobiology than the former.

Finally, we found some evidence that the evolutionary behavioral sciences divide into several distinct research programs since the citation patterns differ between evolutionary psychologists and human behavioral ecologists. However, the similarities between the citation patterns of evolutionary psychology and human behavioral ecology suggest that they do not form two distinct competing paradigms. Furthermore, our quantitative analysis of the citations in the articles written by evolutionary psychologists and human behavioral ecologists shows that the typical contrast drawn by proponents of the disparaging characterization is incorrect: Evolutionary psychologists are as much influenced by evolutionary biology as human behavioral ecologists, and it is human behavioral ecology rather than evolutionary psychology that is more influenced by the sociobiology of the 1970s.

Thus, there is certainly a grain of truth in the disparaging characterization. Evolutionary behavioral scientists ignore much of the research on the phylogeny of humans. Their research is somewhat less influenced by evolutionary biology than one might wish, and it is also a bit more influenced by the

evolutionary biology of the 1970s than one would expect. Finally, the evolutionary behavioral sciences do divide into distinct research programs.

That acknowledged, our results are at odds with some important claims made by the proponents of the disparaging characterization of the evolutionary behavioral sciences. Evolutionary behavioral scientists ignore neither the biological sciences nor, more specifically, evolutionary biology, they are not blind to the recent research in evolutionary biology, they are not much influenced by classical sociobiology, and the identifiable research traditions do not really form competing paradigms. Keeping in mind the inherent limitations of quantitative citation analysis, our findings suggest that it is erroneous for philosophers to base their evaluation of the epistemic worth of the evolutionary behavioral sciences on the disparaging characterization of these sciences.

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Edouard Machery
Department of History and Philosophy of Science,
University of Pittsburgh, 1017CL,
Pittsburgh, PA 15260,
USA
machery@pitt.edu

Kara Cohen
elpoep@gmail.com

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Appendix A: The Influence Assumption

Because the assumption that citation is a valid measure of influence is central for the research reported in this article, it is important to examine it more closely.[27] Both components of this assumption have been criticized.[28] First, some view citation as a rhetorical tool. According to this view, researchers (exclusively or mostly) cite in order to persuade others of the validity of the research they report (Gilbert [1977], p. 116; Woolgar [1991]), to indicate their familiarity with an established literature, or to mark affiliation with a specific scientific research tradition (Latour [1987], pp. 33–4). Second, other critics have claimed that numerous influences are not cited (MacRoberts and MacRoberts [1986], [1987], [1996]).

Much research has been done to test these criticisms, and overall research fails to support them (for review, see Bornmann and Daniel [2008]). As the critics of the influence assumption have argued, researchers do cite for several distinct reasons, including rhetorical reasons.[29] However, surveys of researchers' reasons for citing and analyses of the citations they make have repeatedly shown that most citations are not made for merely rhetorical purposes (e.g. Baldi [1998]; Van Raan [1998]).[30] Furthermore, because rhetorical reasons to cite tend to be idiosyncratic, while acknowledging influence is not, citations provide a measure of influence when one aggregates numerous articles (Stigler [1987]; Kostoff [1998]; Van Raan [1998]).

It is also true that numerous influences are not acknowledged. Citation analysts themselves have shown that, when a work becomes so well-known as to enter the common knowledge of the researchers in a field, it is cited less frequently because researchers expect their readers to understand its connection with the reported research (a phenomenon called 'obliteration by

[27] One might worry that the influence assumption cannot be correct as one can cite an article to argue against it instead of acknowledging an influence. However, bibliometric research shows that in science citations are almost always positive.

[28] Another controversy spurred by citation analysis is whether the number of citations is a good measure of the quality of an article, book, etc. (Moed [2005]). The research reported here does not depend on one's views about this controversy.

[29] As Kostoff puts it ([1998], p. 31): '[T]here are many reasons for an individual to select particular references for inclusion in a paper, only one of which is the dominant contribution of citations to research impact, significant intellectual heritage.'

[30] Of course, a citation can have several functions simultaneously: It can acknowledge influence and try to persuade.

incorporation' by Garfield [1975] and Garfield and Cawkell [1975], following Merton [1949]). Older works are also less cited than more recent works, which constitute 'the research front' (De Solla Price [1965]; Braam *et al.* [1991a], [1991b]). However, these considerations do not undermine the reliance on the influence assumption in most situations. While it would be inappropriate to compare the influence of works or authors that are separated by decades (e.g. Einstein and physicist Sean Carroll) by looking at the number of citations, it is fine to rely on the influence assumption when one is focusing on a single period (as we do in this article). In addition, the influence assumption is valid when one is comparing the influence of authors, institutions, research traditions, or fields and the causes that explain non-citation (e.g. obliteration by incorporation) affect these authors, institutions, traditions, or fields similarly.

Furthermore, quantitative citation analysis, based on the influence assumption, has been used in numerous successful studies in the sociology of science, documentation, and information science. For instance, in a ground-breaking study, Garfield ([1972]) used a quantitative citation analysis to study the dissemination of information across the network of scientific journals (for another classic, see De Solla Price [1965]). If the influence assumption were mistaken, then Garfield's study and numerous similar studies would have been entirely uninformative, and the utility of such studies in, e.g. the management of libraries and science policy would be puzzling (Garfield [1972]; Wade [1975]). In addition, many results of quantitative citation analyses have been validated with other measures (e.g. Garfield [1997], [1998]; Garfield *et al.* [1978]), providing further evidence for the influence assumption.

Appendix B

Table B1. Distribution of citations by periods for the eight fields

Field	<1950 (%)	1950–59 (%)	1960–69 (%)	1970–79 (%)	1980–89 (%)	>1990 (%)
Evolutionary biology	3.8	1.4	4.5	19.2	16.4	54.7
Animal behavior	0.6	1.1	1.7	11.2	28.7	56.7
Phylogeny	0.0	2.5	2.5	7.5	47.5	40.0
Evolutionary behavioral sciences	0.1	0.1	0.5	4.2	19.6	75.4
Medicine, etc.	0.9	2.3	0.9	11.3	23.7	60.8
Behavioral sciences	4.0	4.6	4.0	12.7	25.6	49.1
Neuroscience	0.0	0.0	0.0	6.3	31.3	62.5
Others	29.6	12.3	15.2	11.8	20.8	47.1

Table B2. Distribution by fields of the citations made by distinct groups of authors

	Evolutionary psychology (%)	Behavioral ecology (%)	Dual-inheritance theory (%)	Evolutionary biology and animal behavior (%)	Medicine and physiology (%)	Others (%)
Evolutionary biology	8.7	9.9	1.8	13.0	3.1	3.6
Animal behavior	4.3	7.1	8.8	8.9	0.0	2.7
Phylogeny	0.9	1.3	0.9	1.4	1.5	1.6
Evolutionary behavioral sciences	35.4	42.0	21.1	36.3	33.8	25.5
Medicine, etc.	20.7	8.1	0.0	24.7	35.4	5.4
Behavioral sciences	23.5	24.0	66.7	11.0	23.1	48.2
Neuroscience	1.2	0.2	0.0	0.0	0.0	2.0
Others	5.2	7.4	0.9	4.8	3.1	11.0

Table B3. Distribution of citations by periods for the eight fields in the articles written by evolutionary psychologists (left columns) and by behavioral ecologists (right columns)

Field	<1950 (%)		1950–59 (%)		1960–69 (%)		1970–79 (%)		1980–89 (%)		>1990 (%)	
Evolutionary biology	16.7	22.7	6.3	15.4	15.2	10.0	15.4	22.0	6.9	7.0	8.1	8.4
Animal behavior	0.0	4.5	6.4	0.0	6.1	0.0	7.4	5.5	4.6	9.4	3.8	7.1
Phylogeny	0.0	0.0	0.0	0.0	3.0	0.0	0.6	2.2	1.8	2.3	0.7	0.9
Evolutionary behavioral sciences	4.2	0.0	3.1	0.0	6.1	15.0	11.7	23.1	28.9	37.1	43.5	50.6
Medicine, etc.	20.8	0.0	34.4	0.0	6.1	5.0	25.3	6.6	21.1	7.0	19.9	9.5
Behavioral sciences	41.7	45.5	37.5	76.9	36.4	55.0	30.9	29.7	29.9	29.1	19.3	17.7
Neuroscience	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.5	0.5	1.1	0.2
Others	16.7	27.3	12.5	7.7	27.3	15.0	7.4	11.0	5.3	7.5	3.9	5.6