Technology and Peer Review Panel Skills

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Abstract

Several authors note the need for studies about peer review related to the people involved, the process, and the training available. This exploratory study examined how the use of technology in conducting panel reviews for agencies that fund research affects the development and improvement of the panel review skills needed by effective reviewers. Two specific review formats were considered: in-person face to face and virtual video conference. Program officers and expert reviewers were interviewed to compile a list of skills possessed by high quality reviewers. Interviews also addressed skill development and the relationship between skill development, review format, and technology. Responses formed the basis of a quantitative survey concerning reviewer skills and the use of technology in panel reviews. Results include the skills that are necessary to be a high quality panel reviewer, and the ways review format and technology affect these skills. Suggestions include that ORISE analyze reviewer skills and informational needs in relationship to software and processes, further development of reviewer skills training, and consider using this report to inform regular re-evaluation of its virtual participation software and reviewer orientation materials.

Introduction

Accurate, efficient, and measured peer review of research is critical to the scientific enterprise. Peer review literature has focused on outcomes in terms of funding decisions. With respect to panel reviews of research grants, the process of reviews and ways the format (face-to-face or virtual/ technology-based) affects the process has received less attention. This exploratory study examined the development and refinement of the skills reviewers need and use in peer review activities. The question of review format, whether a particular format has an effect on skill development, was also considered.

Peer review panels consist of more than one expert reviewer and have a shared purpose of evaluating research efforts. Peer review panels are constructed in a variety of ways and may function differently from one another. In essence, no two review panels are the same. Panelists may be selected by the granting agency or a contractor (National Academies of Sciences, Engineering, and Medicine (NAS), 2016). Standing panels, consisting of the same reviewers serving together for a period of time, may be formed or panel membership may change each time a panel is formed (NAS, 2016; NRC, 2012). Panelists may "provide important input to agency leaders" (NRC, 2004, p. 5) or may make funding decisions together and by consensus (Markin, 2008). Panelists receive proposals to review in advance and individuals may be assigned, or asked, to summarize the salient points on a group of proposals to present to the panel. In some cases this leadership function may also include making an individual recommendation on funding (Markin, 2008).

Peer review has come to be viewed as the "defacto" or "gold" standard in decision making for most funding bodies (Carpenter, et al., 2015; Demicheli & Pietrantonj, 2007; NAS, 2016; Mayden, 2012). An "overwhelming majority of researchers believe that their work is improved as a result of the peer review process" (Research Information Network, 2010, p. 7). However, work that has not been subjected to peer review may, or may not, be of lesser quality than that which has been subjected to peer review (Roberts & Shambrook, 2012). One possible reason is that the peer review process relies on people and people are fallible (Markin, 2008; Research Information Network, 2010). Assembling the group of reviewers is the very crux of the matter: "the peer review process, no matter how well designed, is only as effective as the people involved" (NRC, 2004, p. 2).

Peer review is not without criticism. The peer review process has been alleged to exhibit bias against innovative research, weakness in predicting future research success, cronyism, failure to detect misconduct and malpractice, subjectivity, lack of accountability, inconsistency, incompleteness, conservatism, and negativity towards interdisciplinary research (Guthrie, Ghiga & Wooding, 2017). The Research Information Network (2010) concluded that these types of criticisms are often directed at deficiencies in practice rather than principle.

Although peer review is considered the "defacto" standard in research funding decision-making, it remains relatively understudied (Demicheli & Pietrantonj, 2007; Jennings, 2006; NAS, 2016). Carpenter, et al. (2015), Jennings (2006), and Kostoff (2004) have argued for more systematic studies about peer review specifically on decision-making, teamwork, review format, and costs compared to quality and improvement. Panel format has been examined but only to determine if using technology produces better outcomes and funding decisions (Fogelholm, et al., 2012; Pier, et al., 2017; Pier, et al., 2018; Venkatraman, 2014; Vo, Quiggle & Wadhwani, 2016; Vo & Trocki, 2015).

Little attention has been paid to the impact of reviewer skills on panel success and the role technology may play in developing reviewer skills. The question remains, do reviewers with better skills produce better reviews, and are face-to-face or virtual reviews better at developing those skills? This exploratory study focused solely on synchronous and interactive panel peer reviews in two formats: virtual (all panelists participate at the same time, but not in the same place) and face-to-face (all panelists participate at the same time and in the same place). While the authors understand in certain circumstances reviewers may be allowed to call in to a face-to-face meeting or participate in a virtual review without a webcam, blended forms of panels were purposely excluded.

Literature Review

Two specific areas of literature were examined closely: panel format (face-to-face and virtual) and panelist skill.

While the prevailing sense is that face-to-face panels are the "gold standard," increasing costs and improvements in technologies have made virtual formats appealing (Carpenter, et al., 2015), but it is unclear whether review quality differs across formats (Fogelholm, et al., 2012; Pier, et al., 2017). Therefore, examining the impact of technology on reviews, and the question of whether technology can meet the gold standard of in-person reviews, is particularly relevant (Bohannon, 2011).

Virtual panels provide the benefits of lower financial and time costs and the potential inclusion of more diverse and higher level reviewers owing to the absence of investment in travel. Criticisms of virtual panel reviews include negative impacts on conversation, networking, debate, confidentiality, and engagement (Lavery & Zou, 2016; Venkatraman, 2014; Webster, 2015). Face-to-face benefits include advancing reviewers' education as researchers, improving their ability to obtain research funding, and having the opportunity to share ideas, learn from others, and embrace the collective effort to move science forward (Gallo, Carpenter & Glisson, 2013). Criticisms of face-to-face reviews include being primitive, environmentally irresponsible, and of limited social benefit to reviewers (Venkatraman, 2014).

Communication, time management, interpersonal, writing, critical thinking, problem solving, and decision making were skills identified as necessary for peer reviewers and important to the scientific enterprise (Gallo, et al., 2013; Lavery & Zou, 2016; Woods, et al., 2013). In addition, effective participation in a panel review requires panelists to have subject matter expertise, think independently, be prepared, humble and fair, exercise discretion, and be willing to change their minds (Gallo, et al., 2013; Langfeldt, 2001; Markin, 2008; Vo, et al., 2016). Several other desirable characteristics noted include being independent, competent, objective, respectful, open minded, and creative, as well as possessing expertise in theoretical models, methods, and analytical techniques (Hackett & Chubin, 2003; Markin, 2008; NAS, 2016; NRC, 2004; U.S. Department of Energy, 2003). The skills of efficiency, discernment, evaluation, grant writing, and decision-making were developed or strengthened through participation in a panel review (Irwin, Gallo & Glisson, 2013; Porter, 2005).

Specific content for training peer reviewers was mentioned sparsely and focused on process and logistics more so than skills. Examples of suggested training content included general principles and policies of peer review, purpose of peer review, how to apply review criteria, and the use of model reviews (National Research Council (NRC), 2004). A 2007 British Academy report recommended training in professional norms, academic quality, professional ethics, intellectual property, and fair consideration of work by colleagues. A 2016 NAS report suggested offering online modules and webinars, mentorship, and orientation focusing on the peer review process.

Becoming a great reviewer only comes with time and experience (Kibbe, Setterburg & Wilbur, 1999). Kibbe, et al. (1999) suggested the ways to improve one's reviewing skills were by reading proposals with care, engaging in conversations about the strengths and weaknesses of each proposal, utilizing the expertise of other professionals, and making reviewing a "profoundly conscious act" (p. 14). Kenyon College (n.d.) suggested that improving one's review skills is learned by engaging in the review process. Tang, Tan and Uma (2015), remarking on the effectiveness of implementation, indicated that review skills must be practiced and observed.

Despite the importance placed upon peer review within the scientific community, the identification of, and training for, the specific skills necessary for successful peer reviewers has been overshadowed by an emphasis on review outcomes. Review skills, referred to frequently as professional skills in the literature, emphasize personal and professional effectiveness. For example, professional skills are the "interpersonal, human, people or behavioral skills needed to apply technical skills and knowledge in the workplace" (Weber, Finley, Crawford & Rivera, 2009, p. 359), and the "cluster of personal qualities, habits, attitudes and social graces that make someone a good employee and a compatible coworker" (Lorenz, 2009 as cited in Ibrahim, Boerhannoeddin, & Bakare, 2017, p. 389). Banai and Tulimieri (2013) added complementary competencies to the definition including strategic and tactical conceptual abilities, cognitive dexterity, emotional stability, tolerance for ambiguity, integrity, openness, and agreeableness.

There is recognition that additional training is needed in the kinds of professional skills required to be an effective panelist. However, hardly any of the reasons given include the need to be an effective peer reviewer. Guilford's (2001) article on manuscript peer review was the only reference uncovered that concerned the relationship between professional skills education and peer review. While some of the skills required for peer review may be learned in traditional graduate training or professional development programs, the connection between developing the skills and using them in this unique setting (panel peer review) has not been well articulated. The assumption appears to be that the skills necessary for success in peer review will be obtained "along the way" (Hurst, Cleveland-Innes, Hawranik & Gauvreau, 2013) and they will be both present and developed when needed.

Methods

Data were collected in two stages. In Stage 1, semi-structured telephone interviews with experienced peer review program officers (n=7) and expert reviewers (n=5) were conducted. The purpose of the interviews was to identify skills or characteristics of a reviewer that were considered important to an effective panel review, to ascertain how those skills were developed, and to determine if panel format (virtual or face-to-face) had any effect on the development of such skills. An online survey based on the skills identified in the interviews comprised Stage 2. Respondents were asked about the development and use of professional skills, the impact of panel format on skills, activities that developed or improved professional skills, and demographic questions. Survey invitations were issued using two methods. One used a LinkedIn advertisement and one used a direct email invitation to randomly selected faculty members at Research 1 universities in the United States in STEM-related fields. The overall response rate was 8.1% (61/750). Nine responses were unusable resulting in a valid response rate of 6.9% (52/750).

Qualitative data analysis consisted of content analysis for descriptive patterns of the areas of interest (reviewer skills, reviewer skill development, relationship between panel format and skill development) as well as emergent and related concepts. Quantitative data analysis included calculation and comparison of frequencies, percentages, and averages. Reliability analyses were conducted for scales composed of numerous items aimed at measuring underlying constructs to determine if they demonstrated sound scale measurement properties. T-tests were used to determine whether the average for an individual item was significantly different from the overall scale average.

Results & Findings

Interviewees consisted of seven program officers who currently or previously work(ed) for three U.S. federal agencies, including the Department of Energy. The five experienced reviewers had served as panelists for seven U.S. federal agencies, including the Department of Energy. Collectively interviewees served on hundreds of panels in multiple formats.

Survey respondents were predominantly male, between the ages of 35-54, in the later stage of their career, in the fields of Physics and Engineering, and had participated on a number of panels for various U.S. federal agencies (see Appendix for participant characteristics).

Table 1 indicates the number of review panels respondents served on by format type (virtual and face-to-face). 93% of respondents participated in at least one face-to-face panel while 89% participated in at least one virtual panel. No respondent had participated in more than 16–25 virtual panel reviews, while 5 respondents had participated in 16–25 face-to-face reviews and 2 respondents had participated in more than 50 face-to-face reviews, indicating that face-to-face participation was more common.

Table 1: Frequency of Panel Participation by Format

Count Category	Virtual Panel Participations (n = 45)	Face-to-face Panel Participations (n = 45)
0	5 (11%)	3 (7%)
1 – 5	25 (56%)	14 (31%)
6 – 15	11 (25%)	17 (38%)
16 – 25	4 (9%)	5 (11%)
26 – 50	0 (0%)	4 (9%)
>50	0 (0%)	2 (4%)

Reviewer Skills

Interview findings

In analyzing interviewees' comments, reviewer skill was found to be impacted by frequency of panel review participation, nature of participation (agency sponsoring panel and panel format), and point in career when participation occurred. Interviewees also noted differences in the nature and purpose of panels as run by different agencies; these are important in terms of the skills called upon and how they are developed. For example, some interviewees stated the DOE does not require consensus among reviewers concerning funding recommendations whereas the NSF does. Therefore, the communication and interpersonal skills required on these panels may differ. DOE panelists can agree to disagree; NSF panelists cannot. The frequency of using a review panel to review research proposals also varied by agency and, within DOE, by program.

Interviewees identified twelve skills (Figure 1) that described the best peer reviewers:

• Subject Matter Expertise	• Diversity
• Broad Scientific Understanding	• Communication Skills
• Impartiality	• Technical Adeptness
• Time Management / Being Prepared	• Analytical Thinking
• Attending to the Purpose	• Interpersonal / Social Skills
• Understanding the Purpose and Role of Peer Review	• Open Mindedness and Trust in Self

Figure 1. Twelve skills identified by interviewees.

Definitions of skills

Both having *Subject Matter Expertise* and possessing a *Broad Scientific Understanding* were most frequently cited as important skills. One interviewee summed this up by emphasizing the importance of having both "broad and deep knowledge of subject areas." *Impartiality* was discussed in terms of fairness and sensitivity towards, avoidance of, and the ability to mitigate bias and conflicts of interest. Interviewees noted the importance of panelists managing their time to complete tasks well enough that they arrived fully prepared to participate (*Time Management/Being Prepared*). *Attending to the Purpose* of the work by reading the solicitation, the directions, and the criteria for decision-making was also considered vital. *Understanding the Purpose and Role of Peer Review* was a trait less frequently noted than others were, but it was stated as distinct.

Diversity was mentioned as a trait of a panel rather than a reviewer and several interviewees stated it was important to the success of panel reviews. Program officers indicated diversity of perspectives and backgrounds was something they looked for when forming panels. Interviewees said that panels with institutional, demographic, and scientific diversity were more balanced and therefore better.

Communication Skills, including speaking, writing, and listening, were considered important to effective review participation by many interviewees. Good English language skills were also noted, as was the ability to synthesize thoughts clearly and concisely whether verbally or in writing. *Technical Skills* were mentioned only with respect to the virtual review format and were described as being adept at sustaining decent audio levels and clarity, internet connections, and camera placement. *Analytical Thinking* included the ability to complete an evaluative analysis by weighing the individual and comparative merit of proposals. Reviewers needed to identify strengths and weaknesses, judge relevance, and critically evaluate the contribution to science.

Interpersonal / Social Skills were important to group function. Whether reviewers needed to come to consensus or not, they needed to listen to each other, interact respectfully, conform to the agreed-upon processes, manage their interactions with one another, and engage with a spirit of contribution and improvement as opposed to apathy or negativity. One interviewee stated, "interpersonal relationships and abilities distinguish panel reviews from individual reviews;

panel review success is the combination of technical expertise and interpersonal relationships and abilities".

A sense of *Open Mindedness* balanced by a *Trust in Self* was also needed to interact successfully in a panel setting. Panelists needed to be "adept at the delicate balance between being open minded enough to be willing to change one's mind when appropriate, yet confident enough in one's opinions and knowledge to stick to what one thinks when important."

Survey findings

For quantitative measurement, the 12 skills identified in the interviews were broken into 20 discreet competencies (Figure 2):

•Build Rapport	•Sensitive to Bias	•Open to Novel Research Ideas
•Active Listening	•Put Research in Context	•Being Prepared
•Politely Redirect Conversation	•Stay on Topic	•Confidence in Own Position
•Politely Disagree	•Panel Review Familiarity	•Clear Writing
•Interpret Body Language	•Articulate Ideas Clearly	•Broad Scientific Understanding
•Sustain Attention to Task	•Agency Review Process Familiarity	•Analytical Thinking
•Open to Other's Opinions/Ideas	•Impartiality	
Cronbach's alpha for the 20 items was .91 indicating good reliability.		

Figure 2. Twenty discrete competencies.

Based on their experience, survey respondents were asked to indicate, on a 5-point Likert scale, their level of agreement that each competency was important to being an effective review panelist (1 = Strongly Disagree to 5 = Strongly Agree). The mean response for 18 of 20 items was between 3.6 and 4.7 indicating respondents tended to agree or strongly agree that 90% of the competencies were important. Respondents expressed neutral feelings that *Build Rapport* (mean = 3.3) and *Interpret Body Language* (mean = 3.2) were important to being an effective review panelist.

An overall average was calculated for the 20 competencies in order to determine if there was a significant difference between agreement that a particular competency is important and overall agreement that the competencies are important. Using a 95% confidence interval seven competencies (Figure 3) had means significantly higher than the overall average, indicating respondents were significantly more likely to agree these competencies were important to being an effective reviewer.

↑ Impartiality	↑ Analytical Thinking
↑ Being Prepared	↑ Open to Other's Opinions/Ideas
↑ Open to Novel Research Ideas	↑ Politely Disagree
↑ Put Research in Context	

Figure 3. Competencies significantly higher ↑ than overall average.

Six competencies (Figure 4) had mean responses significantly lower than the overall average.

↓ Politely Redirect Conversation	↓ Panel Review Familiarity
↓ Agency Review Process Familiarity	↓ Build Rapport
↓ Confidence in Own Position	↓ Interpret Body Language

Figure 4. Competencies significantly lower ↓ than overall average.

The mean response for seven additional competencies (Figure 5) showed no statistically significant difference in importance from the overall average response.

ⓝ Broad Scientific Understanding	ⓝ Sensitive to Bias
ⓝ Stay on Topic	ⓝ Sustain Attention to Task
ⓝ Active Listening	ⓝ Clear Writing
ⓝ Articulate Ideas Clearly	
Competencies showing no significant difference ⓝ than overall average.	

Figure 5. Competencies showing no significant difference ⓝ than overall average.

Additional comments concerning the competencies necessary for an effective review panelist were "know who the other members are and their background" and "understanding politics of funding agency, competing research groups, etc." or "understand goals for the funding agencies." One respondent noted the importance of interpersonal skills stating that the panel "is a team, meaning you have to play well with others." Concerning consensus one respondent wrote, "there has to be room for vigorous disagreement as there are questions where consensus has not yet emerged" and another stated "it is important to express one's scientific opinion but accept that everyone can have different opinions. Consensus is not the goal. Fair and unbiased evaluation against a consistent set of criteria and standards is the goal." In addition, one respondent stated "Many of these [competencies] have increased importance as panels begin to move to remote panel reviews [using] teleconference or video conference where the ability to stay on topic and professionally direct the conversation is vital."

Panelist Skills and Panel Format

Interview findings

While interviewees described the skills needed in face-to-face and virtual panel formats as the same, they indicated there were additional challenges when using technology. Overall virtual participation was said to be more difficult requiring more sustained attention, better technical skills such as understanding proper camera placement, and more developed interpersonal and communication skills such as higher level listening skills.

Survey findings

Survey respondents were asked to indicate which panel setting best helped develop or improve each competency. Seven of the 20 competencies were clearly considered more improved by participation in face-to-face than by video conference settings (see Figure 6).

- Build Rapport
- Active Listening
- Politely Redirect Conversation
- Politely Disagree
- Interpret Body Language
- Sustain Attention to Task
- Open to Other's Opinions/Ideas

Figure 6. More improved face-to-face.

For two competencies, *Sensitive to Bias* and *Stay on Topic*, nearly half the respondents chose improved more by participation in face-to-face panels while approximately one-third chose improved equally by either setting. No more than 16% of respondents selected "Improved more by virtual participation" for any of the competencies. However, respondents did report the ability to *Put Research in Context* and the ability to be *Open to Novel Research Ideas* were equally improved by either panel format (face-to-face or virtual).

Broad Scientific Understanding and *Analytical Thinking* had the greatest amount of agreement that they were not improved by either format, although nearly as many respondents felt they were equally improved by either.

For the remaining seven competencies (*Panel Review Familiarity, Articulate Ideas Clearly, Agency Review Process Familiarity, Impartiality, Being Prepared, Confidence in Own Position, Clear Writing*), the proportions of respondents choosing "Equally Improved by Either Format" and "Not Improved by Either Format" were nearly identical thus indicating little agreement among respondents about how these competencies are improved.

How Panelist Skills Develop

Interview findings

A common response when asked how participation in either of the two formats helped develop reviewer skills was that it does not. Program officers indicated it was important for reviewers to possess the necessary skills prior to serving on a review panel. One interviewee stated, "I don't know if [either format] develops them, as much as takes advantage of them ... I think you bring a lot of the skills with you..." Another interviewee said participation on a panel allowed one to "gain an appreciation" for the skills needed to be an effective panel reviewer, but overall, interviewees who had not been program officers or managers shared the sentiment that "most of the time… [program officers] think I have the skills already."

Despite generally feeling they needed to have the necessary skills prior to participation, having the skills modelled was noted as a way to develop skills, e.g. "you learn how it is supposed to work especially if you see a good model in play." One interviewee stated, "the interpersonal/ social skills needed for peer review are not taught in science programs. You learn by watching it done (on a panel)."

At least three interviewees also stated that being on a panel improved their review skills, e.g. "There is no substitute for doing." Overall, interviewees suggested "On the job training in which you learn from more seasoned and senior colleagues who are co-panelists" was extremely important.

Virtual panels were thought to make skill development more difficult. One interviewee noted "skills develop to a lesser degree in virtual settings" while a second said "perhaps skills develop only half as well as in face-to-face settings." Virtual settings were considered less engaging for participants and required more effort from the reviewers to pay attention and not get distracted. In the virtual setting, the management of the panel (how it is run) was seen to be as important as the panel itself. One interviewee stated program officers must "make sure to cue participants in to what is happening, be aware of noises like shuffling of papers and scraping of chairs, and be deliberate about capturing results, timelines, breaks, etc." Because there are no cues from which to read these things everything must be explicitly handled.

Survey findings

Thirteen activities/experiences (Figure 7) were developed from the interview responses and provided to respondents in order to assess how panelist skills improved:

• Being the chair/ running a discussion	• Reading reviews of my own research proposals
• Listening to panelists make arguments	• Casual discussions with senior colleagues
• Participating on more than one panel	• Being mentored by colleagues - in panel reviews
• Writing / submitting research proposals myself	• Mentoring others - participation in panel reviews
• Sharing my thoughts during discussions	• Training / instructions from funding agencies
• Serving as a peer reviewer of manuscripts	• Academic training (e.g. graduate programs, workshops)
• Observation of other panelists	
Cronbach's alpha for this set of items was .88 indicating good reliability.	

Figure 7. Thirteen activities to assess how panelist skills improved.

At least 70% of all respondents had experienced all 13 activities; slightly fewer than 2/3 experienced *Being the Chair/ Responsible for Running a Discussion*; almost 1/3 had never been mentored in peer review and nearly 1/4 had not served as a mentor.

All 13 experiences were considered to have at least 'somewhat improved' reviewer skills. Only one experience, *Being the Chair/ Responsible for Running a Discussion*, was rated towards 'strongly improved.' Three activities (*Being the Chair/ Responsible for Running a Discussion, Listening to Panelists Make Arguments,* and *Participating on More than One Panel*) were significantly more likely than the competencies overall to be rated as having improved panelist skills (Figure 1). Despite being experienced by > 90% of respondents, *Training/ Instructions from Funding Agencies* and *Academic Training* were significantly less likely than other competencies to be rated as having improved panelist skills (Figure 8).

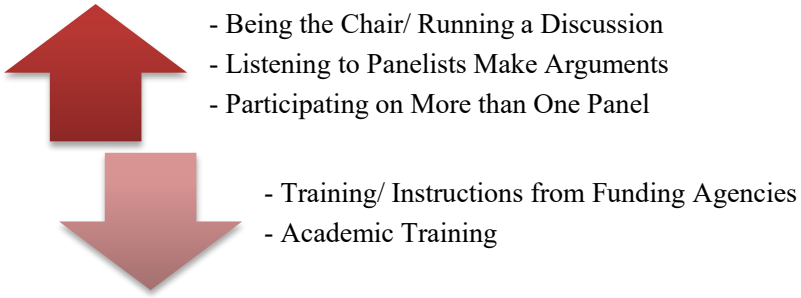

Figure 8. More and less likely that the overall average to improve skills.

Other experiences that helped develop or improve review panelist competencies included conflict resolution courses, leading technical discussions in the field, and a good program officer/ chair who sets clear expectations. Diverse panels with multiple backgrounds represented were said to help broaden thinking during the proposal review.

Additional Interview Comments

Several interviewees discussed the benefits of participating in panel reviews. Chief among these was the opportunity to improve one's own grant writing and evaluation skills, e.g. "Being on a panel, you learn a lot about how to write grants and how to evaluate grants" and "you become a better proposal writer by watching and listening to what it is that other people think is important in a proposal." Participation was also seen as improving knowledge about one's own field and networking.

Interviewees noted the key role played by those who moderated panel reviews in terms of panel success, such as in teasing out and identifying the conservative tendencies that keep panelists from highly ranking truly innovative work. The moderator was seen as essential in setting the tone, providing instruction and direction, and moving "things from not going well to better." The critical role of the moderator was particularly evident in virtual settings as expressed in this statement, "Management of a panel online is as important as the panel itself. You have to move people through the process more deliberately because they only have auditory cues, they can't see what's coming next, can't tell when a conversation is wrapping up. You have to plan how to capture results, have a concrete timeline, plan breaks, and have a map for what is going to happen, how and for how long, and at what time."

Suggestions for acquiring the necessary skills for effective panel review included starting with smaller panels and in junior roles such as reviewing seed grant proposals, or reviewing manuscripts to learn how to judge what is required to successfully complete research, whether a question has merit, organizing one's comments, and making helpful suggestions. Another interviewee commented on mentoring and training efforts at their university to expose junior faculty to the process of writing and reviewing conference proposals.

Discussion

By focusing on reviewer skills, their development, and how that may be influenced by panel format and the use of technology in panel reviews, this exploratory study provides ORISE with information needed to determine whether current technology and processes are optimal for preparing effective reviewers and enabling virtual panel discussions. To understand and evaluate review panel skills, this examination looked to literature concerning professional skills needed by scientists to conduct their work. Major findings included:

- general support of the literature in terms of the skills needed regardless of technology;
- identification of three panel review skills not noted in the literature;
- the idea that peer review skills are professionals skills;
- having competencies modelled and modelling them improve panelists' skills;
- peer review guidance and training, and general academic training improve panelist competencies the least of all experiences measured, and no more so than the average of all experiences measured;
- and being the chair / running a panel improves skills more than any other experience measured and more than the average of all experiences measured.

Findings concerning the relationship between review panelist skills and review panel format were less conclusive. These and other related findings are discussed below.

Of the twelve skills (Figure 9) identified by experienced panel reviewers and program officers/managers as necessary for effective participation in peer review panels, three are newly identified (1 – 3), nine appear in the literature (4 – 12), and eleven qualify as professional skills (1 – 11).

1. Broad scientific understanding (the ability to put proposed research in broader context)
2. Understand the purpose and role of peer review
3. Technical issues / technical adeptness
4. Impartiality (ability to be impartial, sensitivity towards bias, honesty about conflicts of interest)
5. Time management (preparation, adherence to deadlines)
6. Attend to the purpose/follow directions (read the solicitation, evaluate in context of solicitation, conform to the process)
7. Communication skills (speaking, writing, listening)
8. Analytical thinking and evaluation (critical thinking)
9. Interpersonal skills
10. Open mindedness vs. trust/confidence
11. Subject matter expertise
12. Diversity in/of panel

Figure 9. Twelve skills necessary for effective participation

Diversity was identified more as a trait of a panel than as a skill of a reviewer, but also appeared in the professional skills literature in terms of scientists' ability to work well within diverse teams (Cheetham & Chivers, 2001; Yen, Horner-Devine, Margherio & Mizumori, 2017).

Given the definitions and examples above, the skills identified by program officers/managers and experienced reviewers as necessary to effectively participate in panel peer review can be seen as

professional skills. For example, given the importance of peer review to the scientific enterprise, understanding the purpose and role of peer review is a requirement for a professional scientist. Technical aptitude is required for the conduct of modern science from basic computer skills, to software proficiency, to microphone and webcam placement when participating in a video conference. Impartiality reflects integrity, ethics, best practices, and critical thinking. Time management, following directions, attending to purpose, being able to communicate, and getting along with others are all the "interpersonal, human, people or behavioral skills needed to apply technical skills and knowledge in the workplace," in this case, in the scientific workplace (Weber, et al., 2009, p. 359).

When a broader, random sample of reviewers indicated their level of agreement that competencies, derived from these 12 skills, were important to being an effective review panelist, the seven competencies rated significantly higher than the overall average were all derived from the professional skills identified. These included the ability to put proposed research in a broader context, impartiality (an application of critical thinking to the concept of bias), being prepared (an aspect of time management), the ability to politely disagree (an aspect of both communication and interpersonal skills), and openness to novel research ideas (an aspect of open mindedness). Of the six competencies rated significantly lower than the overall average, only four were professional skills.

Review panel skills identified in this investigation and professional skills identified in the literature have not been discussed as overlapping. Of the numerous reasons given for the need to train scientists, researchers, and graduate students in professional skills, only Guilford's (2001) article concerning manuscript peer review noted these skills are needed by researchers for the purpose of participation in peer review. Panel reviewers will be unprepared to call upon these professional skills during panel reviews if the connection is not clarified by educators and mentors.

The peer review literature does not discuss *Broad Scientific Understanding*, a skill that interviewees indicated was nearly as important as *Subject Matter Expertise*, nor does it discuss *Understanding the Purpose and Role of Peer Review*, or *Technical Issues and Technical Adeptness*. The reason(s) these skills have not previously been identified as necessary for effective peer review is unclear. Whereas the reviewer skills identified in this inquiry come from first person observations and experiences, few past studies have examined peer review panel skills at all, and even fewer (Markin, 2008; Member, 2003; Porter, 2005) have done so in the manner of this investigation – asking those who are and have been panel reviewers about review panel skills.

While very little has been written in the peer review literature about the skills needed for effective panel review participation, even less was found on how such skills might be developed. Interviewees described two ways they had developed their panel review skills in face-to-face

panels: 1) modeling by others, and 2) "doing it." No methods of skill development specific to virtual panels were mentioned.

Training/ Instructions from Funding Agencies and *Academic Training* were rated the lowest in terms of their average ability to improve panelists' competencies, and were also significantly less likely than the activities overall to improve panelist competencies. If training does not improve panelist competencies, and the average improvement in review panelists' competencies of all the activities measured was only somewhat improved, what activities or experiences would be helpful?

Three competencies rated statistically higher than average in importance to being an effective reviewer were also reported as clearly more improved by face-to-face participation:

- Open to Other's Opinions
- Politely Disagree
- Being Prepared

Approximately half the respondents reported two of the remaining four competencies rated significantly higher than average in importance were equally improved by face-to-face or virtual formats:

- Put Research in Context
- Open to Novel Research Ideas

When it comes to improving several of the most important panelist skills, face-to-face panels were preferred. However, other clearly important panelist skills were deemed equally improved by either format. Unfortunately, these findings do not indicate why respondents considered a particular competency to be improved more by one format than another. Since none of the competencies identified were noted as improved more by the virtual format, we concluded that the virtual format may be excellent for the review of research, but it does not serve as well to improve reviewer's panel review skills.

Debates in the peer review literature included whether face-to-face or virtual settings are better, and how technology affects panel reviews, but there is little discussion on the different skills needed for each format. Impacts to communication were the exception, yet the literature there focused on the quantity and quality of communication in different settings, not on communication as a skill. Venkatraman (2014) noted "panelists [within virtual panels] appear to work harder to communicate" but the work of evaluation is still accomplished (§Virtual Downsides, para. 1). This opinion was shared by the expert peer reviewers and program officers interviewed in this inquiry; they described the skills needed in face-to-face and virtual panel formats as the same, but noted additional challenges when using technology. The overall sentiment was that virtual participation is more difficult and therefore communication skills are even more important.

No consensus was uncovered among interviewees and survey respondents, or between participants and the literature, concerning where and how panelist skills develop – be it outside of, or prior to, review panel participation. Some authors indicated skills are/were developed by participating in face-to-face panels (virtual panels were not discussed relative to skill development) (Irwin et al 2013; Member 2003; Porter 2005). However, interviewees said skills for effective engagement needed to be, and were, present prior to participation but were also improved by participation. Survey respondents indicated skills were more likely to be improved by face-to-face formats, equally by either format, or by neither format. Neither interviewees nor survey respondents concluded any skills were improved more through the virtual panel format.

Limitations

The main limitation of this exploratory study was the small sample size. The potential target population was doctorate holders in the United States working in STEM-related disciplines. According to the National Science Board (2018) Science and Engineering Indicators 2018, the size of the target population is estimated at 448,900 (6.7% of 6.4 million workers). Only 750 members of the target population received invitations. In addition, while the sample focused on STEM-related disciplines, it may not have been distributed equally across those disciplines, career stages, reviewer experience, or type of institution.

Recommendations

Based on the findings and limitations, several recommendations for practice and further research are evident.

First, some factors are not completely within ORISE's control.

- Face-to-face participation is not always feasible. It might be desirable for new reviewers to participate in a face-to-face panel before participating in other types of reviews, in order to maximize skill development in their first experience as a reviewer, but opportunities might not be available at the appropriate time.
- According to literature reviewed, current professional skills training efforts are sporadic, inconsistent, and insufficiently made relevant to peer and panel review. More uniform incorporation of professional skills training into the preparation of scientists and researchers, and specifically connecting relevant professional skills to the panel review setting, could be beneficial.

Nevertheless, ORISE can address the relevant issues at several levels: further research, training development, and at a minimum, review of, and where needed, enhancements to current reviewer orientation materials and technology.

This paper does not address the reasons training from funding agencies and academic training are not helpful, for example: Do instructions from funding agencies fail to address panelist skills at all, or are the instructions' treatments of panelist skills inadequate? Do new researchers receive no academic training in peer reviewer skills, or is the training they receive ineffective? Do mentors of graduate students and postgrads never think to cover the topic, or do they not know enough to provide helpful advice? Therefore we recommend further analysis of existing research, and possibly additional research, on effective training in reviewer skills.

In order to compare different strategies or methods for training reviewers, ORISE could consider replicating peer review panel meetings, using actual previously-evaluated proposals (with permission) with first-time reviewers who have been exposed to various types of training. Training effectiveness could be evaluated based on participant ratings of their own and others' application of the relevant skills, trained observers ratings, or program officers and moderators ratings.

Since both the literature reviewed and the results in this investigation suggest that the peer reviewer training currently available is insufficient, ORISE should consider developing formal training that focuses on the important competencies and skills discussed in this report.

ORISE writes reviewer orientation materials, prepares and coordinates webinars for reviewers, and has created web videos for reviewers. However, none of these focus specifically on the reviewer skills identified in this inquiry as important for reviewers. In addition to systemic

changes in professional skills training, two practical changes to ORISE's current panelist orientation are suggested:

- ORISE develops reviewer orientation materials that describe and emphasize the most important competencies: the abilities to be impartial, put proposed research in context, be prepared and manage one's time, apply critical and analytical thinking, balance openness to new ideas and other's viewpoints with confidence in one's own opinions, and remain polite and collegial in the face of disagreement.
- ORISE develops reviewer orientation materials for virtual reviews that mention research results on the challenges that are most difficult and different from their face-to-face review experiences, if they've had them, along with suggestions or "tips": the increased need to focus and sustain focus; the need to consciously limit interruptions to one's physical space by putting a sign on the door, turning off email and messaging; camera and microphone placement and use; and how to access internet connection troubleshooting assistance.

The technology used in virtual review panels is an important aspect of review success. The results of this exploratory study indicate that access to, and use of, the best technology available for virtual participation helps ensure effective participation. In addition, being an adept user of the chosen technology is critical to effective virtual participation. ORISE currently uses Adobe Connect and Zoom for virtual participation by reviewers. Adobe Connect was selected after extensive evaluation for usability and for qualities that might support development or improvement of some skills relevant to this exploration. For example, one criterion was that the tool includes features such as raising a hand, agreeing and disagreeing, polling, and webcam to address politely disagreeing and being engaged. Zoom was selected through a different process and using different but overlapping criterion. We recommend that ORISE regularly re-evaluate the virtual participation software it uses as well as the reviewer orientation content it offers in light of the results articulated in this report.

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Appendix: Respondent Characteristics

Frequency of Type of Employment *

Type of Employment	n	% (N = 45)
University	44	98%
Government agency/office	1	2%
National lab	1	2%
Non-profit	1	2%
Other (=Consultant in technology)	1	2%
Corporation	0	0%

**Respondents could select more than one type of employment.*

Frequency of Education Degree *

Educational Degree	n	% (N = 45)
Doctorate	42	93%
Master's Degree	7	16%
Bachelor's Degree**	6	13%
Professional Degree	2	4%
Associate's Degree	0	0%
Other	0	0%

**Respondents could select more than one type of educational degree, answering the question, "What educational degree(s) have you earned?" **It is assumed respondents responded with only their highest degree earned.*

Frequency of Gender

Gender	n	% (N = 45)
Male	29	64%
Female	12	27%
Other	2	4%
Prefer not to answer	2	4%

Frequency of Career Stage

Career Stage	n	% (N = 44)
Senior (21+ years)	25	56%
Middle (11 – 20 years)	15	33%
Early (1 – 10 years)	4	9%

Frequency of Age Categories

Age Categories	n	% (N = 44)
18 – 24 years	0	0%
25 – 34 years	0	0%
35 – 44 years	11	25%
45 – 54 years	14	32%
55 – 64 years	12	27%
65+ years	6	14%
Prefer not to answer	1	2%

Frequency of Field of Work

Field of Work	n	% (N = 45)
Physics	11	24%
Engineering	8	18%
Chemistry	6	13%
Materials science	6	13%
Computer science	4	9%
Biology	3	7%
Environmental sciences	2	4%
Mathematics	0	0%
Other*	5	11%

**One response each for Medicine, Emergency Management, Astronomy, Pharmacology, Economics/Regional Planning.*

Frequency of Agencies for Which Respondents Participated in Panel Reviews of Research/Grant Proposals

Agencies	n	% (N = 45)
NSF (National Science Foundation)	37	82%
DOE (Department of Energy)	24	53%
NIH (National Institutes of Health)	9	20%
DOD (Department of Defense)	8	18%
NASA (National Aeronautics and Space Administration)	6	13%
International Agency(ies)	5	11%
USDA (United States Department of Agriculture)	5	11%
DHS (Department of Homeland Security)	2	4%
EPA (Environmental Protection Agency)	2	4%
CDC (Centers for Disease Control)	1	2%
NIST (National Institute of Standards and Technology)	1	2%
AIBS (American Institute of Biological Sciences)	0	0%
Bill & Melinda Gates Foundation	0	0%
DOI (Department of Interior)	0	0%
DOJ (Department of Justice)	0	0%
NOAA (National Oceanic and Atmospheric Administration)	0	0%
Robert Woods Johnson Foundation	0	0%
William T. Grant Foundation	0	0%
Other*	12	27%

**Of those who selected other and provided additional information, the following meaningful responses were recorded:* NHPRC, IMLS, NEH, SSHRC, CLIR, US NPS, US NETL, AHA, JDRF, Research Corporation, Kaufman Foundation, Beckman Foundation, Welch Foundation, Internal grant review at my institution, Smithsonian, Soros Foundation, Greek funding agencies, Czechoslovakian funding reviews, Austrian Science Foundation, European Agencies, and "review committees for several foreign institutions."