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A Quantitative Linguistic Analysis of National Institutes of Health R01 Application Critiques from Investigators at One Institution

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Abstract

Purpose—Career advancement in academic medicine often hinges on the ability to garner research funds, and the National Institutes of Health's (NIH's) R01 award is the “gold standard” of an independent research program. Studies show inconsistencies in R01 reviewers' scoring and in award outcomes for certain applicant groups. Consistent with the NIH recommendation to examine potential bias in R01 peer review, the authors performed a text analysis of R01 reviewers' critiques.

Method—The authors collected 454 critiques (262 from 91 unfunded and 192 from 67 funded applications) from 67 of 76 (88%) R01 investigators at the University of Wisconsin-Madison with initially unfunded applications subsequently funded between December 2007 and May 2009. To analyze critiques the authors developed positive and negative grant application evaluation word categories and selected 5 existing categories relevant to grant review. The authors analyzed results with linear mixed effects models for differences due to applicant and application characteristics.

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Results—Critiques of funded applications contained more positive descriptors and superlatives and fewer negative evaluation words than critiques of unfunded applications. Experienced investigators' critiques contained more references to competence. Critiques showed differences due to applicant sex despite similar application scores or funding outcomes: more praise for applications from female investigators; greater reference to competence/ability for funded applications from female experienced investigators; and more negative evaluation words for applications from male investigators (P s < .05).

Conclusions—Results suggest that text analysis is a promising tool for assessing consistency in R01 reviewers' judgments and gender stereotypes may operate in R01 review.

An important determinant of career advancement in academic medicine is the ability to compete for research support.¹ The National Institutes of Health (NIH) is the largest funder of research at U.S. academic medical centers, and its R01 award is considered the “gold standard” of an independent research program.¹ The NIH's two-stage system of peer review determines R01 funding.² In the first phase, ~3 peer reviewers assign preliminary scores and write critiques based on the proposed work's overall impact/priority, significance, innovation, approach, investigators, and environment.^{2,3} Applications with the top ~50% of preliminary impact/priority scores are discussed at review-group meetings where all members contribute a final score.³ Applicants receive a Summary Statement with individual reviewers' critiques, a summary paragraph, and the average final impact/priority score for discussed applications. In the second stage, NIH staff and the Advisory Council of each NIH Institute and Center (IC) weigh peer review outcomes and IC priorities to make final funding recommendations to IC directors.^{2,3} The NIH continually evaluates its review process. Although NIH peer review is considered one of the best systems in the world, studies have identified inconsistencies among R01 reviewers' scores,⁴⁻⁶ and unexplained differences in award outcomes for some groups of R01 applicants.^{3,7-13} If bias unrelated to the quality of the proposed science negatively impacts the outcome of a grant review, it runs counter to the NIH's goal to fund the best science, threatens scientific workforce diversity, and undermines the competitiveness of the U.S. scientific enterprise.^{7,14-16}

An Advisory Committee to the NIH Director,¹⁷ followed by a plan for action by the NIH's Deputy Director,¹⁸ made recommendations to examine the NIH's grant review process for bias. Recommendations included the need for “text-based analysis of the commentary on individual grant reviews.”¹⁷ Prior studies of R01 peer review outcomes have analyzed application success rates or applicant funding rates,^{8-12,19} award probabilities,^{7,13} or reviewer-assigned scores.^{4,5,8,12} These methods can effectively identify award or scoring disparities between certain groups of applicants or proposal types, but provide little insight into reviewers' reasoning for scoring or award recommendations. Text analysis of reviewers' critiques would be novel to the study of scientific review because it can provide a window into reviewers' decision-making processes.²⁰⁻²⁶ When used in combination with traditional comparisons, text analysis would permit testing whether reviewers' judgments are congruent with scores and funding outcomes.²¹ Our research aligns with the NIH's call for action and, to our knowledge, is the first text analysis of the written critiques of R01 applications. In this study we empirically link the contents of critiques to funding outcomes

and scores to test for consistency in reviewers' judgments across different categories of R01 investigators.

Method

The institutional review board at the University of Wisconsin-Madison (UW-Madison) approved all aspects of this study. In June 2009, we searched the NIH's Computer Retrieval of Information on Scientific Projects (CRISP) database for all principal investigators (PIs) at UW-Madison with R01 awards funded with amended status (i.e., initially unfunded and subsequently revised applications) in the NIH's 2008–09 fiscal years (FY). Award dates spanned December 2007 through May 2009. We invited PIs, via 3 rounds of email letters, to send us electronic PDF copies of all Summary Statements from unfunded and funded award cycles. R01 recipients provided consent by emailing PDF copies of their Summary Statements and could request withdrawal of their materials from the study.

We assigned identifiers (IDs) to applicants, Summary Statements, and critiques (as surrogate for the anonymous reviewer). We recorded (if present): application funding outcome, application type (Type 1/new R01 or Type 2/renewal), impact/priority score, the NIH IC, and use of human subjects. To ascertain applicant sex, we searched the Internet using a strategy similar to that employed by Jagsi and colleagues.¹⁹ We also examined home institution websites to ascertain each applicant's training background. We searched CRISP for all grants held by investigators prior to the study award period, and classified investigators as "experienced" according to NIH criteria.²⁷ We electronically formatted and de-identified each critique prior to text analysis.

We analyzed critiques with the Linguistic Inquiry Word Count text analysis software program (LIWC 2007, Austin TX), which calculates the percentage of words from predefined linguistic categories in written documents.²⁸ We examined words in the LIWC's 80 default word categories and 7 others developed for use with LIWC,^{23–25} and identified five categories relevant to scientific grant review (Table 1). These word categories are "ability" (e.g., skilled, expert, talented), "achievement" (e.g., honors, awards, prize), "agentic" (e.g., accomplish, leader, competent), "research" (e.g., scholarship, publications, grants), and "standout adjectives" (e.g., exceptional, outstanding, excellent). We developed two categories that reflect "positive evaluation" (e.g., groundbreaking, solid, comprehensive) and "negative evaluation" (e.g., illogical, unsubstantiated, diffuse) of a grant application.

Employing a modified Delphi technique^{29,30} we solicited lists of positive and negative evaluation words relevant to NIH grant applications from four local experienced NIH grant reviewers. We collated and resent lists for feedback, and gathered experts for a final vote.^{29,31} To further validate these categories we recruited two students to rate on Likert scales the levels of negative or positive evaluation words in critiques. Students' ratings and LIWC output were correlated for both positive ($r = .22$) and negative ($r = .24$) evaluation words ($P_s < .01$).

We imported LIWC results and priority scores into IBM SPSS statistical software, Version 20.0 (Armonk, NY; IBM Corp., 2011), and matched these data to applicant IDs, and Summary Statement and applicant information. We analyzed all data with linear mixed-effects models and deemed *P*-values $\leq .05$ as statistically significant.

Results

Out of 76 eligible PIs identified from the NIH's CRISP database, 67 (88%) participated. Of these 67, 44 participants were male (66%) and 23 (34%) were female; 59 (88%) held PhDs; 17 (25%) proposed clinical research, 12 (27% of 44) male, 5 (22% of 23) female; and 54 (80%) were experienced investigators. Our final sample included 454 critiques (262 from 91 unfunded and 192 from 67 funded applications). Investigators were from 45 different departments, and 15 of the NIH's 27 ICs funded their applications. There were between 2–5 critiques from each unfunded and 2–4 critiques from each funded application; 28 investigators (42%) had two unfunded applications.

We computed the intraclass correlation coefficient (ICC) for each linguistic variable^{32,33} and identified significant between-subject variation in each word category (word count = 11.3%; achievement = 14%; ability = 18.3%; agentic words = 22.3%; negative evaluation = 22.8%; positive evaluation words = 11%; research = 37%; and standout = 41%). We modeled each linguistic word category as a dependent variable with application funding outcome (unfunded vs. funded), applicant experience level (new vs. experienced investigator), and applicant sex (M vs. F) as fixed effects. Models included applicant IDs as a random effect and used restricted maximum likelihood (REML) estimation. Initial models assessed main effects and subsequent models included interaction terms.

Models showed a main effect for funding outcome for five word categories. Critiques of funded applications contained significantly more ability, agentic, standout, and positive evaluation words; and significantly fewer negative evaluation words than critiques of unfunded applications (Table 2) (*P*s $< .05$). There were also main effects for experience level and applicant sex for four word categories. Critiques of experienced investigators' applications contained significantly more ability, agentic, standout, and positive evaluation words than critiques of new investigators' applications (*P*s $< .05$). Critiques of female investigators' applications contained significantly more words from the ability, agentic, and standout categories and significantly fewer negative evaluation words than those of male investigators (*P*s $< .05$).

Main effects were qualified by significant three-way interactions between funding outcome, investigator experience level, and applicant sex for ability [$\beta = .40$, $t(397) = 2.76$, $P = .006$], agentic [$\beta = .70$, $t(402) = 2.62$, $P = .009$], positive evaluation [$\beta = -.97$, $t(397) = -2.67$, $P = .008$], and standout words [$\beta = .11$, $t(391) = 2.64$, $P = .009$]; and two-way interactions between funding outcome and applicant sex [$\beta = -.55$, $t(412) = -2.73$, $P = .007$] and experience level and applicant sex [$\beta = -.32$, $t(166) = -2.17$, $P = .032$] for negative evaluation words. To probe these results we performed pairwise comparisons, based on estimated marginal means (Table 3), on three-way interaction terms. We used the Bonferroni correction to adjust *P* values.

There were no significant linguistic category differences between male and female new investigators' unfunded application critiques (Table 3). However, critiques of funded applications from female new investigators contained significantly more positive evaluation [$F(1, 175) = 13.1, P < .001$] and standout words [$F(1, 126) = 7.74, P = .006$], and significantly fewer negative evaluation words than those from male new investigators [$F(1, 272) = 19, P < .001$] (Figure 1).

Pairwise comparisons showed significantly more standout and significantly fewer negative evaluation words in female than male experienced investigators' critiques from both unfunded and funded applications. Female experienced investigators' critiques from funded applications also contained significantly more ability and agentic words (P s < .01). Experienced investigators can submit either Type 1 (new R01) or Type 2 (renewal) applications, so we segregated their text analysis results and computed another set of linear mixed-effects models using REML estimators for each linguistic category with funding outcome (unfunded vs. funded), applicant sex (M vs. F), and application type (Type 1 vs. Type 2) as fixed effects; we included interaction terms. Models used applicant IDs as a random effect. Models showed a significant three-way interaction effect between funding outcome, applicant sex, and application type for ability [$\beta = .39, t(320) = 2.91, P = .004$], agentic [$\beta = 1.16, t(329) = 4.76, P < .001$], and standout words [$\beta = -.10, t(319) = -2.67, P = .008$]; and a significant two-way interaction effect between funding outcome and applicant sex for negative evaluation words [$\beta = -0.44, t(360) = -2.77, P = .006$]. Pairwise comparisons showed that compared with critiques of applications from equivalent male investigators, only critiques of funded Type 2 applications from female experienced investigators contained significantly more ability words [$F(1, 114) = 50.61, P < .001$], and only critiques of unfunded Type 2 applications from female experienced investigators contained significantly more standout words [$F(1, 80) = 41, P < .001$] (Figure 1). Critiques of both Type 1 and Type 2 funded applications from female experienced investigators contained significantly more standout and agentic words (P s < .01). Negative evaluation words occurred significantly more often in male than female experienced investigators' Type 1 and Type 2 critiques from both unfunded and funded applications (P s < .01). Models showed no significant differences in word counts or in research or achievement words.

We found no significant correlation between study variables and an LIWC category called "negate" (e.g., not, never). This suggests that words from each linguistic category do not co-occur in critiques with words that would reverse their meaning (e.g., "not" enthusiastic).

Priority scores assigned to 118 applications from 53 (98%) experienced investigators were available for analysis [54 scores from Type 1 (30 unfunded, 24 funded) and 64 from Type 2 (35 unfunded, 29 funded) applications]. We computed a linear mixed-effects model with priority score as the dependent variable; and funding outcome, applicant sex, and application type as fixed effects—we included interaction terms. Models used applicant IDs as a random effect to account for repeated measures per applicant. Results showed a significant main effect only for funding outcome (i.e., funded applications had better scores), [$\beta = -51, t(68) = -7.65, P < .01$]. Priority scores and linguistic word categories showed significant correlations indicating that lower (i.e., more competitive) scores were associated with critiques containing more words in the ability, agentic, positive evaluation, and standout

categories, but fewer negative evaluation words ($P_s < .05$). Separate correlations of female and male experienced investigators' data showed that correlations were significant only for female investigators (Table 4).

To test whether high or low levels of words from each category in critiques predicted priority scores and whether this differed by applicant sex, we split each LIWC word category at its median to create dichotomous indicators of "high" vs. "low" levels of words. We then analyzed experienced investigators' priority scores using a set of linear mixed-effects models with each word category indicator variable (high vs. low), and applicant sex (M vs. F) as fixed-effects; we included interactions terms. Models used applicant IDs as a random effect; and REML estimators. Models showed significant two-way interactions between applicant sex and the high/low-indicators of ability [$\beta = 20$, $t(327) = 2.60$, $P = .010$], agentic [$\beta = 20$, $t(326) = 2.45$, $P = .015$], standout [$\beta = 23$, $t(317) = 2.57$, $P = .011$], and negative evaluation words [$\beta = -19$, $t(318) = -1.89$, $P = .05$]. Pairwise comparisons, performed on the interaction terms showed that when critiques of female experienced investigators' applications contained high levels of words from the standout [$F(1, 317) = 7.58$, $P = .006$], ability [$F(1, 323) = 8.36$, $P = .004$], and agentic categories [$F(1, 322) = 8.17$, $P = .05$], and low levels of negative evaluation words [$F(1, 319) = 4.69$, $P = .031$], their proposals were assigned significantly lower (i.e., more competitive) scores. By comparison, male experienced investigators' priority scores did not differ significantly by the levels of linguistic category words in their critiques.

Discussion

Our findings suggest that text analysis of application critiques is a promising tool for evaluating potential bias in peer review of NIH R01 grant applications. Text analysis appropriately sorted R01 applications that were unfunded from those that were funded as well as those from new investigators from experienced investigators. Overall, critiques of funded R01s contained more positive evaluation and standout words, more references to ability and competence (e.g., agentic words), and fewer negative evaluation words than critiques of unfunded applications. Critiques of experienced investigators' applications contained more words from the ability, agentic, standout adjective, and positive evaluation categories than critiques of new investigators' applications. However, these patterns were not consistent across critiques of applications from male and female investigators, suggesting that text analysis may be able to uncover discrepancies in reviewers' judgments that are masked when only scores or funding outcomes are compared. We identified three patterns of differences in R01 critiques by applicant sex that occurred despite similar scores or funding outcomes: more positive descriptors, praise, and acclamation for funded applications from all types of female investigators; greater reference to competence and ability for funded applications from female experienced investigators, particularly for renewals; and more negative evaluation words for applications from all types of male investigators. Sub-analyses of experienced investigators' data again confirmed the potential of text analysis to uncover discrepancies in reviewers' judgments masked by comparing scores and funding outcomes alone. High levels of standout, ability, and agentic words and low levels of negative evaluation words in critiques predicted more competitive priority scores—as one would expect—but only for female experienced investigators.

When taken together, our findings suggest that subtle gender bias may operate in R01 peer review. Such gender bias may be unconscious and derives from pervasive cultural stereotypes that women have lower competence than men in fields like academic medicine and science where men have historically predominated.^{14,34,35} A large body of experimental research concludes that in such male-typed domains, gender stereotypes lead evaluators to give a woman greater praise than a man for the same performance.^{21,36–38} By comparison, the assumption of men's competence in male-typed domains leads evaluators to more often notice and document negative performance from men because it is not expected.^{37,39} This could be one interpretation of the comparable scores and funding outcomes for male and female investigators despite the greater occurrence of negative evaluation words in critiques of men's proposals and the apparent stronger critiques of women's proposals. Male and female evaluators are equally prone to such gender biased judgments.^{40,41}

Paradoxically, gender stereotypes also lead reviewers to require more proof of ability from a woman than a man prior to confirming her competence,^{37,42} and greater proof to confirm men's incompetence in male-typed domains.^{37,39} This may also explain why men's vs. women's proposals were funded despite more negative critiques (i.e., higher standards for incompetence), and why there were more references to ability and competence in critiques of applications from female vs. male experienced investigators. Being an experienced investigator, particularly one renewing an R01, conflates two male-typed domains: science and leadership.^{43,44} Therefore, women scientific leaders would be held to the highest ability standards to confirm competence.^{21,37}

Despite the more laudatory critiques of women's applications, particularly for renewals, we cannot conclude from our study that women needed to outperform men to receive an R01. If this were the case, we would expect to find that women had to earn more competitive scores than men to have their applications funded, which we did not. We think it is more likely that the same level of performance was interpreted in gender-stereotypic ways, leading to more positive commentary about women's applications. This does not fully rule out the possibility that gender stereotypes may also inadvertently influence reviewers to hold female investigators to a higher standard of competence. Such gender bias could help explain results from prior studies showing lower success rates for female vs. male R01 applicants, particularly for renewals.^{9,10,45}

A potential limitation of our text analysis is that although we selected word categories relevant to grant review we did not include all possible categories. Another limitation is that the LIWC software program does not account for the context in which words are used, but word categories showed no correlation with "negate" words (i.e., that would reverse their meaning), and positive and negative ratings of critiques from our sample correlated with LIWC output for our positive and negative evaluation categories. Our study is limited to a single site, but UW-Madison is similar to other large public research institutions, and proposals represented 45 departments and were reviewed across 15 NIH ICs. Participant selection bias is possible, although we had an 88% response rate from all eligible PIs. We studied no critiques from initially funded or from unfunded unsubmitted applications. We cannot rule out the possibility that observed differences in critiques occurred because of differences in background qualifications or because men and women are engaged in

different research areas, but ~90% of our sample held PhDs and similar proportions of male and female PIs performed clinical research.

We studied R01 critiques before the NIH implemented its streamlined review process. Priority scores and commentary based on the 5-criteria areas continue to be used to evaluate R01 applications; however, changes include a broader range for impact/priority scores, scoring for the 5-criteria, use of a bullet-point format instead of narrative format for critiques, and limit of a single resubmission for unfunded applications. These changes might reduce the amount of text available for analysis, but we have no reason to believe that they would change the impact of cultural stereotypes on judgment. Findings from our study may provide a useful comparison point for future studies of the impact of streamlining on R01 peer review. Our results should encourage future experimental studies. If stereotype-based bias is confirmed, promising interventions that foster behavioral change could be studied in the context of R01 peer review.^{46,47}

The NIH R01 is critical for launching the scientific careers of new investigators and in maintaining the research programs of experienced investigators. Promoting an equitable peer review process will ensure that the best and most innovative research will advance. Our text analysis of R01 critiques suggests that gender stereotypes may infuse subtle bias in the R01 peer review process.

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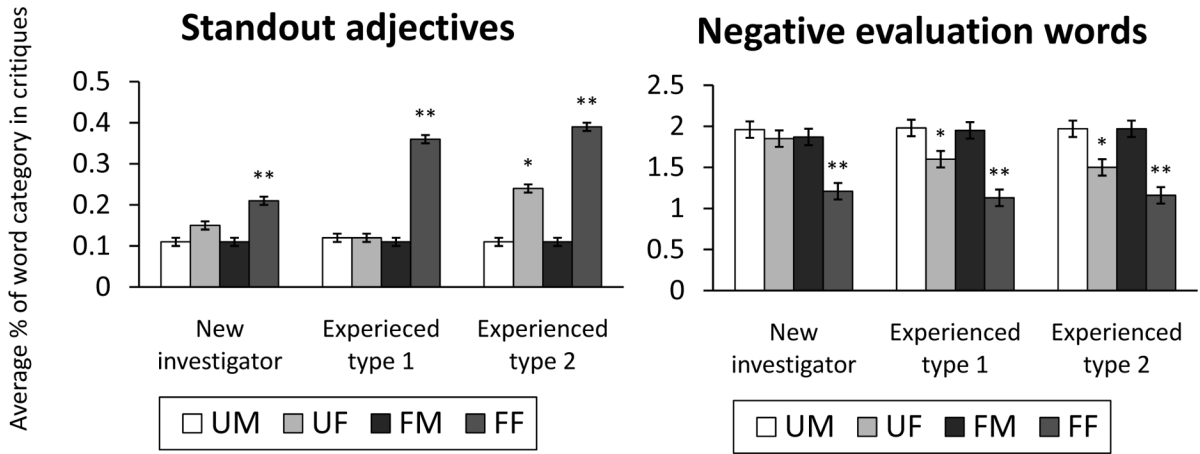


Figure 1. Average percentage of standout adjectives and negative evaluation words in National Institutes of Health R01 grant application critiques, from a text analysis study of 454 critiques, University of Wisconsin-Madison, 2008–2009. Figure reflects estimated marginal means (and standard error bars) of standout and negative words in critiques of unfunded and funded applications submitted by male and female applicants as new or experienced investigators of Type 1 or Type 2 R01s. UM = unfunded male; UF = unfunded female; FM = funded male; FF = funded female.
 *UM vs. UF, $P < .01$.
 **FM vs. FF, $P < .01$.

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Words in Linguistic Categories Used With the LIWC Software Program, From a Text Analysis Study of 454 Critiques of R01 Applications From Male and Female Investigators, University of Wisconsin-Madison, Fiscal Year 2008–2009

Table 1

Category	Word or root word ^a
Ability words ^{24,25}	ability*, able, adept*, adroit*, analy*, aptitude, brain*, bright*, brilliant*, capab*, capab*, capaciti*, clever*, compet*, creati*, expert*, flair, genius, gift*, inherent*, inmate, insight*, instinct*, intell*, knack, natural*, proficien*, skill*, smart*, talent*
Achievement words ^{28,b}	ability*, able*, accomplish*, ace, achiev*, acquir*, acquisition*, adequa*, advanc*, ambiti*, attempt*, attain*, approv*, ahead, ambiti*, award*, beat*, best, better, bonus*, burnout*, capab*, celebrat*, challeng*, climb*, closure, compet*, conclud*, conclus*, confidence, confiden*, conquer*, conscientious*, control*, creat*, crown*, defeat*, determin*, diligen*, domina*, demote*, driven, dropout*, cam*, effect*, efficien*, effort*, elit*, enabl*, endav*, excel*, fail*, finaliz*, first, firsts, found*, fulfill*, gain*, goal*, hero*, hon*, ideal*, importan*, improva*, inadequa*, incapab*, incentiva*, incompeten*, ineffect*, initiat*, irresponsibl*, king*, lazie*, lazy, lead*, lesson*, limit*, los*, maste*, medal*, mediocr*, motiv*, obain*, opportun*, organiz*, outcom*, overcome, overconfiden*, overtak*, perfect*, perform*, perseve*, persist*, plan*, potential*, power*, practice, prais*, presiden*, pride, prize*, produc*, proficien*, progress, promot*, proud*, purpose*, queen, queently, quit*, rank*, recover*, requir*, resolv*, resourceful*, responsib*, reward*, skill*, solution*, solv*, strateg*, strength*, striv*, strong*, succeed*, success*, super, superh*, surviv*, team*, top, tried, tries, triumph*, try, trying, unable, unbeat*, unproduc*, unsuccessful*, victor*, win*, won, work*
Agentic words ²³	accomplish*, achiev*, active*, agentic, aggress*, ambiti*, analy*, assert*, assiduous*, assurance, blumt*, bold*, candid*, compete*, competi*, confident*, conscientious*, daring, decisive*, defend*, direct*, domina*, dynami*, driv*, dynamic*, forc*, forthright*, frank*, hardwork*, hosti*, independen*, individualistic, influence*, initiat*, intellectual, lead*, manage*, masculine, master*, mechanic*, mechanistic*, poetic, organiz*, original*, outspoken, perform*, perserver*, power, produc*, rational*, reliabl*, risk, solid, start*, strength, strong*, success*, suggest*, superior, sure, worldly
Negative evaluative words	bias*, concern*, deficient, dependent, detract*, diffuse*, diminish*, fail*, ill*, inaccura*, inadequate*, inappropriate*, incomplete*, insignificant, insufficient, lack*, limit*, missing, narrow*, need*, not, omission, omit*, overambitious, overly, overstat*, poor*, question*, quo, shaky, simplistic, tentative*, unacceptabl*, unclear, underdevelop*, unproductive*, unproven, unsubstantiated, unsupported, weak*
Positive evaluative words	accept*, accomplish*, advanc*, ambitio*, appropriat*, art, believabl*, best, breadth, clear*, commit*, competitive*, complet*, comprehensive, convinc*, creat*, detail*, didactic, efficac*, energ*, enthus*, exceptional*, expans*, expla*, fascinat*, feasib*, focus*, groundbreaking, high*, impact*, impress*, includ*, indisputabl*, innovat*, interest*, logic*, mechanistic, meticulous*, new*, nice*, novel, obvious*, original, outstanding, pioneer*, productiv*, provocative*, quality, reasonabl*, reliab*, rigor*, significant*, solid*, sophistic*, sound*, specif*, stellar, strength, strong*, success*, superior*, support*, tailor*, target*, target*, target*, transform*, unimpeachable, unique*, valid*, valu*, well*
Research words ^{24,25}	contribution*, data, discover*, experiment*, finding*, fund*, grant*, journal*, manuscript*, method*, project*, publication*, publish*, research*, result*, scholarship*, scient*, studies, study*, test, tested, testing, tests, theor*, vita, vitas
Standout adjectives ^{24,25}	amazing, *excellen*, exceptional*, extraordinary*, fabulous*, magnificent, most, outstanding, remarkable, suberb*, suprem*, terrific*, unique, unmatched, unparalleled, wonder*

Abbreviation: LIWC indicates Linguistic Inquiry Word Count text analysis software program.

^a An asterisk (*) indicates root words counted with any ending; some words appear in more than one category.

^b Category condensed to accommodate space; full category available from authors on request.

The Average Percentage of Words in Unfunded vs. Funded, New vs. Experienced Investigators', and Male vs. Female Investigators' R01 Application Critiques, from a Text Analysis Study of 454 Critiques, University of Wisconsin-Madison, Fiscal Year 2008–2009^a

Table 2

Linguistic category	Funding outcome		Experience level		Applicant sex	
	Unfunded (n = 262)	Funded (n = 192)	New (n = 86)	Experienced (n = 368)	Male (n = 292)	Female (n = 162)
Ability	.49 (.03)	.63 (.03) ^b	.49 (.05)	.63 (.03) ^c	.48 (.03)	.64 (.04) ^d
Achievement	2.83 (.08)	2.95 (.08)	2.81 (.13)	2.98 (.07)	2.82 (.09)	2.70 (.11)
Agentic	1.04 (.05)	1.35 (.06) ^b	1.04 (.09)	1.34 (.04) ^c	.92 (.06)	1.46 (.07) ^d
Negative	1.78 (.04)	1.61 (.04) ^b	1.72 (.05)	1.67 (.03)	1.97 (.04)	1.42 (.04) ^d
Positive	2.24 (.07)	2.60 (.07) ^b	2.24 (.11)	2.61 (.06) ^c	2.41 (.07)	2.44 (.09)
Research	2.67 (.12)	2.66 (.12)	2.58 (.20)	2.75 (.10)	2.62 (.13)	2.71 (.16)
Standout	.14 (.01)	.20 (.01) ^b	.15 (.02)	.19 (.01) ^c	.09 (.01)	.24 (.01) ^d

^aNumbers in table reflect estimated marginal means (and standard errors) of words by linguistic category in critiques of applications from 67 investigators. N = 454 total critiques; n in table = number of critiques per category.

^bDifference in means of unfunded vs. funded grant critiques is significant at $P < .05$.

^cDifference in means of new vs. experienced investigators' grant critiques is significant at $P < .05$.

^dDifference in means of male vs. female investigators' grant critiques is significant at $P < .05$.

Table 3

The Average Percentage of Words from Linguistic Categories in Critiques of Unfunded and Funded R01 Applications from Male and Female Investigators by Experience Level and Application Type, from a Text Analysis Study of 454 Critiques, University of Wisconsin-Madison, Fiscal Year 2008–2009^a

Linguistic category	Experienced investigators																	
	New investigators						Type 1						Type 2					
	Male		Female		Male		Female		Male		Female		Male		Female			
Unfd n = 27	Fd n = 18	Unfd n = 22	Fd n = 19	Unfd n = 70	Fd n = 56	Unfd n = 70	Fd n = 17	Unfd n = 28	Fd n = 17	Unfd n = 70	Fd n = 51	Unfd n = 45	Unfd n = 70	Fd n = 51	Unfd n = 45	Fd n = 31		
Word count	1,031 (134)	1,096 (154)	767 (145)	828 (153)	1,107 (88)	915 (93)	1,024 (143)	837 (168)	1,211 (88)	1,026 (97)	993 (111)	777 (124)						
Ability	.41 (.08)	.49 (.09)	.46 (.08)	.57 (.09)	.60 (.48)	.56 (.05)	.57 (.08)	.70 (.09)	.45 (.05)	.53 (.05)	.50 (.06)	1.14 ^c (.07)						
Achievement	2.60 (.22)	2.87 (.24)	2.97 (.23)	2.83 (.24)	2.68 (.97)	3.04 (.97)	2.94 (.98)	3.55 (.99)	3.03 (.97)	2.85 (.97)	3.00 (.97)	2.96 (.98)						
Agentic	.96 (.13)	.90 (.15)	.96 (.14)	1.26 (.15)	1.02 (.07)	1.04 (.08)	1.19 (.11)	1.52 ^c (.15)	1.00 (.07)	1.01 (.08)	1.24 (.09)	2.72 ^c (.10)						
Negative	1.96 (.09)	1.87 (.11)	1.85 (.10)	1.21 ^c (.11)	1.98 (.05)	1.95 (.06)	1.60 ^b (.09)	1.13 ^c (.11)	1.97 (.05)	1.97 (.06)	1.50 ^b (.07)	1.16 ^c (.08)						
Positive	1.76 (.17)	2.25 (.20)	1.82 (.20)	3.26 ^c (.20)	2.46 (.11)	2.73 (.11)	2.26 (.70)	2.41 (.21)	2.58 (.11)	2.74 (.12)	2.53 (.13)	2.74 (.15)						
Research	2.54 (.30)	2.22 (.31)	2.74 (.32)	2.81 (.32)	2.61 (.20)	2.78 (.20)	2.67 (.25)	2.23 (.30)	2.80 (.20)	2.86 (.21)	2.96 (.21)	2.92 (.24)						
Standout	.11 (.03)	.11 (.03)	.15 (.03)	.21 ^c (.03)	.12 (.01)	.11 (.01)	.12 (.02)	.36 ^c (.03)	.11 (.01)	.11 (.01)	.24 ^b (.02)	.39 ^c (.02)						

Abbreviations: Unfd = unfunded; Fd = funded.

^aNumbers in table reflect estimated marginal means (and standard errors) of words by linguistic category in critiques of unfunded (Unfd) and funded (Fd) applications from New (n = 13) and Experienced Type 1 (n = 24) and Type 2 (n = 30) Investigators. N = 454 total critiques; n in table = number of critiques.

^bmale vs. female investigators' unfunded grant critiques, $P < .01$.

^cmale vs. female investigators' funded grant critiques, $P < .01$.

Correlations Between Priority Scores and Words in LIWC Categories in Critiques of R01 Applications from Experienced Male and Female Investigators, from a Text Analysis Study of 454 Critiques, University of Wisconsin-Madison, Fiscal Year 2008–2009^a

Table 4

Variable	1	2	3	4	5	6	7	8
1 Priority scores	--	-.417 ^b	.008	-.406 ^b	.290 ^b	-.199 ^c	-.071	-.425 ^b
2 Ability	-.061	--	.073	.575 ^b	-.336 ^b	.072	-.041	.395 ^b
3 Achievement	-.070	.075	--	.161	-.005	.300 ^b	-.066	.078
4 Agentive	-.089	.430 ^b	.293 ^b	--	-.130	.275 ^b	-.063	.386 ^b
5 Negative	.020	.052	.083	.074	--	-.087	.171	-.346 ^b
6 Positive	-.112	-.007	.204 ^b	-.014	-.003	--	.024	.176
7 Research	.101	.076	.173 ^b	.167 ^b	-.013	.101	--	.022
8 Standout	-.110	-.017	.030	.051	.330 ^b	-.119	-.038	--

Abbreviations: LIWC = Linguistic Inquiry Word Count text analysis software program.

^aCorrelations between experienced female investigators' scores and word categories in critiques are above the diagonal; experienced male investigators' are shown below.

^bCorrelation is significant, $P < .01$.

^cCorrelation is significant, $P < .05$.