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The Social Resonance of Competitive and Progressive Evolutionary Metaphors

BRENDON M. H. LARSON

Metaphors of competition and progress have played a key role in the scientific conception and public understanding of evolution. These scientific and public aspects have been in continual tension, however, since these metaphors have been broadly interpreted in the social realm despite scientists' attempts to isolate their meaning. To examine how this occurs, I conducted a Web survey of evolutionary biologists (Society for the Study of Evolution), evolutionary psychologists (Human Behavior and Evolution Society), biology teachers (National Association of Biology Teachers), and members of a Teilhardian spiritual organization (Foundation for Conscious Evolution) (N = 1892 respondents). Respondents were asked to evaluate the scientific and social dimensions of 18 evolutionary statements with metaphorical elements, including arms race, complexity, cooperation, drift, intelligent design, progress, selfish gene, sperm competition, and struggle for survival. The responses generally confirmed the demise of a progressive view of evolution, whereas competitive metaphors remained popular even though respondents indicated that they had a negative social resonance. The survey reveals how biological metaphors retain connections to everyday understanding, which has implications for teaching biology and for thinking about how biologists may unwittingly endorse particular social policies with their metaphors.

Keywords: biology education, dead metaphor, naturalistic fallacy, root metaphor, worldview

In an article in *BioScience,* Rozzi (1999) explored the reciprocal interaction between evolutionary–ecological sciences and environmental ethics, focusing on the role of metaphors as "cultural messengers." He reviewed how the individualistic and Hobbesian ethics of Victorian society endorsed application of the phrase "a struggle for existence" within biological science. Through this transfer from its usual social context to a natural one, the struggle became metaphorical. Furthermore, it now inhered in nature itself, so it became a "fact" that could be used to justify policies such as social Darwinism. By a similar process, metaphors may commonly create feedback between biological understanding and its cultural milieu (figure 1; see also Bono 1990, Maasen et al. 1995). Particular metaphors may thus reinforce prevailing cultural values by giving them a basis in the natural world ("naturalization") and in science (Gilbert 1979, Stepan 1986). The struggle for existence, for example, "is only one particular mode of representation of natural relationships" (Rozzi 1999), but it has had a marked impact on how scientists and others interpret social interactions (Taylor 1998, Jackson 2003).

Biological metaphors act as cultural messengers because they are drawn from everyday language and hence cannot be isolated from their social context. Biologists cannot restrict the movement of their metaphors simply by giving them a technical meaning, for they continue to resonate with their usual one (Keller 1991, Baake 2003). As an example, the metaphor of progress entwined evolutionary biology with popular culture because it was impossible to remove its association with cultural progress, the idea that human societies improve over time (Ruse 1996). Even if scientists lose sensitivity to this initial meaning of a metaphor—it becomes "dead"—nonscientists may still detect it. Furthermore, Baake (2003) describes how this resonance may vary for people of different backgrounds and social situations, giving rise to "harmonics" that we need to understand for effective science communication (see Weber and Word 2001).

Some of these metaphoric harmonics might lead people to draw social conclusions from scientific research findings, a move that has been dubbed the naturalistic fallacy. One commits this fallacy by drawing a value inference (an "ought") from a factual premise (an "is"). Evolutionary psychologists invoke the naturalistic fallacy to prevent this inference, but they simultaneously avoid necessary discussion of the ethical dimension of their claims about evolved behaviors (Wilson et

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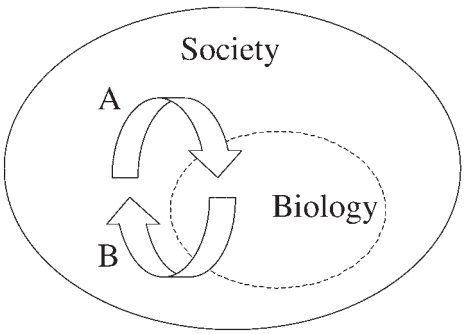

Figure 1. Metaphors as cultural messengers. This figure emphasizes that metaphors move bidirectionally between science and society, creating a circularity (A, from society into biology; B, from biology into society). When biologists select a metaphor (A) they may endorse particular cultural values and assumptions, which may reinforce them within our thought, language, and worldview (B). For elaboration, see Larson (2004).

al. 2003). Similarly, Futuyma (1986) states in his classic evolutionary biology textbook that "the objective science of evolutionary biology has often been extended into the subjective realm of ethics and used illegitimately as justification for both pernicious and humanitarian economic, social, and political policies" (p. 16). Wilson and colleagues (2003) point out, however, that scientific findings should certainly have some bearing on society—it is just not clear how best to integrate them with desired social objectives. When biologists appeal to the naturalistic fallacy, they disclaim responsibility for the potential social ramifications of their research. More important in the context of this article, history demonstrates that this purported fallacy has done little to prevent unruly metaphors from combining "is" and "ought" and moving haphazardly between science and society.

Here I report the results of a large-scale Web survey that examined the role of metaphors as cultural messengers linking biology and society. It focused on how people evaluate two metaphors, competition and progress, which have been critical to the constitution, reception, and social implications of evolutionary theory. The survey sought to address three questions: (1) Do respondents consider these metaphors empirically accurate? (2) Do respondents detect a social resonance in these metaphors? and (3) Do these results differ among respondents from organizations with contrasting relationships to evolutionary science?

Progress and competition as evolutionary metaphors

Before addressing the questions above, I will briefly review the social context of progressive and competitive evolutionary metaphors since Darwin's time.

Progress. A progressive interpretation of history came into its heyday in the 18th and 19th centuries because of the technological success of science. This success enticed Western scientists to see themselves as the apex of a long line of human history and to metaphorically project this view onto nature. Although Darwin himself equivocated about progress, the 19th-century zeitgeist contributed to a progressive interpretation of his theory (see Larson 2004 for further discussion). In his magnum opus on evolutionary progress, Ruse (1996) details how that concept motivated such influential evolutionists as R. A. Fisher and Sewall Wright in the 20th century, concluding that "evolutionary thought is the child of Progress."

Evolutionary progress is an ambiguous and contested concept. For clarification, Shanahan (2000) defined it as "gradual directional change embodying improvement." While this definition helps insofar as gradual directional change is intrinsic to neo-Darwinian naturalism, biologists may still contest it because of an explicit valuation component, that of improvement. Improvement may occur in two forms, relative (or comparative) and absolute (Ruse 1993). Relative improvement occurs when there is gradual change against a standard within a lineage over time, and it is most evident in directional trends in the fossil record. These trends result from natural selection, which adapts organisms to their environment such that the "fit" may become better over time. With absolute progress, in contrast, life improves on the whole, even among evolutionary lineages. Biologists are less comfortable with absolute progress because its proponents have tended to emphasize anthropocentric features that place humans at the apex of evolutionary history.

Partly because of this anthropocentrism, evolutionary progress became less popular in evolutionary biology over the course of the 20th century. Ruse (1996) argued that evolutionists had to exclude progress and its cultural values for their field to be recognized as a valid, professional science. Simultaneously, the cultural elements of progress came under scrutiny as environmental destruction, totalitarianism, and world wars drew into question a progressive view of history. Progressive metaphors also contributed to social Darwinism by elevating some humans above others and to environmental destruction by elevating humans above other species (Gould 1977, Rozzi et al. 1998). Despite the cultural salience of evolutionary progress, however, we have little empirical data concerning its current popularity among evolutionists and even less for its popularity among nonscientists.

Competition. Darwin's ideas reflected competition-based economic metaphors that were prevalent in 19th-century Britain (Moore 1986, Radick 2003). Accordingly, Darwin emphasized competition in *On the Origin of Species,* which stimulated its priority among the next few generations of biologists (McIntosh 1992). The Lotka-Volterra equations yielded stable cooperative interactions as easily as competitive ones, for example, but ecologists emphasized the latter (Boucher 1986, Keller 1992). Although evolutionary biology has harbored a tradition of accounting for cooperation since Darwin's *The Descent of Man,* cooperation remained "largely ignored" by

most evolutionary biologists until the 1960s (John Maynard Smith, cited in Singer 1999).

Biologists have revived studies of cooperation over the past few decades partly to counterbalance attempts to justify social competitiveness in terms of our biological "nature." In many cases, these social Darwinist policies have drawn on metaphors such as "struggle for survival" and "survival of the fittest" (Young 1985, Lakoff and Johnson 1999). In reviewing the recent shift, Boucher (1986) proposed "a programme to replace Newtonian ecology's 'competition is the basic organizing principle of nature' with 'mutualism is the basic organizing principle of nature'. Instead of being red in tooth and claw, nature is seen as green in root and flower" (p. 23). Sober (2002) extended this one step further by declaring, "The picture of nature as thoroughly red in tooth and claw is one-sided. It is no more adequate than the rosy picture that everything is sweetness and light. Kindness and cruelty both have their place in nature, and evolutionary biology helps explain why" (p. 54). Both Boucher (1986) and Sober (2002) underscore that it is misguided to ask whether cooperation or competition predominates in nature, since we cannot parse their relative role in the grand scheme of evolutionary history. As with competition, however, we have little empirical insight into the distinct issue of whether one perspective or the other still flavors human assessment of natural systems. This is a crucial question because a competitive view tends to reinforce the belief that humans and their societies are by necessity also competitive.

Organizations surveyed

To obtain empirical data concerning the contemporary popularity of competitive and progressive metaphors, I surveyed four groups that relate evolutionary science to its social context in contrasting ways.

Evolutionary biologists. Members of the first group, the Society for the Study of Evolution (SSE), claim a lineage dating back to Darwin himself and often refer to themselves as neo-Darwinists. The SSE is the world's largest organization of evolutionary science, comprising 2900 members in 50 countries who seek to promote "the study of organic evolution and the integration of the various fields of science concerned with evolution" (*http://lsvl.la.asu.edu/evolution/ordrinfo.html*).

Evolutionary psychologists. Whereas evolutionary biologists emphasize the study of nonhuman organisms, members of the Human Behavior and Evolution Society (HBES) attempt to explain human behavior in terms of evolutionary history. According to its Web site (*www.hbes.com*), the 1000-member HBES is "an interdisciplinary, international society of researchers, primarily from the social and biological sciences, who use modern evolutionary theory to help to discover human nature." This distinction has led to tension with evolutionary biology, one of its root disciplines, and hence both groups were included in the survey for comparative purposes.

Biology teachers. The National Association of Biology Teachers (NABT) is the largest group of American biology teachers, with over 9000 members; its mission "empowers educators to provide the best possible biology and life science education for all students" (*www.nabt.org/sites/S1/index.php?p=5*). Consequently, its members are an important medium between evolutionary biologists and society (see Eckstrand 1998), mainly because they provide the only education about evolution that many people will ever have.

Conscious evolution adherents. Members of the fourth organization, a small one named the Foundation for Conscious Evolution (FCE), harbor a progressive evolutionary worldview that they describe as follows:

> Conscious Evolution is a new social/scientific/spiritual meta-discipline.... We are participating in the evolution of evolution from unconscious to conscious choice, from natural selection to selection according to human purpose.... The ultimate purpose of Conscious Evolution as a worldview is to foster the evolution of our species to full potential...in harmony with the deeper patterns of nature and the Great Creating Process itself, traditionally called God.
> (*www.evolve.org/pub/doc/evolve_what_is_ce.html*)

This religious vision may seem odd, yet it conforms with the beliefs of illustrious evolutionists such as Dobzhansky, Huxley, and Stebbins, who measured biological progress along an absolute spiritual axis and placed humans at the apex of "goodness" (Ruse 1996). They generally sided with Teilhard de Chardin (1959), the French Jesuit and paleontologist who proposed an "omega point" toward which evolutionary processes aim, a belief vehemently opposed by other scientists. I included the FCE in my survey to exemplify the beliefs of those who apply evolutionary ideas toward a broader sociospiritual vision, a common pattern in the history of evolutionary theorizing.

Research methods

I collected data from these four groups using the recommended methodology for an Internet-based survey (Schonlau et al. 2001, Sills and Song 2002). In particular, the survey was designed to reduce the burden to respondents and was pretested. Respondents were contacted in November 2003 with a personalized introductory e-mail that provided a link to one of two randomized versions of the survey, and after two weeks nonrespondents were sent a reminder e-mail. For further details, see Larson (2004).

The survey asked respondents to evaluate 18 statements containing competitive and progressive metaphors (tables 1, 2). These statements sought to reflect aspects of larger-scale competitive or progressive evolutionary gestalts, or "root metaphors" (Pepper 1942, Larson 2004). They also needed to be cogent to evolutionary biologists while still accessible to nonscientists, allowing both groups to generalize from

Table 1. Mean response to survey statements with progressive metaphors, for both question sets, and statistical test results.

Statement	Question set 1				Question set 2			
	SSE	HBES	NABT	FCE	SSE	HBES	NABT	FCE
Progress typifies the evolution of life on earth.	1.89	2.09	2.42	**3.19**	2.19	2.39	2.74	3.38
Evolution has an aim or purpose.	1.26	1.38	1.83	**3.85**	1.67	1.93	2.35	4.02
Evolutionary change requires intelligent design.	1.23	1.46	1.69	3.13**	1.52	1.94	2.05	3.76
Gradual improvement typifies the evolution of life on earth.	2.44*	**2.61**	2.67	**3.19**	2.53	2.67	2.94	3.42
Species that exhibit a division of labor, such as ants, are more successful.	2.19	2.61*	2.92	**3.46**	2.44	2.76	3.16	3.34
Cooperation typifies the interaction between animals.	2.25	2.77	2.63	3.34	3.18	3.38	3.50	4.29
Increasing complexity typifies the evolution of life on earth.	3.22	3.44	3.56	4.28*	2.72	2.90	3.25	3.87
Long-term evolutionary change is often caused by random drift.	3.45	3.20	3.68	**2.68**	2.99	2.98	3.22	2.41

FCE, Foundation for Conscious Evolution; HBES, Human Behavior and Evolution Society; NABT, National Association of Biology Teachers; SSE, Society for the Study of Evolution.

Note: The statements here loaded on a "progress" factor in a factor analysis of the survey results (see Larson 2004) and are listed in order of their factor loading for question set 1. Question set 1 consisted of the questions "Do you believe [this statement] to be factually true? In your opinion, has biological research provided sufficient evidence to support it?" Question set 2 consisted of the questions "Do you believe [this statement] would be beneficial if applied within society? Would it be a good thing if people were to use this statement as a guide for social practices?"

Values indicate mean response, ranging from 1 (strongly disagree) to 5 (strongly agree). Members of the four organizations responded differently to each statement, in response to both question set 1 and question set 2 (Kruskal-Wallis tests, df = 3, all tests $p < 0.001$). The statistical significance of differences between responses to question set 1 and question set 2 (Wilcoxon signed-ranks test) for members of each organization are reported in the columns for question set 1 thus: no symbol, $p < 0.001$; **, $p < 0.01$; *, $p < 0.05$; boldface, not significant.

specific empirical cases (of which there are many possibilities) to an impression of biological evolution as a whole.

Respondents were asked to evaluate each statement in terms of two sets of questions:

- Question set 1: Do you believe [this statement] to be factually true? In your opinion, has biological research provided sufficient evidence to support it?
- Question set 2: Do you believe [this statement] would be beneficial if applied within society? Would it be a good thing if people were to use this statement as a guide for social practices?

Question set 1 sought respondents' conception of the empirical support for various metaphorical statements about evolution. In contrast, question set 2 investigated their sensitivity to potential applications of these metaphors within society. Although some statements could be applied in numerous ways (with implications too complex to address in a brief survey) and others might not have any clear application, question set 2 nonetheless asked respondents to reflect on their social valence.

There were 1892 usable responses to the survey. The response rate ranged from 41.5 percent of evolutionary psychologists (n = 317 responses) and 33.4 percent of evolutionary biologists (n = 789) to approximately 23 percent of biology teachers (n = 745) and 13.1 percent of FCE members (n = 41) (see Larson 2004). These response rates are within the range reported for previous Web and e-mail surveys (7 to 44 percent and 6 to 68 percent, respectively; Schonlau et al. 2001), including a study of job satisfaction among scientists with a response rate of 37 percent (Sills and Song 2002). Nonetheless, there were many nonrespondents, which could introduce systematic bias that must be kept in mind when making inferences from the results to entire organizations and to comparisons among them. Because of these concerns about sampling randomness, in the following discussion I mainly compare the organizations impressionistically, though statistical test results are reported in tables 1 and 2. Also note that a quantitative study such as this one provides little interpretive nuance for understanding why people responded to particular statements in the way they did.

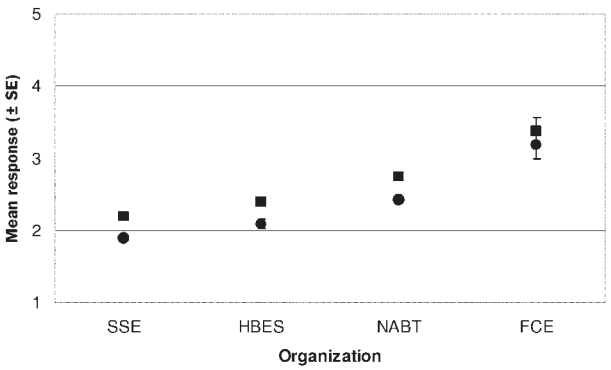

Figure 2. Mean response (± standard error [SE]) to question set 1 (circles) and question set 2 (squares) about the statement "Progress typifies the evolution of life on earth" by individuals from four organizations. The mean values correspond to response options in the survey: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. Abbreviations: FCE, Foundation for Conscious Evolution; HBES, Human Behavior and Evolution Society; NABT, National Association of Biology Teachers; SSE, Society for the Study of Evolution.

Table 2. Mean response to survey statements with competitive metaphors, for both question sets, and statistical test results.

Statement	Question set 1				Question set 2			
	SSE	HBES	NABT	FCE	SSE	HBES	NABT	FCE
There is an arms-race between predator and prey as they evolve in response to one another.	4.14	4.27	4.00	3.18	3.13	3.47	3.32	2.47
Sperm compete with one another to fertilize an egg.	4.12	4.09	3.89	**3.44**	3.25	3.40	3.47	3.09
Over time, animal populations evolve tactics and strategies in response to problems they encounter.	3.95	4.21	3.94*	**4.33**	3.63	3.84	3.90	4.15
Evolution by natural selection would not occur without competition.	2.87	3.75	3.55	2.98*	2.48	2.97	3.20	2.58
A struggle for survival characterizes evolution.	3.77	3.90	4.32	3.68	2.13	2.49	3.06	2.63
Animals compete with one another to secure territories.	3.91	4.08	4.33	3.88	2.58	3.09	3.29	2.38
Over time, species become better adapted to their environments.	3.72	3.88	4.05	**3.98**	3.42	3.54	3.82	3.84
A population's genetic variability determines its evolutionary potential.	4.40	3.99	4.61	**3.66**	3.38	3.13	3.95	3.71
Animals are competitive because of their selfish genes.	2.78	3.46	2.55	**2.11**	2.31	2.88	2.42	2.11
Natural selection favors cooperation between closely related animals.	3.41	4.12	3.09	**3.67**	3.12	3.68	3.27	3.82

FCE, Foundation for Conscious Evolution; HBES, Human Behavior and Evolution Society; NABT, National Association of Biology Teachers; SSE, Society for the Study of Evolution.

Note: The statements here loaded on a "competition" factor in a factor analysis of the survey results (see Larson 2004) and are listed in order of their factor loading for question set 1. Question set 1 consisted of the questions "Do you believe [this statement] to be factually true? In your opinion, has biological research provided sufficient evidence to support it?" Question set 2 consisted of the questions "Do you believe [this statement] would be beneficial if applied within society? Would it be a good thing if people were to use this statement as a guide for social practices?"

Values indicate mean response, ranging from 1 (strongly disagree) to 5 (strongly agree). Members of the four organizations responded differently to each statement, in response to both question set 1 and question set 2 (Kruskal-Wallis tests, df = 3, all tests $p < 0.001$ except for the statement about sperm competition, $p = 0.01$). The statistical significance of differences between responses to question set 1 and question set 2 (Wilcoxon signed-ranks test) for members of each organization are reported in the columns for question set 1 thus: no symbol, $p < 0.001$; *, $p < 0.05$; boldface, not significant.

The popularity of progressive and competitive metaphors

The survey demonstrated that members of the HBES, NABT, and SSE disagreed (on average) that the statement "Progress typifies the evolution of life on earth" is empirically supported (figure 2, table 1). SSE members rejected this statement most strongly, whereas FCE members strikingly agreed that evolution is progressive. Respondents evaluated the potential social benefit of this statement in much the same way that they evaluated its empirical support, though ratings for social benefit were slightly higher.

In contrast, members of each organization agreed that the statement "A struggle for survival characterizes evolution" is empirically supported (figure 3, table 2), yet members of all organizations except the NABT disagreed that this statement would be beneficial if applied in society. In short, respondents felt that a "struggle for survival" characterizes evolution, but that this knowledge should not be applied to human society.

Survey respondents evaluated the statement "Cooperation typifies the interaction between animals" quite differently (figure 4, table 1). Individuals from all organizations except the FCE disagreed that this statement is empirically supported by biological research, whereas all organizations agreed that it would be socially beneficial. Since respondents generally characterized evolution as a "struggle for survival," it is perhaps unsurprising that they considered animals uncooperative even though they believed that it would be beneficial if animals were perceived this way. The lack of credence accorded to this cooperative statement relative to the statement that evolution is a "struggle for survival" points toward a competitive perspective on the natural world.

These findings were generalized to all of the survey statements by means of factor analysis, which suggests that the

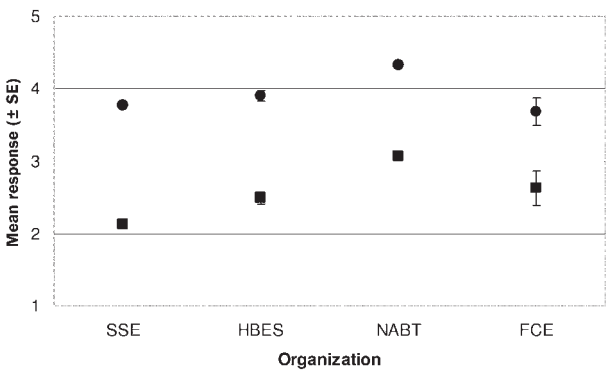

Figure 3. Mean response (± standard error [SE]) to question set 1 (circles) and question set 2 (squares) about the statement "A struggle for survival characterizes evolution" by individuals from four organizations. The mean values correspond to response options in the survey: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. Abbreviations: FCE, Foundation for Conscious Evolution; HBES, Human Behavior and Evolution Society; NABT, National Association of Biology Teachers; SSE, Society for the Study of Evolution.

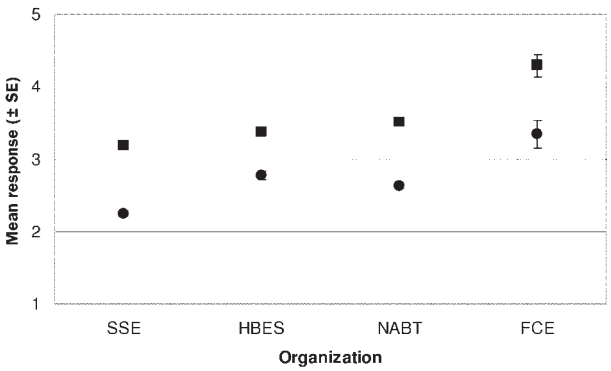

Figure 4. Mean response (± standard error [SE]) to question set 1 (circles) and question set 2 (squares) about the statement "Cooperation typifies the interaction between animals" by individuals from four organizations. The mean values correspond to response options in the survey: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. Abbreviations: FCE, Foundation for Conscious Evolution; HBES, Human Behavior and Evolution Society; NABT, National Association of Biology Teachers; SSE, Society for the Study of Evolution.

survey detected competitive and progressive "root metaphors" within evolutionary biology. The details of this analysis are reported elsewhere (Larson 2004).

Contextual interpretation

With these results in mind, we can examine how respondents from different organizational contexts evaluated additional statements. Consider how evolutionary biologists responded to the progressive statements (figure 5). They gave the greatest empirical standing to the statement about complexity by tending to agree with it, whereas they disagreed with the statements about improvement and progress, and strongly disagreed with those concerning purpose and intelligent design. Evolutionary psychologists and biology teachers also demonstrated this pattern for the progressive statements, though they disagreed with them less strongly (table 1). Overall, these results indicate that particular metaphoric aspects of progress have been scientifically accepted, whereas others have been rejected.

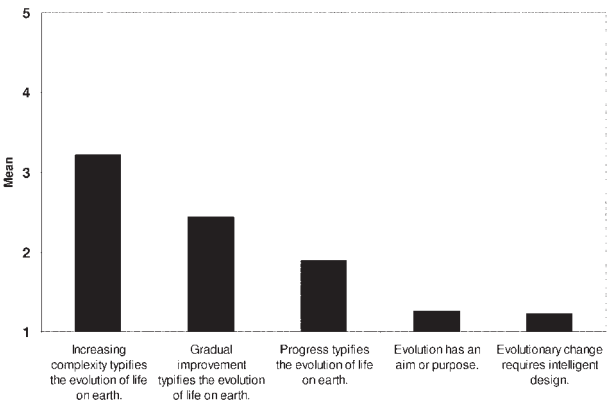

Figure 5. Mean response by evolutionary biologists to various progressive statements. The mean values correspond to response options in the survey: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree.

In contrast, FCE members agreed with each of the progressive statements and disproportionately agreed with those concerning intelligent design and purpose. They were also much more likely than members of the other organizations to reject the statement "Long-term evolutionary change is often caused by random drift" (table 1). They probably rejected it because it did not resonate with progress and purpose rather than because of its technical meaning. These results demonstrate how a metaphor can be interpreted by nonscientists according to its resonance regardless of any trend among scientists. This phenomenon may account for the appeal in some circles of "intelligent design," a phrase that has probably been spun for this very reason.

The statement about "selfish genes" also reveals problems that may arise with varied interpretations of a metaphor. Over 59 percent of evolutionary psychologists agreed that the statement "Animals are competitive because of their selfish genes" has an empirical basis, compared with 13 to 34 percent for the other groups. While an association between selfish genes and competitiveness might seem self-evident, Radcliffe Richards (2000) points out that it is "rather ironic that Dawkins's well-known expression, 'the selfish gene,' has apparently entrenched in the popular mind the idea that evolution can produce only selfishness, when the shift to a metaphorical selfishness at the level of genes was precisely what allowed for real altruism at the level of organisms. Perhaps 'selfish gene' is popularly misinterpreted as 'gene for selfishness.' Whatever the reason, the expression seems to have misled a great many people" (p. 165). Seventy-two percent of FCE members disagreed with the statement about selfish genes, most likely because of the misunderstanding Radcliffe Richards mentions, which is one reason to be wary of this metaphor. By contrast, of the groups surveyed, evolutionary psychologists gave selfish genes the strongest causal role in competitiveness. This suggests that evolutionary psychologists have less sensitivity to the social resonance of the term "selfish gene" because it is constitutive within their field. While it has become "dead" for them, it is less so for the other groups.

Two other statements demonstrate how scientists using particular metaphors may become less aware of their social resonance. Over 87 percent of evolutionary biologists and psychologists agreed that there is empirical support for the statement "There is an arms-race between predator and prey as they evolve in response to one another," compared with 80 percent of NABT members and 60 percent of FCE members. Similar results held for "Sperm compete with one another to fertilize an egg," though agreement was lower and the divergence between groups was less marked (SSE, 84 percent

agreement; HBES, 79 percent; NABT, 74 percent; FCE, 58 percent; table 2). These results provide evidence that the phrases "arms race" and "sperm competition" were more naturalized among evolutionary biologists and psychologists because of their technical knowledge. They have come to think of predator–prey interactions using a cold war analogy, so that now they perceive that these organisms really *do* evolve reciprocally in response to one another in this fashion. Similarly, sperm *do* compete with one another, from these scientists' perspective, rather than it being a question of whether this is an adequate conception of how they interact. As one evolutionary biologist wrote after completing the survey, "Be aware that competition means just what it means technically[;]...we use it in ecology without the emotional connotations it has among laymen." Another way to interpret this sentiment is that some biologists have simply become inured to the "reality" of these metaphors.

FCE members, in contrast, were quite sensitive to the associations of these statements. As Martin (1991) observed, even the idea that sperm compete is not ideologically neutral, for "the picture of egg and sperm drawn in popular as well as scientific accounts of reproductive biology relies on stereotypes central to our cultural definitions of male and female." Similarly, "arms race" could have a negative valence for FCE members because of its military associations. For many nonbiologists, Sober's (2002) observation that "the mother-child relationship is the setting for an arms-race in which each side evolves strategies and counterstrategies in response to the other" would be quite unsettling as a characterization of human interactions, regardless of whether the phrase has a technical meaning in evolutionary biology and evolutionary psychology.

NABT members held a rather competitive view of evolution. Eighty-seven percent of them agreed that it can be characterized as a "struggle for survival," compared with 70 to 74 percent of respondents from the other organizations. More than 62 percent of biology teachers (and 72 percent of evolutionary psychologists) also agreed with the statement "Evolution by natural selection would not occur without competition," whereas fewer than 49 percent of the members of the two other groups agreed with it. This statement concerned the emphasis different organizations placed on competition as an element of evolution by natural selection. It was motivated by Keller's (1992) observation that attempts "to clarify the distinction between natural selection and competition (what Engels called 'Darwin's mistake') have done little to stem the underlying conviction that the two are somehow the same." In their agreement with the characterization of evolution as a "struggle for survival," and their confounding of natural selection with competition, the NABT members' responses suggest that high school education may take a particularly competitive view of evolutionary processes, perhaps driven more by evolutionary psychology than evolutionary biology.

Conclusions

Survey respondents generally agreed that competitive metaphors adequately describe evolutionary processes. While it may seem axiomatic that evolution is competitively based, could this simply be the way we have been taught to conceptualize it? Keddy (1989) proposed reasons for a bias toward studies of competition in ecology, observing that "scientists can only draw models from the possibilities of which they are aware, and perhaps ecology has been hampered by restricted access to individuals (and ideas) offering co-operative models for society and nature" (p. 163; see also Jackson 2003). Although this bias has lessened over the past century, the survey results presented here suggest that people continue to perceive biological systems as inherently competitive. The 1993–1994 General Social Survey in the United States supports this finding, since 64 percent of respondents agreed or strongly agreed that "Nature is really a fierce struggle for survival of the fittest," whereas only 14 percent disagreed or strongly disagreed (*http://webapp.icpsr.umich.edu/GSS*). Together, these survey results highlight a dilemma for contemporary biology: Many people recognize that a competitive interpretation of the natural world could have negative social implications (though the survey cannot address the greater issue of whether people would act on the beliefs expressed here), yet nonetheless find it difficult to believe otherwise.

We will not solve this dilemma by skewing our findings to be more cooperative, but by recognizing that our competitive outlook reveals cultural and metaphysical commitments rather than anything scientific. To help see this, it is worth recalling that scientists considered evolution to be progressive not so long ago. And one might ask whether even complexity "is just a modern substitute, a kind of code word for perfection, progress, and proximity to us" (McShea 1996). If this is the case, then it appears that the concept of evolutionary progress has not died out altogether, even in scientific circles; and it has certainly not died for FCE members and others who adapt it to form novel social visions. In general, survey respondents evaluated the potential social benefits of progressive metaphors more favorably than their empirical support, suggesting that a progressive view of evolution still has a place in people's imagination. For similar reasons, our interpretation of evolution may change form over time in response to varied scientific and social pressures, though competition is likely to remain one component of how we understand evolution.

The social resonance of metaphors has implications for teaching biology. While educators may construe students' perception of metaphoric resonance as naive misunderstanding that simply needs to be overcome, it is not necessarily easy to erase interpretive frameworks if they are part of an entire worldview. In this sense, science education becomes a matter of "foreign affairs" (Cobern 1995), so educators need to strike a balance between stifling political correctness and nonchalant insensitivity. It thus becomes worthwhile to discuss with students how "arms races," "progress," "sperm competition," and other metaphors relate to their experience.

Otherwise, there is a risk that certain metaphors may prime some students for a rejection of evolution or reinforce their prior doubts about it.

Metaphors reflect particular social narratives and frame the way we perceive natural processes. Metaphors are not just rhetorical embellishment. Given their interweaving of science and society, they may have significant consequences, which occurs regardless of the naturalistic fallacy. Both scientists and nonscientists thus have a responsibility to attend to the process by which metaphors transfer and reinforce particular social values. Otherwise, the "deadening" of metaphors can become harmful, for scientists may use them primarily for their "technical" meaning while simultaneously and unconsciously promoting an ideology tied to their broader resonance. All metaphors have shortcomings, yet some are more likely than others to set themselves up for misinterpretation and misuse.

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