

Citation Analysis and the Anti-Vivisection  
Controversy. Part II. An Assessment of  
Lester R. Aronson's Citation Record

Number 48, November 28, 1977

Earlier this year I discussed the controversy surrounding animal experimentation at the American Museum of Natural History in New York City.<sup>1</sup> The controversy has focused mainly on the work of Lester R. Aronson, Chairman and Curator of the Museum's Department of Animal Behavior. Incidentally, Dr. Aronson is also Adjunct Professor of Biology both at the City University of New York and New York University.

I was originally drawn into the controversy because Dr. Aronson telephoned me to question the use (or abuse) of *Science Citation Index*<sup>®</sup> (*SCI*<sup>®</sup>) data in a *Science* news article written by Nicholas Wade.<sup>2</sup> Wade, an excellent and regular columnist for *Science*, used *SCI* data rather casually to assess Aronson's research.

The work in question involved removing certain glands and tissues from domestic cats in order to determine the effect on the cats' sexual behavior. Wade's rather superficial analysis seemed to imply that Aronson's work was unimportant. This accorded with a conclusion anti-vivisectionists had drawn in advance—that the cats were enduring mutilation for a minor or trivial gain in scientific information.

Before I report the results of our assessment of Aronson's citation record, it should be remembered

that citation analysis can tell us much more about well-cited persons than it can about those who are infrequently cited. There is much mediocre and inferior research that is uncited. So it is easy to denigrate some possibly significant work that is, for other reasons, also uncited. Furthermore, superstars in very large fields are more visible than those in smaller fields because the chances are greater for their milestone papers to exceed average citation rates. Thus the superstars in biochemistry are more visible than those in a small branch of behavioral biology.

Defining and delimiting Aronson's field were important first steps in the analysis, since Aronson claims that he has been working in a small field. We began by asking Aronson to identify the articles he considered most relevant and significant for his cat research. He chose eight papers published between 1958 and 1974.<sup>3</sup> They are marked with an asterisk in Figure 1 on page 8. In these eight papers Aronson and his co-authors cited 226 other items in the literature written by 137 authors. Excluding self-citations, Aronson's eight cat research papers were cited in 85 papers written by 51 different authors. When duplications were eliminated, 176 individual authors were identified that either cited Aronson's papers at least once or were cited by Aronson

at least once. Using citation relationships as the indicator, 176 people have been involved in the field which we have, with Dr. Aronson's concurrence, named "sensory and hormonal influences on cat sexual behavior."

It could be argued, however, that a single reference is a rather weak indicator that two people are working in the same field. So we raised the citation threshold to two for those papers citing Aronson, in an attempt to identify the key papers and scientists in his field. Later these were checked against the subjective data provided by the key individuals themselves. The number of papers *citing* Aronson at least twice was 23, representing 15 unique authors.

For papers *cited* by Aronson we raised the citation threshold to three. The threshold is different for *citing* and *cited* papers because there are more references *from* a typical paper than *to* it. In general, scientific papers have about 12 to 15 references. But the average item in the *SCI* is cited only 1.87 times per year.<sup>4</sup> Even after five years, the average item has gained only about one more citation.

Fourteen papers by 10 authors cited Aronson at least three times. Eliminating duplicates between citing and cited authors, we created a list of 21 primary authors. These authors had either cited Aronson at least twice or had been cited by him at least three times. Thus one might say that the "invisible college" concerned with "sensory and hormonal influences on cat sexual behavior" comprises about 22 people including Aronson. To put this number in perspective, Derek deSolla Price of Yale University has estimated that the typical invisible college is composed of a "hundred or so really active and knowledgeable people in any particular part of the research

front of science."<sup>5</sup>

To confirm the size of the field of "sensory and hormonal influences on cat sexual behavior," we spoke with three key researchers identified by our analysis: Frank A. Beach of the University of California at Berkeley,<sup>6</sup> R.A. Gorski of UC/Los Angeles,<sup>7</sup> and B.L. Hart of UC/Davis.<sup>8</sup> They unanimously agreed that 15 of the 22 authors we identified had worked in the same field as Aronson. And *none of the remaining seven was disputed or unknown by all three*. They also confirmed that no important researcher in the field was omitted. Thus the field certainly is too small to sustain a specialized journal, which ordinarily requires about 100 researchers.<sup>9</sup>

Figure 1 is a diagram which I call an historiograph. It shows the citation connections between the 21 authors who either cited Aronson's key papers (at least twice) or were cited by him (at least three times). Each node represents a paper or group of papers by the same authors. The size of the node roughly indicates the number of papers it represents. The oldest paper is at the top; the most recent work at the bottom. Citation links are indicated by lines which connect the nodes. A line can indicate one or more citation connections.

The bibliography from which the historiograph was derived, on pages 8-9, shows that Aronson's field is multi-disciplinary. It involves the disciplines of biology, psychology, physiology, anatomy, endocrinology, zoology, urology, and biochemistry.

Having characterized Aronson's field, the next step in our analysis was to examine the relative impact of his work within that field. In his analysis Nicholas Wade stated, "Of the 21 articles that Aronson and his colleagues have published on the

cat study since 1962, 14 have never been cited in the scientific literature between 1965, when the *Science Citation Index* starts, and March 1976. Because of the short citation half-life of scientific papers, it is unlikely that they ever will be cited. The seven other papers have an average 5.6 citations each over the same 11-year period."<sup>2</sup> Although Wade did not register an explicit assessment of Aronson's work, the reader was left with the impression that two-thirds of Aronson's articles were never cited, and that the remaining third have averaged only about half a citation per year. Is this impression accurate?

Wade made several errors. For one thing, the *Science Citation Index* started in 1961, not in 1965. (Perhaps Wade was using the five-year cumulative *SCI* for 1965-1969). In any case, we found that none of the 21 Aronson papers was cited from 1961 to 1964. However, Wade's citation count was inaccurate within the parameters he himself defined. Between 1965 and March 1976, of the 21 articles to which Wade referred, 11 (not 14, as Wade claimed) were never cited (except for self-citations) in the literature covered by the *SCI*. The remaining 10 papers were cited an average of 0.94 times in each year they could have been cited (not 0.5 times per year, as Wade implied).

In reply to Wade's analysis, Aronson claimed, "Of the 21 publications to which Wade refers, the seven full reports, each representing 3 to 5 years of continuous experimental observations, have all been cited except for one which was published in Moscow. In addition, two doctoral dissertations by former students have been cited as such, and later as journal publications. The remaining 14 publications were abstracts of reports given at scien-

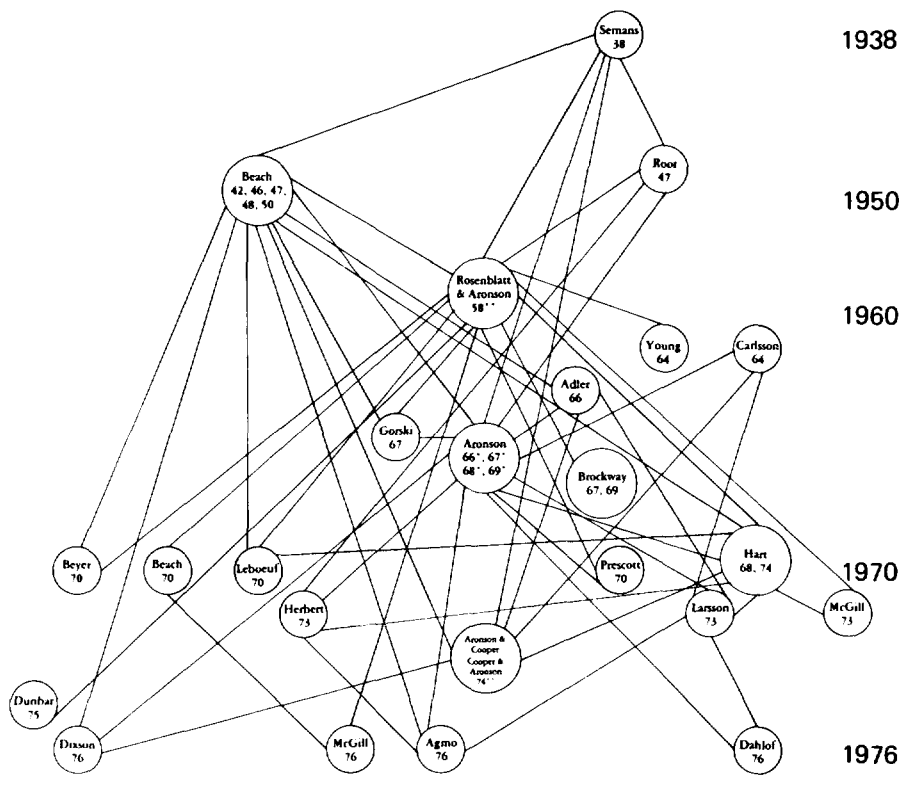
tific meetings while the work was in progress, and even a goodly number of these have been cited."<sup>10</sup>

According to our own examination of the *SCI*, 11 of Aronson's 21 articles were never cited by anyone else. Six of these were never cited at all, and 5 were "self-cited" by Aronson or his colleague Madeline Cooper, but were cited by no one else.

However, the eight papers selected by Aronson as representing his major cat research together received 85 citations over the 15-year period from 1961 to 1975 (excluding self-citations); an average of 1.37 citations in each year that they could have been cited. To put this in perspective, consider that about one quarter of all articles covered by the *Science Citation Index* are never cited at all.<sup>11</sup> And the average number of citations to each item in a five-year cumulative *SCI* is 2.76. This is an average of 0.55 citations per year.<sup>12</sup> So the major papers dealing with Aronson's cat research not only have avoided "uncitedness," they are being cited at a rate that is significantly higher than average for all types of papers that do become cited in all fields of science.

For the years 1961-1975, Aronson's eight major cat papers together averaged about 10 citations yearly. When all his work, including that on species other than the cat, is considered, Aronson's average yearly citation rate rises to about 12 for the years 1961 to 1976. For each cited author in the *SCI*, the average yearly citation rate is 7.48.<sup>4</sup> Looked at from this perspective, Aronson's citation record as an individual author is slightly better than average. But one cannot fail to observe that 36 of the citations Aronson received were to the paper he co-authored with Rosenblatt in 1958 on

**Figure 1.** Historiograph based on Lester R. Aronson's research on sensory and hormonal influences on cat sexual behavior. Each node represents a paper or group of papers by the same authors; larger nodes represent more than one paper. Lines between nodes represent citations; a single line may represent multiple citations. The most recent contributions appear toward the bottom. See below for bibliographic data.



**Figure 1. Bibliographic Data**

Adler N & Bermant G. Sexual behavior of male rats: effects of reduced sensory feedback. *Journal of Comparative and Physiological Psychology* 61:240-3, 1966.

Agmo A. Mating in male rabbits after anesthesia of glans penis. *Physiology and Behavior* 17:435-7, 1976.

\*Aronson L R & Cooper M L. Seasonal variation in mating behavior in cats after desensitization of glans penis. *Science* 152:226-30, 1966.

\*\_\_\_\_\_. Penile spines of the domestic cat: their endocrine-behavior relations. *Anatomical Record* 157:71-8, 1967.

\*\_\_\_\_\_. Desensitization of the glans penis and sexual behavior in cats. *Perspectives in reproduction and sexual behavior*. (Diamond M., ed.) Bloomington: Indiana University Press, 1968, p. 51-82.

\*\_\_\_\_\_. Mating behavior in sexually inexperienced cats after desensitization of the glans penis. *Animal Behaviour* 17:208-12, 1969.

\*\_\_\_\_\_. Olfactory deprivation and mating behavior in sexually experienced male cats. *Behavioral Biology* 11:459-80, 1974.

Beach F A. Analysis of the stimuli adequate to elicit mating behavior in the sexually inexperienced male rat. *Journal of Comparative Physiology* 33:163-207, 1942.

- ..... . Mating behavior in male cats castrated at various ages and injected with androgen. *Journal of Experimental Zoology* 101:91-142, 1946.
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- ..... . Coital behavior in dogs. 6. Long term effects of castration upon mating in the male. *Journal of Comparative and Physiological Psychology Monograph* (Part 2), 70:1-32, 1970.
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- Dunbar I F.** Behavior of castrated animals. *Veterinary Record* 96:92, 1975.
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- Hart B L.** Alteration of quantitative aspects of sexual reflexes in spinal male dogs by testosterone. *Journal of Comparative and Physiological Psychology* 66:726-30, 1968.
- ..... . Gonadal androgen and sociosexual behavior of male mammals—comparative analysis. *Psychological Bulletin* 81:383-400, 1974.
- Herbert J.** Role of dorsal nerves of penis in sexual behavior of male rhesus monkey. *Physiology and Behavior* 10:293-300, 1973.
- Larsson K & Sodersten P.** Mating in male rats after section of the dorsal penile nerve. *Physiology and Behavior* 10:567-71, 1973.
- Leboeuf B J.** Copulatory and aggressive behavior in prepuberally castrated dog. *Hormones and Behavior* 1:127, 1970.
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\*The eight papers selected by Lester R. Aronson as representing his most significant research on sensory and hormonal influences on cat sexual behavior.

the role of prior sexual experience in the decline of sexual behavior in male cats after castration.

Having determined Aronson's overall citation record, we then tried to gauge Aronson's importance within his own field. To do this, we ranked the 22 people involved by their first-author citation records for the years 1961-1976. They are listed in Figure 2 below. The results place Aronson eleventh in total citations received. This ranking is not

**Figure 2.** Authors appearing in Figure 1 ranked according to total citations from 1961 to 1976. Based on data from the *Science Citation Index*<sup>®</sup>.

Rank	Name	Average	
		Total Citations 1961-1976	Annual Citations 1961-1976
1.	Beach FA	2424	152
2.	Young WC	1837	115
3.	Larsson K	891	56
4.	Gorski RA	797	50
5.	Beyer C	438	27
6.	Rosenblatt JS	327	23
7.	Root WS	362	23
8.	Hart BL	269	17
9.	McGill TE	213	13
10.	Herbert J	198	12
11.	Aronson LR	191	12
12.	Adler N	141	9
13.	Leboeuf BJ	124	8
14.	Brockway BF	102	6
15.	Semans JH	82	5
16.	Carlsson SG	49	3
17.	Prescott RG	26	2
18.	Agmo A	14	—
19.	Dixson AF	11	—
20.	Cooper KK	10	—
21.	Dunbar IF	1	—
22.	Dahlof LG	0	—

based just on citations to research in the field of "sensory and hormonal influences on cat sexual behavior," but includes references to Aronson's work on other species. The same is true for the others named in Figure 2.

Is Aronson a small fish in a big pond or a big fish in a small pond? According to the results of this

analysis, he seems to be neither. His work won't attract the attention of Nobel Prize committees, but he has had some influence on others whose work may.

An interesting aspect of this controversy is the claim that Aronson's cat work is not cited as much as it might be because the cat and rat people live in separate worlds. It has been claimed that rat experiments far outnumber cat experiments, and that while the rat people do not cite the cat literature, the cat people *do* cite the rat literature. Aronson himself asserts that, "the investigators of rat behavior seem to have a tradition of limiting their citations to rats (or rodents) even when they are aware of the research on other groups.... On the other hand, those working on the sex behavior of other species usually know the rat literature quite well and seem to cite it regularly. At least I do."<sup>3</sup> Gorski and Hart strongly support Aronson's claim of species discrimination, as does Beach, who also, after the publication of Wade's article, wrote a letter to the editor of *Science* defending the value of Aronson's research and its relevance to humans.<sup>13</sup> That letter was never published, so we decided to include it immediately after this essay on pages 13-14.

Robert Goy of the Wisconsin Regional Primate Research Center told us that, "Dr. Aronson works in a specialized field, and the number of other investigators working in the same field that might be likely to cite his work is relatively small.... Specifically with regard to his work on the importance of the genital sensory input, there is a lot of work going on in that area in the rat that I know of, and I think relatively few of the rat workers cite his work...."<sup>14</sup>

Goy pointed out that Aronson "has worked with fishes, frogs, lizards and a couple of different mam-

mals. In other words, he has cut across all vertebral classes. His choice of mammals, I think, has been largely dictated by the fact that there were many people in this area who were working with rats, mice, hamsters, guinea pigs—common laboratory rodents—but very few people in comparative reproduction were working with species like dogs and cats.”

Goy also claims that the rat people do not cite the cat people because of the restrictions journals place on bibliographies. “Today almost all leading journals require very conservative bibliographies,” he said. “They don’t like to give up space for comprehensive bibliographies. In fact, there are many journals that have ruled that the number of references used in an article should be limited to 20, and that if more than one reference is appropriate, to cancel them all and use a review article that cites all of the articles rather than citing each article separately. When authors are faced with restrictions like that, they don’t cite primary sources as often as they should. If they did, I think Aronson’s work would be more often cited.”<sup>14</sup> I believe, however, that this contention is somewhat specious, since such practices affect the citation counts of all authors whose articles are superseded by citation of review articles.

B.L. Hart adds, “If Aronson didn’t do his studies on cats there is a good chance that no one would do them. No one would do them on dogs, cats, or any intermediate species between primates and rats because of the expense and laboratory facilities needed and so forth. You cannot say that about work on rats. If someone doesn’t do a study on rats, then another person is going to do it.... We really don’t know how much we owe to Aronson in that respect.”<sup>8</sup>

Of course, there is always the chance that Aronson’s work has been premature,<sup>15</sup> or that he has produced a “stepping-stone” paper—one that helps someone else produce a classic, heavily cited paper. Perhaps Aronson illustrates the Ortega hypothesis.<sup>16</sup> Perhaps his contributions have been necessary to the achievement by others of more significant—and more highly cited—work. Or perhaps it is too early to tell. There is always the possibility that the citation record may change in the future, when the significance of the work is better appreciated or when other investigators are not inhibited from conducting related experiments.

In any research evaluation—and especially in analyses dealing with individual researchers—there are many caveats. The underlying assumptions and limitations must be clearly stated.<sup>17</sup> And the objective data obtained by counting citations must be viewed in the light of the subjective data provided by knowledgeable people. This example illustrates that a proper evaluation of an individual’s work should not consist of a superficial examination of *SCI* or any other source.

The preceding analysis, which included testimony both from the *Science Citation Index* and from scientists themselves, has indicated that Lester R. Aronson’s experimental work on cats has been reasonably valuable to the research community. This conclusion is important in light of recent events connected with the anti-vivisection controversy.

Over the past two years Lester Aronson has become the primary target for the outrage of a vocal group of anti-vivisectionists. On August 18, 1977, the residents of Lester Aronson’s hometown received, in the mail, literature concerning his cat experiments. The

literature included Dr. Aronson's home address and telephone number, and encouraged his neighbors to call him to voice their opinions of his research, as well as to write their Federal representatives and demand that their tax money "not be spent for torture of live animals in research."<sup>18</sup> This type of harassment of an individual scientist is unfortunate.

While it is clear that Lester Aronson's cat research does not merit the kind of furious criticism it has received, the case brings up some more fundamental issues.

I am perplexed by the assertion that Aronson's work is deemed quite significant by Beach and others when their citation of his work is minimal. And I am increasingly suspicious of generalized claims that we can never know in advance (and often not even in retrospect) what value "basic" research may have in the future. In the days when

there were just a few thousand people in the world doing basic research, such assertions were acceptable. But when the world's scientific population exceeds one million persons, we need something more than the bland assertions by established investigators or their peers that basic research pays off.

Finally, it is the responsibility of individuals like Aronson to do more than complain that the "rat people don't cite the cat people." In short, had Aronson done a bit of "selling" to his rat colleagues and perhaps helped to educate the public on the ramifications and value of his research, he might have prevented the unfortunate abuse heaped on him. In this respect the American Museum is equally at fault. But we should remember that most of Aronson's cat work was done when few people were questioning our medical research priorities.

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*This letter was addressed to the editor of Science on December 1, 1976, but was not accepted for publication. It is published here for the first time.*

December 1, 1976

Dear Sir:

Nicholas Wade's article on "animal rights" and Dr. L. R. Aronson's experiments at the American Museum of Natural History (*Science*, October 8) is of special concern to me for two reasons. First, I was Dr. Aronson's predecessor as Chairman of the Department of Animal Behavior at the Museum; and second, my own research over the past 40 years at the Museum, at Yale University and at the University of California in Berkeley has dealt with the same kind of problems with which Aronson has been dealing.

Mr. Wade's descriptions of reactions by opponents of such research indicate that these people do not understand what is being done or why. In fact I am not sure that Wade himself is entirely clear on these matters. The particular experiment chosen for the focal point of the emotional attack is a case in point. The purpose was to determine how and to what degree sensations from the penis influence sexual behavior. Anyone who has the slightest knowledge of human sexuality is aware that impotence in the male is one of the most common complaints bringing patients to the physician or sex counselor. The symptoms may consist of premature ejaculation or of inability to reach climax. Experiments on rats have demonstrated that males deprived of genital sensation exhibit predictable abnormalities of mating behavior. They are much less likely than normal males to ejaculate or achieve climax, and if they do so the time needed is much longer than normal.

If we can demonstrate similar symptoms in a number of other species, that may provide a rationale for treat-

ment of some types of human impotence. Premature ejaculation may be delayed by decreasing penile sensitivity, and patients incapable of orgasm may be helped by increasing their genital responsiveness.

Other experiments conducted by Dr. Aronson and his associates at the Museum have already contributed importantly to our understanding of various factors that control sexual behavior in animals, and to some degree in man as well. They have shown, for example, that male cats which are altered (castrated) before acquiring mating experience are unlikely ever to achieve normal sexual performance, whereas males that have mated many times before operation are likely to retain their potency for long periods of time. Such findings have definite theoretical relevance to clinical problems of hypogonadism in men.

The fact that many studies carried out in the Department of Animal Behavior have yielded results with indirect bearing on human sexuality can be demonstrated, but this is not the major reason for supporting and encouraging such experimentation. The broader objective of achieving more complete knowledge of the ways in which any species reproduces is a central one to all of biology. Results of a given investigation may reveal similarities to human sexual psychology or they may demonstrate marked differences, and very often the differences are more illuminating than the similarities. For example, Dr. Aronson's work on the hormonal control of courtship and mating in fish fits in nicely with other experiments on amphibians, reptiles, birds and lower mammals to show that the human animal is nearly unique in a marked independence from hormonal control over sexual feelings and performance. This fact makes it easier for scientists to understand how it is possible for societies to control and redirect sexual impulses into a variety of nonreproductive but socially useful kinds of behavior. It also has bearing upon our understand-

ing of some pressing issues such as the origins of homosexuality.

I suspect that one reason some laymen question the importance or value of studies such as the one singled out for criticism in Aronson's case is that they do not know the scientific literature well enough to see how separate studies in different laboratories fit together to provide answers to major issues in science. It takes a long time and many experiments by many scientists to arrive at a satisfactory answer to most basic problems. Any single investigation by itself may well appear pointless to a judge such as Mr. Henry Spiro, New York high school teacher and free-lance journalist who is identified by Nicholas Wade as "the chief architect" of the attack on Dr. Aronson and the American Museum of Natural History. Mr. Spiro and others of his persuasion are, of course, free to debate issues of ethics and morality, but any knowledgeable scientist must discount their judgmental assertions that experiments can just as well "use alternatives to live animals", or that particular experiments are "crude and routine and unlikely to produce any new knowledge." These are judgments that demand full familiarity with past and current research in the area under investigation as well as a grasp of theoretical issues with which nonspecialists have no acquaintance whatsoever.

One more aspect of Mr. Wade's article calls for special comment because it reflects upon Dr. Aronson's scientific reputation and indirectly involves the worthwhileness of the entire research program at the Museum. Under Dr. Aronson's leadership the Department of Animal Behavior has for nearly three decades served as a focus of original research, and a training ground for young scientists concerned with problems of behavior. Many graduate and undergraduate students have gone on from a period of apprenticeship at the Museum to take positions in major universities and research in-

stitutes and to develop their own worthwhile programs of research. This has constituted an important contribution by the American Museum to science, a contribution quite unique as museums go. Aronson's work itself is widely acknowledged to be of the highest quality. Many of his contributions are classic and have appeared in numerous reviews and textbooks on animal behavior.

Mr. Wade's critique states that the titles of some published reports from the museum do not appear in the *Science Citation Index*<sup>®</sup>, and he concludes therefore that these articles cannot have constituted important contributions to knowledge. The criterion is highly debatable since many workers, myself included, are influenced by papers we have read but have never had occasion to cite in our own publications. Research in my own laboratory certainly has been stimulated by publications of Dr. Aronson and his colleagues, and in my teaching I frequently use their experiments to illustrate important theoretical problems or useful methodological approaches; but this type of effect does not show up in the *Science Citation Index*.

Through its Director, Dr. Thomas D. Nicholson, the American Museum of Natural History has staunchly supported Dr. Aronson and his scientific work. Those of us who are committed to the importance of behavioral research, and who are aware of the important contributions which have been made by scientists working at the American Museum, hope that the lasting value of that research will continue to be recognized, and that emotional issues involved in the current teapot tempest will not exert any lasting detrimental effect on the scientific work in the Department of Animal Behavior.

Sincerely,

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