

The anatomy and art of writing a successful grant application: a practical step-by-step approach

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Abstract Writing a compelling grant application is a skill that is crucial to conducting high-quality and high-impact scientific research. A successful grant proposal provides the resources necessary to foster activity in an important area of investigation. A concise and practical overview of the anatomy and art of grant writing is provided in this article, along with citations to resources that are particularly useful for junior investigators.

Keywords Research funding · Pediatric radiology · Grant writing · Junior investigators

Introduction

Conducting significant and high-impact scientific research requires sufficient funding that covers the cost of research materials, equipment and time of researchers and staff. Research funding is usually allocated competitively, the goal being to finance research that is most likely to have a substantial impact. A well-written grant proposal clearly communicates the potential significance of a topic of research, the impact of the work to be carried out, and the feasibility of the research team successfully carrying out the proposed work. Researchers need to have a deep understanding of the previous and current work in the domain of interest, appropriate intellectual training, innovative ideas and goals, and a scientifically sound study design that indicates a high probability of success. Articulating a successful grant application requires writing ability and organization skills to communicate the significance and impact of the proposed work.

The goal of this article is to provide a concise and practical review of such skills from a grant writer's perspective.

A good grant proposal should communicate clearly by being (1) easy to read, (2) concise and (3) attractive. Headlines, subheadings and highlighted parts are helpful to convey the message. The writing itself should respond appropriately to the review criteria. It is also critical to find and identify an appropriate funding agency and review panel that matches both the science being proposed and the investigator proposing the research. Here we discuss aspects of pre-writing along with an overview of the fundamental anatomy of a typical grant application and essential points for successful grant writing. We also discuss specific considerations for different types of grant applications such as pilot grants, research grants, and career development grants. Finally, we present considerations about the review process and review criteria.

Prior to writing

High-impact research questions arise at different points over a research career. We assume that during a period of research and training the applicant has identified a critical need, has considered a research strategy, has formulated an overarching hypothesis and is committed to investigating the problem in detail. Throughout this process, the applicant should have thoroughly reviewed and critically analyzed the literature describing background and previous work and performed preliminary studies to assess the feasibility of the research strategy. It is essential for the applicant to critically assess the overarching hypothesis and compare it to alternatives in the literature, and improve or modify it if needed. Such a process leads to the proposed idea and research strategy being refined to maximize their impact. Finally, the applicant designs a research plan that is scientifically based, ethically appropriate and technically feasible. Now, it is time to write

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one or more grant applications to receive funds and resources that enable the principal investigator and research team to execute the research strategy. It is recommended to start the writing process at least 6–12 months in advance of the projected due date of the grant submission. Clear expression and communication of scientific ideas requires that substantial quality time be assigned for writing, and time should be set aside to allow co-investigators, collaborators and a few experienced colleagues or a mentor to go through the application and provide feedback. Preparing a realistic work plan and a detailed timetable is always helpful and often leads to success.

Prior to writing a grant proposal, it is important to find a funding agency or institution that offers the funding opportunities that fit the main idea or purpose of the research project. Ideally, the overall objective of the proposed project should be an ideal fit with the agency's mission so the project can help the agency achieve its main goals. Sometimes a request for applications or a program announcement fits well with the project; however it is strongly discouraged to try to invent a project or substantially change a project to fit such a funding stream. Although finding a good funding opportunity is an absolute necessity, the latter is considered chasing funding (i.e. money), which is inappropriate and often a waste of precious time. The search may vary based on the type and size of the project and should include a wide spectrum of available national and international institutes, societies and foundations [1–5].

Anatomy of a grant proposal

The fundamental anatomy or different sections of a grant proposal is often defined by the specific funding agency or institution. However, it typically involves common components that are discussed in this section. These are general descriptions that need to be tailored to each grant application. Therefore we refer to available resources for grant writing [6–11] as well as scientific communication [12, 13] and only mention the essential points here.

Title, abstract and summary

Clearly conveying an easily understandable, scientifically valuable and technically achievable main goal of the research proposal to the reviewers is essential for success of the grant application. Such information should be effectively included in the title, abstract and summary of the grant application. The abstract, or project summary, is a stand-alone section that should be interpretable by a layperson and clearly communicate the essence of the project. The project summary explicitly describes the overall objective, significance, contribution, innovation, specific aims, and the positive impact of the project. As a consequence, the project summary is often the last section that is written in a grant proposal. In fact, it can be

written by putting together the highlighted parts of the main sections of the proposal.

Objectives and specific aims

For many grant applications, the goals of the project can be described in hierarchy. The statement of goals may begin with a long-term overall objective that describes the ultimate aim of a body of research, including the proposed project. Then, shorter-term goals describe gaps in knowledge or techniques and critical needs that should be addressed. Last, these statements end with a set of specific aims that will fill the gaps and address the critical needs. It is important to recognize that the value of the long-term overall objective is often as important as the specific aims in the requested funding period. The main reason is because it defines the significance and long-term impact of the project. The relationship between achieving the overall objective and the specific aims is a key point to be clearly and logically written. Therefore, three main points are often described in the objectives/specific aims section: (1) overall objective (what will be possible after this project that is not currently attainable?), (2) rationale (why do we want to do this?, i.e. identify the critical need and gap in knowledge or technique), and (3) specific aims. The most important aspect of the specific aims is that they clearly state the objectives and milestones of the body of research that together address the overall objective of the proposed study. The specific aims provide a series of experiments that will be carried out, the successful execution of which conclusively addresses a specific aspect of the overall objective. They provide an answer to the question “What are you going to do?” The details of the execution of each of the specific aims are provided in the research strategy section of the proposal.

Within the specific aims, a set of hypotheses and a central hypothesis are defined. The central hypothesis is presumably the narrowest testable outcome of the proposed project in the funding period. Thus, it should be explicitly defined in the objectives/specific aims section and other sections of the proposal as the single overarching question that needs to be answered. A hypothesis must be based on evidence that is supported by preliminary data and is compatible with established facts, and it must lead to observable consequences that are readily tested. The evidence, facts, tests and alternatives should all be discussed in the research approach sections of the grant proposal. Finally, by definition, a hypothesis should be written in a form such as “the central hypothesis is that A causes B,” rather than “the central hypothesis is if A causes B” or “the central hypothesis is to prove that A causes B.” The words “if” and “prove” are contradictory to the definition of a hypothesis.

It is also often helpful to include statements about the investigators and why they are the best research team to perform the proposed research by explicitly linking to their

expertise, background, track record and previous work. Finally, the objectives/aims section can be concluded with a statement or paragraph about the deliverables (i.e. the expected outcomes of the research, which is in line with the mission of the funding agency). Explicit statements about the positive impact of the research and the return for investment always enhance the chance of receiving a positive decision from the funding agency.

Background and significance

Because the proposed research project and hypotheses are based on scientifically sound evidence and knowledge about the specific field, the project's background, literature and active projects/grants should be thoroughly communicated to the reviewers. This review should be concise but must also be comprehensive and include appropriate citations. Ideally, all the related references should be provided so the reviewers don't need to search for related material on their own. With the current pace of research, it may be particularly important to describe related activity being carried out through ongoing multi-institutional studies or clinical trials in the background review.

Significance defines the main positive impact of the research project on the subject related to the mission of the funding agency. The significance section often comprises three main components: (1) the identification of a gap and critical need through background and literature review (with appropriate citations), (2) the expected contribution to address the critical need and the significance of the contribution through focused, highlighted statements and (3) the positive impact of the project. It is critical to convey in several key places of the grant application what the research community and the funding agency should expect from the grantee for the investment. This should be clearly highlighted in the three key areas of the grant application including: (1) the significance section, (2) the abstract and project summary section and (3) the section that describes the innovation and approach.

Innovation

Innovation is defined as “the application of better solutions that meet new requirements, unarticulated needs or existing market needs.” In other words, innovation is a new and substantive departure from the status quo, which opens new horizons that would otherwise be unattainable [8]. Innovation can be technical or conceptual. To diplomatically state the innovation in a grant application, three components should be carefully considered and presented: (1) description and clarification of the status quo through citations, (2) explicit statement of innovation in the proposed research and (3) description of the new research horizons, preferably relevant to the funding agency's mission, that will be attainable through the innovation in this project.

Approach

The approach section should contain a brief introduction, preliminary results, detailed research design, and expected outcomes, and it may contain a literature review and citations, as needed. The introduction and preliminary results are used to provide justification and feasibility of each aim and task. Because the approach section is often the lengthiest section of the proposal, it is critical to keep it (1) easy to read, (2) concise and (3) attractive. Two components should not be underestimated in writing the approach section: (1) research design details, which are often supported by statistical analysis on preliminary data and power and sample size calculations; and (2) thoughtful description of potential problems and alternative approaches. Both of these components are to support the feasibility of the research project. The essence of research is that it may not always lead to expected outcomes. Funding agencies and institutions are well aware of this. However, their goal is to finance the grant proposals with the highest likelihood to succeed. Therefore it is the grant writers' task to provide evidence as effectively and clearly as possible, often in terms of (1) well-designed studies, (2) preliminary results, (3) appropriate statistical analyses and (4) potential problems with alternative solutions. Such well thought-out and carefully constructed research proposals have a high likelihood of success and can handle potential problems by taking predefined alternative routes. It is thus useful to ask several colleagues with experience in grant application to read the proposal and prospectively think about questions reviewers may ask, and then answer them explicitly at the end of the approach section. We note that potential problems discussed at the end of the approach section should not have a high probability of occurrence; otherwise, they should be considered more seriously in the study design.

Budget and personnel

The budget should be designed based on the needs of the project and the funding agency's policies and instructions. It often includes personnel, equipment, supplies, patient care, animal care, travel and publication costs, each of which should be justified for the particular project through a written justification. The suitability of the personnel of the research team is often an important consideration in assessing the likelihood of successfully executing the research strategy. It is important to have personnel with all of the necessary experience and skills, but it is undesired to have redundancy in skills and overlap in tasks. Personal statements clearly describing each co-investigator or key person's expertise and role in the project are a necessity. Letters of commitment from collaborators should be detailed and explicitly describe their expertise and role in the project and the service they commit to provide for the successful completion of the proposed research project.

Environment and resources

The location or environment where the proposed research is to be performed, the available resources (both shared and core facilities), and the proximity and extent of access to those resources directly impact the success of a project. Therefore they are important review criteria. Again, it is the grant writer’s responsibility to provide such information in a concise and easily understandable format. The facilities section may describe laboratory and office space, animal and clinical equipment, and computer resources. This information is often accompanied by institutional commitment regarding space, equipment, protected research time and administrative support and personnel, as well as career development opportunities and support including start-up, travel and general funds. Intellectual resources and collaborations are other subjects to be discussed in a grant proposal. In addition to the resources and facilities, there are often critical considerations about human subjects [14], vertebrate animals [15, 16] and institutional review board activities that need to be carefully addressed in a proposal.

Specific notes on grant mechanisms

Small pilot grants

These grant mechanisms are mainly designed to support early-stage projects with the main purpose of collecting preliminary data for a large project. Therefore a small pilot grant is mainly designed to collect the pilot data, analyze the data, and provide the proof-of-concept for the hypotheses and specific aims toward the long-term objective. The overall objective, level of innovation and the originality of the proposal are thus more important in these types of grants and should be emphasized in the grant application. As a consequence of the smaller funding, pilot projects should be small, focused in scope, and should be appropriately designed for the duration of funding. Intramural funds (departmental, institutional, society and foundation funds) are usually excellent sources for these types of grants but they are also available from national and international institutes and societies [2, 5].

Research grants

The standard research grants, which often provide moderate amounts of funding for 3–5 years, require a substantial amount of preliminary data that establish the feasibility of the specific aims. Without such data it is unlikely to be funded under these mechanisms. All review criteria including significance, innovation, investigator, approach and environment are seriously considered here. Mechanisms such as program project grants or cooperative agreements have been designed to support

bigger multi-investigator or multi-institution studies including national and international projects, and clinical trials [2].

Training, education and career development grants

These types of grants are mainly for young or junior researchers in their early stages of a research career. The long-term goal in these types of grants can be something like “to develop an independent research career in ...” followed by a scientific step toward this goal. These grant applications require clearly stated rationale, specific aims, and expected outcomes. The inclusion of a paragraph describing the candidate’s and the mentors’ credentials is an important part of these types of grants. Scientific and technical merit, potential of the candidate, quality of the training plan, quality of the mentorship, research environment, and institutional commitment are all taken seriously. Therefore they should be explicitly and carefully addressed in the application. Budget should be carefully designed based on the grant mechanism instructions.

The review process

Often the funding agency or institution provides review criteria [17–21]. It is extraordinarily beneficial to go through these criteria before starting to write a grant. It is helpful to prepare the grant application in such a way that the reviewers can easily find the information they want to evaluate. For example, if significance and innovation are two important review criteria, underlined and highlighted statements in the form of “this project is significant because...” or “the innovation in this project is...” can communicate it effectively with the reviewers. To simplify the review process for the reviewers’ better and easier understanding of the grant proposal, it is recommended to avoid dense writing, complex words or acronyms, jargon and complex illustrations and instead use descriptive headlines, simple sentences and purposeful illustrations [12, 13]. Table 1 shows some of the most common review criteria and the corresponding questions that reviewers

Table 1 Some of the most common review criteria and their meaning in terms of questions that reviewers should be able to answer after reading a grant proposal

Significance	Does the project address a critical problem?
Innovation	Does the project involve development of significantly different concepts or methods?
Investigators	Are the investigators and collaborators well-suited to carry out the project?
Approach	Is the research approach appropriate to accomplish the aims of the project?
Environment	Are the project site and environment appropriate for the success of the project?

are asking. Ideally the grant application should help reviewers easily answer these questions.

In support of the significance, competitiveness and feasibility of the project, it is recommended to explicitly explain to the reviewers the main reason that the investigators are well-suited and their environment is unique for the proposed project. In fact, if the review panelists find convincing positive answers to the following four essential questions, they are more likely to support the project: (1) What particular skills and expertise do the investigators bring to the project?, (2) Are the investigators competitive nationally and internationally?, (3) In case of a career development or training grant, what particular intellectual skills would the grantee or trainee bring to the field of research?, and (4) Would the grantee bring unique and significant expertise to the community?

Conclusion

Grant application preparation is a skill that is complementary to conducting high-quality and scientifically sound research to foster an area of innovation and investigation. The use of online resources and the information provided by funding institutions and peers is valuable. As various resources show, the elements of grant writing involve clear statements about the significance, rationale and innovation in the proposed research. In addition, a detailed description of a research plan that builds upon an innovative idea that addresses a critical need and fills a gap in knowledge or technology is essential.

It is crucial (1) to convey your enthusiasm and communicate with your reviewers through illustrations and (2) to avoid common mistakes such as flawed project design, unfocused hypotheses or specific aims, lack of significance or innovation, and an overly ambitious project design [22]. It is also critical to provide explicit information so the reviewers can easily address the review criteria. This includes a description of the experience and expertise that the investigators bring to the field and the unique environment that is available to them to successfully conduct the project and furnish the specific aims.

Conflicts of interest None

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