Publishing in the field of neuroscience:

Scientists at the University of Minnesota Institute for Translational Neuroscience describe problems and potential solutions

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Abstract

Publishing in the field of neuroscience is a chaotic, inefficient, and increasingly difficult process to navigate. Scientists disagree on the value of traditional publishing versus Open Access publishing, predatory journals pollute the literature, and researchers suffer from the widespread practice of submitting to high-impact journals, facing rejection, and delaying publications. To gain a better understanding of how neuroscientists navigate this process, I interviewed ten researchers at the University of Minnesota Institute for Translational Neuroscience. Through interviewing investigators with varying levels of publishing experience—graduate students, beginning investigators, and senior investigators—I aimed to 1.) gain a more complete picture of how researchers approach the publishing process, cope with the associated problems, and view potential changes to the system; 2.) generate a more concrete notion of what changes might best suit the future field of neuroscience; and 3.) understand how predatory journals fit into the transitional state of neuroscience publishing. To create a better publishing system, I suggest that we apply the research findings of economist Elinor Ostrom, integrate conversations about publishing within graduate neuroscience programs, and utilize research from the field of Scientific and Technical Communication.

Introduction

In my two years as a researcher at the University of Minnesota Institute for Translational Neuroscience (ITN), I have become increasingly aware that the publishing process is troubled. I consistently hear scientists express confusion, misunderstanding, and frustration in conversations about the peer review process, paper rejections, and decisions about how, how much, and with whom to publish results. A few examples reflect this frustration:

A perplexed researcher in my laboratory recently asked, *our… work got rejected from… journal … how did this (paper) ever get published in Nature?*

A graduate student working in my building said, *I got rejected from…journal and the reviewers said that I didn't perform the right experiments to make…claim. And then I thought, did they even bother to read my methods section? It's right there.*

In a recent lab meeting discussion about a controversial *Nature* paper, a colleague concluded, *The only reason this is in Nature is because they made it seem sensational…they made it seem cool. But the actual work, the science…it's not great. It's actually really questionable.*

A colleague that often collaborates with international researchers told me, *I have colleagues in other countries working at Universities that don't have great resources and accessibility to the literature—they often ask me to access the PDFs and send them so that they can read them.*

These are just a few of the many grievances that I have heard through working in an environment that rests on a broken but highly necessary process of research publishing.

A "traditional publishing model"—a system in which journal subscription fees cover production costs—has long guided the scientific publishing process (Ware, 2015). These hefty subscription fees, paid primarily by libraries, allow authorized users—generally students and faculty—to access large academic databases that archive the articles. As such, literature is disseminated with restricted access. In an *Atlantic* article, Laura McKenna (2012) criticizes this system:

> *Step back and think about this picture. Universities that created this academic content for free must pay to read it. Step back even further. The public—which has indirectly funded this research with federal and state taxes that support our higher education system—has virtually no access to this material, since many libraries cannot afford to pay those subscription costs (4).*

With the advent of web-based publishing, an Open Access (OA) movement gained significant momentum. Peter Suber directs the Harvard Open Access project. He is

widely considered to be the leader of the OA movement, and in 2012 he authored the book *Open Access*. In this book he argues,

> *OA benefits literally everyone. It benefits researchers as readers by helping them find and retrieve the information they need, and it benefits researchers as authors by helping them reach readers who can apply, cite, and build on their work. OA benefits non-researchers by accelerating research and all the goods that depend on research, such as new medicines, useful technologies, solved problems, informed decisions, improved policies, and beautiful understanding (Suber, 2012, preface).*

Open Access journals are available online, subscription-free, and at no cost to readers. They are generally not under the same types of stringent licensing and copyright restrictions as traditional publishers, but they employ peer review, and are widely indexed in Pubmed and other large literature databases. Since these journals are not funded by library or personal subscriptions, other methods are used to cover production costs. Open Access journal publishers typically use an "author pays" system in which the researcher pays some amount—widely ranging fees—to submit and publish his or her work (West, 2014). For example, OA publisher Elsevier articles are made freely available for everyone to read immediately upon publication, and prices are set on a per journal basis, typically ranging from $500 -$5,000 per article (PLoS, 2015).

In the transition from a traditional publishing system to Open Access publishing, science is suffering. Furthermore, the substantial emphasis that is placed on the Impact Factor (IF) of journals and scientists further complicates the publishing process. Formally established by the Institute for Scientific Information (ISI) in 1975 (Cawkell, 1977), Impact factor is defined as the total number of citations divided by the number of citable articles over a two-year period.

Publishing in the field of neuroscience is in a particularly disordered state; the nature of this discipline makes publishing an especially troubled process. For one, neuroscience aims to understand the incredibly complex brain, and studies demand interdisciplinary collaborations that draw on biology, behavior, chemistry, psychology, physics—many fields of study. Progress in neuroscience depends upon the development of a large-scale, connected understanding of brain systems, and the widespread integration of new technologies.

In a proposed update to the publishing system, Kravitz and Baker (2011) argue,

> *The intuitions and theories conveyed by a paper and the relationship between those theories and the literature are often as important as the data itself. The current system encourages novel seeming, isolated research, which is often directly contrary to establishing theories and interpretations in relation to the literature* (11).

Neuroscience is a massive and rapidly growing field, which has led to additional publishing problems—difficulties that will compound as the field grows. A significant increase in the number of scientists leads to an increase in the number of submissions to scientific journals, an increase in the number of paper rejections (Van Noorden, 2011), and increased difficulty—inability even—to follow the work of other researchers in the field. Meanwhile, this growth coincides with the creation of many new online journals that operate in various ways, with varying degrees of stringency and integrity. There were 252 journals listed within the category of "Neurosciences" in Journal Citation Reports (JCR), provided by Thomson Reuters in 2015.

Kravitz and Baker (2011) state their concern:

> *As the field and the associated literature grow, the inefficiencies of the current system will become increasingly problematic. The amount of time it takes to publish a paper, the number of reviews written, and the difficulty in organizing and comprehending the literature will increase and become a limiting factor on progress in the field, if it is not already* (11).

Meanwhile, the email inboxes of most scientists are filled with invitations to publish in various scholarly journals. The following solicitation, received by a senior investigator at the ITN, provides an example of these messages:

SUBJECT: Golden Opportunity to Publish as Open Access

Dear Dr. _____

The Open Spectroscopy Journal is a peer reviewed Open Access online journal, which publishes research articles, reviews, letters and guest edited thematic issues representing important scientific progress in all areas of spectroscopy and applied spectroscopy. . It is indexed in all major indexing databases such as Directory of Open Access Journals (DOAJ), Chemical Abstracts, Open J-Gate, Genomics Journal Seek, Media Finder®-Standard Periodical Directory, J-Gate, Pubs Hub and Index Copernicus. In addition to regular articles, the journal also publishes thematic issues on contemporary themes which are guest edited by eminent scientists. Thank you in advance for your submission to The Open Spectroscopy Journal. We look forward to hearing from you soon.

With kind regards,
Yours sincerely,
Eduardo A. Castro
Editor-in-Chief: The Open Spectroscopy Journal

In discussing these invitational emails, the recipient commented, *I get this kind of publishing garbage all the time. Sometimes they don't even bother to spell check. I just trash them.*

What makes this "Golden Opportunity" message garbage? It is one example of the increasingly pervasive "academic journals" that employ questionable publishing practices with the primary goal of profiting from the author's submission payments. Unlike legitimate scientific journals—publishers that operate to communicate quality, peer reviewed data—these journals will publish anything as long as they are making money. Some of these operations are single-title independent journals,

while others have expanded to function as collective of "fleet" journals in their portfolios of unethical work.

Jeffery Bealle, a librarian at the University of Colorado, has termed these operations "predatory publishers"; he dedicates considerable time to uncovering and shunning them through blog postings and a running list of flagged journals (Bealle, 2016, Scholarly Open Access). According to Bealle,

> *Evaluating scholarly open-access publishers is a process that includes closely, cautiously, thoroughly, and skeptically examining the publisher's content, practices, and websites: contacting the publisher if necessary, reading statements from the publisher's authors about their experiences with the publisher…examining any additional credible evidence about the publisher, compiling very important 'back-channel' feedback from scholarly authors, and taking into account counter-feedback from the publishers themselves* (Bealle, Scholarly Open Access, 2015, 1).

Bealle utilizes an extensive list of "red flags" to create a collection of predatory journals. This list includes questionable and unethical practices pertaining to the editorial review boards, business motives, and general integrity of the journal. These warnings include the following key examples: The editor and/or review board members do not possess academic expertise to reasonably qualify them to be publication gatekeepers in the journal's field; no academic information or institutional affiliation is provided regarding the editor, editorial staff, and/or review board members; a general lack of transparency in publishing operations;

lack of a digital preservation method, meaning that if the journal ceases operations, all of the content disappears from the internet; sending of spam requests for peer reviews to scholars unqualified to review submitted manuscripts; minimal or no copyediting or proofreading of submissions is provided; insufficient resources are dedicated to preventing and eliminating author misconduct such as plagiarism and image manipulation (Bealle, Scholarly Open Access).

Sound peer review is tried and true; it is generally a very dependable guardian against the propagation and circulation of "bad science", as scientists "check" other scientists: Is their logic right? Do their methods make sense? Have they done the proper analyses? Are further experiments needed to draw conclusions? The editors of predatory journals do not facilitate this crucial process. They will sometimes send submitted papers to scientists that have entirely different areas of expertise from the work that is to be reviewed. This is not peer-review, yet it is a common practice for predatory publishers, and the primary danger that accompanies their rise.

According to Bealle's analysis, the list of potential, possible, or probable predatory publishers has risen dramatically over the past five years. In 2011 there were 18 predatory journals. Today there are 923 journals (Bealle, Scholarly Open Access) operating with open wallets and an irritating disregard for the scientific process of genuine peer review. Ten years ago, starting a scientific journal was not an easy task—it required specialized teamwork, substantial financing, and applied expertise in a particular discipline. Papers were published in hard-copy journals, while

students and scientists sat in libraries and read these journals. The Internet explosion and accompanying Open Access movement has made it possible for virtually anyone to start a scientific journal. Predatory publishers have found a fertile ground for growth and success, and further complicated a transitional and already confused scientific publishing world.

For scientists, especially young investigators with minimal publishing experience or mentorship, Bealle's list is a useful tool. And even without this list, predatory journals are generally not difficult for scientists to avoid—the websites are commonly littered with grammatical errors and the names of editorial board members that don't even exist. It may be difficult to imagine that these operations could actually be successful at baiting researchers to publish, but in fact, scientists do occasionally fall into these traps.

Predatory journals are certainly troublesome, but they accompany many other complex problems in the neuroscience publishing process. Scientists disagree on the value of traditional publishing versus Open Access publishing, predatory journals pollute the literature, and researchers suffer from the widespread practice of submitting to high-impact journals, facing rejection, and delaying publication. Researchers are voicing their frustrations and making suggestions for improvement (Kravtiz, 2011; Eisen, 2016), yet there is little agreement on what kinds of changes would be best suit the field and be widely embraced.

To gain a better understanding of how neuroscientists navigate this perplexing publishing process, I interviewed researchers at the University of Minnesota's Institute for translational Neuroscience (ITN). Through talking to investigators with varying levels of publishing experience (graduate students, new investigators, and senior investigators), I aimed to **1.) gain a more complete picture of how researchers approach this process, cope with the associated problems, and view potential changes to the system**. Furthermore, I conducted interviews in order to **2.) generate a more concrete notion of what changes might best suit the future field of neuroscience, support new investigators, and ultimately lead to the most effective dissemination of science for society.** Through these conversations, and by investigating the practices of predatory journals I aimed to **3.) understand how predatory journals fit into the transitional state of neuroscience publishing, and potentially threaten the careers of scientists and science dissemination.**

Methods

I interviewed ten scientists that conduct research at the University of Minnesota Institute for translational Neuroscience (ITN). Interviews lasted 30-60 minutes and were audio recorded using Voice Record Pro. I transcribed interviews into text documents in order to conduct close readings and extract common themes. Interviewees included:

- 6 ITN senior investigators
- 1 ITN postdoctoral researcher
- 3 ITN graduate students

Interview questions differed slightly, and were based on the researcher's level of experience (i.e., I asked senior scientists about mentoring their students in publishing, whereas I questioned graduate students about the ways that they are actively learning about the publishing process). Interviews were structured around the following questions:

- How have you navigated the publishing process throughout your scientific career? How do you/your colleagues decide which journal to submit your work to?
- What problems and frustrations have you/your colleagues experienced with regard to publishing research?

- What problems and frustrations have you/your colleagues experienced with regard to the peer review process specifically?
- Are you familiar with "predatory publishers"? Do you see them as problematic?
- How often, and in what ways do you use impact factors in the publishing process? How often, and in what ways do you use impact Factors as you read literature?
- (Senior Investigators) If you were asked to give one piece of advice about publishing to a graduate student beginning a career in neuroscience, what would you say?
- (Graduate Students) How are you learning to navigate the publishing process? Have you discussed the publishing process in courses? Would more guidance or advice about navigating the publishing process be beneficial to you and fellow graduate students?

To gain a better understanding of how predatory journals operate, I investigated one predatory publisher based out of Anoka, Minnesota—Medical Research Archives (MRA) (http://journals.ke-i.org/index.php/mra). I communicated with the MRA editor and one scientist that published work in MRA.

Results

Researchers collectively agree that the current system of publishing in neuroscience is bad for scientists, bad for science, and bad for society. Researchers experience common frustrations and problems in publishing, and agree that the field would benefit significantly from substantial renovations to the publishing system.

As researchers explained their methods for navigating the publishing process, it became evident that four main issues pervade neuroscience publishing:
1.) predatory publishers, 2.) the practice of journal "shopping down", 3.) a reluctance to publish in Open Access journals, and 4.) undermined peer review.

Result summary

1.) Predatory publishers:

- Despite some cases of scientists unknowingly publishing in predatory journals, investigators generally do not see predatory publishers as an immediate danger to their personal research or careers. Rather, they see predatory publishers as problematic for the public and the media—audiences that may not have sufficient understanding of a journal's peer review practices.
- Graduate students are not aware of predatory publishers. These journals are not discussed in career development courses or program seminars.

2.) The practice of journal "shopping Down":

- Scientists at all levels follow a journal "shopping down" movement when publishing: they submit work to a high-impact journal, face rejection—sometimes multiple times—and eventually publish their research in less "prestigious" journals.
- Prominent, established senior investigators will argue directly with the editors of high-impact journals in order to get their work published.

3.) Reluctance to publish in Open Access Journals:

- Scientists support publishing Open Access, and generally agree that all scientific publishing is inevitably moving toward an Open Access system, but they express hesitancy, even an inability, to actually reject the traditional system at this time.
- Scientists consider publishing in Open Access to be a waste of lab resources— to not publish significant work in a high impact journal is to threaten funding, careers, and the future work of the laboratory.

4.) An undermined Peer Review processes

- There is insufficient incentive for scientists to participate in the peer review process.
- Despite being the most critical component of scientific publishing, peer review is undervalued by a disconnect between published papers and the scientists that review them.

Predatory publishers

To more closely examine how predatory journals operate, I investigated one predatory publisher being run out of Anoka, Minnesota—Medical Research Archives (MRA). MRA is part of one family of predatory journals—KNOWLEDGE ENTERPRISE JOURNALS (KEJ). It is essentially a one-man operation being run by a person with no scientific background. The contact information on the KEJ website is merely a mail-forwarding and spamming address, but the listed 612 area code signals the Minnesota-based operation.

In looking through the list of MRA papers, I focused on one article authored by a young scientist at the University of California, San Diego. Her research aims to understand the mechanisms of cancer cell replication in order to develop novel therapeutics. As a post-doctoral researcher for about one year, she was funded by a prestigious training grant from the National Cancer Institute. Her research quickly resulted in a scientific paper. When I contacted this researcher, she opened our

conversation with*, I'm happy to talk to you about my research, but you should know that my supervisor and I are currently trying to retract my recent paper from publication, and we may be taking legal action against the journal editor*. When I explained that my reason for calling was, in fact, the Journal and not her research, she launched into a vehement story of paying to submit her article, and the confusion and frustration that followed.

The author submitted her manuscript to MRA—regrettably without much thought—at the suggestion of her supervisor who received an invitational email from the editor of the new journal. Within a couple of weeks, the author received confirmation from the editor that her manuscript had gone through peer review and would be published in a January issue. Her paper failed to show up in PubMed and other scholarly database searches, and she was unable to access the MRA journal without paying a subscription fee. Inquiries that she sent to the editor went unanswered, apart from a "We are experiencing some publishing delays" email. She explained to me,

> *I'm really proud of the work, and at this point I certainly don't want it published at MRA, but if that does happen, I'm worried that I won't be able to retract the paper so I can submit it somewhere else. In submitting a paper, you have to give your word that the work isn't published anywhere else. And what am I suppose to say? Well, it's published, but in some fake journal?*

Eventually her paper appeared in the No. 2 (2015) edition of MRA. She explained that, mostly because the editor is virtually impossible to get ahold of and she is tired of wasting her time on retraction attempts, she plans to keep her article in MRA. The journal contains papers on anything from female veteran weight management to specific anabolic pathways—this wildly broad scope highlights one of many troublesome aspects of MRA and other predatory journals. Peer review exists to ensure that experts vet the research of other experts within the same field, and these journals fail to uphold this process.

Some argue the implications and negative impact of predatory publishers are huge: *Predatory, pay-to-publish, non-peer-reviewed journals flood disciplines with bad or fake science, making it hard, much as light pollution does, to see the real stars. Worse, publication pollution lessons the impact of legitimate science (Caplan, 2015, 1).*

Furthermore, a real danger comes with the possibility that the general public or the media will garner information, form opinions, and shape policy based on science that is published in these journals—science that has not gone through legitimate peer review. One senior investigator described this fear:

> *Predatory publishers, for me personally, are more of just an annoyance than anything. My concern is less about the fact that they're "predatory", or trying to trick people—because I mean, what is predatory anyway? Is Nature Communications predatory? It costs 5,000 dollars to publish in it. We just want*

> *to separate out journals whose goal is to publish REAL science—quality data, and journals that will publish anything just to make money. My worry—my fear—is that since we have done a terrible job of explaining how science works to non scientists, the public and the media might be not be able to tell the difference.*

One graduate student expressed similar fears, along with a concern that students are particularly vulnerable to utilizing insufficiently vetted or "bad" methods from predatory publications:

> *One big problem with this (predatory publishing) that I could see is that if there really is not a legit review process, then if someone picks up the title—like if for whatever reason a lay person does—and it gets out into the public, then news reports are going to be flooded with flaws, and people will just have no idea. Or also, a grad student could be using bad methods from a paper in journal that they don't know is bad, that hasn't really even been reviewed—especially if they don't have an advisor that's very present to clue them in.*

A study by Shen and Bjork (2015) examined predatory journals more closely; since most of the reporting about predatory publishers has been concerned with individual cases, the aim of the study was rather to estimate the overall size of predatory publishing. They demonstrated how these operations have expanded in the last few years, and measured key characteristics of this market. Despite this

trend, researchers concluded, *The problems caused by predatory journals are rather limited and regional, and the publishing volumes in such journals will cease to grow in the near future* (Shen, 2015).

These studies, and interviews with investigators who spoke about predatory publishers, indicate that predatory publisher "trickery" is not a major concern. Cases do exist in which predatory journal editors successfully target and fool scientists into spending money to publish, but generally authors that publish in predatory journals are not "tricked" into submitting their paper. As such, the danger of increased predatory publishing lies primarily in 1.) studies being published in these journals without first undergoing legitimate peer review, and passing methods to graduate students or junior scientists, and 2.) communicating false conclusions to the public and media—audiences that may not be aware of the deficient journal practices.

In considering the transitional state of scientific publishing—the movement from traditional publishing toward Open Access—it became evident that predatory publishing is a problem, but it is not the core problem. Rather, it is a symptom of a very confused and chaotic state of scientific communication.

The practice of journal "Shopping Down"

In discussing their methods for navigating the publishing process and selecting journals, scientists that I interviewed shared a common experience of journal "shopping down". The process works like this: Investigators first aim as "high" as realistically possible for their paper, meaning they first submit their work to a "luxury" journal such as *Nature*, *Science,* or *Cell*—well-established journals that offer widespread readership and high rejection rates. After facing rejection from these journals, scientists commonly submit their research to a journal with a lower impact factor. Sometimes the work will then go through peer review and be published. In other cases, the scientist will face another rejection, and the paper will find a home in a lower-tier journal.

One senior investigator described the way that scientists frequently aim for the top and subsequently face rejections before publication:

> *We immediately go for the highest impact journal that we have a shot of getting into. There's a joke, but it's also actually true, that if your papers aren't getting rejected a third of the time, you're not shooting high enough.*

One post-doctoral researcher described the journal "shopping down" process in his simultaneously humorous and troubling description of publishing practices:

> *You have to take an honest look at your work—like if it's all cell culture, it's not going to ever get into Science. Then you think about your conclusions, you figure out the caliber of your work, and then you COMPLETELY abandon those things, and submit it to a journal WAY too high the first time. You abandon reality and shoot for the stars. Then it immediately gets kicked out by the editor. You face rejection, and then go back to a more realistic level. And that's it, like honestly...experienced PIs do that, grad students do that. Everyone does that. I know that this sounds foolish and insane, but also, it's just true.*

One senior investigator expressed the practice of journal "shopping down" as he described how navigating the publishing process has changed through his career:

> *In the beginning it was mostly just my advisor deciding where we'd submit a paper. Because often students in the beginning think, Wow my research is great! Let's go for the highest possible level, without really even thinking about whether this is appropriate. But now I know that if you submit to the wrong journal, you're wasting so much time. It's obvious that you'll be rejected. So then you go back to the beginning—go back to another journal, and six months is already gone, and then maybe your work gets published.*

One graduate student shared an experience of a fellow student journal "shopping down" as she entered the world of publishing in neuroscience:

> *I never really know what journal to publish in…where to submit. I'm always asking somebody else. And then they give me a suggestion. Because no one really ever tells you how to publish. I mean you do the science, you write it up, and that's just a final piece that we're never really taught—we're not really taught a strategy about where to aim. Right now I guess I just rely on my PI. But as far as experiences of my peers? I think they usually start big, like at Science, then get rejected, go a little lower, get rejected, and then find a place. One of my peers, she started big—went for Science, got rejected, rejected again, and then resubmitted, and I asked her recently, "where did you submit it to?" And she was like, "I don't even know. I can't even remember the name".*

Another graduate student described how journal "shopping down" is a process that is promoted by UMN graduate program in neuroscience:

> *Mostly we want to publish somewhere with a lot of readership—so you want to publish in the highest impact journal, like Nature or Science. And if you then can't get into one of those journals, you just aim lower after that. With Nature, if it's rejected sometimes they'll "triage it*" (automatically transfer the paper to lower affiliated journals, such as Nature Communications)*. But it's a lot of trial and error, and you always have to know that if you have to resubmit, you run the risk of being "scooped"* (another researcher publishes similar findings before you). *I don't have a lot of pressure from my advisor to get into a big journal, but some pressure from the graduate program. Like they'll ask, "Why*

didn't you submit to Science right away? You're not going to know unless you try?" So I suppose there's pressure more- so from the Institution to aim for one of the high tier journals, because of the impact factor, mostly.

2013 Nobel Prize Winner Randy Schekman has gained further notoriety for his decision to no longer publish work in top tier journals, as he argues that their incentives distort the scientific process and motivate the "sensationalizing" of data (Schekman, 2013). One senior investigator discussed this boycott, expressing frustration at the necessity of "shopping down", despite his general agreement with Schekman's arguments:

There are basically 4 tiers of journals—high profile, medium profile, low profile, and super low profile. So I just first shoot for the best one I can. Once you've won a Nobel Prize I think you can operate like Schekman [submit only to lower tier journals], once you have a big reputation, you can. But publishing in high-profile journals is the only way to do that, to establish that reputation. The problems are even worse now because there are just so many people doing science. In the old days, you never had to worry about publishing in Nature or Science...It's not even about just getting data out there anymore. It's about people advancing their own career. But I mean, they're not to blame. It's the system. It just rewards people for publishing in high-impact journals, as opposed to the quality of their work.

Reluctance to publish in Open Access Journals despite prevalent support for Open Access progress and antipathy to impact factors

Investigators acknowledge the fact that a movement toward total Open Access is a positive one that, and that full Open Access in neuroscience publishing remains highly likely in the long run. At present though, publishing a paper in a "prestigious" journal remains critical to career advancement and academic respect; therefore, scientists are reluctant to publish Open Access. Furthermore, while graduate students and beginning scientists are intellectually supportive of Open Access, if their mentors, advisors, and institutions recommend publication in a subscription-based journal as the key to achieving tenure and gaining further lab funding, authors will follow this advice.

Scientists offer many criticisms of how peer review works, and of the impact factor. They wholly support the development of an alternate system for presenting and sorting work that does not rely upon the established cues of under-incentivized peer review and impact factors. Furthermore, they largely regard the failing efforts to shake the field's withstanding embrace of the impact factor as a basic, human natured resistance to losing what is familiar.

Many researchers, librarians, and publishers project an eventual overcoming of this resistance, and an inevitable Open Access system (Jha, 2012; Lewis, 2012). Publishers are effectively agents for scientists, and they will need to respond in new

and collaborative ways to the widespread increase in immediate Open Access that will undoubtedly occur—one post doctoral researcher described this inevitable movement toward immediate, Open Access publishing:

> *Open Access is, and should be the future. It has to be. It's where the world is going. With the Internet…I think it's just undeniable. The Internet has simplified registration and dissemination, so everything is going to be Open Access eventually, and publishers will need to just adapt.*

One senior investigator described the need for more stringent peer review, or better "policing" in Open Access publishing in order to legitimize the system. He also denounced impact factors in his opposition to submitting work to traditionally prestigious, "high-impact" journals:

> *Open Access is definitely a good idea, but there just has to be some better policing implemented—ways of keeping the journals honest and more stringent about what they publish. But generally yes, Open Access is a great thing because the impact factor is highly over-rated anyway… it should be better to have a string of publications in lower journals than to have one big Nature publication. Because sometimes you just have to—you should—just get your work out there.*

One graduate student viewed the impact factor as mainly problematic due to it's undermining of scientific reproducibility; replicating studies is a highly important practice, yet it is under-valued by an overwhelming emphasis on impact factors:

> *One problem I really see (with using the impact factor) is the issue of reproducibility. If others were incentivized to replicate work, and often times people don't if they're just trying to up their own impact factor, science would be much better off. Doing this is thought of maybe as a waste of time, or not exciting, and it won't land you in a big journal. But publishing should be better at fostering this type of research because it's so important to replicate work. But the big ones don't because of the emphasis that's put on impact factor.*

One senior researcher described the "sensationalizing" of science that is problematically fostered through use of the impact factor:

> *My biggest issue with impact factors is the sensationalizing that it encourages. That to do really good work—carefully controlled work—and to actually interpret your data in a properly conservative way without completely overhyping it, you usually won't get it published in a big journal with a high impact factor. And now all everyone talks about is impact factors…because its one of the main things you're judged by for jobs or tenure. So people are pressured, or motivated, to overhype their work in order to publish in these high impact journals. It's bad. It's crazy.*

Highly successful senior investigators, especially those overseeing large laboratories and numerous students and employees, view publishing in Open Access journals as a waste of money and resources, even though they support the Open Access movement. One such scientist described this predicament:

> *Yes, in an ideal world, everyone should publish Open Access. But the problem right now is that if I submit my potential Nature paper to an Open Access journal, that's a huge cost to me and to my lab. It would be a criminal act to my lab. With the way it works right now… that would be a waste of thousands of dollars of lab resources. So I cannot afford to switch. I cant afford to waste my work in this way, when a Nature paper is worth my post-doc's career—it gets you jobs, grants. You're not going to get the private money that founds a center. It makes the difference in career paths. The future science I can do depends on my ability to publish in one of these fancy journals.*

Under-incentivized peer review

Researchers I interviewed largely supported a thorough overhaul of the scientific publishing industry. Alternative visions of a new system offered two key properties: the uninhibited sharing of research findings, and a new peer review system that widely incorporates the neuroscience community's feedback. The currency of scientific research is the number of papers published and the citation counts of

these papers. Emphasis rests on the creation of new and exciting knowledge—and although this is ultimately the goal of science, significant contributions to the quality and contextualization of that knowledge in the form of peer review goes largely unrecognized. This facilitates a community in which researchers view their role as reviewers as a time-consuming, secondary chore with little incentive.

One senior scientist, after expressing frustration that researchers are publishing too often, criticized the lacking quantity and quality of peer review:

> *People don't review nearly enough. I mean people should review at least as many papers as they submit. But people review way less than they submit. And the quality of reviewing—that's another big problem. The reviews are just ridiculous sometimes, and things get published without any criticism. At Frontiers they put the reviewers names on the paper, which is kind of neat. I mean the best model I've seen is just a complete overhaul of the system—to make an online community where scientists have ratings as scientists, and a paper has a rating as a paper, and reviewers also have ratings, as reviewers.*

Another senior scientist mentioned that peer review frequently becomes a "backburner":

> *The problem as I see it is that there's just so much more workload now—so many more publications now. And then if you're a reviewer, how much time can you spend reviewing a paper—on that process? And I suppose it's just*

> *required because we're in academia—that you review other people's work. But it's really a backburner because you don't get credit for doing it.*

Another senior scientist suggested that increasing feedback between authors and reviewers would improve the peer review process:

> *With reviewing, you spend so much time doing it, and your name never appears anywhere. I think we need more feedback between reviewers and authors, and after a submission, you shouldn't just get a critique but you should get more suggestions to improve….people will spend very little time reviewing the paper because they just can't read all the details and there's not enough motivation to review papers.*

Interviews indicated a collective agreement that the current system of publishing in neuroscience suffers from several problems, and is bad for scientists, bad for science, and bad for society.

Discussion

After outlining his own methods for navigating the publishing process, one senior scientist made a statement that brought cause and clarity to many of the publishing problems that researchers discussed in our interviews: He said, "The problem is a Problem of the Commons."

In 1968 the ecologist Garrett Hardin published a *Science* article entitled "The Tragedy of the Commons" (Hardin, 1968). In this paper, Hardin writes, *We may well call it "the tragedy of the commons," using the word "tragedy" as the philosopher Whitehead used it: "the essence of dramatic tragedy is not unhappiness. It resides in the solemnity of the remorseless working of things"* (Hardin, 1244). At a basic level, the Tragedy of the Commons describes a scenario in which commonly held land is inevitably degraded because everyone in a community behaves according to personal best interests in allowing their livestock to graze. As a rational being, each herdsman will seek to maximize his own gain.

In this context, "Commons" applies to any shared natural resource, such as land for animal grazing, fishing waters, timber-rich forests, and also more intangible resources, like knowledge. The problem with these limited shared resources, as discussed by Hardin, is that they are misused or exploited when people behave opportunistically and maximize their individual benefits while neglecting the collective best interest.

When further extended, “Commons” can mean much more than water, or trees or grazing land—

> *It is the vast realm that is the shared heritage of all of us that we typically use without toll or price…the stores of human knowledge and wisdom, the informal support systems of community— these are all aspects of the commons. Some are gifts of nature, others are the collective products of creativity and endeavor. Some are new, such as the Internet. Others are as ancient as folklore and calligraphy. But they all ‘belong’ to all of us, if that is the word* (Rowe, 2001, 3).

Without a framework for protection, Commons are subject to constant invasion and abuse.

> *Each day brings news of yet another assault — upon our quiet, our civic spaces, the cohesion of our communities, our collective store of knowledge, the air and water that we need for life. Drug companies take ownership of university research, so that the goal becomes to produce more money instead of to advance the cause of knowledge* (Rowe, 2001, 4).

When applied to the present state of scientific research, the Tragedy of the Commons manifests as the presently highlighted problems—the problems that pervade publishing and hinder the effective sharing of findings and knowledge. Furthermore, a scarcity of research funding further forces intense competition and ultimately drives scientists to behave in self-serving ways. A recent report from the

Massachusetts Institute of Technology ominously paints this picture with the title, "The Future Postponed: Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit" (MIT, 2015). It highlights the massive decline in public funding of basic research, and its implications for America's health and national security. *Basic research is often misunderstood, because it often seems to have no immediate payoff*, the report states. According to another study by *The Journal of the American Medical Association*, U.S. investment in medical research between 2004 and 2012 declined significantly—over this period the amount of money for research decreased by 0.8 percent a year, and the United State's global contribution to biomedical research dollars dropped from 57 to 44 percent (Hamilton, 2015).

As such, young scientists are entering an increasingly tough world of academia—a variation on the Tragedy of the Commons problem in which shared resources—knowledge, data, and funding—are inevitably being misused. Intense competition for funding fosters a system in which careers are driven by impact factors instead of scientific merit, and a barrier for the Open Access movement builds. Sensational work is rewarded, peer review is neglected, and predatory journals find easier success. Furthermore, the booming field of neuroscience is an especially troubled "grazing pasture"—as Harding wrote, *by any reasonable standards, the most rapidly growing populations on earth today are (in general) the most miserable* (Hardin, 1968, 1245).

Until the work of 2009 Nobel Prize Winner Elinor Ostrom (1999), popular theories about the Tragedy of the Commons posited that privatization and markets are the only effective methods to promote societal well-being and to prevent the Commons from being misused (Sinden, 2007). Shaking these theories, Ostrom studied how various communities manage common resources equitably and sustainably over the long term; she created a framework for solving many of our social and environmental problems. Ostrom's research demonstrated that, within communities, non-market rules and institutions can emerge from the bottom, and move upward to ensure a sustainable, shared management of resources—one that benefits everyone and is also economically efficient.

The applied study of knowledge and information as Commons has recently emerged. Whether the focus is on traditional—usually environmental—resources, or information, the essential questions for any analysis of the Commons are inevitably those of equity, efficiency, and sustainability. The important connection between "information" and "Commons", in their various forms, has caught the attention of scholars, Ostrom being one of them. In their book, *Understanding Knowledge as a Commons*, Hess and Ostrom curate the ideas of experts from a range of disciplines on knowledge commons in the digital era—how to conceptualize it, protect it, and build it sustainably. They discuss ways in which we can understand its great possibilities, but also what threatens it (Hess, 2007). The authors describe this as,

A complex ecosystem that is a Commons—a resource shared by a group of people that is subject to social dilemma…the concept of the "Commons" has helped them [scholars]

to conceptualize new dilemmas they were observing with the rise of distributed, digital information (Hess, 4).

Some chapters of the book (Hess, 2007) focus specifically on science communications, but the issues presented have crucial relevance that extends far beyond the "ivory tower" of prestigious journals. In it's discussion of the role of intellectual property in a new knowledge commons, this work also touches on possible funding models for scholarly publications, the application of an Open Access model to scientific knowledge, and the effect of academic "collaborative communities" on scholarly communication. These ideas should certainly be applied as the field of neuroscience seeks to develop a better model for it's own unique collaborative community.

Interviews with scientists confirmed four primary problems within it's own Tragedy of the Commons—predatory publishing; a reluctance, even inability, to publish Open Access; a journal "shopping down" practice; and an undervaluing of peer review/overvaluing of the impact factor. As the field of neuroscience seeks an improved model for publishing, a complete overhaul of the current system indeed seems best. In developing this system, Ostrom's research is very applicable; she offers eight principles for how commons can be governed sustainably. These principles were discovered and developed after conducting many empirical studies on common resource governance. Five of them are especially relevant to the dissemination of science:

1. Provide accessible, low-cost means for dispute resolution.
2. Match rules governing use of common goods to local needs and conditions.
3. Develop a system, carried out by community members, for monitoring members' behavior.
4. Make sure the rule-making rights of community members are respected by outside authorities.
5. Build responsibility for governing the common resource from the lowest level up to the entire interconnected system.

The field of neuroscience undoubtedly requires a system that integrates two key properties: the uninhibited, low-cost sharing of research findings, and a new peer review system that incorporates the scientific community's feedback through incentivized peer review. In order to attain this, science should stop emphasizing impact factors, and embrace a model in which papers, scientists, and reviewers are all openly judged on their individual merit through citation counts. In this way, monitoring a community member's behavior will not require that scientists "sensationalize" work in order to be published in prestigious journals. The unique needs and conditions of neuroscience publishing would be much better met by the journal practices of *Frontiers* (Frontiers, 2007), but in order to fully meet these needs, authors will have to collectively and widely embrace *Frontiers*' (or another similar system) journal practices. In building a better system, scientists—young investigators especially—should be guided with the notion that the *Frontiers* model is a perfectly viable way to publish. This could be an important step away from the existing need to sensationalize work in order to publish in prestigious journals and journal "shop down".

Ostrom emphasizes the fostering of a system in which the rule-making rights of community members are respected by outside forces. The public, media, and funding agencies exist as outside forces influencing the dissemination of science. In order to assist the transitioning field of neuroscience, these forces should deemphasize the seeking and spotlighting of large scientific breakthroughs and cures, and reposition themselves to the highlighting of processes and development. Over emphasizing or "hyping" research breakthroughs contributes to publishing problems, as it undermines the scientific method and ultimately decreases research funding. A single research finding or a sudden discovery rarely cures a disease. Rather, scientists succeed, fail, adapt, replicate, and incrementally advance the treatments that better health and humankind. The gradual but steady improvement in the ability to detect, treat, and prevent cancer and disease indicates that medicine grows by evolution, not revolution. This is how science actually works, and the public, media, and funding agencies should acknowledge this fact in order to support the implementation of a more sensible publishing system.

National Public Radio science correspondent Joe Palca visited the Twin Cities to participate in a round table discussion with scientists from the University of Minnesota and 3M Corporation (MPR, 2015). From three unique perspectives, experts talked about the role of setbacks and mistakes in science. Through stories of research endeavors, production applications, teaching, and science reporting, their discussion highlighted one major point: failure is essential to science. Perhaps equally important, the *possibility* for failure is essential to science. This applies not

only to "failed" experiments, or cases in which data lead to nothing conclusive, or fail to support a hypothesis. It also applies to the publication step, which should give value to all legitimate findings, not just those that may immediately seem sensational. Presently, science publishing does not allow for this kind of failure.

Science sometimes appears to progress in a seamless and logical way, as a smooth flow from hypotheses to discovery. But the realities of the process are far from cut and dry. Scientists will inevitably make mistakes and draw incorrect conclusions. These misinterpretations are understandable, and they are necessary. In *The Secret Anarchy of Science*, Michael Brooks shares research stories that shatter the notion that science is removed from human error and immune to "radicals" that aim for hype instead of truth. Brooks writes,

> *It is time to embrace the reality about science, and discard the fantasy—Before it's too late. We are building a civilization on the foundations of science, placing our faith in its ability to support our hopes and deliver our needs…the work of science is too precious…too urgent* (Brooks, 13).

In facing this "reality about science", the allowance for real failure potential—for "negative" data—in the process is critical, but it is harmfully devalued by the present neuroscience publishing system.

Finally, Ostrom suggests that a community build responsibility for governing a common resource from the lowest level up to the entire interconnected system. The current, widespread practice of journal "shopping down" goes completely against

this sensible approach. A new system should foster an upward movement in which everyone publishes at a basic level, and exceptional research is able to rise to the top through citation counts and extensive reviews. These measures could allow more impactful work to shine, and perhaps even be featured in a "higher-tier" collection of frequently cited research. Again, the *Frontiers* model of publishing, in a basic sense, could initiate this sort up upward movement in its acceptance of all legitimate work.

ITN Interviewees described the disarray that pervades neuroscience publishing, and the need for changes. Several scientists, librarians, and journal editors have posited promising ideas for new systems, but any system will need to be widely agreed upon and adopted in order to be successful and sustainable. Certainly, given the dire state of biosciences funding and a human-natured reluctance to embrace change, the process will be a gradual one full of impassioned conversations. Nonetheless, these conversations should be more integrated within graduate neuroscience programs. Interviews indicated that students are largely learning to navigate the publishing process with little acknowledgement of these critical issues, even though their careers both depend on, and will shape the future of scientific publishing.

As scientists, students, librarians, and publishers consider various changes and new models, other fields offer great potential to contribute expertise. In addition to the work of Ostrom and other economists on Commons management, the field of Scientific and Technical Communications offers a breadth of research that should be

utilized. As specialists in designing and delivering content, writing for a wide range of audiences, and organizing information in a systematic and user-friendly way, scientific and technical communicators offer valuable expertise. The field of Scientific and Technical Communication includes a full spectrum of work associated with the production, communication, and use of information; from the time a scientist gets a research idea, through the evolving process of publishing results and communicating knowledge for various audiences, this discipline should be integrated. Scientific and Technical Communication covers the effective sharing of data among scientists in a laboratory meeting to the more formal aspects of scientific communication such as journals, review articles, and books. Scientific and technical communicators are writing and information specialists, and their field offers a pool of research that can certainly aid in the endeavor to create a better publishing model for neuroscience.

William Garvey, A former research psychologist at Johns Hopkins University, published several articles and books on the role of scientific and technical communicators in the dissemination of scientific knowledge (Garvey, 1975; 1979). He presented several explanations for both the “information crisis” in science, and for the need to effectively integrate scientific communication services and expertise in the research process. Garvey studied the ways in which scientists use information at various career points, through various stages in the research method, and in various scientific disciplines. In *The Dynamic Scientific- Information User* (1975), Garvey concludes,

> *This picture of the scientist's production and use of scientific information is indeed complex….to the extent that we can describe and explain the rational structure underlying this efficiency, hopefully we shall be able to shape information services to match the dynamic information needs of individual scientists* (512).

Although Garvey's research was published several decades ago, it is certainly applicable—perhaps even more relevant—to current problems in neuroscience publishing. His work ultimately called for the integration of Scientific and Technical Communications expertise within the research process; as the field of neuroscience adopts new publishing practices, this proposal should resound. Ultimately, the problems demonstrated through the present ITN interviews will be solved through open conversations and interdisciplinary collaboration to build a better publishing model; this model is needed so that we can set scientists free to work in a way that lends the best chance of making progress.

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