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Being highly productive in the Biomedical Sciences: A qualitative study of motivation and habits of high-throughput researchers

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Abstract

Background:
Quantity, quality, and impact of scientific publications are used to assess national, institutional, and individual levels of research productivity. While the importance of quality research is stressed among the medical research community, minimal research has been conducted on analyzing which factors affect research productivity. Current literature assesses the quality of research institutions rather than that of individual researchers; there is also no research on the difference between high-impact researchers and other researchers. This study, conducted in 2015, sought to investigate the underlying reason for high-throughput authors' success by understanding their similar habits and motivations leading to high productivity.
Methods:
The authors conducted a qualitative study via interviews of high-throughput researchers from around the world. Semi-structured interview scripts guided the interviews in accordance to the grounded theory method for qualitative studies. Broad themes from preliminary interviews were identified and explored in subsequent interviews.
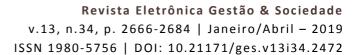Results:
Qualitative analysis of participant interviews identified eight major themes: "Writing habits," "Writing strategy," "Previous training and writing experience," "Major driver," "Balancing volume and impact of publications," "Ideal and non-ideal conditions," "Timelines," and "Role of networking on high-throughput productivity." These themes are not exclusive nor required qualities of high-throughput researchers but highlight similarities and broadly unifying characteristics of these researchers.
Conclusion:
This study identified the common qualities and attitudes of high-throughput researchers. We found common factors in most individuals that can be considered markers of high productivity.

Keywords: Productive research, high-throughput, impact, writing habit, motivation.
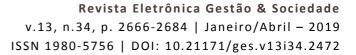
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BACKGROUND

Scientific writing is the primary method of data dissemination in the biomedical community. Publications contribute to knowledge base, development of new ideas, and an indication of researchers' "performance" and "value added." Measurement of the quantity, quality, and impact of scientific publications is increasingly used to assess national, institutional, and individual levels of research productivity. Prolific publication records lead to financial gains that allow for freedom to determine the research agenda and enhance prestige or reputation.

Although no accurate estimates exist, it is possible that a large percentage of scientific information is wasted by either not being appropriately communicated, or not being communicated at all (Agha et al., 2007; Balasubramanian et al., 2006; Wang et al., 2007; Bhandari et al., 2002; Sprague et al., 2003). Numerous factors ranging from time constraints, funding limitations, limited confidence in writing skills, attention divided among numerous studies, co-authorship issues, motivation, institutional policies' selection bias against negative results, and lack of persistence after being rejected by a journal are to blame (Sprague

et al., 2003; Kwong et al., 2007; Hartley and Branthwaite, 1989).

Some biomedical researchers consistently achieve high throughput in scientific writing, publishing at a rate far above average. While cognitive and behavioral characteristics/practices inevitably play a role in explaining how these researchers become so prolific, few studies in the biomedical research literature have evaluated this question. Moreover, previous studies demonstrate that most authors will only have one or two articles published throughout their careers. However, a few authors will be prolific in terms of number of publications, high impact, or both. Previous literature assesses what these prolific writers believe encourages quality publications (Zelko et al., 2010). Despite the importance of both productivity and quality in scientific writing, to date, no study has conducted in-depth investigations on how these high-productivity or high-impact researchers differ from most other researchers.

Bland, using a more comprehensive model (combining individual, institutional, and leadership variables) of faculty research productivity found that individual factors (e.g., motivation) work in combination with

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institutional and leadership factors to facilitate research productivity (Spinthourakis et al., 2009). The current literature is limited in that only one medical institution or one medical specialty faculty was evaluated.

While research has focused on revealing organizational/institutional, resource, or field-specific factors that explain variation in research productivity, it largely ignores the researchers themselves. To date it remains unclear which cognitive or behavioral characteristics, practices, and factors affect research productivity. The aim of this qualitative study was to conduct in-depth interviews with researchers with a consistent track record of high productivity from the start of their careers, investigating the underlying factors that motivate their behavior as well as concomitant habits leading to high productivity.

METHODS

Institutional review board at Faculdade Inga (CEP), Maringa, Brazil, reviewed and approved the study. Eleven participants agreed to participate and provided written informed consent. Consent was obtained by signing an informed consent that provided all information about the research and its participation, benefits, and risks. All of them were males from various locations around the world.
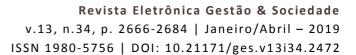
SUBJECTS

For the purpose of this study, we defined high-throughput researchers as individuals publishing more than 20 publications annually for more than 2 years. We shortlisted them by identifying prominent researchers and reviewing their publication profiles using the highly cited tool (http://isihighlycited.com/) available from ISI Web of Science and Google Scholar. First, we approached potential study participants through exploratory emails. After they agreed to participate in the study, we sent them a soft copy of the consent form and answered questions by email. Participants sent signed consent forms via email. Additionally, at the beginning of qualitative interviews with each participant, we explained the study concept and stressed the potential risks of confidentiality and privacy. Finally, we shared the emerging themes (results) with each participant, allowing them to review and comment on issues.

INTERVIEW PROCEDURE AND TRANSCRIPTION

Since the participants were from multiple locations globally, we chose to conduct the qualitative interviews by videoconferences,

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thus ensuring standard interview procedures for all participants. All interviews were pre-scheduled and conducted using a conference call application from Google, the Google Hangouts (https://hangouts.google.com/). Each interview lasted for 30–40 minutes and was digitally recorded. Recorded files were then transcribed using standard qualitative methods (Poland, 1995; Oliver et al., 2005) by two researchers (a medical student and a physician) with a clinical background and qualitative research experience.

In accordance to the grounded theory method for qualitative studies, we utilized semi-structured interview scripts to guide the interviews. This methodology mirrored that used to explore the mechanism that contributes to high impact publications (Zelko et al., 2010).
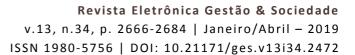
We attempted to understand factors contributing to the high-throughput nature of their work. At the end of each interview, members from our team (physicians and a medical student) discussed the responses and modified the interview script if necessary. We compared the responses from each interview with those from the previous interview, allowing us to identify and validate the preliminary themes. Finally, broad themes were identified and further explored in subsequent interviews. The final

version of the interview script can be accessed in the appendix.

ANALYSIS

INTERVIEWS

The qualitative interview transcripts were independently reviewed and coded by members of the research team (a physician, a psychologist and a nurse) using manual coding. Codes were grouped into categories, which were then reduced to themes through discussion and repeated review of interview scripts by the research team members (medical student, psychologist and physicians) (Glaser and Strauss, 1967). Ambiguities and disagreements were resolved by discussion. Most of the team members collecting the data were clinicians or medical student with previous experience with the design and conduct of qualitative studies and the use of grounded theory. In contrast to hypothesis-driven studies, grounded theory aims at identifying emergent themes from qualitative responses. The codes and overarching concepts used to analyze the interview transcripts helped in identifying the underlying coherent themes.

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Finding validation

We shared the resultant emerging themes with participants for feedback. This respondent validation helped confirm our findings and minimized the influence of personal bias. To validate our findings, themes and respondent feedback were triangulated against notes collected during the interviews and analysis. Further validation was carried out by discussing the findings with all authors. We continued triangulation procedures until we reached a saturation point where no new themes were evident.
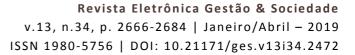
RESULTS

Subjects

We emailed more than 150 biomedical researchers globally who matched our criteria for high-throughput scientific researchers. Most of them did not reply or expressed their inability to participate due to a busy schedule. Eleven participants agreed to participate in our study and provided informed consent. All of them were males located in various locations around the world. We refrained from providing further information about the participants to protect their privacy and confidentiality.

Emerging themes

Qualitative analysis of participant responses resulted in the emergence of three major themes, originated from eight sub-themes: Writing Skills, composed by "Writing habits", "Writing strategy" and "Previous training and writing experiences"; Autonomous motivation, composed by "Major driver" and "Role of networking"; and Regulated motivation, composed by "Volume and impact of publications", "Ideal and unideal conditions" and "Timelines".

Writing skills refer to the ability and strategies used to enhance scientific writing time and technique. This major theme was common across participants and was defined as a core skill for being a high throughput researchers. Autonomous motivation gathered sub-themes related to self-determined behavior of research conduction and scientific writing. Specifically, individual autonomous drives to be a researcher guided their motivation to keep a high volume and impact of publications. Drives such as joy, making a difference, dedication and relatedness (networking). Regulated motivation refereed to external factors providing extrinsic motivation such as dealing with timelines, ideal conditions to volume of publications. These major and

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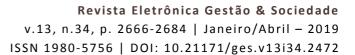sub-themes and their categories are seen in (Figure 1).

WRITING HABITS

Most participants reported a preferred writing time during the day, although the time of the day varied. Most importantly, they found it more productive to write when they had access to uninterrupted time devoid of distractions and disturbances: "I try to do it when I am most productive, ideally in the morning but if that's not possible then I do it at night when it is especially uninterrupted time." Another reported, "I prefer to work early in the morning when there is less distraction and there is less traffic in my office and other things like phones and all that are not bothering me at that time." Others preferred a protected time that guaranteed uninterrupted time to write ensuring higher efficiency. This can be seen from the following responses: "If necessary, I block 2 to 3 hours of my calendar and try and sit and do my writing during that period" and "I cannot write during short time periods, so I can't do a half an hour writing and be efficient in that half an hour. I find, for me, protected time during writing days is the most efficient." The time of day for writing varied as per individual preferences and schedules: "In the last two years, I found my

most productive writing time either the morning or the afternoon in the office" or "I prefer to write more in the evening than I do in the day, so I actually start between 6 pm and depending on how the paper goes, late into the night."

In many cases, participants preferred to separate different types of writing activities (e.g., writing a draft, editing) at separate times during the day. For example, one of them reported: "physically sitting down to compose, that I try to do in the early morning and then late in the evening what I usually do is edit what I have composed in the early morning." One reported that this division was primarily because of greater creativity in the morning: "I usually like to write in mornings, if possible. I feel I am more creative in mornings. So usually I try to start as soon as I get into work and I try to keep interruptions to the minimum then" edit in the afternoon.

Others reported that they did not have a fixed time preference. They wrote as their time permitted, as per the situation, or as per work demands. One participant said, "I sometimes have to do it whenever I find time, if I have a few hours during the day, I might lock myself in my office." Another participant reported, "I do it on demand. Usually during the week, I may have one or
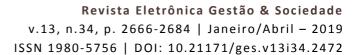
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two afternoons. I could devote time to that, but it is based on student demand; if really needed, I can work during the night. I do not have a fixed time for writing." Similarly, "I think there are certain situations where I write nonstop. For example, if I get into a plane, and there is no internet connection, I write as long as I have battery. If I am in a plane with a power outlet for the computer, I will write as long as I am awake."

WRITING STRATEGY

Participants shared details of strategic processes they routinely follow while writing. Preparing an outline to guide the writing task at hand was one such process for the participants. For example, one participant prepared an outline of major headings, focused on methods and results section first, and used them to guide the remaining sections: "I use an outline, so immediately in the manuscript I outline the major headings. I will go in and write the methods and results first and then I will build the case for the paper around the findings and around the procedures."

Along similar lines, another respondent preferred to spend time planning an outline and proceeded to first write the results which then helped him narrate the remaining sections. He explained, "I spend

on average somewhere between half an hour to an hour thinking about things before I put something down and then I go ahead and I start writing. I almost invariably start with my tables and figures, and the tables and figures in my mind tell me the story and then I fill it in." Another participant reportedly created a superstructure (outline) and allocated further development to a colleague: "What I usually do is create a superstructure and send somebody a paper with a little hole in it and say please fill it in, that may be a junior colleague but it may not, it may be somebody who is more senior." A similar strategy is apparent from another participant: "I sit down with the people in the library and I say 'ok, this is the paper we are trying to write. This is the main take-home message we are trying to get across. We are going to need this figure, this figure, and this table. That is what you are going to work on, you do not do anything else, you just work on that." On the other hand, one participant bypassed the outline strategy as he could visualize the structure and write accordingly: "I actually don't write an outline or anything like that. I can quite easily visualize the outline based on the structure of the data." Another strategy involved the distribution of tasks within the group and reviewing the final end product:

"I don't actually do a lot of the writing, by and large nowadays; I rely much more on my group for the writing, so basically I come involved at the very beginning and at the very end of the writing process."
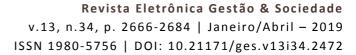
Other strategies included the idea of pursuing a simple message in the manuscript and developing it from the end using backward design. One participant, explaining the former strategy, said, "I try to keep the whole paper following a simple, very concrete message that I can relay to the readers. I avoid, as I used to do very early on, having a paper with 5, 6, 7 key points where people get lost." Alternatively, another reviewer explained his use of backward design, "I start with the end, I actually start with the journal where it should be published. That dictates what it's going to look like, then I start with the title page and then I go forward."

Finally, one participant shared how being in the writing rhythm helped him intersperse work with play: "I just write with the utmost attention. I write two paragraphs then I go play some video games, […], I come back, correct the paragraphs, play a couple of more video games, and go back to the paper and start work on the next paragraph, you know it's the rhythm that you get into."

PREVIOUS TRAINING AND WRITING EXPERIENCES

Respondents cited good training as a key factor in becoming a high-throughput writer. According to some respondents, working under or alongside trainers and mentors in the field was the best training they received. "[…] I work with people who write manuscripts very well… I do the first draft and they basically edit it; having them script and edit it was very useful." A few participants mentioned that handling large numbers of writing assignments helped them learn scientific writing skills. "I think volume [is important.] Just being exposed to a number of studies, and having an immense amount of writing responsibilities, was actually great training too; it probably helped me more than anything."

Some participants picked up scientific writing skills by analyzing available literature and learning from it: "Another factor was going through multiple papers and trying to read them for structure more than content. […] We read several linguistic books and papers, and assessed how to evaluate the structure of a text, and then we developed our own methods of structure evaluation." Most participants thought they had acquired good writing skills by learning from various sources: "Writing with my

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supervisor. Second, writing and correcting and rewriting based on a mentor's corrections, and third, theoretical information gathered from courses or lectures."

Participants reported past writing activities and interests influenced their high-throughput writing skills. Some participants reported being writers in their "school or college days." One participant had actively written as a student and had published in local literary magazines: "I had an interest in writing, as a student I wrote short stories. I had a chance of getting a couple of those published in local literary magazines. I had some teachers who were encouraging there, but I think that helped, in a couple of ways." Another participant, an active writer since childhood, said, "I really like to write. I have been writing since I was a kid, we had a newspaper that I created myself in elementary school and later into middle school." Similarly, one participant reported a previous interest in writing poetry.
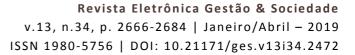
On the contrary, some participants had not participated in writing activities in the past and in fact had less-than-average accomplishments in writing. For example: "When I first started writing, I was a horrible writer; back in college I couldn't write my own papers." Similarly, another participant recollected that he had been a poor writer and struggled immensely while writing compositions.

MAJOR DRIVER

Participants' responses reflected a variety of drivers (motivating factors) responsible for their high-throughput writing. Some reported that the joy in putting together a manuscript and the satisfaction of having contributed to the literature was a major driver: "I guess the manuscript itself; it's nice to be able to put it together, and refine it and have a nice piece of work." Writing, for some, was calming, and the motivation in and of itself: "Writing to me is like a drug to someone addicted, it's calming, it makes me happy." The ability of disseminating information to people was seen as a source of joy and hence served as a major driver, as one participant explained, "I didn't write papers to be famous, I wrote papers because I thought that is the way to disseminate information to people, I think that was for me and is […]the greatest joy."

Another participant cited improved patient care techniques as an outcome of his research as his biggest driver: "The most important thing is when I know that I've made a difference to patient care in some capacity. I think there is nothing like it; it

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gives you more gratification than anything else." Another major driver was the feeling their work repaid the community and their mentors who had helped and supported them; one participant said, "I think I need to give back to the community that has supported me. Part of it is that I want to give back to my mentors; it's an important driver." Similarly, some cited their mentees as a driver: "The feeling that [...] my student is growing, it is important to him, and in some way paying them back for their trust in deciding to work with me."
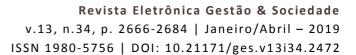
BALANCING VOLUME AND IMPACT OF PUBLICATIONS

Both impact and volume were considered important factors that influenced participant's writing choices and in turn their overall productivity. Many respondents preferred publishing fewer articles with high impact than more articles with little or no impact. For example, impact mattered a great deal to one respondent, as he explains, "If I wrote 25 papers and they were never heard from again it would be discouraging. Impact is probably the biggest thing for me." Another respondent reported that given a choice while writing papers, he would prefer to write one which had the prospect of higher impact: "I think if I have 3 papers to write and if I can write only one

then I will write the one with higher impact."

Although a high-impact publication was preferable, sometimes, due to several reasons, participants chose to pursue low impact projects. One respondent reasoned that writing a paper suitable for high-impact journals was time consuming, which had the potential to adversely affect the progress of his colleagues and students: "I don't try to target all our publications to that level of journal because it's not fair to the people I work with. Many times there are young staff, or clinical fellows, and it takes several years of work to get, let's say, a Nature paper, and they don't have that time to sacrifice to one publication, they need to build a CV." Another participant provided a similar view that exclusively pursuing publications for high impact journals would negatively affect the overall productivity of the group: "I think the really important other thing is if you insist that all your manuscripts be really high-profile, high-risk–type research then a lot of people from your lab will have few publications even if they are talented people."

Some participants mentioned that in the early phases of their careers, the volume of publications is more important than the impact. One participant said, "When I first

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started writing it was volume, it was 100% about volume." Similarly, another stated, "I think initially for me as a junior faculty the number of papers was my driver because I knew that I had to be recognized. If you ask me now what the most important thing is, it's the scientific impact." One participant, pointing out the need for balance between impact and volume, said, "It's a balance and I do try and weigh the two, hopefully there is a place where there is a little bit of overlap […]."
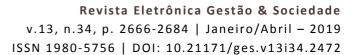
IDEAL AND UNIDEAL CONDITIONS

Some participants require particular settings to foster efficiency. For example, one participant said, "[…] at my writing desk, I have small things like candles and incense, and I set the mood in that way. This helps me adjust to get the job done, so I kind of meditate on it." Similarly, another respondent stated, "It's hard for me to focus, so I need to do it in a ritualized fashion; in my home, with quiet, a soda and my video games, so if I don't lose concentration I can really focus. I would rather sleep and work early the next day, because I know when I'm less tired I'm more creative and I can do better work."

Some participants mentioned that a planned or scheduled day/work time was the ideal setting for efficiency; one respondent said, "My writing day is absolutely protected. I take nothing on that day, the work falls around me, and people won't have access to me. That concentrated effort allows me to be very productive and I find it probably doubles my normal efficiency." To increase his productivity, another participant mentioned , "A systematic process improves my efficiency, I know exactly what needs to be there and I can write the manuscript. I have written a manuscript in a day before, so it's about systematic process and efficiency." Unlike our other responses, one participant simply said, "I think the most important thing for me in terms of writing is simply to have time to write."

Participants also listed conditions which negatively impacted their writing. Mostly these were unplanned adverse events throughout a day. Physical or mental exhaustion decreased the efficiency of their writing, as two respondent said, "I find that when I am really, really tired I'm not very efficient and it's better probably just not to write," and "if I was really fatigued, brought down with other activities I would probably not feel creative." One cited a busy schedule as adversely affecting their writing because they were distracted: "The only other thing that typically affects a writing day is another critical research-related

issue, like a grant, [...]or various deadlines that come up." Similarly, another respondent answered, "When I have a busy or tough day [...] my attention span is shorter, my focus is less than optimum, my attention to detail for data management is decreased, and my language is not as good."

TIMELINES

Timelines are important because if a project is not published within an appropriate length of time, a scientific result may lose its impact: "I teach a 'five day publication' method, because if you can't write it up in five days, it's not newsworthy. The literature is alive and breathing and if you are not contributing to it, you'll kill it. I have it organized how to write a publication in five days; I teach that to my group and I try to practice that with them."
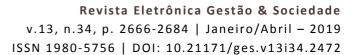
Respondents described several strategies to keep up with timelines. One respondent explained how he planned his work to follow timelines: "If it's something like a grant I create a little Excel table with a timeline. If it's a paper without a definite deadline, it's a little bit less formal, but I do try to have timelines and update them." Another respondent mentioned his work method, which helped him to follow deadlines, "I write papers usually around deadlines. For a

primary draft, it will be somewhere between 3 to 4 days, maximum, for a large clinical trial, or 1 to 2 days for a non RCT that we have the figures and tables done." Some participants cite involving colleagues in their use of timelines: "Multi-center trial papers will have to go back and forth through a multiple number of authors and we give them deadlines, if authors don't respond in 48 hours they miss their chance."

In spite of the importance of timelines, some respondents did not follow timelines or deadlines during manuscript writing. "Interviewer: Do you keep timelines for yourself? Interviewee: No. Not for papers." Another respondent explained, "I don't really work that way, it's nice to really get it done quickly but unfortunately I keep rather busy."

ROLE OF NETWORKING ON HIGH-THROUGHPUT PRODUCTIVITY

Networking in scientific research allows gathering information pertinent to a research project from people or groups working on similar research topics. "By interaction and networking," one respondent said, "I get information that I couldn't get otherwise; information that isn't published yet and colleagues feedback are very important." The same respondent

mentioned that networking encompasses 50% of the positive influence on the quality of his writing.

Another participant mentioned that networking used in the right context not only improved the quality of work but also acted as a driver for working in his case: "There are certain things which you can do better individually but networking, if in the right setting, will substantially improve the depth of the argument, acts like an incentive." The statements about the association with research people or group working (their networking) highlight two sub-themes presented below: "Involvement of coworkers and colleagues" and "Role of mentors."

INVOLVEMENT OF COWORKERS AND COLLEAGUES

A researcher's output is greatly impacted by colleagues and staff; one respondent said, "Ultimately my impact and my productivity are directly related with the productivity of the people I work with; therefore, I want to find like-minded individuals. When we find these like-minded individuals you realize that all of us are putting in probably 50% less and probably getting 200% output."
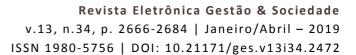
In their research groups, most respondents had specialist staff instrumental for all aspects of research by decreasing the workload and time involved: "Essentials for a productive research team, as far as support individuals go, are: Grant support individuals, […] IRB personnel, and a professional statistician."

ROLE OF MENTORS

When asked if they had help from any mentors to become a high-throughput writer, many respondents acknowledged the scientific writing skills they learned from their mentors: "He helped me more in terms of researching language, how to write scientifically, how to be more concise, be more direct and how to use references and things like that."

A few participants cited that observing their mentors work taught them all they needed to learn about scientific writing: "[…] his writing style was pleasurable to read, it had great flow between sentences and paragraphs, his writing style was very eloquent. So […] my goal was to use some of his sensible writing style. I think I might have been able to do that."

While mentors were considered necessary to learn the basic skills of scientific writing, it was also considered important to seek consistent feedback and guidance on the manuscripts from peers. A respondent

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mentioned the need for both mentors and peers: "Number one key thing is proper mentorship. You need mentorship and then you need an appropriate apprenticeship. The mentor is someone who can guide when you have problems but mentors are not going to write your papers, you need to have an apprenticeship where you are working with skilled individuals who are correcting your papers time and time again."

Multiple mentors can be more helpful, as authors can learn more from different people than one individual: "I have really tried to have a lot of mentors, and take the best from all of them; I also compare various ways, and try and pick up on positive and negative examples."
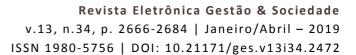
DISCUSSION

In our study, we investigated how the writing habits and scientific writing skills affect scientific productivity. We conducted in-depth interviews with researchers who had achieved high throughput in scientific writing using semi-structured interviews. Based on responses, we analyzed factors contributing to the high-throughput nature of their work. Qualitative analysis of participant responses resulted in the emergence of eight major themes: "Writing habits," "Writing strategy," "Previous training and writing-related experiences," "Major driver," "Balancing volume and impact of publications," "Ideal and unideal conditions," "Timelines," and "Role of networking on high-throughput productivity."

Most respondents preferred regular, scheduled intervals during the day or week to write, allowing uninterrupted working conditions. As expected, the time of day varied as per individual preferences and schedules. Participants discussed a regular time-slot for writing asked about ideal and unideal conditions for writing, as was a busy schedule as a major adverse factor to writing productively. Those without a fixed time preference for writing cited limited time for writing or excessive workload. In such cases participants used any available time for writing as found in prior literature (Hartley and Branthwaite, 1989; Hasse, 2013).

Favorable writing conditions varied with individual preferences. Similar to prior findings, common factors observed included scheduled or planned work time (Kellogg, 1986). Similarly, the literature and our data suggest that mentorship and persistence lead to successful writing (Hasse, 2013). Unfavorable conditions that negatively
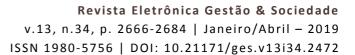
impact writing include busy schedules and heavy workloads, as well as physical and mental exhaustion (Hasse, 2013).

Participant writing strategies were usually similar, especially the use of an outline. A majority of participant researchers utilized this strategy, but each applied the technique in their own way. Earlier studies on writing habits and productivity found that using written outlines, while not frequent, was consistent with high scientific productivity (Kellogg, 1986). Most other strategies varied per individual. It was seen that most participants used various methods in order to keep to timelines and deadlines. This usually involved using scheduled writing times, distribution of work, and working according to outlines. This suggests most high-throughput writers prefer regularity in their work and agrees with previous studies where highly productive writers were seen to work in more regularly rather than in sporadic bursts (Hartley and Branthwaite, 1989).

Most high-throughput researchers attributed their success to good training, including working under or alongside mentors, handling large numbers of scientific writing assignments, and learning from available literature on scientific writing. Previous studies have shown the benefits of experience gained from involvement in many writing assignments (Hasse, 2013; Jerde and Taper, 2004; LibarKin and Ording, 2012). Similarly, some cited that prior writing experiences, even non-scientific writing, enhanced their scientific writing skills, while others had not been efficient or functional writers previously. This suggests that while early writing activities may help increase proficiency in scientific writing, it is not a prerequisite to become a highly productive researcher.

Previous studies established the importance of mentorship on research productivity (Hasse, 2013; Steiner et al., 2002; Stanley et al., 2002). Our results support these findings, as our participants acknowledged that personal training from their mentors or emulation of the mentor's work helped them improve their writing skills. Some proposed that consistent feedback and guidance from the mentors while writing manuscripts were more useful. Other than mentorship, coworkers, colleagues, and specialized staff are instrumental in decreasing individuals' workload and increasing the net productivity of the lab as supported by prior literature (Stanley et al., 2002). Networking for background unpublished information and peer input was said to improve the quality of their work.

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The volume of publications was balanced with the impact of publications differently based on the phase of their career. Most of our participants chose to publish fewer articles with high impact than more articles with little or no impact later in their career, but in the early phases of their careers, they prioritized volume over impact.
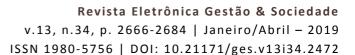
Individual motivations for productivity varied greatly; the enjoyment derived from writing was commonly reported as an important motivator, similar to Mitchell's findings that "the enjoyment of doing it" was the most important motivating factor among writers in the organizational sciences (Mitchell et al., 1985).

Our findings must be received in the context of some of the inherent limitations of our study. First, we conducted a qualitative survey based study with a relatively small population of 9 respondents. While this is a small sample size, the similar emerging themes suggest agreement on the overlying concepts of high-throughput researchers, which was the aim of the paper. Given no new themes were determined from the final interviews, this limited sample size reached saturation. Next, while the themes cited are associated with productivity, none of the suggested themes can be causative characteristics. Similarly, while these characteristics and themes identified of highly productive researchers are common among many of them, they are not 'requirements' of productivity, just common among this group.

CONCLUSION

We identified eight common characteristics of high-throughput researchers and hence likely markers of high productivity. Factors included keeping scheduled writing time, use of systematic writing strategies, balancing volume of publications versus impactful publications, and adherence to timelines. Writing training through mentorship and apprenticeships, networking, and prior writing experiences also contributed to increased productivity. Even though participants' motivations varied, the enjoyment of publication was a common motivator also found in the literature.

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