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MAKING JUDGMENTS ABOUT GRANT PROPOSALS: A BRIEF HISTORY OF THE MERIT REVIEW CRITERIA AT THE NATIONAL SCIENCE FOUNDATION

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This is a brief study of the changes in the merit review criteria for proposals submitted to the National Science Foundation (NSF) over its 60-year history. Because far more worthy proposals are received than are fundable, it has been necessary for the NSF to develop review criteria to distinguish among meritorious proposals. For reasons of politics and policy, NSF has had to consider criteria other than simply good science—what are now known as "broader impacts." This study shows that the general nature of the criteria has not changed over the years. Instead, the NSF has fought a continuing battle to clarify the criteria and persuade the peer communities to use the criteria as set down. The trend from the 1960s has been to reduce the number of criteria, but to broaden the definition of those that remain.

Key words: National Science Foundation; Merit review criteria; Peer review

In December 1951, the then 1-year-old National Science Foundation (NSF) issued its first call for grant proposals. The decision of the senior staff to meet its mandate through grants rather than contracts was contrary to the usual practice of most federal science agencies. Rather, it followed the model established by private American foundations that supported scientific research. The mission of the NSF was to support basic research across the entire spectrum of science and engineering disciplines, as well as fund science and engineering education. In the opinion of the NSF staff, a contract was not the appropriate vehicle for providing funds to support basic research. Contracts called for the delivery of an agreed upon product to the contracting agency, but the basic research that the NSF would fund was to be made available to the entire world, not limited to the use of the NSF. Moreover, implicit, if not explicit, in the issuing of a contract was a reasonable assuredness of delivery. There was great uncertainty, however, what the final "product" might be in basic research (6).

In yet another early far-reaching decision, the NSF elected to utilize external peer review as one, but only one, tool in its decision-making process. The NSF staff and the scientific community were engaged in what Director Alan Waterman described in the 1952 annual report (15) as a "collaboration" (p. vi). Although the NSF solicited advice from the research community concerning the funding of specific proposals through advisory panels—sometimes in the early history of the NSF called "panels of scientific consultants"—and mail reviews—with each NSF program given the freedom to decide what was the proper and appropriate balance between the two methods of review—the recommendations for funding came not from the panels but from the NSF program officer, with ultimate decision making reserved for the National Science Board (NSB), the governing board of the NSF (15, p. 14).

The history of proposal review at the NSF is a large topic. It encompasses issues like the evolution of the mechanisms of review, the transparency of the process, the perception of fairness, and the extent of Congressional oversight, to name but a

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few topics. Although George Mazuzan has written a study of the review system through the mid-1980s (8) that looks at many of these topics, he did not consider the history of review criteria. More generally, considerations of review criteria are missing from historical studies of the NSF (although not from the literature of the sociology of science). This study is a preliminary overview in an attempt to begin to fill a gap. The focus will be on issues of general policy regarding review criteria from the perspective of the NSB and NSF senior management.

It was understood by the NSF from the beginning that if the review system was to be fair, clear criteria for evaluating proposals had to be established. These criteria would have to serve two purposes. The first was to eliminate poor proposals from consideration—to ensure that good rather than mediocre research was being supported. The additional and more difficult consideration was selecting from among the good proposals when the NSF's budget allowed it to fund only a fraction of the proposals it deemed worthy of support. This issue arose early in the NSF's history. In fiscal year (FY) 1952, the first year the NSF issued grants, Director Waterman estimated that at least 40% of the proposals submitted were fundable (6, p. 174). But, of the $13 million requested by applicants that year, only $1.1 million (8%) could be handed out (15, p. 13). During the subsequent rapid increase of NSF funding through FY 1968, the percentage of proposals funded steadily climbed, peaking and holding at approximately 61% in the late 1960s (17, p. 10). Since 1980, the rate has never exceeded 40% (9,20,25).

So what criteria were the external peer reviewers asked to consider? How were they to decide among the proposals? The initial criterion (announced to the research community in the December 1951 call for proposals) (15) was "the scientific merit of the proposed research, including the competence of the investigator" (p. 51). However, in practice, additional considerations were necessary for a final judgment (15). The external reviewers were asked to evaluate the proposal using four related criteria. In additional to scientific merit, they were to consider duplication of effort—how unique was the proposed research; reasonableness of budget—no proposal was turned down exclusively for reasons of budget, but negotiating budgets downward became commonplace; and the quality of available personnel and facilities at the host institution. The NSF program officers were asked to evaluate the proposed research's relation to the national effort, as well as issues of geographic and institutional distribution. Technical competence was a necessary—and the most important—element in proposal evaluation, but it was not sufficient. And this remained true throughout NSF history. Over the next six decades, the NSB modified the NSF review criteria language: refining, clarifying, and responding to changes in the make-up of the NSF portfolio of programs. But one aspect of the criteria remained constant. Nontechnical issues were an important element in the NSF's official criteria. In current NSF language, proposals also had to address the issue of "broader impacts."

After the first flurry of decisions in the early 1950s, the next major statement regarding selection criteria occurred in 1967, at the end of a decade and a half of sustained growth and major changes in the scope and volume of NSF activities. Congress had enlarged the NSF budget from FY 1952 to 1967 from $3.5 million in FY 1952 to almost $480 million by FY 1967 (6,16). Although the number of research grants approved by the NSF increased from 96 in FY 1952 to 3,976 in FY 1967, there were also important qualitative differences in the way the NSF was distributing its funds, especially beginning in the late 1950s. In FY 1956, for example, over half the NSF funding went for grants to support basic research. Only approximately 3% went for the support of research facilities. The distribution of funds was quite different in FY 1967. Only 36% of the funding went to basic research projects. Research facilities, including the national research centers like Kitt Peak National Observatory and the National Center for Atmospheric Research, which first became significant recipients of NSF funds in FY 1956, absorbed 8% of the FY 1967 spending. The institutional grants programs, which provided funds for construction and for discretionary spending by academic institutions, and were first awarded in FY 1959 (5), represented another 17% of the NSF expenditures in FY 1967.

In addition, support for applied research was becoming an obvious issue. Although the Daddario amendment, which made support of applied re-

search explicitly part of the NSF charter, did not pass until 1968, Rep. Emilio Q. Daddario had introduced it in March 1966, and the NSF management was keenly aware of it, as demonstrated by a discussion of its provisions in the FY 1967 annual report (16, pp. 5–6).

The "Criteria for the Support of Research" approved by the NSB in May 1967 (16) were presented to the scientific community "as a clarification and reaffirmation" (p. 213) of NSF philosophy that had been in place from the very beginning, not as a radical new vision. The NSB concluded the discussion of these criteria by reiterating that they constituted "no major departure from current practice" (p. 219). One conclusion that could be drawn from such public declarations is that the concern about the potential broader impacts of a grant proposal, at least in the form of the education of graduate students and possible technological benefits, which appear among the 1967 criteria, predates its codification in 1967.

The NSB decided to divide the criteria by the type of institution receiving the funding. There were different criteria applied to academic research compared to research conducted in research institutes or national centers. For academic research, the NSB established five criteria. Three can be viewed as proving clarification for the criteria related to the scientific merit of the proposal. These included the "promise of scientific results," "the potential scientific impact," and "the degree of novelty, originality, or uniqueness." But the other two looked beyond the laboratory to the rest of the academic institution and the wider world. One asked about "the educational value of the proposed research." The last criterion was "the relevance of the proposed work to potential applications." This criterion explicitly raised the possibility that among relatively equal proposals, a practical payoff might give a proposal an edge (pp. 217–218).

The issues facing reviewers of grants for research institutes and national centers were quite different than those evaluating research grants. Reviewers might be deciding whether to establish the institution in the first place, increase funding for an established center, terminate a program, or have it transferred to another facility. Two of the criteria dealt with technical merit. Did this institution "meet a real scientific need" and was it supported by "first-class scientists." Two were more relational: could the research be done by other organizations or institutions and what was the relationship of the research facility to the academic community? The final three worried about the impact of the research on the wider world, asking the reviewers to consider the training potential of the facility, the possibility of crossing disciplinary boundaries, and the possibility of "tangible social benefits" emerging (pp. 218–219).

Seven years later, the NSB revisited (12) the question of selection criteria. In the interim, applied research had become a major element in the NSF portfolio, while institutional grants program had fallen into disfavor with the Nixon administration. Not only had the Daddario amendment passed, but new programs had been developed to fund applied research proposals. In November 1968 Director Leland J. Haworth asked for a modest $15 million for a new program called Interdisciplinary Research Relevant to Problems of Our Society (IRRPOS). IRRPOS only lasted 2 year before it was replaced by a larger, more elaborate program. In the winter of 1971, with the encouragement and support of President Richard Nixon's administration, the NSF established a new program, Research Applied to National Needs (RANN), and a new home for its applied research activities, the Directorate for Research Applications. The NSF was now in the business of funding goal-oriented programs. In FY 1974, RANN represented approximately 12% of the NSF expenditures. In contrast, funding for institutional grants had fallen sharply and in that fiscal year constituted only 1.5% of the expenditures (1,18).

The NSB response to the increasing number of grants supporting applied research was to rethinking the selection criteria. The new criteria, 11 in number, grouped into four categories, were approved in October 1974. It was understood that for any given NSF program, some of the criteria would be more important than others. The NSB also emphasized that there was to be no effort to provide "precise quantification" or "unambiguous rank ordering" among the criteria (18, p. 131). The four broad categories were to the ability of the researcher and the adequacy of his/her institutional base; the quality of the science, with particular emphasis on the possibility of an impact upon other

disciplines; the utility or relevance of the research; and the long-term scientific potential, including impact upon younger colleagues and students, institutional structure, and diffusion of techniques. In all cases, the criteria set out in the first category would be applied.

For grants that focused on institutions rather than individuals, such as those that supported national research centers, there were two additional criteria: need and potential (18, p. 132). Wrapped into these two criteria were most of the criteria established in 1967 for institutional grants. What had disappeared were the questions of social benefits and other wider impacts. But those were covered by the fourth category of criteria for all grants.

Seven years later, circumstances had changed and the review criteria were revisited once again. In particular, the NSF had gone through a number of reorganizations as it attempted to find the proper home for applied research. The Directorate for Research Applications had given way to the Directorate for Applied Science and Research Applications in 1978, which in turn gave way to the Directorate for Engineering and Applied Science in 1979, which in turn gave way to the Directorate for Engineering in 1981. Engineering was now a full partner in the NSF, while applied activities were scattered among a number of directorates (1).

As a result of these changes, the language of the review criteria, although not the thrust, underwent some serious tweaking and consolidation. The changes were partly cosmetic. The number of criteria was reduced to four, but each criterion corresponded to one of the four previous categories: research competence, merit of the research, utility, and effect on infrastructure (21). One major change in language was the introduction of the word engineering in the criteria dealing with merit of research and infrastructure. Another major change was in the form of explanatory commentary, not an actual change to the criteria. In the discussion of criterion 4, the NSB specified what the phrase "effect of the research on the infrastructure of science and engineering" meant, making the concern of the NSF with broader impacts more explicit. Participation of underrepresented groups—minorities and women, the allocation of resources among institutions and geographical areas, and the stimulation of underdeveloped fields were all to be considered part of this criterion (p. 13).

A new issue arose in the mid-1980s. The Federal budgets for FY 1983, 1984, and 1985 all contained direct Congressional authorization or appropriations for significant academic projects, ranging (3) from $750,000 for a pediatric research center at the University of Connecticut to $19,000,000 for the construction of an engineering research center at Boston University. Part of the context for this crisis, a decline in funding for scientific and engineering facilities in academia, will not be addressed here. What is important for this study was the perception by the NSF and the NSB that the introduction of directed appropriations (usually designated in the media as "pork-barrel funding") into federal funding of scientific and engineering facilities was threatening to undermine the peer review process, and according to the NSB Committee in Excellence in Science and Engineering (14), could ultimately "threaten the integrity of the U.S. scientific enterprise" (p. 1). The committee also acknowledged that the nature of academic science and engineering was changing, with increasing resources being directed towards large multidisciplinary and even multiinstitutional projects. In reaction to its committee's warnings, the NSB called upon the NSF to reaffirm the importance of the merit review system, while at the same time, reexamining and analyzing the review process.

NSF Director Erich Bloch responded to the NSB's call by establishing an external Advisory Committee on Merit Review. Chaired by Norman Hackerman, a former chair of the NSB, the 11-member committee spent over a year examining the issue, looking at peer review at other federal agencies as well as the NSF, before reporting back in September 1986 with a set of recommendations (19) which were, for the most part, accepted by the NSF. The committee affirmed that the review process at the NSF was "by and large functioning well" (p. 2), although it did call for what it perceived to be necessary modifications to improve the process and quality of the reviews.

The committee also recommended a major terminology change, one that went to the heart of the issue of review criteria. According to the committee, the term "peer review" was properly a restric-

tive term referring to the evaluation of the technical aspect of the proposal. However, for more and more federally funded research, "technical excellence" was, in the words of the committee, "a necessary but not fully sufficient criterion for research funding" (19, p. 2). Acknowledging that the NSF (as well as other federal agencies) was using a wide range of nontechnical criteria as part of the decision-making process, the committee suggested that the term "merit review" more accurately described the NSF selection process (19, p. 2). The recommendation was accepted by Bloch. As of December 1986 the NSF officially utilized "merit review" (2).

In doing so, the NSF had to reassure the research community that it was not discarding technical review. Director Erich Bloch reminded the staff (2) (and indirectly the larger community) that "the quality of the proposed research and the competence of the investigators" have always served as the "primary criteria for selection of research projects." This was an effort to reassure the research community, which was uneasy about the change (26). However, he also reminded them (2) that "once excellence has been established," other factors, such as "goals of equity and distribution of resources among institutions and geographic areas" had to be taken into account.

Another point raised by the committee was how important it was for the NSF to support innovative but possibly high-risk research (19, pp. 29–30). Implied in the report was that the NSF had to go beyond the peer review process if innovation was to be encouraged. Later NSF statements reinforce this point. There was a danger that peer review, with its emphasis on technical competence, could result in "incrementalism and conservatism" (7, p. 123).

A number of changes and circumstances led to the next reexamination of the review criteria, beginning in 1996. According to congressional testimony (4) by Mary E. Clutter, Assistant Director for the biological sciences at the NSF, the reexamination was due at least in part by the realization that the four criteria had been adopted at a time when the NSF had little involvement in education (it coincided with the Regan administration attack on NSF funding of education that resulted in a cut of some 81% of the NSF FY 1982 budget for education, including all of the funds for precollegiate programs) and that the NSF was now very concerned with the integration of research and education and was rethinking the criteria for that reason. Other considerations included the new NSF Strategic Plan, which embraced new long-range goals and core strategies and the Government Performance and Results Act, which emphasized the necessity of linking NSF goals and strategies to results. Surveys of reviewers conducted in 1991 and NSF program officers in 1995 were also important contributors to the decision to reexamine the criteria. These surveys showed that most reviewers ignored at least one of the four criteria, and in those cases, it was much more likely that criteria 3 and 4 (utility and infrastructure), which did not deal with the more technical aspects of the proposal, were the criteria ignored. They also pointed to a lack of understanding of these nontechnical criteria among the reviewers. In addition, a NSF staff committee tasked with looking at the criteria added its view in February 1996 that the criteria needed clarification and should be rewritten (10).

As a result of all these issues and concerns, the four criteria were reduced to two very broad criteria. One focused on the intellectual merit and the quality of the research. The other focused on the broader impacts of the research. This change was not, in the words of NSB chair Richard N. Zare at the press conference announcing the new criteria (24), "any real change." Instead, "it's a great simplification." By reducing the number of questions asked, Zare was optimistic that "we might do a lot better in terms of being able to judge the value of these proposals." It was the expectation of the NSF, as expressed by the then Acting Deputy Director Joseph Bordogna (23, p. 7), that the new criteria were "clearer and easier to apply."

In 2007, the criteria were revised once again, this time to reinforce NSF's interest in transformative research. As far back as 1999, the National Science Board (11) had seen "a need to revitalize a commitment to innovative research." In 2004, a task force was established (13) "to serve as a Board focal point for gaining a better understanding of National Science Foundation (NSF) policies to solicit, identify, and fund innovative, 'potentially transformative' research" (p. v). The report of the

committee came out in May 2007, and at the August Board meeting, approval was give to adding the words "or potentially transformative" to the first merit review criterion. As Director Arden Bement noted (22), this was an enhancement that would result in enhance support for transformative research, not a radical transformation.

This article is a very quick overview of the changing proposal criteria. There have been four constants in this discussion. Far more worthy proposals are received than are fundable, requiring some criteria to be developed to distinguish among meritorious proposals. Program expansion and external issues have forced the NSF to consider criteria other than simply good science. The peer review community does not necessarily apply the criteria in the manner the NSF wishes. And there are always new programs and new issues forcing the NSF and the NSB to rethink these criteria.

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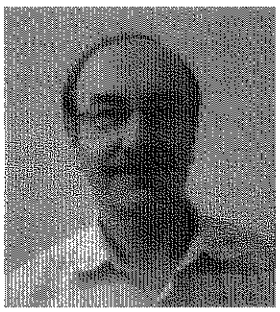

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