Predictors of grantsmanship and funding success for U.S. researchers

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Scientific discoveries constitute the cornerstone of modern civilization. Such discoveries typically come about thanks to funded research efforts, cleared through competitive grant processes. To investigate the behavioral and other characteristics of researchers who excel in such processes, we conducted a nationwide survey of U.S. academics. The survey focused on the academics' grant proposal tactics, scholarly profiles, and personality traits. Here we show that simple tactics, including thoughtful choice of grant competitions and agencies, as well as long research hours are universal primary predictors of grantsmanship and grant funding success. Academic fame is a secondary predictor of grantsmanship and grant funding prowess, as is the case with certain personality traits, notably introversion. On the one hand, these results confirm the public persona of accomplished scholars as dedicated and reflective knowledge workers. On the other hand, the results suggest a relative departure from the stereotype of successful researchers as famously gifted individuals to that of foremost methodical people.

Introduction

Science is the bedrock of our civilization and remains as such through ceaseless advances driven by research (*1*). The organization of scientific research has evolved over time and differs from country to country (*2, 3*). An invariant characteristic of research, however, is that it needs financial resources and thus, is an object of behavioral economics (*4, 5*). U.S. academic research in particular is anchored in competitive funding from a handful of federal agencies (*6*). Funds are largely awarded through the solicitation of proposals from programs within these funding agencies. Such proposals are typically due specific dates during the year, known as grant deadlines, which are non-negotiable. The submissions undergo peer-review and other agency specific selection processes with success rates that rarely exceed 25% (*7*). Hence, pursuance of grant funding is not only stressful, due to its competitive nature, but also risky, due to its low probability of success.

As with all other human enterprises, learned and innate behaviors that lead to success despite the difficulties and against the odds, are of inherent scientific and practical interest. From the science point of view, this is a quintessential nature vs. nurture problem (*8*) - a long-standing question in psychology and related fields. From the practical point of view, the success of the U.S. research model since World War II begs for analysis of its behavioral economics, so that it can inform science policies around the world (*9*).

Here we investigate the role of innate traits and scholarly attributes vs. tactics on grantsmanship and grant funding success. Such success is worth examining, because it has broader impacts. It effects the operationalization of the proposed research designs, leading to developmental cascades that underpin knowledge societies (*10*). Indeed, successful proposals lead to research projects that may eventually bring about new products, services, and culture. To carry out our investigation, we constructed an online questionnaire with corresponding segments for proposal tactics, scholarly profiles, and personality traits. We disseminated this questionnaire to faculty in Science, Technology, Engineering, and Medicine (STEM) departments in U.S. universities, collecting and analyzing data from the respondents. Within the context of a sufficiently resourced, competitive, and fair research ecosystem, such as the U.S. one, our findings shed light on the outsize contribution of tactical moves and the relatively limited role of personal attributions in the pursuance of successful proposals and funding coverage.

Results

The survey associated with this study included a Core Questionnaire (CQ) and three psychometric instruments - the State-Trait Anxiety Inventory (STAI) Form Y2 (*11*), Big-Five Personality Test (*12*), and the Coping Inventory for Stressful Situations (CISS) (*13*). With respect to the Big-Five and CISS inventories, we used their short 10- and 21-item versions, respectively (*14, 15*). The ad hoc CQ consisted of demographic questions, structured questions about research tactics and scholarly profiles, as well as a free-form question; CQ is provided in the Supplementary Materials. The STAI, short Big-Five, and CISS-21 aimed to capture the respondents' innate traits. A total of 435 faculty completed the survey, which was sent via mass email to STEM departments in 70 PhD granting institutions in the United States (Table S1). The email campaign took place between June 4, 2020 and June 3, 2021. Among the respondents, 24 stated that do not submit proposals and did not provide an estimated proposal success rate. Additionally, 8 respondents did not have Google Scholar profiles and did not provide an h-index. Both items are analytically inescapable, because we use proposal success as a response variable in our modeling, while h-index is a key predictor associated with academic fame. Accordingly, we excluded the individuals who lacked data in either of these two crucial variables, reducing the original dataset to the usable sample Ω, with $n_\Omega = 435 - 24 - 8 = 403$ respondents. All subsequent analysis is based on Ω.

The faculty included in Ω were 32.5% (95% Confidence Interval (CI) 27.9 to 37.1) female and 67.5% (95% CI 62.9 to 72.1) male (Fig. 1). This sample distribution is on par with the gender distribution of the faculty population in U.S. universities (χ^2 test, $p = 0.252$), which per the National Center for Science and Engineering Statistics (NCSES) had in 2017 35.2% female and 64.8% male members (*16*). The Ω faculty spanned the gamut of STEM disciplines with 16% (95% CI 12.6 to 19.7) belonging to biomedical sciences, 10% (95% CI 7.5 to 13.5) belonging to behavioral sciences, 29% (95% CI 24.3 to 33.1) belonging to engineering, 18% (95% CI 14.6 to 22.2) belonging to computer and information sciences, and 27% (95% CI 23.1 to 31.8) belonging to natural sciences (Fig. 1). Based on the university affiliations of the respondents, the sample Ω was distributed geographically as follows: 18% in the East, 19% in the West, 20% in the Midwest, and 43% in the South of the continental United States (Fig. 1). The respondents were career-driven professionals, with 92% (95% CI 89.4 to 94.6) of them working over 40 hours per week (Fig. 1). A significant portion of their work time was devoted to research, with 43% (95% CI 38.2 to 47.8) of the Ω faculty reporting that research activities constituted at least 50% of their workload (Fig. 1). The great majority of the respondents - 91% (95% CI 88.2 to 93.8) - were funding at least part of these research activities via competitive grants (Fig. 1).

Predictors

Our analysis focused on grantsmanship (Logit Models (2) and (3), Methods), grant funding record (Logit Models (4) and (5), Methods), and a combination thereof (Logit Model (6), Methods). Model optimization converged to a set of predictors that correlate with the odds of successful grantsmanship or/and successful funding record. Per the design of our survey, the said predictors were drawn from a broader set of variables that fall under three categories: Research Tactics, Scholar Profile, and Personality. This broader set of variables is briefly reviewed in

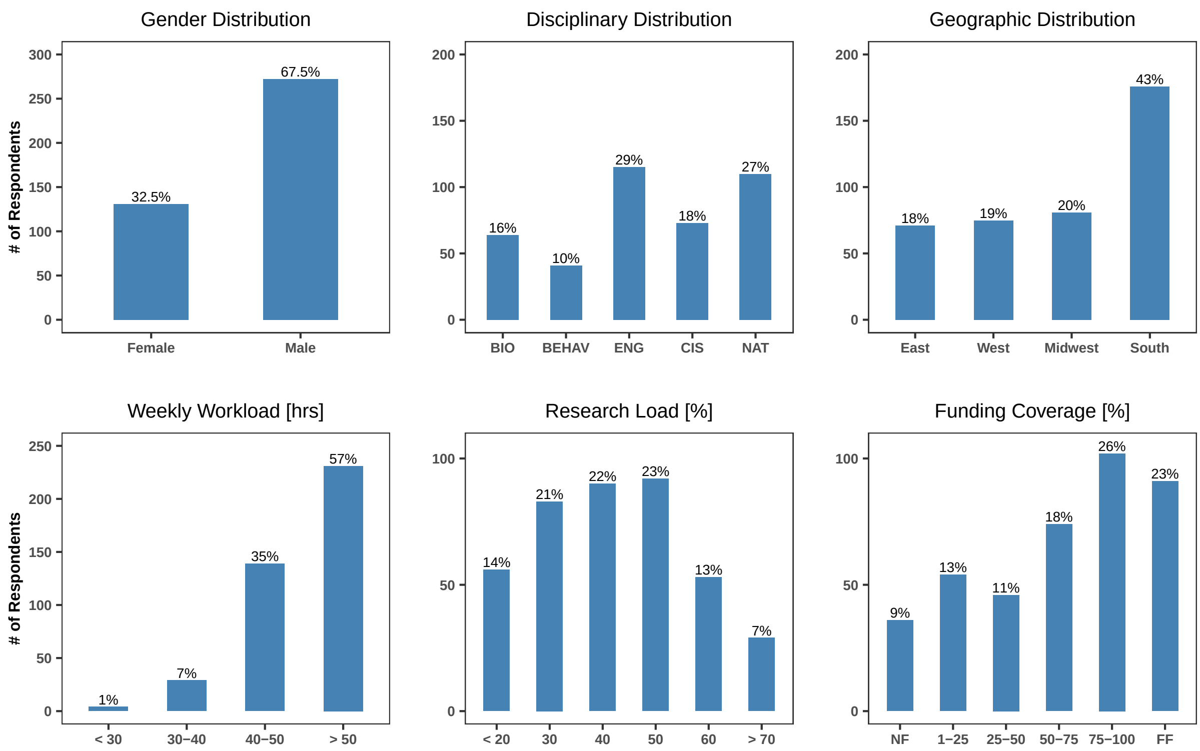

Figure 1: **Descriptive statistics for the usable faculty sample of $n_\Omega = 403$ respondents.** Shown are: gender distribution; distribution across disciplinary clusters with BIO≡biological sciences, BEHAV≡behavioral sciences, ENG≡engineering, CIS≡computer and information sciences, and NAT≡natural sciences; distribution across the geographic regions of the continental United States; respondents' typical weekly workload in hrs; percentage of time devoted to research; coverage of the respondents' research activities through grants, with NF and FF denoting not funded at all and fully funded, respectively. Number ranges in the axes indicate semi-open intervals; e.g., $75 - 100 \equiv [75 - 100)$, including values $75 \leq x < 100$.

Methods; the values of the Research Tactics and Scholar Profile variables were collected though CQ, which can be found in the Supplementary Materials; the values of the Personality variables were collected through the STAI (*11*), short Big-Five (*14*), and CISS-21 inventories (*15*). The select variables that survived optimization and constitute the predictors of Logit Models (2) - (6) are described in detail here. In this description, note that some predictors persist across models, while others do not.

Research Tactics Predictors

Number of Proposals (NP). How often researchers submit proposals emerged as a consequential grantsmanship tactic. Proposal preparation entails significant effort and is associated with high risk (*7*). Per the respondents' free-form feedback, proposals contribute to ideation and formulation of research directions, but upset a number of other research and non-research activities. Consequently, the models appear to capture the need for a delicate balance in proposal activities. The original NP variable had five levels (Supplementary Materials, CQ, Question 17). Due to the skewed distribution of the responses, however, the NP variable was aggregated to the following three levels: NP_1 (1-2 proposals per year), NP_2 (3-4 proposals per year), and NP_3 (5 or more proposals per year). Among the respondents in the usable sample Ω, 36.0% (95% CI 31.3 to 40.7) belong to NP_1, 37.0% (95% CI 32.3 to 41.7) belong to NP_2, and 27.0% (95% CI 22.7 to 31.4) belong to NP_3.

Funding Agency (FA). The funding agency researchers choose to direct most of their proposals emerged as a key tactical predictor for both grantsmanship and funding record (Supplementary Materials, CQ, Question 18). In general, US funding agencies are considered highly competitive, but there are operational and cultural differences among them (*17*), which apparently play a career shaping role. From the respondents in the usable sample Ω, 62.5% (95% CI 57.8 to 67.3) stated they submit most of their proposals to the National Science Foundation (NSF group). From the remaining respondents, 17.9% (95% CI 14.1 to 21.6) stated they direct their proposals to the National Institutes of Health (NIH group), 5.0% (95% CI 2.8 to 7.1) to the Department of Energy (DOE group), 5.5% (95% CI 3.2 to 7.7) to the Department of Defense (DOD group), 2.7% (95% CI 1.1 to 4.3) to the National

Aeronautics and Space Administration (NASA group), and 6.5% (95% CI 4.1 to 8.9) to an assortment of other agencies and foundations (OT group).

Break Frequency (BF). The frequency of breaks appears to play an important tactical role in grantsmanship. Frequent breaks during research tasks may be associated with difficulty to concentrate owing to distractions (*18*) or low engagement (*19*); both of these factors undermine knowledge worker productivity. To establish levels for the BF variable, we took as yardstick the typical length of a research lecture, which is one hour; longer, if it is followed by a Q&A session. At the very least, a researcher should be able to go through such a fundamental scholarly activity without a brake. The original BF variable had four multiples of this break unit (i.e., four levels - Supplementary Materials, CQ, Question 14). Due to the skewed distribution of the responses, however, the BF variable was aggregated to the following two levels: BF_1 (every 1-2 hours or less) and BF_2 (every 3-4 hours or longer). From the respondents in the usable sample Ω, 52.4% (95% CI 47.5 to 57.2) belong to BF_1 while 47.6% (95% CI 42.8 to 52.5) belong to BF_2.

Pilot Research (PR). In a highly competitive research funding environment, review panels may take into account evidence from pilot research regarding the viability of the proposed idea. Pilot research, however, can be a burden on resources and is often misused (*20*). Accordingly, the length of time devoted to pilot work in support of proposal activity emerged as a crucial predictor of grantsmanship. The PR variable has levels PR_1 (less than 1 month), PR_2 (1-3 months), PR_3 (3-6 months), PR_4 (6-12 months), and PR_5 (more than 12 months) - see Supplementary Materials, CQ, Question 21. From the respondents in the usable sample Ω, 6.0% (95% CI 3.6 to 8.3) belong to PR_1, 22.1% (95% CI 18.0 to 26.1) belong to PR_2, 21.1% (95% CI 17.1 to 25.1) belong to PR_3, 24.8% (95% CI 20.6 to 29.0) belong to PR_4, and 26.1% (95% CI 21.8 to 30.3) belong to PR_5.

Time of Submission (TS). In a deadline, the most precious resource is time and the time of submission emerged as crucial predictor of funding record. On the one hand, exhausting all the available time provides maximum opportunity to researchers to enhance the quality of their submission. On the other hand, such tactic increases the risk of a last minute mistake and may be a sign of procrastination - a behavior known to negatively affect human performance (*21*). Certain exogenous conditions may also interact with the time of submission, notably the collaborative nature of certain proposals, which tends to add delays beyond the control of individual investigators (*22*). The original TS variable had five levels (Supplementary Materials, CQ, Question 25). Due to the skewed distribution of the responses, however, the TS variable was aggregated to the following two levels: TS_1 (submission the deadline day) and TS_2 (submission earlier than the deadline day). From the respondents in the usable sample Ω, 45.9% (95% CI 41.0 to 50.8) belong to TS_1 and 54.1% (95% CI 49.2 to 59.0) belong to TS_2.

Percentage of Work Time Devoted to Research (TWR). Research activities in general and preparation of proposals in particular take a lot of time (*23*). Hence, faculty who devote a considerable portion of their time to research at the expense of their teaching and service activities, may have a competitive advantage. Accordingly, the percentage of work time devoted to research (Supplementary Materials, CQ, Question 13) emerged as key funding record predictor. For the respondents in the usable sample Ω, the descriptive statistics for TWR are: $42.1 \pm 15.8\%$, with minimum value 30% and maximum value 100%.

Scholar Profile Predictors

h-index (H). h-index is the most widely used measure of research productivity and is strongly associated with academic fame (*24*). The caliber of the research team is an explicit scoring criterion in the proposal review forms of many funding agencies, such as NIH (*25*).

The Google Scholar h-index (Supplementary Materials, CQ, Question 4) emerged as key predictor of grantsmanship and to some degree of funding record. For the respondents in the usable sample Ω, the descriptive statistics for H are: 29.6 ± 21.4, with minimum value 2 and maximum value 198.

Research Style (RS). The emergence of team science necessitated division of labor and the imposition of a hierarchy in research operations, thus spurring the proliferation of generalists as go-between or team managers (*26, 27*). The said emerging persona is in contradistinction to the more traditional persona of deeply involved researchers. Accordingly, the RS variable has levels RS_1 (hands-off) and RS_2 (hands-on), where hands-off researchers restrict themselves to research management and document composition only, while hands-on researchers are directly involved in experimentation and analysis (Supplementary Materials, CQ, Question 10). This underlying grouping in the research population emerged as a funding record predictor. From the respondents in the usable sample Ω, 39.0% (95% CI 34.2 to 43.7) belong to RS_1, while 61.0% (95% CI 56.3 to 65.8) belong to RS_2.

Personality Predictors

Deadline Stress (DS). Deadlines are stressful by nature and thus, is not surprising that many people feel more stressed than usual on deadline days. Deadline stress levels may also be affected by anxiety predisposition, as well as the adequacy of the preparatory work towards the proposal submission. Stress levels on deadline days proved to be predictive of grantsmanship. The original DS variable had five levels (Supplementary Materials, CQ, Question 26). Due to the skewed distribution of the responses, however, the DS variable was aggregated to the following two levels: DS_1 (similar or lesser stress than regular day) and DS_2 (more stress than regular day). From the respondents in the usable sample Ω, 32.8% (95% CI 28.2 to 37.3) belong to DS_1, while 67.2% (95% CI 62.7 to 71.8) belong to DS_2.

Trait Anxiety (TA). Trait anxiety measured via STAI is a measure of predisposition to stress (*11*). Such predisposition reduces work performance (*28*) and thus, is not conducive to highly competitive professions, like the research profession. Hence, it is not surprising that trait anxiety emerged as grantsmanship predictor. The score range of STAI is $[20, 80]$, where the sub-range $[20, 37]$ is considered low anxiety, the sub-range $[38 - 44]$ moderate anxiety, and the sub-range $[45, 80]$ high anxiety. For the respondents in the usable sample Ω, the descriptive statistics for TA are: 41.3 ± 10.3, with minimum value 20 and maximum value 70.

Extraversion (E). Extraversion is one of the Big-Five personality traits (*12,14*) and emerged as an important grantsmanship predictor. Extraversion and introversion are typically viewed as a single continuum, so to be high in one necessitates being low in the other. Extraversion tends to be manifested in outgoing, talkative, energetic behavior, whereas introversion is manifested in more reflective and reserved behavior. Plentiful anecdotal evidence suggests that famous scholars throughout history were introverted personalities (*29*). The extraversion variable E takes values in the range $[2, 10]$ (*14*). For the respondents in the usable sample Ω, the descriptive statistics for E are: 6.0 ± 2.2, with minimum value 2 and maximum value 10.

Openness (O). Openness is one of the Big-Five personality traits (*12, 14*) and emerged as a funding record predictor. People with high levels of openness are more likely to seek out a variety of experiences and be comfortable with the unfamiliar. This sometimes goes contrary to the need to run a focused research operation in a highly competitive environment. The openness variable O takes values in the range $[2, 10]$ (*14*). For the respondents in the usable sample Ω, the descriptive statistics for O are: 7.5 ± 1.8, with minimum value 3 and maximum value 10.

Agreeableness (A). Agreeableness is one of the Big-Five personality traits (*12,14*) and emerged as an important predictor in the combined grantsmanship and funding record model. People who are high in agreeableness tend to be more collaborative. This is an important attribute for researchers to have in the team science era. The agreeableness variable A takes values in the range $[2, 10]$ (*14*). For the respondents in the usable sample Ω, the descriptive statistics for A are: 7.5 ± 1.7, with minimum value 2 and maximum value 10.

Avoidance Coping (AC). This is part of the factor structure of CISS (*13, 15*) and emerged as a grantsmanship predictor. Individuals practicing avoidance coping try to avoid stressors rather than dealing with them - generally a maladaptive response. Nevertheless, given the deleterious effect of stress on cognitive processes (*30*), avoidance coping may provide a protective ego-capsule, conducive to the conduct of research work. The avoidance coping variable AC takes values in the range $[5, 35]$ (*15*). For the respondents in the usable sample Ω, the descriptive statistics for AC are: 18.8 ± 5.2, with minimum value 7 and maximum value 33.

Grantsmanship Analysis

Winning a grant is a prerequisite for establishing a research line and ultimately advancing science. Accordingly, the first direction of our analysis honed in on grantsmanship and the factors that predict it (Logit Models (2) and (3), Methods). To form the response variables for the relevant models, we asked respondents to estimate their success rate in proposals they submit to their favorite funding agency, based on the following scale: $[< 10\%, 10-20\%, 20-30\%, 30-50\%, 50-75\%, 75-90\%, > 90\%]$ (Supplementary Materials, CQ, Question 19). We binarized the data collected through this seven-point success scale in two different ways, reflecting configurations characterized by different definitions of success in grantsmanship:

Successful Grantsmanship (S^{G30}). This is the baseline configuration, featuring a relatively more permissive definition of success in grantsmanship. Accordingly, respondents who estimated their success rate to be equal or greater than 30% constituted the most successful class S_1^{G30}. Respondents who estimated their success rate to be lower than 30% constituted the least successful class S_0^{G30}.

Highly Successful Grantsmanship (S^{G50}). This is the ultimate configuration, featuring a relatively stricter success criterion in grantsmanship. Specifically, the select few respondents who estimated their success rate to be equal or greater than 50% constituted the most successful class S_1^{G50}. Respondents who estimated their success rate to be lower than 50% constituted the least successful class S_0^{G50}.

The aim of pursuing a multi-configuration analysis was to identify any predicting factors that differentiate exceptional from merely successful grantsmanship performance. In this respect, the choice of the configuration thresholds was a critical decision, which we anchored on the nationwide mean success rate of proposals submitted to the National Science Foundation (NSF) - the preferred agency of the respondents. Accordingly, we chose the 30% threshold of the Successful Grantsmanship configuration, to be slightly above the nationwide 26% mean success rate of NSF proposals in the period 2000 to 2013 (*7*). Hence, while the Successful Grantsmanship configuration meant to capture the cohort inclusive of above average performers, the Highly Successful Grantsmanship configuration with threshold almost twice the nationwide mean, meant to capture elite performers. We found a number of predictors to correlate with the odds of belonging to the successful classes S_1^{G30} and S_1^{G50} in the corresponding configurations. Some of these predictors persist in both configurations, while others do not. Model optimization converged to the following variables per configuration and predictor category (Logit Models (2) and (3), Methods):

Successful Grantsmanship Configuration – S_1^{G30} vs. S_0^{G30}

In the Successful Grantsmanship configuration S^{G30}, 30.5% (95% CI 26.0 to 35.0) of the respondents belong to the most successful class S_1^{G30} and 69.5% (CI 65.0 to 74.0) of them belong to the alternative S_0^{G30}. The configuration is expressed by Logit Model (2) in Methods, while Table S2 provides a comprehensive list of the model's parameter estimates. In the discussion that follows about the S^{G30} configuration, we report comparative results with respect to the *Reference Successful Grantsmanship Researcher* (RR^{G30}). This reference researcher is defined by the baseline levels of categorical predictors and the mean values of quantitative predictors that survived the model optimization process (Logit Model (2), Methods). Accordingly, RR^{G30} submits 1-2 proposal per year (group NP_1), mostly to NSF (group NSF); the day of the deadline, s/he experiences stress no higher than any other working day (group DS_1); and, her/his h-index stands at 29.6, which is the mean h-index in our dataset. Furthermore, the RR^{G30} reference researcher has a trait anxiety score of 41.3, which is the mean STAI score in our dataset. There is 56.5% probability for the reference researcher RR^{G30} to belong to the most successful class S_1^{G30} (95% CI 43.2 to 69.0). Next, we provide a detailed description of how this success estimate changes per Logit Model (2) and in response to varying levels and deviations of categorical and quantitative predictors, respectively, assuming the remaining terms in the model are those of the reference researcher RR^{G30}.

Research Tactics – S_1^{G30} vs. S_0^{G30}

As the number of submitted proposals increases, the probability for faculty to belong to the most successful class S_1^{G30} rapidly decreases - Fig. 2a. For group NP_2, this probability drops by

25.4% with respect to the reference researcher RR^{G30}, while for group NP_3, the said probability drops by a massive 42.9% (logistic regression, $p < 0.001$ for both cases).

The NIH, DOE, and NASA groups are on par with the reference researcher RR^{G30} with respect to the probability of belonging to the most successful class S_1^{G30} (logistic regression, $p > 0.05$). The DOD and OT groups, however, have 26.4% and 28.9% higher probability to belong to S_1^{G30}, respectively (logistic regression, $p < 0.01$ for both cases - Fig. 2a).

Scholar Profile – S_1^{G30} vs. S_0^{G30}

Academic fame, expressed by the h-index, plays a significant positive role for attaining membership in the most successful class S_1^{G30} (logistic regression, $p < 0.05$ - Fig. 2b). For faculty with h-index one standard deviation above the mean, the probability of belonging to S_1^{G30} increases by 7.9% with respect to the reference researcher RR^{G30}.

Personality – S_1^{G30} vs. S_0^{G30}

Faculty who experience higher stress in deadlines with respect to regular work days (group DS_2), have 17.5% lower probability to belong to the most successful class S_1^{G30} with respect to the reference researcher RR^{G30} (logistic regression, $p < 0.01$ - Fig. 2c).

Not only situational stress patterns around deadlines are consequential, but also long-term anxiety profiles. Indeed, trait anxiety scores, obtained via STAI , suggest a negative impact on the probability of belonging to the most successful class S_1^{G30} (logistic regression, $p < 0.05$ - Fig. 2c). For faculty with STAI score one standard deviation above the mean, the probability of belonging to the most successful class S_1^{G30} drops by 7.8% with respect to the reference researcher RR^{G30}.

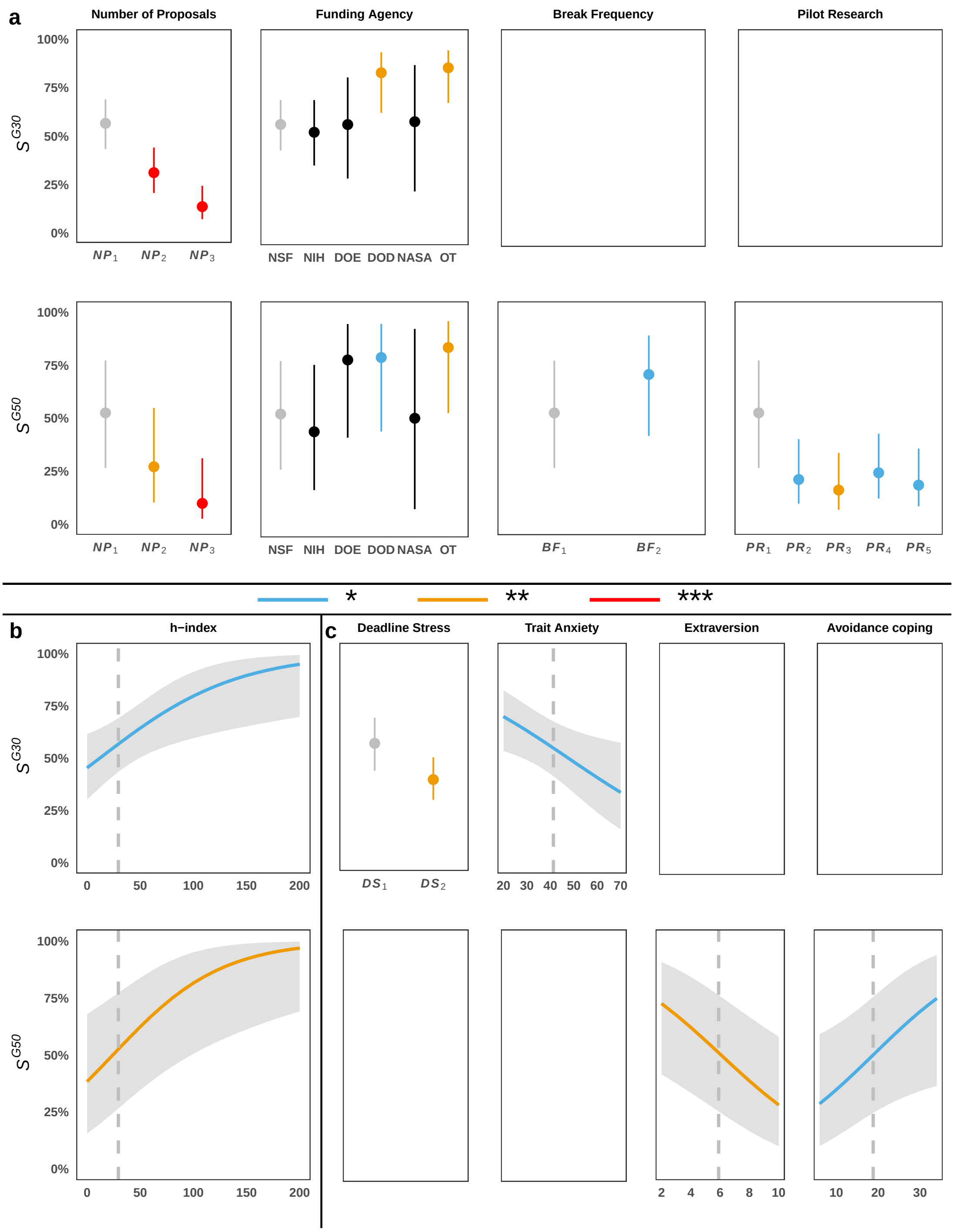

Figure 2: **Main effects for the configurations S^{G30} and S^{G50} of Successful and Highly Successful grantsmanship, respectively.** Blank panels denote the absence of an effect for the specific configuration. Gray error bars in categorical predictors are associated with the configuration's reference researcher. Hyphenated lines mark the mean values of the corresponding quantitative predictors; these mean values are associated with the configuration's reference researcher. While black error bars do not significantly differ from the corresponding error bars of the reference researcher, color error bars do, as the figure's legend in the middle indicates. In this legend, significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$. **a.** Effects of tactical predictors on the grantsmanship of respondents. **b.** Effects of scholarly predictors on the grantsmanship of respondents. **c.** Effects of personality predictors on the grantsmanship of respondents.

Highly Successful Grantsmanship Configuration – S_1^{G50} vs. S_0^{G50}

In the Highly Successful Grantsmanship configuration, 15.9% (95% CI 12.3 to 19.4) of the respondents belong to the most successful class S_1^{G50} and 84.1% (CI 80.5 to 87.7) of them belong to the alternative S_0^{G50}. Logit Model 3 in Methods expresses this configuration and Table S3 provides a comprehensive list of the model's parameter estimates. In the discussion that follows about the S^{G50} configuration, we report comparative results with respect to the *Reference Highly Successful Grantsmanship Researcher* (RR^{G50}). This reference researcher is defined by the baseline levels of categorical predictors and the mean values of quantitative predictors that survived the model optimization process (Logit Model (3), Methods). Accordingly, RR^{G50} submits 1-2 proposal per year (group NP_1), mostly to NSF (group NSF), takes breaks frequently, that is, every 1-2 hours (group BF_1), and conducts limited pilot research, that is, less than 1 month in duration (group PR_1). Additionally, RR^{G50} has h-index = 29.6, which is the mean h-index value in our dataset. Furthermore, s/he has extraversion and avoidance coping scores of 6.0 and 18.8, which are the mean extraversion and avoidance coping values in our dataset, respectively. There is 52.5% probability for the reference researcher RR^{G50} to belong to the most successful class S_1^{G50} (95% CI 26.5 to 77.2). Next, we provide a detailed description of how this success estimate changes in response to varying levels and deviations of categorical and quantitative predictors, respectively, assuming the remaining terms in the model are those of the reference researcher RR^{G50}.

Research Tactics – S_1^{G50} vs. S_0^{G50}

Much like in the case of S_1^{G30}, as the number of submitted proposals increases, the probability for faculty to belong to the most successful class S_1^{G50} rapidly decreases - Fig. 2a. For group NP_2, this probability drops by 25.4% with respect to the reference researcher RR^{G50}, while for group NP3, the said probability drops by a massive 42.7% (logistic regression, $p < 0.01$ and $p < 0.001$, respectively).

The NIH, DOE, and NASA groups are on par with the reference researcher RR^{G50} with respect to the probability of belonging to the most successful class S_1^{G50} (logistic regression, $p > 0.05$). The DOD and OT groups, however, have 26.4% and 31.0% higher probability to belong to S_1^{G50}, respectively (logistic regression, $p < 0.05$ and $p < 0.01$, respectively - Fig. 2a).

Faculty who do not take frequent breaks during knowledge work (group BF_2), have 18.1% higher probability to belong to the most successful class S_1^{G50} with respect to the reference researcher RR^{G50} (logistic regression, $p < 0.05$ - Fig. 2a).

Interestingly, faculty who perform lengthy pilot research have significantly lower probability to belong to the most successful class S_1^{G50} with respect to the reference researcher RR^{G50} - Fig. 2a. Specifically, researchers in the PR_2, PR_4, and PR_5 groups have 31.4%, 28.3%, and 34.1% lower probability to belong to S_1^{G50}, respectively (logistic regression, $p < 0.05$ for all cases). The worst case is for group PR_3 who feature 36.4% lower probability to belong to S_1^{G50} (logistic regression, $p < 0.01$).

Scholar Profile – S_1^{G50} vs. S_0^{50}

Much like in the case of S_1^{G30}, academic fame, expressed by the h-index, plays a significant positive role toward attaining membership in the most successful class S_1^{G50} (logistic regression, $p < 0.01$ - Fig. 2b). For faculty with h-index one standard deviation above the mean, the probability of belonging to S_1^{50} increases by 10.2% with respect to the reference researcher RR^{G50}.

Personality – S_1^{G50} vs. S_0^{G50}

Extraversion scores, obtained via the short Big-Five questionnaire, are associated with a significant negative impact on the probability of belonging to class S_1^{G50} (logistic regression, $p < 0.01$

- Fig. 2c). For faculty with extraversion score one standard deviation above the mean, the probability of belonging to the most successful class S_1^{G50} drops by 13.1% with respect to the reference researcher RR^{G50}.

In contradistinction to extraversion, avoidance coping scores are associated with a significant positive impact on the probability of belonging to class S_1^{G50} (logistic regression, $p < 0.05$ - Fig. 2c). For faculty with avoidance coping score one standard deviation above the mean, the probability of belonging to the most successful class S_1^{G50} rises by 9.1% with respect to the reference researcher RR^{G50}.

Grant Funding Record Analysis

Due to the structure of the academic system in the United States, faculty do not necessarily need to fund the entirety of their research operations via external grants. For example, faculty may support some of their Ph.D. students via Teaching Assistanships (TA). Naturally, TAs cannot spend as much time on research as Research Assistants (RA), who are directly supported by external grants. However, teaching assistanships offer a workable solution and lower the grant hunting burden on faculty. Indeed, some faculty although highly successful in winning grants when they pursue them, may opt for a hybrid internal-external funding model because it better suits their style and career goals. Hence, successful grantsmanship and successful funding record are overlapping but not coincidental terms. Accordingly, the second direction of our analysis honed in on grant funding records and the factors that predict them (Logit Models (4) and (5), Methods). To form the response variables for the relevant models, we asked respondents to estimate the percentage of research operations in their group that was funded by external grants, per the following scale: $[\text{Fully funded}, 100-75\%, 75-50\%, 50-25\%, 25-1\%, \text{Not funded}]$ (Supplementary Materials, CQ, Question 7). We binarized the data collected through this sixpoint scale in two different ways, reflecting configurations characterized by different definitions of success with respect to grant funding levels:

Well-Funded Research Operations ($S^{\$75}$). This is the baseline configuration, featuring a relatively more permissive definition of success with respect to grant funding levels. Accordingly, respondents who estimated their grant funding level to be equal or greater than 75% of their total needs, constituted the most successful class $S_1^{\$75}$. Respondents who estimated their grant funding level to be lower than 75% constituted the least successful class $S_0^{\$75}$.

Fully-Funded Research Operations ($S^{\$\$}$). This is the ultimate configuration, featuring a stricter success criterion with respect to grant funding levels. Specifically, respondents who stated that are fully funded by external grants constituted the most successful class $S_1^{\$\$}$. Respondents with grant funding level lower than 100%, constituted the least successful class $S_0^{\$\$}$.

The aim of pursuing a multi-configuration analysis was to identify any predicting factors that differentiate exceptional from merely successful grant funding records. In this respect, the choice of the configuration thresholds was a critical decision, which we anchored on the percentage of papers published by U.S. researchers, whose content is funded by grants. Accordingly, we chose the 75% threshold for the Well-Funded Research Operations configuration, to be clearly above the nationwide 60% funded papers portion reported in the literature (*6*). Hence, while the Well-Funded Research Operations configuration meant to capture the cohort inclusive of researchers with above average grant funding records, the Fully-Funded Research Operations configuration with threshold at 100%, meant to capture researchers with perfect grant funding records.

We found a number of predictors to correlate with the odds of belonging to the successful classes $S_1^{\$75}$ and $S_1^{\$\$}$ in the corresponding configurations. Some of these predictors persist in both configurations, while others do not. Model optimization converged to the following variables per configuration and predictor category (Logit Models (4) and (5), Methods):

Well-Funded Configuration – $S_1^{\$75}$ vs. $S_0^{\$75}$

In the Well-Funded configuration, 47.9% (95% CI 43.0 to 52.8) of the respondents belong to the most successful class $S_1^{\$75}$ and 52.1% (CI 47.2 to 57.0) of them belong to the alternative $S_0^{\$75}$. Logit Model (4) in Methods expresses this configuration and Table S4 provides a comprehensive list of the model's parameter estimates. In the discussion that follows about the $S^{\$75}$ configuration, we report comparative results with respect to the *Reference Well-Funded Researcher* ($RR^{\$75}$). This reference researcher is defined by the baseline levels of categorical predictors and the mean values of quantitative predictors that survived the model optimization process (Logit Model (4), Methods). Accordingly, $RR^{\$75}$ submits proposals mostly to NSF (group NSF); s/he files these proposals the day of the deadline (group TS_1); s/he devotes 42.1% of her/his weekly work time to research; her/his h-index stands at 29.6, which is the mean h-index in our dataset; and, s/he has a hands-off research style (group RS_1). Furthermore, the $RR^{\$75}$ reference researcher has an openness score of 7.5, which is the mean Big-Five openness score in our dataset. There is 57.4% probability for the reference researcher $RR^{\$75}$ to belong to the most successful class $S_1^{\$75}$ (95% CI 46.7 to 67.4). Next, we provide a detailed description of how this success estimate changes in response to varying levels and deviations of categorical and quantitative predictors, respectively, assuming the remaining terms in the model are those of the reference researcher $RR^{\$75}$.

Research Tactics – $S_1^{\$75}$ vs. $S_0^{\$75}$

The NIH, NASA, and OT groups are on par with the reference researcher $RR^{\$75}$ with respect to the probability of belonging to the most successful class $S_1^{\$75}$ (logistic regression, $p > 0.05$).

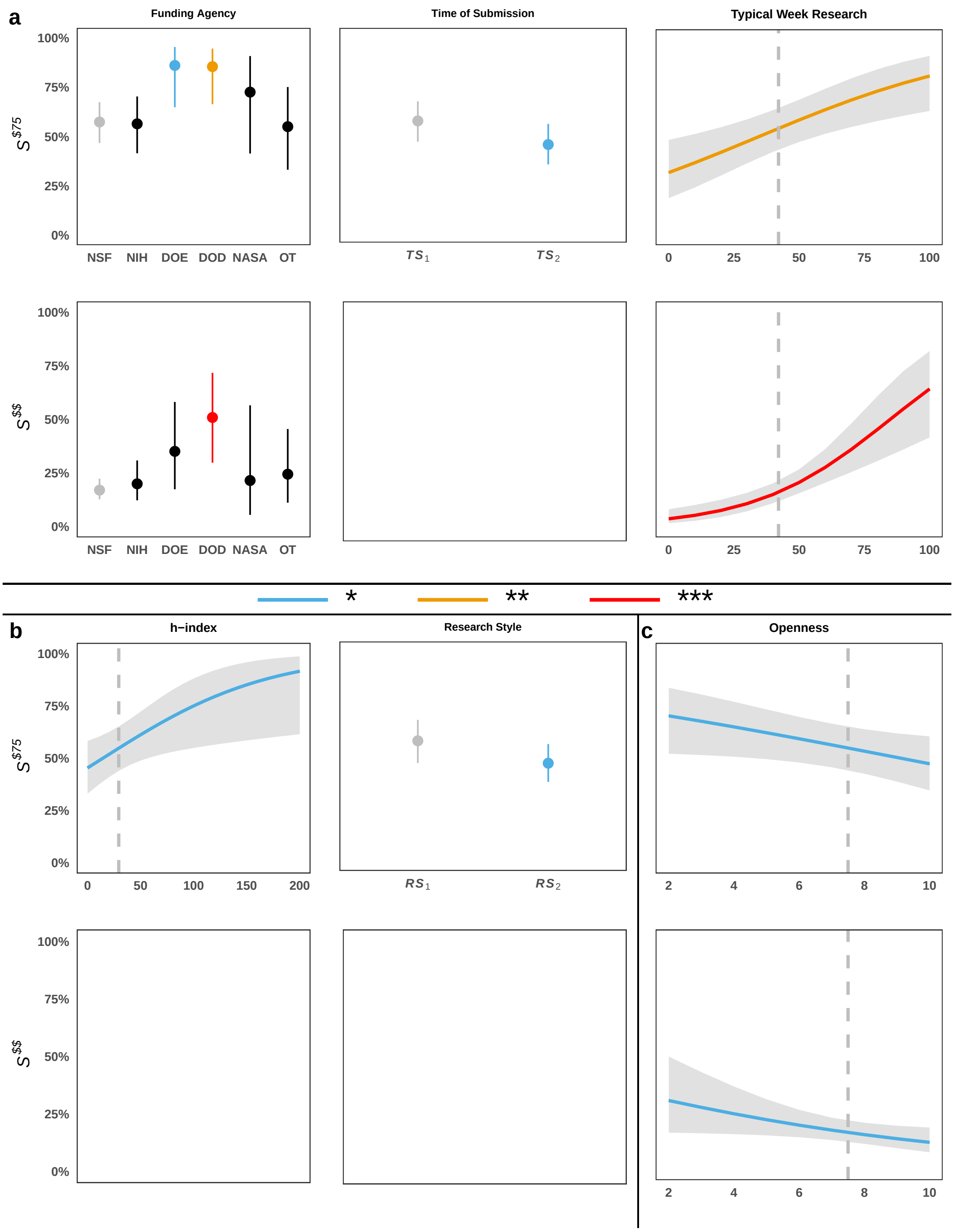

Figure 3: **Main effects for the Well-Funded and Fully-Funded configurations** $S^{\$75}$ **and** $S^{\$\$}$**, respectively.** Blank panels denote the absence of an effect for the specific configuration. Gray error bars in categorical predictors are associated with the configuration's reference researcher. Hyphenated lines mark the mean values of the corresponding quantitative predictors; these mean values are associated with the configuration's reference researcher. While black error bars do not significantly differ from the corresponding error bars of the reference researcher, color error bars do, as the figure's legend in the middle indicates. In this legend, significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$. **a.** Effects of tactical predictors on the grant funding record of respondents. **b.** Effects of scholarly predictors on the grant funding record of respondents. **c.** Effects of personality predictors on the grant funding record of respondents.

The DOD and DOE groups, however, have 28.0% and 28.6% higher probability to belong to $S_1^{\$75}$, respectively (logistic regression, $p < 0.01$ and $p < 0.05$, respectively - Fig. 3a).

Faculty who file their proposals earlier than the deadline day (group TS_2), have 12.2% lower probability to belong to the most successful class $S_1^{\$75}$ with respect to the reference researcher $RR^{\$75}$ (logistic regression, $p < 0.05$ - Fig. 3a).

The percentage of work time devoted to research (TWR) plays a significant positive role on the probability of belonging to the most successfully funded class $S_1^{\$75}$ (logistic regression, $p < 0.01$ - Fig. 3a). For faculty with TWR one standard deviation above the mean, the probability of belonging to the most successful class $S_1^{\$75}$ rises by 8.3% with respect to the reference researcher $RR^{\$75}$.

Scholar Profile – $S_1^{\$75}$ vs. $S_0^{\$75}$

Much like in the grantsmanship configurations S^{G30} and S^{G50}, the h-index plays a significant positive role toward attaining membership in the most successfully funded class $S_1^{\$75}$ of the funding configuration $S^{\$75}$ (logistic regression, $p < 0.05$ - Fig. 3b). For faculty with h-index one standard deviation above the mean, the probability of belonging to $S_1^{\$75}$ increases by 6.5% with respect to the reference researcher $RR^{\$75}$.

Faculty who adopt a hands-on research style (group RS_2) have 10.8% lower probability to belong to the most successful class $S_1^{\$75}$ with respect to the reference researcher RR$^{\$75}$ (logistic regression, $p < 0.05$ - Fig. 3b).

Personality – $S_1^{\$75}$ vs. $S_0^{\$75}$

Openness scores, obtained via the short Big-Five inventory, suggest a significant negative impact on the probability of belonging to the most successfully funded class $S_1^{\$75}$ (logistic regression, $p < 0.05$ - Fig. 3c). For faculty with openness score one standard deviation above the mean, the probability of belonging to the most successful class $S_1^{\$75}$ drops by 5.3% with respect to the reference researcher $RR^{\$75}$.

Fully-Funded Configuration – $S_1^{\$\$}$ vs. $S_0^{\$\$}$

In the Fully-Funded configuration, 22.6% (95% CI 18.5 to 26.7) of the respondents belong to the most successful class $S_1^{\$\$}$ and 77.4% (CI 73.3 to 81.5) of them belong to the alternative $S_0^{\$\$}$. Logit Model (5) in Methods expresses this configuration and Table S5 provides a comprehensive list of the model's parameter estimates. In the discussion that follows about the $S^{\$\$}$ configuration, we report comparative results with respect to the *Reference Fully-Funded Researcher* ($RR^{\$\$}$). This reference researcher is defined by the baseline levels of categorical predictors and the mean values of quantitative predictors that survived the model optimization process (Logit Model (5), Methods). Accordingly, $RR^{\$\$}$ submits proposals mostly to NSF (group NSF) and s/he devotes 42.1% of her/his work time to research. Furthermore, the $RR^{\$\$}$ reference researcher has an openness score of 7.5, which is the mean Big-Five openness score in our dataset. There is 17.0% probability for the reference researcher $RR^{\$\$}$ to belong to the most successfully funded class $S_1^{\$\$}$ (95% CI 12.7 to 22.3). Next, we provide a detailed description of how this success estimate changes in response to varying levels and deviations of categorical and quantitative predictors, respectively, assuming the remaining terms in the model are those of the reference researcher $RR^{\$\$}$.

Research Tactics – $S_1^{\$\$}$ vs. $S_0^{\$\$}$

The NIH, DOE, NASA, and OTHER groups are on par with the reference researcher $RR^{\$\$}$ with respect to the probability of belonging to the most successful class $S_1^{\$\$}$ (logistic regression, $p > 0.05$). The DOD group, however, has 33.9% higher probability to belong to $S_1^{\$\$}$ (logistic regression, $p < 0.001$ - Fig. 3a).

The percentage of work time devoted to research (TWR) plays a significant positive role on the probability of belonging to the most successfully funded class $S_1^{\$\$}$ (logistic regression, $p < 0.001$ - Fig. 3a). For faculty with TWR one standard deviation above the mean, the probability of belonging to the most successful class $S_1^{\$\$}$ rises by 10.4% with respect to the reference researcher $RR^{\$\$}$.

Scholar Profile – $S_1^{\$\$}$ vs. $S_0^{\$\$}$

Interestingly, there are no scholar profile predictors for the Fully-Funded configuration $S^{\$\$}$ - Fig. 3b; success in this case depends entirely on research tactics and personality attributes.

Personality – $S_1^{\$\$}$ vs. $S_0^{\$\$}$

Openness scores, obtained via the short Big-Five questionnaire, suggest a significant negative impact on the probability of belonging to the most successfully funded class $S_1^{\$\$}$ (logistic regression, $p < 0.05$ - Fig. 3c). For faculty with openness score one standard deviation above the mean, the probability of belonging to the most successful class $S_1^{\$\$}$ drops by 3.4% with respect to the reference researcher $RR^{\$\$}$.

Combined Grantsmanship and Grant Funding Record Analysis

To investigate what drives performance in both Grantsmanship and Grant Funding Record at the same time, we constructed a new model. In this model, the response variable was formed by classifying the respondents into one of two classes: the most successful class $S_1^{G50\$\$}$ included faculty with grantsmanship ratio above 50% and research operations fully funded by grants; the least successful class $S_0^{G50\$\$}$ included the rest of the sample. In this combinatorial configuration, 6.2% (95% CI 3.8 to 8.6) of the respondents belong to the most successful class $S_1^{G50\$\$}$ and 93.8% (CI 91.4 to 96.2) of them belong to the alternative $S_0^{G50\$\$}$. Logit Model (6) in Methods expresses this configuration and Table S6 provides a comprehensive list of the model's parameter estimates. In the discussion that follows, we report comparative results with respect to the *Reference Highly Successful in Grantsmanship and Well-Funded Researcher* ($RR^{G50\$\$}$). This reference researcher is defined by the baseline levels of categorical predictors and the mean values of quantitative predictors that survived the model optimization process (Logit Model (6), Methods). Accordingly, $RR^{G50\$\$}$ submits 1-2 proposal per year (group NP_1) and s/he devotes 42.1% of her/his work time to research. Furthermore, s/he has extraversion and agreeableness scores of 6.0 and 7.5, which are the mean extraversion and agreeableness values in our dataset, respectively. There is 10.3% probability for the reference researcher $RR^{G50\$\$}$ to belong to the most successful class $S_1^{G50\$\$}$ (95% CI 6.0 to 17.0). Next, we provide a detailed description of how this success estimate changes in response to varying levels and deviations of categorical and quantitative predictors, respectively, assuming the remaining terms in the model are those of the reference researcher $RR^{G50\$\$}$.

Research Tactics – $S_1^{G50\$\$}$ vs. $S_0^{G50\$\$}$

Borrowing from the grantsmanship configurations, as the number of submitted proposals increases, the probability for faculty to belong to the most successful combined class $S_1^{G50\$\$}$ rapidly decreases - Fig. 4. For group NP_2, this probability drops by 8.4% with respect to the reference researcher $S_1^{G50\$\$}$, while for group NP_3, the said probability drops by 9.4%; logistic regression, $p < 0.01$ for both cases.

Borrowing from the funding configurations, the percentage of work time devoted to research (TWR) plays a significant positive role on the probability of belonging to the most successful combined class $S_1^{G50\$\$}$ (logistic regression, $p < 0.01$ - Fig. 4). For faculty with TWR one standard deviation above the mean, the probability of belonging to the most successful class $S_1^{G50\$\$}$ rises by 7.4% with respect to the reference researcher $RR^{G50\$\$}$.

Scholar Profile – $S_1^{G50\$\$}$ vs. $S_0^{G50\$\$}$

There are no scholar profile predictors for the combined configuration $S^{G50\$\$}$; success in this case depends entirely on research tactics and personality attributes.

Personality – $S_1^{G50\$\$}$ vs. $S_0^{G50\$\$}$

Extraversion scores, obtained via the short Big-Five inventory, are associated with a significant negative impact on the probability of belonging to class $S_1^{G50\$\$}$ (logistic regression, $p < 0.05$ - Fig. 4). For faculty with extraversion score one standard deviation above the mean, the probability of belonging to the most successful class $S_1^{G50\$\$}$ drops by 4.3% with respect to the reference researcher $RR^{G50\$\$}$.

In contradistinction to extraversion, agreeableness scores are associated with a significant positive impact on the probability of belonging to class $S_1^{G50\$\$}$ (logistic regression, $p < 0.05$ - Fig. 4). For faculty with agreeableness score one standard deviation above the mean, the probability of belonging to the most successful class $S_1^{G50\$\$}$ rises by 5.6% with respect to the reference researcher $RR^{G50\$\$}$.

Qualitative Analysis

It is well documented in the literature that mixed quantitative-qualitative approaches lead to more informed study outcomes (*31*). Accordingly, in addition to the structured questions in support of quantitative analysis, we included in the survey a free-form question to support a complementary qualitative analysis. This free-form question was inviting respondents to:

‘*Write about any other aspect of your proposal deadline actions, perceptions, and feelings that you consider important and are not covered in this questionnaire. Please include ideas about mechanisms to replace proposal deadlines, if you have thought of any.*’ (Supplementary Materials, CQ, Question 28).

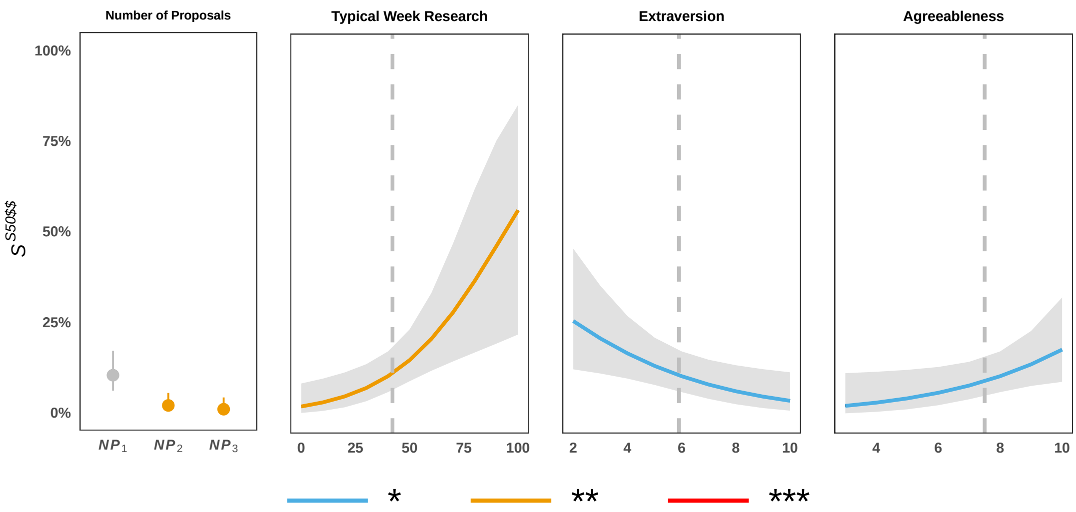

Figure 4: **Main effects for the combinational configuration $S^{G50\$\$}$ of exceptional grantsmanship and grant funding record.** Gray error bars are associated with the configuration's reference researcher. Gray error bars in categorical predictors are associated with the configuration's reference researcher. Hyphenated lines mark the mean values of the corresponding quantitative predictors; these mean values are associated with the configuration's reference researcher. While black error bars do not significantly differ from the corresponding error bars of the reference researcher, color error bars do, as the figure's legend in the middle indicates. In this legend, significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$. The two left/right panels depict effects of tactical/personality predictors.

The said item meant to provide a more in-depth understanding of proposal related behaviors through unforeseen information. Response to the free-form question was optional and of the $n = 403$ faculty who successfully completed the survey, only $n = 186$ addressed this item. Seven of the provided responses were trivial, with statements such as 'no comment' and 'none'. This left an analyzable set of $n = 179$ open text responses. The said sub-sample of $n = 179$ faculty that contributed to the qualitative dataset was representative of the total sample of $n = 403$ faculty that contributed to the quantitative dataset. Indeed, the two sets did not differ in terms of disciplinary, geographic, workload, and funding coverage distributions (χ^2 test, $p > 0.05$ for all cases). Importantly, the two samples did not differ in terms of scholarly attributes, featuring similar h-index distributions (two-sample t-test, $p > 0.05$).

Inductive coding resulted into a set $\mathcal{D}_S$ of $|\mathcal{D}_S| = 369$ statements extracted out of the $n = 179$ open text responses. In turn, these 369 statements were classified under 35 codes i, $\mathcal{D}_C = \{i|1 \leq i \leq 35\}$ (Table S7). Applying the law of diminishing returns, a subset of 9 codes was chosen out of these 35 codes, $\mathcal{D}'_C = \{i|1 \leq i \leq 9\}$ (Methods, 'Coding of qualitative data'). The $\mathcal{D}'_C$ subset was optimal in economic terms, that is, with minimal size it captured the great majority of the information in $\mathcal{D}_S$, thus rendering deeper analysis both practical and meaningful. Accordingly, the remaining qualitative analysis focused on this small subset $\mathcal{D}'_C$, excluding the other 26 codes in superset $\mathcal{D}_C$. Free-form responses from $n = 19$ faculty contained statements belonging solely to the excluded 26 codes. Consequently, the responses of these $n = 19$ faculty were also excluded, thus reducing the usable set of open text responses Ω_{QL} to $n = 160$ items. The nine surviving codes in $\mathcal{D}'_C$ were hierarchically aggregated into the following three main themes: Negative Associations (NA), Positive Associations (PA), and Suggestions for Improvement (IS). Next, we describe in some detail these ultimate themes and codes.

Negative Associations (NA)

We grouped proposal stressors experienced by the researchers into several codes of negative associations. From these codes only the following five survived the application of the law of diminishing returns:

Negative Association 1 (NA_1): This code included a cluster of $|NA_1| = 29$ statements from the $\mathcal{D}_S$ dataset. Through these statements, the respondents made clear they found the ever-changing requirements of the funding agencies highly unhelpful. One of the relevant statements perfectly captured the common sentiment on the matter and we quote it verbatim: 'The granting agencies keep changing formats, requirements, and online submission sites. Just keeping up with those is a job in itself.'

Negative Association 2 (NA_2): This code included a cluster of $|NA_2| = 22$ statements from the $\mathcal{D}_S$ dataset. In these statements, the respondents considered additional proposal requirements imposed by their own institutions to be especially burdensome. A characteristic statement that falls into this code reads as follows: 'One issue is the amount of paperwork that we need to submit to our own office of research on top of the agency requirements.'

Negative Association 3 (NA_3): This code included a cluster of $|NA_3| = 21$ statements from the $\mathcal{D}_S$ dataset. Through these statements, the respondents expressed frustration in managing staff and co-investigators during the proposal process. As one of the researchers put it: 'The most stressful part is the necessary reliance on other people. For example, will the research administration people get their budgets and paperwork done on time? I often have to remind them multiple times. Will my co-PIs get their parts done on time?'

Negative Association 4 (NA_4): This code included a cluster of $|NA_4| = 21$ statements from the $\mathcal{D}_S$ dataset. In these statements, the respondents underlined the difficulty they experience in pursuing proposals while having to cope with all the other academic duties, including teaching and service. 'It seems that the NSF programs I submit to have due dates at the worst times, like end of semester or final exam week,' a respondent wrote.

Negative Association 5 (NA_5): This code included a cluster of $|NA_5| = 18$ statements from the $\mathcal{D}_S$ dataset. In these statements, the respondents concluded pessimistically that irrespective of how proactive they are, deadlines would remain stressful because of their nature. As one researcher put it: 'I think no matter how early I start or how late I start the stress of the deadline is always there.'

Positive Associations (PA)

Researchers found some positive aspects in the proposal process, which we grouped into several codes of positive associations. From these codes only the following two survived the application of the law of diminishing returns:

Positive Association 1 (PA_1): This code included a cluster of $|PA_1| = 35$ statements from the $\mathcal{D}_S$ dataset. Through these statements, the respondents made clear that proactive work tactics, such as advance planning, helped them manage proposals effectively, resulting in a positive experience. Characteristically, a researcher stated: 'I have been doing proposals for 34 years and learned to start early, finish early, and not get consumed by it all.'

Positive Association 2 (PA_2): This code included a cluster of $|PA_2| = 33$ statements from the $\mathcal{D}_S$ dataset. In these statements, the respondents found deadlines to play a focusing and anti-procrastination role, thus improving their productivity. One of the relevant statements is emblematic of the group's common sentiment on this issue and we quote it verbatim: 'Deadlines help me focus. Without a deadline the submission might be delayed without significant improvement in the proposal quality.'

Suggestions for Improvements (IS)

Responding to the prompt by the survey's free-form question to share thoughts about improving the proposal process, the respondents articulated thoughtful recommendations, which we grouped into several codes of improvement suggestions. From these codes only the following two survived the application of the law of diminishing returns:

Improvement Suggestion 1 (IS_1): This code included a cluster of $|IS_1| = 52$ coded statements from the $\mathcal{D}_S$ dataset. In these statements, the researchers suggested that agencies should establish grant programs with 'no deadline' submission calls. Recently, NSF has launched such programs, a move that was commended by the respondents. The faculty justified their support to this mode of operation by explaining that arbitrary deadlines imposed by the funding agencies often conflict with the timing of their educational and other duties. Accordingly, they thought that a ‘no deadline’ proposal policy would be the best way to navigate such conflicts. The respondents also felt that ‘no deadline’ calls will likely increase the quality of the submissions, as deadlines sometimes ‘incentivize people to submit proposals even when they have nothing good to submit.’

Improvement Suggestion 2 (IS_2): This code included a cluster of $|IS_2| = 22$ statements from the $\mathcal{D}_S$ dataset. Through these statements, the researchers made clear that the proposal process as it stands is over-complicated and wasteful; it badly needs an overhaul that will bring simplicity and common sense into the system. ‘This is a fantastically effective way to squash diversity, by raising the status bar for individuals who can submit grants’ a researcher commented, before giving a specific example: ‘My last grant to support one student for three years was over 225 pages long - and funding rates hover around 15%. What a tremendous waste of intellectual resources to spend hours and hours compiling CVs, C&Ps, COAs, and all the other required forms. It also strongly benefits senior personnel who have administrative staff that can maintain these resources for them.’

Linking Qualitative and Quantitative Analysis

The results of the qualitative analysis complement the results of the quantitative analysis by providing contextual nuances. For instance, it is evident from the proportion of the most successful classes in configurations $S^{G30}, S^{G50}, S^{\$75}, S^{\$\$}, S^{G50\$\$}$ that grantsmanship and fundraising are challenging. The researchers, however, make it clear through their statements that what find challenging in the proposal process is not the creative part (e.g., ideation) but the bureaucracy that came to envelope it (e.g., NA_1 and NA_2). We also see the difficulty some faculty having to operate in a team-based environment (e.g., NA_3), as research is undergoing a radical transformation from a solitary endeavor to a collective one (*2*). Finally, we become privy of the tension originating from competing requirements the university administrations impose on their faculty (e.g., NA_4).

Beyond complementarity, to examine if there are any associative links between quantitative and qualitative results, we ran logistic regression models with response variables drawn from the five configurations of grantsmanship/grant funding success $S^{G30}, S^{G50}, S^{\$75}, S^{\$\$}, S^{G50\$\$}$ and single predictors drawn from the nine qualitative variables $NA_1,\ NA_2,\ NA_3,\ NA_4,\ NA_5,\ PA_1,\ PA_2,\ IS_1,\ IS_2$. The combinations resulted into 45 models (Methods, 'Investigating links between quantitative and qualitative levels of analysis'). We hardly found any significant associations between levels of success and negative or positive feelings towards proposal deadlines. This suggests that such feelings are distributed among faculty irrespective of their grantsmanship and grant funding records. There were three exceptions to this general picture:

1. First, we found PA_1 to be strongly predictive of S_1^{G30} ($p = 0.008$) and S_1^{G50} ($p = 0.00497$). Accordingly, respondents who believed and practiced advance planning were associated with the most successful grantsmanship classes S_1^{G30} and S_1^{G50}. Such advance planning, presumably reduces stress, making deadlines look like regular days per the respondents' PA_1 statements. This is exactly what the deadline stress predictor DS indicates in the grantsmanship S^{G30} model - Fig. 2c, thus linking quantitative and qualitative analysis in this instance.

2. Second, we found NA_4 to be strongly predictive of $S_1^{\$\$}$ ($p = 0.0163$). Consequently, respondents who complained about the schedule conflicts the pursuance of proposals creates with their other academic obligations, were associated with the most successful grant funding class $S_1^{\$\$}$. To attain their fully funded status, many of these researchers need to

devote exorbitant amounts of time in proposal activities, which unavoidably leads to conflict with everything else they do. As the Percentage of Work Time Devoted to Research predictor TWR indicates in the $S^{\$\$}$ model - Fig. 3a, faculty in the class $S_1^{\$\$}$ spend a lot more time in research with respect to those in $S_0^{\$\$}$, but apparently it is not enough to fulfill their needs.

3. Third, we found IS_2 to be strongly predictive of S_0^{G30} ($p = 0.0218$). Respondents who felt that the proposal process is in need of radical simplification were associated with the least successful grantsmanship class S_0^{G30}.

Other Results

The CQ included one question about the effect of proposal deadlines on the respondents' lifestyle (Supplementary Materials, CQ, Question 27). The question was inviting faculty to rate the level of proposal-induced disruption in the following five aspects of their lives: their regular research schedule, their sleep, their diet, their physical activity, and their interpersonal relationships. This singular item did not fall under any of the three major themes of the survey, that is, tactics, scholarly profile, and personality. The purpose of this rather more personal question was to quantify the toll proposal related activities take on researchers. The results show that the great majority of faculty (82.3%) report moderate to extreme disruptions on their regular research schedule. By contrast, only a minority of faculty (45.62%) report moderate to extreme effects on their diet, which appears to be the least affected aspect of their lives. Sleep, physical activity, and interpersonal relationships fall somewhere in between, with a healthy majority of respondents (69.42%, 68.08%, and 62.65%,, respectively) reporting moderate to extreme disruptions (Fig. S1). With respect to disruptions in the regular research schedule and interpersonal relationships, we also found corroborating evidence in the faculty free-form responses (Table S7). For example, one researcher exclaimed: 'To succeed in acquiring funding, I need to spend more time writing proposals than actually doing research or writing papers.' Another researcher in a state of exasperation wrote: 'The process is amazingly stressful and has resulted in significant strain on my marriage and health. I have decreased the number of proposals I write in a year as a result of these negative outcomes. I've also spent years in marriage counseling, in part due to the strain of proposal writing.' Regarding physical activity and sleep, however, the qualitative record is 'silent', which suggests people do not pay enough attention to physical activity and sleep disruptions. This is unfortunate, as physical activity and sleep are perhaps the best antidotes to stress (*32, 33*), which our models show thrives in proposal preparation periods and negatively affects grantsmanship (Deadline Stress in Fig. 2, DS in Logit Model (2), and DS_2 in Table S2).

Discussion

Using individual-level survey data, collected from a nationally representative sample of 403 faculty in U.S. universities, we arrive at insightful behavioral findings that underpin grantsmanship and grant funding success. On the one hand, these findings contribute to the long-standing nature vs. nurture debate, while on the other hand, they stand to inform research stakeholders and policymakers.

Grantsmanship

Simple tactics appear to play a dominant role in grantsmanship. Two tactics that characterize grantsmanship across levels of success are the frequency of proposal submission and the choice of funding agency. Researchers who submit a few proposals per year have higher probability of success with respect to researchers who submit many proposals per year. To some degree this must be the cascading effect of success or failure. Researchers who win proposals have less need to keep pursuing proposals. In contradistinction, researchers who lose proposals, have an incentive to keep submitting proposals. The latter must be especially true under the pressures of the U.S. academic system, where the award of tenure critically depends on grantsmanship, and moreover faculty need to raise money to fund their summer salary. This logical assumption, however, does not fully explain the analytic result, which is associated with timeless rather than temporary behaviors (Supplementary Materials, CQ, Question 17). Thus, the said result has a habitual dimension and is not solely driven by winning or loosing streaks. On the whole, it suggests that brute force submission approaches do not constitute effective grantsmanship, while measured and thoughtful targeting of proposal competitions do.

With regard to funding agency preferences, researchers who are oriented towards DOD and some other specialty agencies, have higher probability of success with respect to researchers oriented towards NSF and NIH. This is likely due to the so-called 'ARPA model', referring to the role of program managers in the iconic Defense Advanced Research Program Agency (DARPA) who exercise broad discretion over project selection (*17*). This discretion is often manifested in repeated funding awards to investigators with a good delivery record, in order to fulfill the results oriented goals of the agency. The 'ARPA model' is widespread within DOD. By contrast, persistent funding awards are much more difficult in NSF and NIH, even to excellent investigators, due to the pluralism of the panel review system these agencies espouse.

At the highest level of grantsmanship success (S^{G50}), there are two additional tactics that play a significant role; these are the researchers' break patterns and their pilot research record. We found high performance in research proposals to be associated with the investigator's capacity to sustain long bouts of knowledge work without a break. This indicates ability to focus on a cognitive task without getting distracted, which translates into high intellectual productivity (*18*). We also found engagement in preparatory pilot research to negatively affect high levels of grantsmanship. There are several possible reasons for it. Extensive pilot research takes time and resources (*20*), increasing the cost of proposal failure and committing researchers to a certain course of action, which may cause them to ignore or misalign with emerging opportunities. The latter must be especially true in the transformational period we live in, where funding agencies constantly announce new programs, as they race towards convergence while simultaneously trying to catch up with the AI revolution (*34*). Furthermore, any need for extensive pilot research may imply that the proposed concept is highly novel and has thin support in the literature. Highly novel concepts are often met with skepticism and their negative association with impact is well documented (*35*). At least from the grantsmanship point of view, it is probably far more effective to base research proposals on concepts with measured novelty that can be justified in the literature, thus obviating the need for risky and expensive pilot efforts.

Not unexpectedly, success in proposals positively correlates with the investigator's h-index, a widely used marker of research reputation (*24*). It is characteristic that in several funding agencies, like NIH, proposals are explicitly rated, among other things, on the quality of the investigative team (*25*); h-index is simply a proxy of such quality rating. Compared to tactics, however, h-index has a weaker predictive power on grantsmanship (Fig. 2). This result has interesting implications. Generally, high h-indexes are associated with gifted intellectuals. For example, it has been shown that h-index predicts Nobel Laureates (*36*). Conventionally, intellectual brilliance is considered the primary attribute of the successful researcher stereotype (*37*). Here we see, however, that this prized attribute ranks far behind tactical brilliance as a success predictor.

When it comes to personality factors, grantsmanship at the moderate level of success (S^{G30}) is negatively associated with propensity for anxiety. This result is in agreement with the literature, where the negative role of anxiety in work performance has been well documented (*28*). Grantsmanship at the highest level of success (S^{G50}) is positively associated with introversion. This personality factor dovetails with the solitary nature of proposal activity, the reflective requirements of intellectual synthesis (*29*), and the capacity to carry out cognitive tasks with few breaks, as mentioned earlier.

Grant Funding Record

Simple tactics appear to play a dominant role in the level of grant funding, too. Two tactics that characterize grant funding across levels of success are the choice of funding agency and the relative amount of work time devoted to research. The first tactic was also a significant factor in grantsmanship, but the second tactic is unique to grant funding. More specifically, researchers who direct their proposal efforts towards DOD agencies, enjoy both a grant funding and a grantsmanship advantage. By contrast, researchers who devote a large portion of their work time to research, enjoy only a grant funding advantage. The absence of a grantsmanship advantage in this latter case, gives rise to the hypothesis that some faculty may have excellent grantsmanship records, but do not devote the necessary time to turn them into excellent grant funding records. A case in point is that 9.7% of the faculty in our sample have a stellar grantsmanship record ($> 50\%$ hit ratio), but are not fully funded by external grants.

While tactics remain consequential in grant funding, the role of faculty's scholarly profile is fading. Research reputation (as expressed by the h-index) plays a positive role in the lower funding configuration $S^{\$75}$, but no role whatsoever in the higher funding configuration $S^{\$\$}$. This is in contradistinction to the universal importance of h-index across grantsmanship levels. The said result suggests that fully-funded researchers may not generate citation impact commensurate to their plentiful resources. This does not necessarily imply that such fully funded researchers have lesser overall impact than partly-funded researchers. Taking into account that many fully-funded researchers are pursuing DOD-oriented research, it is possible they generate additional impact from technology transfer and product development, aspects that were not captured in our study.

In terms of personality attributes, openness plays a universally negative role across grant funding levels of success. We interpret this to mean that faculty who excel in grant funding have a disciplined focus on specific profitable pursuits and are less inclined to embark on new and risky investigations.

Grantsmanship and Grant Funding Record Considered Together

Faculty can conceivably attain excellent grant funding records through two paths: a) the long path, where they lose most of the grant applications they pursue (i.e., fair grantsmanship), but eventually accrue the necessary funds through sheer numbers; b) the short path, where they win most of the grant applications they pursue (i.e., excellent grantsmanship), accruing the necessary funds in short order. The latter is an elite cohort of researchers. Logit Model (6) predicts such researchers by placing a joint consideration of grant funding and grantsmanship on its response variable. Much like in the grantsmanship and grant funding Logit Models (2) - (5), tactics play a dominant predictive role in Logit Model (6). True to the hybrid attributes of this model, one tactic is borrowed from the predictors of grantsmanship and one tactic is borrowed from the predictors of grant funding. The former is the number of proposals, while the latter is the portion of work time devoted to research. Successful faculty under Logit Model (6) make few but successful grant submissions and devote a large portion of their work time to research.

There is complete elimination of the scholarly profile as a factor in Logit Model (6). This factor, which was omnipresent in the grantsmanship Logit Models (2)-(3), showed sings of receding in the grant funding Logit Models (4)-(5), and in the hybrid grantsmanship/grant-funding Logit Model (6), it has concluded its withdrawal.

Personality-wise, introversion plays a significant positive role. The introversion attribute has pedigree in the top grantsmanship configuration S^{50}. There is a second personality attribute, however, which is unique to Logit Model (6), that is, agreeableness. Agreeableness plays a significant positive role in predicting the hybrid successful class $S_1^{G50\$\$}$. As agreeableness is crucial in teaming arrangements, this may allude to the likely method the successful researchers of Logit Model (6) attain their elite performance.

Nuanced Interpretations Through Combined Quantitative and Qualitative Analysis

Altogether, although the grant funding system of scientific research in the U.S. is far from perfect, as evidenced by some of the free-form comments (Table S7), it appears to work relatively well. The proof for that is that negative and positive feelings expressed by the respondents are largely not associated with successful or non-successful groups in terms of grantsmanship, grant-funding, or both. The fact that grievances are not strongly associated with non-successful researchers and compliments with successful researchers is a sign that the grant funding system is perceived as relatively fair, which perhaps explains its historical success.

Conclusion

Given that research funding is instrumental in the production of science and that U.S. funded research is on the frontier of science, the results of this study provide powerful insights into a key aspect of contemporary civilization. The study reveals that in the U.S. research funding system, simple tactics play an oversized role. Tactics are the strongest predictors of grantsmanship and grant-funding success under all examined scenarios. Scholarly attributes, mainly academic fame, complement tactics in certain cases, but they feature moderate predictive power. These results convey an intriguing message. As the era of solitary and exclusive science recedes into the background and the era of competitively-funded team science takes a firm hold, the incredible science advances we bear witness may often be driven by merely methodical people rather than geniuses. In the eternal debate of nature vs. nurture, the present study makes a case for nurture, in a domain where nature believed to reign supreme. This relative shift from nature to nurture is likely aided by the modern operational framework of the research ecosystem.

Materials and Methods

The Institutional Review Board (IRB) of the University of Houston approved this study on May 18, 2020 with reference ID STUDY00002285. A total of 435 faculty from 70 U.S. universities (Table S1) responded to email solicitations sent between June 4, 2020 and June 3, 2021. However, only 403 of these respondents successfully completed the survey.

Survey Design

The survey consisted of a set of psychometric instruments and a set of ad hoc questions. The psychometric instruments included the State-Trait Anxiety Inventory (STAI) Form Y2 (*11*), the Big-Five Inventory (*12, 14*), the Coping Inventory for Stressful Situations (CISS) (*13, 15*), and the NASA Task Load Index (NASA-TLX) (*38*). The first three inventories meant to capture key relevant aspects of the respondents' personality, while the fourth inventory intended to measure the respondents' daily load. Specifically, the STAI questionnaire measured the respondents' anxiety propensity, an important consideration in a highly competitive, and thus stressful profession, such as the research profession. If stress is the problem, the way to cope with it might be the solution. Accordingly, we included the 21 item version of the CISS questionnaire (CISS-21), which is a reliable measure of stress coping strategies, measured through task-oriented, emotion-oriented, and avoidance coping scales (*15*). We also included the short version of the Big-Five inventory (*14*), which captures key personality factors, including extraversion, agreeableness, openness, conscientiousness, and neuroticism. These factors are potentially useful to any behavioral study, but we consider them to be especially relevant to the challenges of research life. In particular, research demands reflection and thus a measure of introversion, and agreeableness is highly desirable in team science environments, which dominate contemporary research (*39*). Lastly, we included the NASA-TLX questionnaire (with a seven-point scale) to capture a measure of the respondents' workload, not only as potential predictor of success, but also as validation for the demanding nature of the research profession.

The ad hoc portion of the survey, named Core Questionnaire (CQ), included three segments: a set of demographic questions, a set of questions about the scholarly attributes of the respondents, and a set of questions about the tactics they employ in negotiating research proposals. Demographic questions inquired about the respondents' gender and state of residence. Questions on scholarly attributes inquired about the respondents' h-index, faculty rank, and style of research (hands-on vs. hands-off). Questions on tactics inquired about the respondents' volume of proposal submissions, the funding agency of their choice, and the preparation they put behind proposals, including the conduct of pilot studies. Questions on tactics also inquired about the respondents' degree of preoccupation with research vs. other academic activities. All these pieces of information synthesize a comprehensive picture of the respondents' approach in dealing with the challenges of research bootstrapping, that is, where to aim, how often to attempt hitting the target, how much to prepare before each attempt, and what to sacrifice in the process. The complete CQ is given in the Supplementary Materials.

Estimating Main Effects on Grantsmanship, Grant Funding, and Their Combination Thereof

A logistic regression framework is used to estimate the effect of (1) research tactics, (2) scholarly profile, and (3) personality traits on the odds of success in grantsmanship g, grant funding

\$, and their combination $g\$$. The full model is shown in Eq. (1):

$$\mathrm{logit}(S^{\mathcal{C}}(i)) \sim \sum_{\tau_f \in T_f} \beta_{\tau_f} x_{\tau_f}(i) + \sum_{\tau_c \in T_c} \gamma_{\tau_c} x_{\tau_c}(i) + \sum_{\alpha_f \in \mathcal{A}_f} \beta_{\alpha_f} x_{\alpha_f}(i) + \sum_{\alpha_c \in \mathcal{A}_c} \gamma_{\alpha_c} x_{\alpha_c}(i) + \sum_{\psi_f \in \Psi_f} \beta_{\psi_f} x_{\psi_f}(i) + \sum_{\psi_c \in \Psi_c} \gamma_{\psi_c} x_{\psi_c}(i) \tag{1}$$

The response variable $S^{\mathcal{C}}(i)$ differs per case $\mathcal{C} \in \{g, \$, g\$\}$. For the grantsmanship case $\mathcal{C} \equiv g$, the response variable $S^g(i)$ measures the odds of success in configuration g for respondent i, where $g \in \{G30, G50\}$, with $G30$ and $G50$ denoting the Successful and Highly Successful Grantsmanship configurations with success thresholds set at 30% and 50%, respectively. For the grant funding case $\mathcal{C} \equiv \$$, the response variable $S^{\$}(i)$ measures the odds of success in configuration \$ for respondent i, where $\$ \in \{\$75, \$\$\}$, with \$75 and \$\$ denoting the Well-Funded and Fully-Funded Research Operations configurations with success thresholds set at 75% and 100% coverage, respectively. For the combined case $\mathcal{C} \equiv g\$$, the response variable $S^{g\$}(i)$ measures the odds of success in configuration $g\$$ for respondent i, where $g \in \{G50\} \wedge \$ \in \{\$\$\}$, denoting individuals with Highly Successful Grantsmanship record who are also Fully-Funded.

The predictors of the full model in Eq. (1), are the same for all cases $\mathcal{C} \in \{g, \$, g\$\}$. Specifically, $\beta_{\tau_f}, \beta_{\alpha_f}, \beta_{\psi_f} \in \mathbb{R}$ refer to slopes of categorical predictors (factors f) related to research tactics τ_f, scholarly profile α_f, and personality traits ψ_f respectively, while $\gamma_{\tau_c}, \gamma_{\alpha_c}, \gamma_{\psi_c} \in \mathbb{R}$ refer to slopes of continuous predictors (covariates c) related to research tactics τ_c, scholarly profile α_c, and personality traits ψ_c, respectively. A detailed description of the variables in the full model follows.

Research Tactics Variables: $T_f = \{WH, BF, NP, FA, PC, PR, D2T, TS\}$ is a set of research tactics that includes number of work hours per week (WH), frequency of breaks during knowledge work (BF), yearly number of proposal submissions (NP), type of funding agency

(FA), period invested on proposal composition (PC), period invested on pilot research (PR), workload in a deadline week with respect to a typical week ($D2T$), and time of proposal submission (TS). All T_f variables qualify as categorical predictors because are discretely binned per the questionnaire (Supplementary Materials, CQ, Questions 12, 14, 17, 18, 20, 21, 22, 25). $T_c = \{TWR, DWR\}$ is a set of research tactics that includes proportion of time devoted to research during a typical week (TWR) and proportion of time devoted to research during a deadline week (DWR). All T_c variables qualify as covariates because are finely binned per the questionnaire, thus approximating continuous functions (Supplementary Materials, CQ, Questions 13, 23).

Scholarly Profile Variables: $\mathcal{A}_f = \{FR, RS\}$ refers to the set of scholarly profile factors, which includes faculty rank (FR) and research style (RS). $\mathcal{A}_c = \{H\}$ refers to the set of quantitative scholarly profile predictors - here, the Google Scholar h-index (H).

Personality Variables: $\Psi_f = \{DS\}$ refers to the set of personality factors - here, the relative intensity of deadline stress (DS). $\Psi_c = \{TLX, TA, E, A, C, N, O, AC, EC, TC\}$ refers to the set of quantitative personality predictors, which includes scores for NASA TLX (TLX) and trait anxiety (TA); it also includes scores for the short Big Five traits, that is, extraversion (E), agreeableness (A), conscientiousness (C), neuroticism (N), and openness (O); lastly, it includes the CISS-21 scores of avoidance coping (AC), emotional coping (EC), and task-oriented coping (TC).

For each configuration, that is, $\{G30, G50, \$75, \$\$, G50\$\$\}$, we run the following model optimization process: (1) Starting from the full model in Eq. (1), we sculpt a leaner model through the backward elimination method. (2) Starting from an empty model, we build an optimal model through forward selection of the best variables included in Eq. (1), until the model no longer improves. (3) Adding or removing explanatory variables included in Eq. (1) and testing the model quality after each iteration, we construct an optimal model through step-wise selection. (4) To determine the overall best model, we compare the Akaike information criterion (AIC) numbers among the backward elimination, forward selection, and step-wise selection models, taking also into account the number of predicting variables in each model. The model with the smallest AIC is the candidate best model. Next, we attempt micro-adjustments by examining whether any variables can be removed from this model, without losing statistically significant information and without any material changes to the minimal AIC. Through the said optimization process, we arrive at the following ultimate models for the configurations of interest:

Optimized Grantsmanship Models

$$\text{logit}(S^{G30})(i) \sim \beta_{NP}x_{NP}(i) + \beta_{FA}x_{FA}(i) + \gamma_H x_H(i) + \beta_{DS}x_{DS}(i) + \gamma_{TA}x_{TA}(i) \quad (2)$$

$$\begin{aligned} \text{logit}(S^{G50})(i) \sim\ & \beta_{NP}x_{NP}(i) + \beta_{FA}x_{FA}(i) + \beta_{BF}x_{BF}(i) + \beta_{PR}x_{PR}(i) + \\ & \gamma_H x_H(i) + \gamma_E x_E(i) + \gamma_{AC}x_{AC}(i) \end{aligned} \quad (3)$$

Optimized Grant Funding Models

$$\begin{aligned} \text{logit}(S^{\$75})(i) \sim\ & \beta_{FA}x_{FA}(i) + \beta_{TS}x_{TS}(i) + \gamma_{TWR}x_{TWR}(i) + \gamma_H x_H(i) + \\ & \beta_{RS}x_{RS}(i) + \gamma_O x_O(i) \end{aligned} \quad (4)$$

$$\text{logit}(S^{\$\$})(i) \sim \beta_{FA}x_{FA}(i) + \beta_{TWR}x_{TWR}(i) + \gamma_O x_O(i) \quad (5)$$

Optimized Combination Model

$$\text{logit}(S^{G50\$\$})(i) \sim \beta_{NP}x_{NP}(i) + \gamma_{TWR}x_{TWR}(i) + \gamma_E x_E(i) + \gamma_A x_A(i) \quad (6)$$

Coding of Qualitative Data

We sought to analyze the answers to the survey's free-form question (Supplementary Materials, CQ, Question 28) by performing inductive coding. Accordingly, we developed codes from scratch based on the qualitative data itself. In this endeavor, we followed a thematic approach to identify patterns across the faculty's free-form responses. Specifically, we applied the six-phase process proposed by Braun and Clarke (*40*). In Phase 1, a coder from our research team familiarized herself with the data by reading through the free-form answers and keeping notes. In Phase 2, the coder generated initial codes, representative of the patterns she saw in the data. In Phase 3, the coder collated data associated with a particular code. In Phase 4, the coder collated codes into potential themes, thus forming a hierarchy. In Phase 5, the coder through discussions with the rest of the research team reviewed and revised the theme map in successive rounds. As a result of such theme revisions, the coder had often to go back to Phase 4 to adjust code collations. This recursive interleaving between Phase 4 and Phase 5 continued until the coder settled on a final coding scheme. The enlisting of feedback from the rest of the investigative team during this refining process aimed to establish a shared understanding, which would benefit intercoder consistency and coding validity (*41*). In Phase 6, the coder wrote a data story based on the said analysis, choosing appropriate quotes to back up her interpretations. The resulting coded hierarchy, complete with operational definitions and examples of all codes, was stored in a codebook, thus rendering our coding process reproducible. Three months after the completion of the qualitative analysis, a member of our research team other than the original coder was tasked to re-code 10% of the dataset, using the coding scheme stored in the codebook. This exercise aimed to test the reproducibility of our method. To check intercoder consistency, we calculated the Krippendorff's Alpha-Reliability (*42*) $K_{\alpha r}$, between the second set of codes and the original set of codes. We found $K_{\alpha r} = 0.854$ - a value that indicates high agreement, thus confirming the reliability of our method.

In all, the six-phase coding process yielded a set of 35 codes, $\mathcal{D}_C = \{i|1 \leq i \leq 35\}$. Each code i was associated with a set of statements $\mathcal{S}_i$. The cardinality of each $\mathcal{S}_i$ ranged from 1 to 39 statements; in total, the set of sets $\mathcal{D}_S = \{\mathcal{S}_i|1 \leq i \leq 35\}$ encompassed $|\mathcal{D}_S| = \sum_i |\mathcal{S}_i| = 369$ statements. Accordingly, the code set $\mathcal{D}_C$ with 35 items represented an attempt to aggregate information from the much larger set of coded statements $\mathcal{D}_S$ with 369 items; the aim was to facilitate a more manageable analysis. Nevertheless, it was still practically difficult to carry out deeper qualitative analysis on 35 codes, much less attempt to link them with the study's quantitative results. Hence, we needed a criterion to decide which select codes among the 35 were worth keeping for further consideration. For that, we opted to apply the law of diminishing returns (*43*) by casting the problem as an aggregation efficiency question.

$\mathcal{D}_S$ had its coded statement sets ordered in terms of decreasing cardinality, $\mathcal{D}_S = \{\mathcal{S}_i, |\mathcal{S}_i| \geq |\mathcal{S}_{i+1}|\}$. $\mathcal{D}_C$ had its codes i mirroring the order of the corresponding elements $\mathcal{S}_i$ in $\mathcal{D}_S$, thus allowing $\mathcal{D}_C$ and $\mathcal{D}_S$ to be processed in a pairwise manner. We also established two new sets, initially empty, $\mathcal{D}'_C = \mathcal{D}'_S = \emptyset$. We started bringing one by one codes i and their corresponding coded statements sets $\mathcal{S}_i$ from $\mathcal{D}_C$ and $\mathcal{D}_S$ to $\mathcal{D}'_C$ and $\mathcal{D}'_S$, respectively. Each code i added to $\mathcal{D}'_C$ represented $\Delta_i = (1/35) \times 100 = 3\%$ of the total information content of $\mathcal{D}_C$. The corresponding coded statement set $\mathcal{S}_i$, which was added to $\mathcal{D}'_S$, represented $\Delta_{S_i} = (|\mathcal{S}_i|/369) \times 100\%$ of the total information content of $\mathcal{D}_S$. While the code information increment $\Delta_i = 3\%, \ \forall i$ was constant, the coded statement information increment Δ_{S_i} varied, depending on the value of $|S_i|$. To maintain an efficient aggregation process, $\Delta_{S_i} > (\Delta_i = 3\%)$. When this condition was not satisfied anymore, it meant we reached the point of diminishing returns, and must stop adding elements to the sets $\mathcal{D}'_C$ and $\mathcal{D}'_S$. This happened after we added the top nine codes to $\mathcal{D}'_C$ along with the corresponding top nine coded statement sets to $\mathcal{D}'_S$. In all, these select nine codes represented just 25.6% of the information content of $\mathcal{D}_C$ (i.e., 9 out of 35), but were bringing 69% of the information content of $\mathcal{D}_S$ (i.e., 233 out of 369). This subset of codes, although small enough to facilitate a deeper analysis, it captured the great majority of the original coded statements, thus offering an optimal solution in economic terms.

The thus constructed ultimate coding scheme featured three overarching themes: Negative Associations (NA), Positive Associations (PA), and Improvement Suggestions (IS). In turn, these themes encompassed the following nine surviving codes: five NA codes: $NA_1 \equiv S_4, NA_2 \equiv S_5, NA_3 \equiv S_6, NA_4 \equiv S_7, NA_5 \equiv S_8$; two PA codes: $PA_1 \equiv S_2, PA_2 \equiv S_3$; and, two IS codes: $IS_1 \equiv S_1, IS_2 \equiv S_9$.

Investigating Links Between Quantitative and Qualitative Levels of Analysis

To investigate if there are any direct links between the quantitative and qualitative levels of analysis, we used a logistic regression framework to estimate the effect of negative associations, positive associations, and improvement suggestions on the odds of success in grantsmanship g, grant funding \$, and their combination $g\$$ for respondent i:

$$\text{logit}(S^{\mathcal{C}}(i)) \sim \beta_{QL} x_{QL}(i) \tag{7}$$

The response variable $S^{\mathcal{C}}$ draws on the grantsmanship, grant funding, and mixed configurations of success $\mathcal{C} \in \{G30, \quad G50, \quad \$75, \quad \$\$, \quad G50\$\$\}$. The qualitative predictors x_{QL} draw on the negative associations, positive associations, and suggestion improvements $x_{QL} \in \{NA_1, NA_2, NA_3, NA_4, NA_5, PA_1, PA_2, SI_1, SI_2\}$. Hence, Eq. (7) describes a family of $|\mathcal{C}| \times |x_{QL}| = 9 \times 5 = 45$ logistic regression models.

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Supplementary Materials for

Predictors of grantsmanship and funding success for U.S. researchers

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The file includes:

Core Questionnaire (CQ)

Fig. S1

Tables S1 to S7

Core Questionnaire (CQ)

1. **Faculty rank** ☐ Assistant Professor ☐ Associate Professor ☐ Professor

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2. **Gender** ☐ Female ☐ Male ☐ Diverse

---

3. **Departmental affiliation**

   ☐ Biology ☐ Chemistry ☐ Geosciences ☐ Physics ☐ Mathematics ☐ Engineering

   ☐ Computer/Information Science ☐ Psychology ☐ Medicine ☐ Other ______________

---

4. **Google Scholar h-index** ______________

---

5. **What state do you reside in?** ______________

---

6. **How many months of your salary depend on external grants?**

   ☐ Three months ☐ Other ______________

---

7. **What percentage of your group's research operation is funded by external grants? Operational costs include summer salaries for faculty, postdoctoral stipends, research assistantships, & equipment.**

   ☐ Fully funded ☐ 100-75% ☐ 75-50% ☐ 50-25% ☐ 25-1% ☐ Not funded

---

8. **Where do you typically work?** ☐ Office ☐ Home ☐ Other ______________

---

9. **Please indicate your workload today** ☐ Light ☐ Standard ☐ Heavy

---

10. What is your research style?

□ Hands off [management/reading/writing] □ Hands on [plus experiments/analysis]

---

11. Do you have any looming deadline? (either today or the next couple of days)

□ Yes □ No

---

12. In a typical week, how many hours in total do you devote to work? This includes research, teaching, administration, and service/outreach to the scientific community and broader society.

□ $<$ 30 □ 30 - 40 □ 40 - 50 □ $>$ 50

---

13. Distribution of work time in a typical week; approximate in 10% increments.

Research	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Teaching	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Administration	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Service/Outreach	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%

---

14. In a typical day how often do you take breaks during your work?

□ Every hour □ Every 1 - 2 hours □ Every 3 - 4 hours □ $>$ Other ____________

---

15. How do you usually handle email during work?

□ Answer email as it comes □ Answer email in batches once or twice per day

---

16. Do you submit funding proposals? □ Yes □ No

---

17. What is the average number of proposals you submit per year?

□ 1 - 2 □ 3 - 4 □ 5 - 6 □ 7 - 9 □ $\geq$ 10

---

18. What is the funding agency where you submit most of your proposals?

□ NSF □ NIH □ NASA □ DOD □ DHS □ DOE □ Other ____________

---

19. What is your approximate success rate in this agency?

□ < 10% □ 10 - 20% □ 20 - 30% □ 30 - 50% □ 50 - 75% □ 75 - 90% □ > 90%

---

20. Typically, how far in advance do you start composing a proposal? Proposal composition includes writing, team arrangements, and relevant administrative work.

□ Less than 1 week □ 1 - 2 weeks □ 2 - 4 weeks □ 1 - 2 months □ More than 2 months

---

21. What is the typical length of supporting research that precedes a proposal composition in your case? Supporting research includes literature review, development of methods, pilot experiments (if applicable), and any associated data analysis.

□ Less than 1 month □ 1 - 3 months □ 3 - 6 months □ 6 - 12 months □ More than 12 months

---

22. In the week leading to a proposal deadline, how much do you work with respect to a typical week?

□ Significantly less □ Less □ About the same □ More □ Significanlty more

---

23. Distribution of work time in the week leading to a proposal deadline; approximate in 10% increments. Note that proposal composition belongs to research.

Research	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Teaching	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Administration	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Service/Outreach	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%

---

24. Distribution of work time on the day of the proposal deadline; approximate in 10% increments. Note that proposal composition belongs to research.

Research	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Teaching	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Administration	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%
Service/Outreach	□ 0	□ 10	□ 20	□ 30	□ 40	□ 50	□ 60	□ 70	□ 80	□ 90	□ 100%

---

25. When do you typically submit a funding proposal?

□ Minutes before deadline □ 1 - 3 hours before deadline □ 3 - 6 hours before deadline

□ 1 day before deadline □ 2 or more days before deadline

---

26. What is your stress level on the day of a proposal deadline with respect to a regular workday?

□ Extremely Less □ Significantly Less □ Same □ Significantly More □ Extremely More

---

27. What aspect of your life you find to be the most disrupted in the period leading to a proposal deadline?

Regular Research

□ No disruption □ Little □ Moderate □ Significant □ Extreme disruption

Sleep

□ No disruption □ Little □ Moderate □ Significant □ Extreme disruption

Diet

□ No disruption □ Little □ Moderate □ Significant □ Extreme disruption

Physical activity

□ No disruption □ Little □ Moderate □ Significant □ Extreme disruption

Interpersonal relationships

□ No disruption □ Little □ Moderate □ Significant □ Extreme disruption

---

28. **Write about any other aspect of your proposal deadline actions, perceptions, and feelings that you consider important and are not covered in this questionnaire. Please include ideas about mechanisms to replace proposal deadlines, if you have thought of any.**

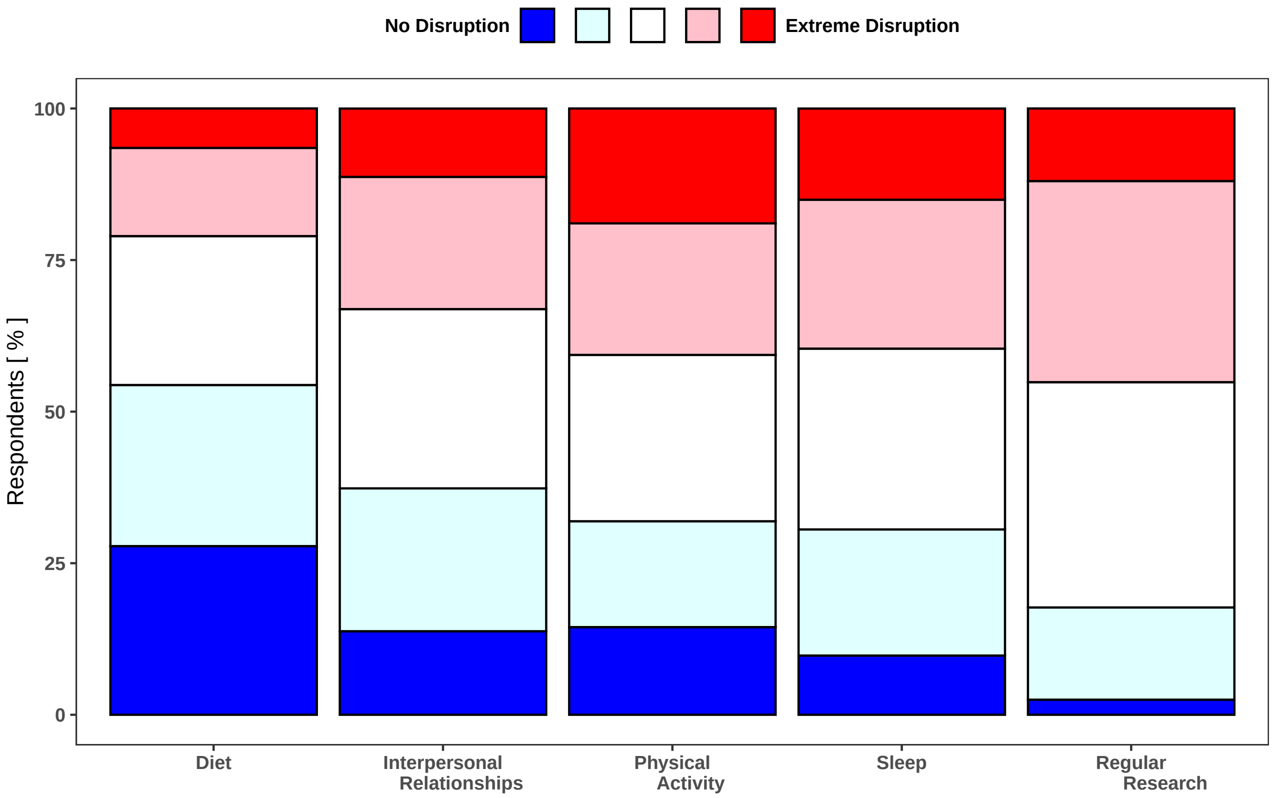

Figure S1: **Distributions of responses to the lifestyle disruptions question (Supplementary Materials, CQ, Question 27).** Blue indicates ‘no disruption’, cyan indicates ‘little disruption’, white indicates ‘moderate disruption’, pink indicates ‘significant disruption’, and red indicates ‘extreme disruption’. The great majority of respondents feel that proposals materially disrupt their regular research schedule, while only a minority of them feel the same about their diet. Estimates about interpersonal relationships, physical activity, and sleep fall somewhere in between the said extremes.

Table S1: **List of survey respondents' universities and their geographic region within the continental United States.**

University	Region
1. Arizona State University	West
2. Binghamton University	East
3. Boston University	East
4. California Institute of Technology	West
5. Clemson University	South
6. Colorado State University	West
7. Columbia University	East
8. Florida State University	South
9. George Mason University	East
10. Georgia Institute of Technology	South
11. Georgia State University	South
12. Iowa State University	Midwest
13. Johns Hopkins University	East
14. Massachusetts Institute of Technology	East
15. Michigan State University	Midwest
16. Morgan State University	East
17. New York University	East
18. North Carolina State University	East
19. Northeastern University	East
20. Northwestern University	Midwest
21. Oregon State University	West
22. Purdue University	Midwest
23. Rutgers University	East
24. Stanford University	West
25. Stony Brook University	East
26. Temple University	East
27. Texas A&M University	South
28. Texas State University	South
29. Texas Tech University	South
30. The George Washington University	East
31. The Ohio State University	Midwest
32. The Pennsylvania State University	East
33. The University of Alabama in Huntsville	South
34. The University of Arizona	West
35. The University of New Mexico	West
36. The University of North Carolina at Chapel Hill	East
37. The University of Oklahoma	South
38. The University of Texas at Arlington	South
39. The University of Texas at Austin	South
40. The University of Texas at Dallas	South
41. The University of Texas at El Paso	South
42. The University of Texas at San Antonio	South
43. The University of Utah	West
44. The University of Washington	West

Continued on next page

Table S1 – continued from previous page

University	**Region**
45. University of Buffalo	East
46. University of California, Berkeley	West
47. University of California, Irvine	West
48. University of California, Los Angeles	West
49. University of California, Merced	West
50. University of California, Riverside	West
51. University of Central Florida	South
52. University of Colorado Boulder	West
53. University of Colorado Denver	West
54. University of Connecticut	East
55. University of Houston	South
56. University of Maryland	East
57. University of Massachusetts Amherst	East
58. University of Michigan	Midwest
59. University of Minnesota	Midwest
60. University of Montana	West
61. University of Nevada, Reno	West
62. University of North Texas	South
63. University of Oregon	West
64. University of South Florida	South
65. University of Tennessee	South
66. University of Virginia	East
67. University of Wisconsin-Madison	Midwest
68. University of Wisconsin-Milwaukee	Midwest
69. Virginia Commonwealth University	East
70. Washington State University	West

Table S2: **Parameter estimates for the Successful Grantsmanship configuration S^{G30} (Logit Model (2), Methods).** The coefficients $\beta.|\gamma.$ are given both probability-wise and odds-wise. The Akaike Information Criterion (AIC) for the model is 426.38. Significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Predictor	$\beta.|\gamma.$ **Prob-wise**	$\beta.|\gamma.$ **Odds-wise**	**Std. Error**	**z value**	**Pr(**$>|z|$**)**	
Intercept	0.743	1.062	0.617	1.721	0.085	
NP_2	0.258	-1.058	0.273	-3.874	<0.001	***
NP_3	0.108	-2.116	0.364	-5.805	<0.001	***
FA_{NIH}	0.460	-0.161	0.329	-0.489	0.625	
FA_{DOE}	0.500	-0.002	0.592	-0.003	0.998	
FA_{DOD}	0.789	1.316	0.504	2.611	0.009	**
FA_{NASA}	0.514	0.057	0.788	0.072	0.942	
FA_{OT}	0.819	1.507	0.491	3.072	0.002	**
H	0.504	0.016	0.006	2.549	0.011	*
DS_2	0.330	-0.709	0.265	-2.679	0.007	**
TA	0.492	-0.030	0.013	-2.331	0.020	*

Table S3: **Parameter estimates for the Highly Successful Grantsmanship Configuration S^{G50} (Logit Model (3), Methods).** The coefficients $\beta.|\gamma.$ are given both probability-wise and odds-wise. The AIC for the model is 305.07. Significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Predictor	$\beta.|\gamma.$ **Prob-wise**	$\beta.|\gamma.$ **Odds-wise**	**Std. Error**	**z value**	**Pr(**$>|z|$**)**	
Intercept	0.401	-0.401	0.866	-0.463	0.643	
NP_2	0.252	-1.090	0.350	-3.114	0.002	**
NP_3	0.089	-2.320	0.531	-4.371	<0.001	***
FA_{NIH}	0.418	-0.331	0.465	-0.713	0.476	
FA_{DOE}	0.760	1.151	0.637	1.806	0.071	
FA_{DOD}	0.772	1.217	0.571	2.133	0.033	*
FA_{NASA}	0.480	-0.079	1.144	-0.069	0.945	
FA_{OT}	0.821	1.524	0.523	2.915	0.004	**
BF_2	0.685	0.777	0.331	2.349	0.019	*
PR_2	0.194	-1.421	0.633	-2.244	0.025	*
PR_3	0.148	-1.752	0.656	-2.670	0.008	**
PR_4	0.224	-1.240	0.601	-2.065	0.039	*
PR_5	0.170	-1.588	0.618	-2.569	0.010	*
H	0.505	0.020	0.007	2.659	0.008	**
E	0.440	-0.240	0.081	-2.974	0.003	**
AC	0.518	0.072	0.034	2.096	0.036	*

Table S4: **Parameter estimates for the Well-Funded Configuration $S^{\$75}$ (Logit Model (4), Methods).** The coefficients $\beta.|\gamma.$ are given both probability-wise and odds-wise. The AIC for the model is 531.61. Significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Predictor	$\beta.|\gamma.$ **Prob-wise**	$\beta.|\gamma.$ **Odds-wise**	**Std. Error**	**z value**	**Pr(**$>|z|$**)**	
Intercept	0.472	−0.111	0.575	−0.192	0.847	
FA_{NIH}	0.491	−0.038	0.284	−0.133	0.894	
FA_{DOE}	0.821	1.520	0.596	2.551	0.011	*
FA_{DOD}	0.813	1.472	0.540	2.725	0.006	**
FA_{NASA}	0.662	0.673	0.650	1.036	0.300	
FA_{OT}	0.476	−0.096	0.440	−0.218	0.827	
TS_2	0.380	−0.488	0.217	−2.247	0.0025	*
TWR	0.506	0.022	0.007	3.212	0.001	**
H	0.503	0.013	0.005	2.340	0.019	*
RS_2	0.393	−0.433	0.218	−1.982	0.047	*
O	0.470	−0.121	0.061	−1.973	0.049	*

Table S5: **Parameter estimates for the Fully-Funded Configuration $S^{\$\$}$ (Logit Model (5), Methods).** The coefficients $\beta.|\gamma.$ are given both probability-wise and odds-wise. The AIC for the model is 406.73. Significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Predictor	$\beta.|\gamma.$ **Prob-wise**	$\beta.|\gamma.$ **Odds-wise**	**Std. Error**	**z value**	**Pr(**$>|z|$**)**	
Intercept	0.109	−2.103	0.654	−3.217	0.001	**
FA_{NIH}	0.549	0.196	0.335	0.585	0.559	
FA_{DOE}	0.725	0.970	0.507	1.914	0.056	
FA_{DOD}	0.835	1.622	0.489	3.318	<0.001	***
FA_{NASA}	0.572	0.290	0.816	0.355	0.723	
FA_{OT}	0.612	0.456	0.514	0.887	0.375	
TWR	0.510	0.039	0.008	4.616	<0.001	***
O	0.463	−0.148	0.072	−2.044	0.041	*

Table S6: **Parameter estimates for the Combined Grantsmanship and Grant Funding Configuration $S^{G50\$\$}$ (Logit Model (6), Methods).** The coefficients $\beta.|\gamma.$ are given both probability-wise and odds-wise. The AIC for the model is 160.95. Significance levels have been set as follows: *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

Predictor	$\beta.|\gamma.$ **Prob-wise**	$\beta.|\gamma.$ **Odds-wise**	**Std. Error**	**z value**	**Pr(**$>|z|$**)**	
Intercept	0.011	−4.516	0.405	−3.214	0.001	**
NP_2	0.147	−1.755	0.577	−3.039	0.002	**
NP_3	0.073	−2.540	0.803	−3.164	0.002	**
TWR	0.510	0.040	0.014	2.925	0.003	**
E	0.434	−0.267	0.111	−2.409	0.016	*
A	0.575	0.302	0.147	2.053	0.040	*

Table S7: **Description of all 35 qualitative codes, complete with corresponding examples from the free-form responses of the faculty. Positive association, negative association, and improvement suggestions codes that survived the 'law of diminishing returns' are labeled with indices and correspond to the codes discussed in the main text (e.g., NA_1, PA_1, IS_1). Positive association, negative association, and improvement suggestions codes that did not rise to the top, bear no indices (e.g., NA, PA, IS) and were not discussed in the main text. None of the $NEUTRAL$ or other specialty codes proved to have sufficient strength, and this is why are not mentioned at all in the main text.**

#	Code	Code Description	Example Statement
1	$NEUTRAL$: faculty have a strategic approach to proposal submissions	Faculty have a strategic approach to proposal submissions. Consequentially, they adapt their work efforts according to their aims.	'Deadlines are good to get things done. Sometimes I try to submit something for a deadline I know isn't realistic just to make enough progress for a future more realistic one. Although the last time I tried that I did finish the proposal and it got funded first time around! So, turning out to be a fantastic strategy.'
2	$NEUTRAL$: perceived stress level depends on the overall workload at the time	Faculty note that the individual stress level associated with a proposal deadline heavily depends on the circumstantial workload. Thus, faculty associate deadlines in relatively neutral terms.	'Often the time compression is related to how much time the solicitation allows for proposal submission. Frequently, this is only one month for many agencies.'
3	PA_2: work tactic - proposal deadlines increase focus; they serve as waypoints	Faculty positively associate deadlines as waypoints that help them focus and make progress.	'Deadlines help me focus. Without a deadline the submission might be delayed without significant improvement in the proposal quality.'
4	PA: collaborations lower the stress level associated with proposal deadlines	Faculty mention that collaborations decrease the overall stress level associated with proposal deadlines. Hence, socio-emotional support or multiple stakeholders working together are viewed as factors that stand to lower deadline stress.	'I have excellent staff support for preparing and submitting. This greatly lowers my stress level.'

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Table S7 – continued from previous page

#	Code	Code Description	Example Statement
5	PA: university-level organizational support lowers proposal stress	Faculty mention that organizational support provided by their university decreases the overall stress level associated with proposal deadlines. Hence, organizational support or procedural guidelines are viewed as factors that stand to lower deadline stress.	'Since the proposal needs to pass by the office dealing with grants in my University, I need to send it to this office at least two weeks in advance. I have help from an administrator in my department in preparing and submitting a proposal. This helps a lot!'
6	PA: experience in submitting proposals significantly lowers deadline stress	Faculty mention that years of experience in grant submissions decrease the overall stress associated with proposal deadlines.	The 5yr + 5yr funding significantly lowers the amount of time and stress associated with obtaining external monies. Also being older and having administered many grants significantly reduces stress.'
7	PA: job security reduces stress associated with proposal deadlines	Faculty mention that job security decreases the overall stress level associated with proposal deadlines. Hence, long-term appointments are viewed as a factor that stands to lower deadline stress.	'Fortunately, I have tenure, it's always possible to get 1-2 students who are funded via TAs or outside employment, and my job security doesn't depend on bringing in grant funding, so proposal-writing is not a major stressor in my life.'
8	PA_1: work tactic - advance planning helps to cope with proposal deadlines	Faculty who plan well in advance, view proposal deadlines in a positive light. Proactive planning is thought to reduce deadline stress.	'I have been doing proposals for 34 years and learned to start early, finish early, and not get consumed by it all.'
9	NA_4: proposal deadlines contribute to overloading	Faculty feel overwhelmed due to their total workload, thus negatively associating deadlines.	'It seems that the NSF due programs I submit to have due dates at the worst times, like end of semester or final exam week.'

Continued on next page

Table S7 – continued from previous page

#	Code	Code Description	Example Statement
10	NA: proposal deadlines affect interpersonal relations	Faculty feel overwhelmed by proposal deadlines. Deadline stress tends to adversely affect their interpersonal relationships and work patterns.	'Proposal deadlines should be abolished across agencies and open submission should be adopted everywhere possible. The process is amazingly stressful and has resulted in significant strain on my marriage and health. I have decreased the number of proposals I write in a year as a result of these negative outcomes. I've also spent years in marriage counseling, in part due to the strain of proposal writing. You might also ask people if they've considered leaving academic research due to overall unhappiness with the funding of academic research. I have done so. I will likely leave my position or work to significantly modify my appointment to avoid this odious, inefficient, horrible process.'
11	NA: proposal deadlines affect intrapersonal behaviors (e.g., procrastination)	Faculty experience intrapersonal behavior shifts when confronted with proposal deadlines. One example of an internal behavior shift is the tendency to procrastinate. Thus, faculty negatively associate proposal deadlines.	'I am literally procrastinating on my NSF due in just a few days right now. And I am stressed to hell. The project is close to ready but one million little things need wrapping up.'
12	NA: funding rates are thought to be misleading	Statements identified with negative associations advance the view that funding rates lack nuance, hiding an unfair distribution of research funding.	'The NSF is LYING about funding rates- the % success rate is likely 5% or less. I have already found that women win NSF grants at a rate 3X compared to men in our dept. The reviews are not based on the grants, rather personal relationships. You should research impact on health when reviews come back full of ad hominem.'

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Table S7 – continued from previous page

#	Code	Code Description	Example Statement
13	IS_2: base level funding should be distributed to all qualified researchers (to boost productivity)	Faculty recommend distributing base funding to a broad demographic.	'I think all researchers meeting some simple fixed criteria should get a base level of funding to ensure productivity can remain high without losing time to large numbers of grant deadlines.'
14	NA_1: proposal deadlines are perceived as highly stressful due to changing requirements of the associated agencies (no universal proposal formatting)	Statements identified with negative associations raise the issue of changing requirements of the funding agencies.	'The granting agencies keep changing formats, requirements, and online submission sites. Just keeping up with those is a job. NSF is the worst agency to write proposals for (no experience with NIH). The NSF system is very rigid, the reviews are random and the paperwork is much more than any DoD agency we dealt with. Deadlines make all this much worse.'

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#	Code	Code Description	Example Statement
15	NA: proposal deadlines are perceived as stressful because of the long odds and onerous workload	Statements identified with negative associations raise the issue of wastefulness in the proposal process.	'It's incredibly frustrating to spend so much time on something that has so little chance of success. The constant need to chase after the next grant to support myself or my students take significant time away from publishing additional articles on past grants, as well as strongly discouraging truly innovative research ideas. If an idea deviates substantially from the natural 'next step' on a topic, I know it has exactly 0% chance of success. It also strongly discourages me from applying to other agencies, since I know I'm not part of the 'old boys' club, which is alive and well. The increase in amount of administration and forms disproportionately advantages researchers from top tier universities (including mine), which provide substantial administrative support in submission and management of grants. If I was at a lower tier university, there is no chance that I could submit and manage as many grants as I do currently. This is a fantastically effective way to squash diversity, by raising the status bar for individuals who can submit grants. My last grant to support one student for three years was over 225 pages long - and funding rates hover around 15%. What a tremendous waste of intellectual resources to spend hours and hours compiling CVs, C&Ps, COAs, and all the other required forms. It also strongly benefits senior personnel who have administrative staff that can maintain these resources for them. Some forms are obviously necessary, but why not refer reviewers to ORCIDs and google scholar or web of science profiles?'

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Table S7 – continued from previous page

#	Code	Code Description	Example Statement
16	NA_5 proposal deadlines are perceived as stressful regardless of work patterns, workload, intrapersonal and interpersonal states	Statements identified with negative associations conclude that proposal deadlines remain stressful regardless of the external circumstances or preparations.	'I think no matter how early I start or how late I start the stress of the deadline is always there - so I find I better not start too early because I am always focused on polishing at the end.'
17	NA: proposal deadlines are perceived as disruptive of the research process	Statements identified with negative associations find proposal deadlines to disrupt creative thinking and the scientific process.	'To succeed in acquiring funding, I need to spend more time writing proposals than actually doing research or writing papers. The current extreme level of funding competition creates huge waste.'
18	NA: pressure to secure funding renders proposal deadlines stressful	Faculty perceive proposal deadlines as stressful. Deadline stress stems from the pressure to secure enough funding for their projects and their employees/research assistants.	'Advance thought processes, preparation will help. However, the stress of not having money in the bank to fund the lab is overwhelming ...'
19	NA: hard to cope with both proposal deadlines and family obligations	Faculty experience difficulties with proposal submissions due to family obligations.	'It is completely impossible to write proposals during COVID lockdown with no childcare. Since daycare stopped I have submitted zero proposals.'

Continued on next page

Table S7 – continued from previous page

#	Code	Code Description	Example Statement
20	NA: proposal deadlines are stressful due to onerous technical requirements imposed by funding agencies	Statements refer to onerous technical requirements imposed by the funding agencies that complicate the proposal submission process.	'To me, the major stressful part of the proposal submission is related to the program administrative requirements rather than the technical part itself. Making sure everything is formatted the proper way, making sure all the documents are uploaded at the right place, with proper heading,... is, to me the most stressful because having a proposal returned without review on a technicality like this would be terrible. The other stressful part is that people depend on you and your ability to secure funding to pay them (grad students, postdocs,...). Every proposal is submitted with these people in mind, having proposal rejected despite having good reviews puts these people in jeopardy. As a person who cares about students, I find this also stressful.'
21	NA_2: proposal deadlines are stressful due to organizational difficulties and process complications at the university level	Statements refer to internal organizational issues and pre-deadline cut-offs that complicate the proposal submission process, adding another layer of stress for faculty.	'My only problem is that the actual submission of the proposal is out of my direct control and most of the stress involved comes from prompting our sponsored research office to submit. Having PI ability to submit would make submitting proposals less stressful.'

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#	Code	Code Description	Example Statement
22	NA_3: perceived stress level depends on the management of Co-PIs and collaborators	Statements indicate a rather neutral or negative association with deadlines due to interpersonal or procedural difficulties during proposal submissions. The indicated process complications arise due to difficulties with Co-PIs. Interpersonal relations, coordination with colleagues, and reliance on third parties in general complicate the submission process, adding another layer of stress for faculty.	'The most stressful part is the necessary reliance on other people. For example, will the research administration people get their budgets and paperwork done in time? I often have to remind them multiple times. Will my co-PIs get their parts done in time?'
23	NA: proposal deadlines undercut the publishing of papers	Faculty feel overwhelmed due to their total workload. Additionally, they report that deadlines disrupt their research activities and hinder them from publishing papers.	'Mentoring and production of manuscripts are also dramatically affected by deadlines.'
24	NA: waiting on proposal reviews is more stressful than negotiating proposal deadlines	Faculty state that the anticipation of granting agency reviews is more stressful than the actual proposal submission process.	'It is more stressful on the days when I expect an answer to the proposal!'
25	NA: the proposal review process takes too long	Faculty state that the proposal review process takes too long. Hence, waiting to hear about the disposition of a proposal is experienced as more stressful than the actual submission of a proposal.	'Programmatic deadlines are rigid even when the government shuts down. The wait for the review process is too long.'

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#	Code	Code Description	Example Statement
26	NA: time and effort spent on proposals are not aligned with the payoff	Faculty state that proposal efforts are not well-aligned with their payoff (i.e., total work hours vs. actual funding received).	'Research proposals to private industry require much more time and effort to engage, identify, and develop potential projects with sponsors. There is an upfront time investments to establish this long-term relationship and trust. These efforts are difficult to quantify in the metric for proposal success.'
27	NA: proposal deadlines are perceived to adversely affect the research quality (faculty feel the pressure to submit something regardless of its quality)	Faculty find the proposal submission process to be suboptimal (i.e., the total workload and the fixed deadlines leave little room for flexibility within the research process). They prefer to submit proposals based on research results rather than on demand. Faculty reported that because they feel pressured to submit proposals, they often submit half-baked work.	'I submit proposals to two different NSF programs. One has deadlines, the other has no deadlines. At the program with deadlines I never got a proposal funded the first time. The other program (without deadline) funded my proposal after the first submission. This is not statistically solid, but I felt I submitted a much better prepared proposal when I had no deadline, because I waited until I found it was perfect.'
28	NA: proposal deadlines are the tip of the iceberg	Deadlines are small parts of an unhealthy research culture.	'Proposal deadlines are not the problem. The problem is an unhealthy work culture in the scientific enterprise as a whole. Replacing proposal deadlines with some other mechanism may have little to no effect on this overarching culture.'
29	IS: call for proposal workshops and guidance on how to engage in collaborative practices	Faculty feel overwhelmed due to the changing requirements, thus negatively associating deadlines. Additionally, they state that workshops and more guidance would help them to lower their stress level during proposal submission.	'Colleagues are insufficiently trained in the science of team science methodologies.'

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#	Code	Code Description	Example Statement
30	IS_1: continuous proposal deadlines are believed to improve the submission process (e.g., NSF's no deadline approach)	Faculty feel stressed in their efforts to meet deadlines. They state that rolling deadlines would help them lower their stress level during proposal submission. Some participants explicitly name the NSF no deadline approach.	'The new rolling proposal deadlines of NSF are great.'
31	IS_1: continuous proposal deadlines are believed to increase the overall quality of proposals	Faculty feel stressed in their efforts to meet deadlines. They state that rolling deadlines would help them lower their stress level during proposal submission while increase proposal quality.	'The stress of deadlines drives me to submissions which do not have deadlines. The quality of the proposals is also higher. But the stress in this case lingers.'
32	IS_1 continuous proposal deadlines are believed to be less disruptive to the research process and other scholarly duties	Faculty feel stressed in their efforts to meet deadlines. Hence, they state that rolling deadlines would help them lower their stress level during proposal submission and reduce their overall workload. Consequentially, faculty hypothesize that rolling deadlines will interfere less with their other scholarly duties.	'Deadlines at the beginning or end of a typical semester are quite stressful. Summer deadlines are best.'
33	IS: critical reflection of the no-deadline approach; faculty hypothesize that such a procedure requires high degree of internal discipline, due to lack of explicit waypoints	Faculty feel stressed in their efforts to meet deadlines. While they state that rolling deadlines would help them lower their stress level during proposal submission and increase proposal quality, they also caution that rolling deadlines might increase suboptimal work patterns, such as procrastination.	'Rolling deadlines is better for stress, but I am less likely to get them done that way.'

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#	Code	Code Description	Example Statement
34	IS_2: proposals could be simplified to ensure a smooth process (e.g., simpler budgets)	Faculty feel stressed in their efforts to meet deadlines. Additionally, faculty underline the need to simplify the submission process, especially with respect to the development of a budget.	‘The proposal process is way too complicated. I think everyone spends a tremendous amount of energy and time on a bet that they might get some funding. This is stressful. Make the entire process much more straightforward and easier to complete. Make the reward worth the effort.’
35	Break patterns irregular	Faculty indicate they take few or no breaks during the proposal submission process.	Categorical variable, based on the quantitative analysis.