Writing experiences of neurodiverse students in graduate STEM programs

Connie Mosher Syharat[1,2]*, Alexandra Hain[1], Arash E. Zaghi[1] and Thomas Deans[3]

[1]Department of Civil and Environmental Engineering, University of Connecticut, Storrs, CT, United States, [2]Department of Curriculum and Instruction, University of Connecticut, Storrs, CT, United States, [3]Department of English, University of Connecticut, Storrs, CT, United States

Background: Despite efforts to increase the participation of marginalized students, neurodivergent students remain underrepresented in graduate STEM programs. Prior research shows that these students often experience challenges related to key aspects of writing. The objective of this qualitative study is to deepen understanding of the writing experiences, strengths, and challenges of neurodivergent students pursuing graduate degrees in STEM fields. In this analysis, we consider the factors that influence the writing-specific challenges faced by neurodivergent students in graduate STEM programs. This work also explores how neurodivergent students leverage strengths and strategies for success in graduate-level writing tasks.

Results: This qualitative study draws on Social Cognitive Theory (SCT) to consider the ways cognitive, behavioral, and environmental factors impact writing experiences. We used thematic analysis of the transcripts from 13 focus groups and 1 interview to examine the writing experiences of 31 students who identify as neurodivergent in graduate STEM programs. The findings suggest that many writing challenges faced by neurodivergent graduate students are behaviors and beliefs that emerge in response to environmental factors such as the culture of STEM fields, prior experiences with writing assignments, anxiety driven by intensive feedback cycles, and perceived and experienced stigma. Study participants employed a range of collaborative and situational strategies to support and enhance their writing productivity.

Conclusion: These findings may provide insight for current and future neurodivergent graduate students as they adjust to the intense writing demands of graduate degree programs and for graduate program administrators and faculty advisors as they consider new ways to support the academic success of neurodivergent graduate students.

KEYWORDS

neurodiversity, ADHD, autism, dyslexia, writing, graduate education, STEM

1 Introduction

In recent years, the concept of neurodiversity, or cognitive variations, has emerged as part of the broader conversation about justice, equity, diversity, and inclusion in higher education (Clouder et al., 2020; Dwyer et al., 2022). This increased recognition of neurodiversity in higher education, and specifically in science, technology, engineering

and mathematics (STEM) learning environments, has also heightened awareness of the ways in which rigid educational environments may weed out neurodivergent students whose neurological profile falls outside of the perceived norm (Chrysochoou et al., 2022).

We favor the adoption of an inclusive definition of neurodiversity that encompasses the full range of natural cognitive variations that lead to diverse ways of being, thinking, socializing, communicating, and experiencing. However, neurodiversity (Singer, 1998) is frequently used as an umbrella term that includes a range of neurological variations that fall outside of the perceived norm (Walker, 2014). Dwyer (2022) notes that the concept of neurodiversity is neither clearly defined nor uniformly understood; some simply define neurodiversity as a fact of life akin to "biodiversity" (Silberman, 2015), while others approach neurodiversity through a theoretical lens, as in Chapman's (2021) model that describes a social ecology of mental functions. Within these multiple approaches, there are differing understandings of which neurological variations may be considered neurodivergence under the neurodiversity umbrella. Some scholars argue that only lifelong conditions such as attention deficit hyperactivity disorder (ADHD), autism, dyslexia, dysgraphia, dyscalculia, and other learning differences that are labeled and understood as disabilities may be considered examples of neurodivergence (Haney, 2018). Some adopt a broader perspective on neurodiversity, including conditions acquired through traumatic brain injuries (Walker, 2014), mental health conditions like anxiety disorders (Mellifont, 2019), major depression, schizophrenia (Armstrong, 2010), as well as Tourette's syndrome and obsessive-compulsive disorder (OCD) (Hughes, 2013). The social construction of neurodivergence implies that the concept may be defined differently depending on perspective and context. In this study, several participants in this study understood their diagnoses of anxiety disorders, OCD, depression, and bipolar disorder as neurodiversity and strongly identified as neurodivergent individuals.

A broader definition of neurodiversity may also be more equitable, as the path to a formal diagnosis may present obstacles for women and students from minoritized backgrounds. There is emerging evidence that, the demographics of children receiving an autism diagnosis might be evolving, largely attributable to the enhancements in screening and services for Asian, Black, and Hispanic children (Centers for Disease Control, 2023). However, the literature shows a history of disparities in diagnosis and services between neurodivergent individuals from racial or ethnic minorities and their White peers (Zuckerman et al., 2014; Moody, 2016; Haack et al., 2018; Chen et al., 2019; Shmulsky et al., 2022). Similarly, the literature related to ADHD and autism points to significant delays in diagnoses of women, as well as a high likelihood for women to present with anxiety or depression, while their ADHD or autism goes unrecognized (Quinn and Madhoo, 2014; Kentrou et al., 2019).

Despite efforts to increase the participation of marginalized students in STEM, neurodivergent students, such as autistic students and students with attention deficit hyperactivity disorder (ADHD) or dyslexia have remained significantly underrepresented

and underserved in STEM fields.[1] Some reports place the number of neurodivergent students somewhere between 1 and 3% of graduate STEM programs (Moon et al., 2012; Honken and Ralston, 2013). However, since many neurodivergent students do not disclose their diagnosis within higher education (Cortiella and Horowitz, 2014) this may be an underestimate. Additionally, graduate students tend to rely even less on accessibility services than undergraduates (Teichman, 2010), potentially because they are unsure if accommodations will be meaningful within the context of graduate studies, particularly in research-based programs.

Irrespective of the many challenges faced by neurodivergent students, a growing body of literature suggests that many neurodivergent individuals possess traits that may be assets in STEM fields (Hain et al., 2018; Syharat et al., 2020; Taylor et al., 2020a,b; Taylor and Zaghi, 2021). These strengths encompass traits like divergent thinking, risk-taking, and hyperfocus associated with ADHD (White and Shah, 2011; Hupfeld et al., 2018; Taylor et al., 2020b), and pattern identification and systemizing abilities commonly found in individuals on the autism spectrum (Mottron, 2011; Crespi, 2021). Some studies have associated dyslexia with superior visual–spatial abilities (Attree et al., 2009; Rappolt-Schlichtmann et al., 2018), while others report a wide range of variability in visual–spatial performance among individuals with dyslexia (Chamberlain et al., 2018). Some scholars also state that dyslexia does not offer strengths but go on to assert its value as part of human neurodiversity (Johnson, 2023). Research exploring the experiences of medical students with ADHD (Godfrey-Harris and Shaw, 2023) and dyslexia (Shaw et al., 2016, 2022; Godfrey-Harris and Shaw, 2023) provides further insight into these challenges and strengths. The broader impacts of neurodiversity on research integrity, social justice, and education have also been emphasized in recent scholarship (Elsherif et al., 2022). Even with the potential of neurodivergent students to leverage these assets to contribute to innovation in their fields, they face a multitude of barriers and difficulties while navigating negative attitudes, stigma, and a rigid academic environment (Clouder et al., 2020). These barriers often impede neurodivergent students from pursuing advanced degrees, thus depriving STEM fields of the skills of this talent pool.

This loss becomes even more apparent when we consider the specific challenges these students face in the realm of technical writing. Writing holds significant importance for all graduate students, with their degrees and career progress reliant on successful completion

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1 A note on language: We have seen a clear preference for identity-first language among autistic individuals (Shakes and Cashin, 2019) and have both adopted and advocated for this usage across settings. Community preferences for either identity-first language or person-first language related to ADHD and dyslexia are less clear; however, some recent scholarly work uses identity-first language such as "ADHDers" or "ADHD adults" (e.g., Crook and McDowall, 2023). The choice of person-first language for ADHD and dyslexia in this paper reflects the preferences and usage of the authors, three of whom have ADHD and/or dyslexia. We have used the terms "neurodivergent" and "neurodivergence," as they conform to grammatical standards and current usage; however, we maintain some concern that this usage may reinforce rigid conceptions of normality and abnormality that we aim to challenge in this work.

of dissertations, publications, research proposals, and reports. As they navigate the unfamiliar and demanding academic writing structures, new graduate students often face stress, low self-efficacy, and emotions like anxiety and shame, which may contribute to the poor mental health outcomes that are frequently observed in graduate school (Jonas and Hall, 2022). Research conducted by Holmes et al. (2018) identified perceived inadequacy, fear of failure, isolation, and difficulties with the writing process as themes related to the writing anxiety and challenges faced by graduate students.

While the challenges of graduate-level writing are universally experienced to some degree, they often take on a unique and intensified dimension for neurodivergent students. Much of the existing literature focused on the writing experiences of neurodivergent students such as autistic students and those with ADHD and dyslexia are framed through a deficit lens that focuses on the ways in which individuals' cognitive impairments may impact writing processes. For example, Filipe (2021) explores the link between executive function (EF) deficits and writing challenges for students with diagnoses of ADHD, autism, dyslexia, and dysgraphia. He proposes that interventions should target each student's unique EF impairments, offering strategies to bolster working memory, goal-setting, and self-regulation. Beyond EF, other research highlights multiple challenges associated with dyslexia, including difficulties with anxiety and fatigue, word recognition, phonological processing, focus, and processing of fine details (Everatt et al., 2008; Richardson, 2015; Daniels and Freeman, 2018) that may impede the success of these students in graduate education because of the emphasis on written communication (Clouder et al., 2020).

Literature suggests that many neurodivergent individuals experience serious challenges with mandatory writing tasks. For example, students with ADHD have been noted to struggle with organizing ideas into a cohesive piece of work, matching their speed of writing with their speed of thinking, and initiating writing tasks (Stamp et al., 2014; Gray et al., 2016). Many studies of neurodivergent students' writing that is undertaken from a traditional psychology lens explore the ways in which neurocognitive differences may impact the writing process, and often focus on student deficits, particularly during the childhood years (e.g., Re and Cornoldi, 2010; Rodriguez et al., 2015; Filipe, 2021). In contrast, some literature within the field of Writing Studies pushes back on deficit-based frames and advocates for less standardized approaches to teaching writing (e.g., Dunn, 2001; Luna, 2002; Lewiecki-Wilson et al., 2007, 2008). Either way, while it is important to understand individual cognitive differences, theories focused solely on individual cognitive processes of writing fail to capture the complex nature of the context(s) in which students develop both writing competencies and sense of identity as a writer (Mitchell et al., 2019).

Despite commonly held conceptions of writers working in solitude, it is well understood within the field of Writing Studies that writing is primarily a social and rhetorical activity in which writers draw on social connections, experiences, and contexts as they make meaning for an audience (Roozen, 2016; Gere, 2019). This underscores the importance of this work for understanding how both individual neurocognitive differences and the social context of graduate STEM programs may impact students' experiences of writing. Increased understanding in this area may contribute to the development of focused writing support for neurodivergent graduate students to enhance both their writing productivity and their success in graduate

programs. Thus, our research does not focus solely on the mechanics of writing; rather, a more holistic analysis is needed to better understand the writing experiences of neurodivergent graduate students. To this end, our study draws on Social Cognitive Theory (SCT) (Bandura, 1986), focusing on the ways in which cognitive, behavioral, and environmental factors shape neurodivergent students' experiences with graduate-level scientific writing tasks.

This paper presents the findings from a series of focus groups with graduate students in STEM disciplines at an R1 university in the Northeastern United States who self-identified as neurodivergent. By concentrating on these students' writing experiences, our study fills an important research gap and provides fresh perspectives that could inspire the creation of tools, programs, or methods to bolster their writing productivity within STEM programs. We then proceed to outline our theoretical frameworks, our position relative to the research, provide an overview of the project, its participants, research methods, and limitations. Subsequently, we discuss our findings in the context of existing literature and their implications for research and practice, culminating in a summary of key findings.

2 Theoretical frameworks

We frame neurological variation as an important facet of human diversity that may enhance society's ability to address complex problems within STEM fields. Taylor et al.'s (2022) theory of complementary cognition proposes that cognitive diversity in populations may improve the adaptability of human societies by employing complementary cognitive strategies that balance societal needs such as the need for both safety and risk-taking. This stance is further supported by Chapman's (2021) ecological model of mental functioning, which considers how individuals' neurocognitive variations contribute to human ecosystems to support persistence and adaptation. This approach provides a framework for viewing neurological diversity as a key component of human adaptation and suggests that the inclusion of neurodivergent individuals in STEM fields may enhance our collective potential for innovation that benefits society (Chrysochoou et al., 2022). We also take a strengths-based approach that emphasizes the assets related to neurodiversity, while acknowledging individual challenges and questioning rigid conceptualizations of "normality" (Brown et al., 2021). The purpose of our research is not only to increase understanding of the challenges faced by neurodivergent students in graduate program environments, but also to contribute to new understandings of their unique strengths and the ways in which they may thrive in graduate programs.

Transitioning from this overarching understanding of neurodiversity, we delve into the specific realm of writing. In this analysis, we draw on Bandura's Social Cognitive Theory (SCT) (1986) as we seek to understand the writing experiences of neurodivergent students pursuing advanced degrees in STEM fields. This lens allows us to consider how individuals' neurocognitive variations, behaviors, and beliefs may impact experiences of writing tasks and/or the writing process, while also considering how the interplay of past experiences, social interactions, and environmental variables may mediate experiences of writing within the context of graduate programs. The social cognitive framework highlights the importance of behavioral factors such as student self-efficacy, which may be defined as a belief

in one's ability to master the skills and expectations of one's field (Bandura, 1995). Recent work by Jonas and Hall (2022) indicates that low self-efficacy for academic writing is a common challenge for graduate students that is often correlated with poor mental health, including high levels of anxiety.

3 Researcher perspectives/ positionality

The positionality of the researcher(s) is a key component that shapes many, if not all, aspects of and decisions made throughout the research study, including the conceptualization of the problem, the formulation of the research questions, recruitment methods, interactions with study participants, and interpretation of the data (Kellam and Cirell, 2018; Hampton et al., 2021). In this section, we examine our own subjectivities, not only to enhance the transparency of our research process, but also to shed light on the ways in which our position in relation to the research may have shaped our understanding and interpretation of the data. Our team is made up of two women and two men, including a research staff member who is also a doctoral student in education, a professor of English who serves as the Director of the university's writing center, as well as a professor and an assistant professor of engineering. Our team thus represents both insider and outsider perspectives of STEM fields and varying levels of privilege within a hierarchical university system. Our team represents a range of identities in terms of gender, cultural background, and other social identities that shape our understandings. It is also important to note that our perspectives have been shaped by our experiences as White individuals in the United States.

Our drive to support the success of neurodivergent graduate students is largely motivated by the personal experiences of several authors with ADHD, dyslexia, and anxiety. We also bring extensive experience working with neurodivergent undergraduate and graduate students within the context of engineering and STEM education research projects. We choose to take a holistic, strengths-based approach that affirms student strengths while acknowledging the challenges encountered in the traditional education environment. This approach is integrated throughout the study, such as through our purposeful use of affirming language in recruitment and in our interactions with study participants. Our proximity to the research area carries an inherent risk of bias; however, it also contributes to the insights and intuitions that enhance our understanding of the experiences of neurodivergent graduate students. The focus groups were facilitated by a neurodivergent graduate researcher; we believe that the shared experiences of neurodiversity and graduate school helped to build rapport with study participants and open a safe space for them to freely express their lived experiences.

4 Materials and methods

4.1 Project overview

This IRB-approved study was part of an NSF-funded research project investigating the experiences of neurodivergent graduate students in STEM fields at a large, R1 university. We conducted a thematic analysis of transcripts from four rounds of focus group sessions involving 31 self-identified neurodivergent students pursuing advanced degrees in STEM. The participants were recruited via emails shared through a graduate student listserv and the university's disability services office. The university's list of STEM majors and the list of National Science Foundation Research Areas (NSF, 2022) were used to confirm the classification of degree programs as STEM programs.

4.2 Participants

In this study, 32 neurodivergent graduate students participated in 13 focus groups and one individual interview. Due to unexpected scheduling conflicts experienced by multiple participants, one scheduled focus group had only one participant in attendance. Because the attendee was not able to reschedule, the session was conducted as an interview using the same protocol used in the focus groups. Additionally, one participant from a STEM-adjacent field was removed from the data set in order to maintain a tighter focus on graduate students in fields clearly defined as STEM disciplines, resulting in a final sample of 31 participants. Six students participated in multiple focus groups, responding to separate recruitment emails for different focus group rounds, each exploring varied topics related to neurodivergent experiences in STEM graduate programs. This participation added depth to the data. The majority of participants were White women pursuing doctoral degrees. Of the participants, 19 (61.3%) identified with ADHD, 6 (19.4%) as autistic, and 18 (58.1%) reported a mental health condition. Over half (54.8%) identified with more than one neurodiversity-related diagnosis or condition. Neurodivergent conditions frequently co-occur (Rubinstein, 2009; Germano et al., 2010; Vetri, 2020). Participants viewed their mental health conditions as neurological variations under the neurodiversity umbrella. Some who reported only mental health-related conditions strongly identified as neurodivergent. To reduce the exclusion of women or students from racially or ethnically marginalized backgrounds in STEM who identify as neurodivergent, we did not require a formal diagnosis as a prerequisite for participation. The demographic data of the 31 participants are summarized in Table 1.

4.3 Data collection

We conducted four rounds of focus groups with neurodivergent graduate students in STEM fields to explore their experiences with graduate-level writing tasks, identify challenges, and discern supportive strategies and resources. The focus groups, determined by participant availability, ranged from 2 to 5 participants. The first round explored broader experiences, with writing emerging as a significant theme. Data from the first three rounds informed a semi-structured protocol for the fourth round, focusing on writing experiences, strengths, challenges, and support strategies. This round included three focus groups and one interview due to scheduling conflicts. All focus groups were held virtually, via Microsoft Teams, and the videos were recorded and transcribed using Otter.ai (2022). Pseudonyms were used for participant anonymity.

We opted for focus groups over individual interviews to counter the isolation often felt by neurodivergent students due to stigma. The group format facilitated shared experiences and meaningful discussions, with participants expressing appreciation for the learning

TABLE 1 Summary of demographic information (Total *N* = 31).

Field of study	*N* (%)
Biology	5 (16.1%)
Biomedical/Health sciences	2 (6.4%)
Chemistry	4 (12.9%)
Data Analytics	1 (3.2%)
Earth Sciences	1 (3.2%)
Engineering	7 (22.6%)
Environmental sciences	3 (9.7%)
Mathematics	1 (3.2%)
Physics	1 (3.2%)
Psychology	4 (12.9%)
Social Sciences	2 (6.4%)
Neurodiverse identity or condition reported	
Anxiety (generalized anxiety disorder or social anxiety)	15 (48.4%)
Attention deficit hyperactivity disorder (ADHD)	19 (61.3%)
Auditory processing disorder	1 (3.23%)
Autism	6 (19.4%)
Bipolar disorder	1 (3.2%)
Depression	7 (22.6%)
Dyslexia	1 (3.2%)
Migraine	1 (3.2%)
OCD (obsessive compulsive disorder)	3 (9.7%)
PTSD (post-traumatic stress disorder)	2 (6.5%)
Mental health (self-harm)	1 (3.2%)
Gender identity	
Woman	19 (61.3%)
Non-binary/Gender non-conforming	3 (9.7%)
Man	9 (29.0%)
Race/Ethnicity	
Black or African American	1 (3.2%)
Hispanic or Latinx	2 (6.4%)
Multiracial/biracial	3 (9.7%)
White	25 (80.7%)
Graduate program	
MS (Master's degree)	5 (16.1%)
PhD (Doctoral degree)	26 (83.9%)

16 participants (51.6%) identified with multiple neurodiverse identities or conditions.

TABLE 2 Summary of focus groups.

Round	Area of focus and sample questions	(N) Groups
Round 1	Strengths and challenges, graduate school experiences, strategies, inclusive environments Sample questions: • What has been your experience so far as a student in your graduate STEM program? • What do you think someone needs to do to be successful in your graduate STEM program?	4
Round 2	Advisor-advisee relationship, graduate-level writing experiences, understandings of neurodiversity Sample questions: • How would you describe your experiences with writing in your graduate program? • How would you describe your writing process?	2
Round 3	Current and past educational experiences, current and past writing experiences, accommodations Sample questions: • Overall, how would you describe your experiences in your current program? • Can you tell me about your experiences with writing in your current field of study?	4
Round 4	Current and past writing experiences, writing strengths and challenges, strategies and resources that support writing productivity. Sample questions: • What feelings or emotions do you have when you think about your writing tasks? • What strengths do you think you bring to your writing? • What strategies do you use to address writing challenges?	4*

*Round 4 included 3 focus groups and 1 interview.

and connection opportunities. This approach highlighted shared experiences and reduced feelings of isolation and marginalization common among neurodivergent students in higher education. The focus group rounds, their focus areas, and sample questions are summarized in Table 2.

4.4 Methodology and data analysis

Qualitative methods were selected because they are appropriate for exploring the inner experiences of participants (Corbin and Strauss, 2015). In this thematic analysis, we take a constructionist approach in which participants' realities are seen as both socially constructed and subjective (Braun and Clarke, 2021). From this perspective, knowledge is created through the interactions and experiences of individuals within their social and cultural contexts (Gergen, 2015). Thus, we aimed to understand the ways in which the study participants made sense of their experiences through interaction with the environment of graduate STEM programs. Our thematic analysis followed the phases of activity described by Braun and Clarke (2006): "(1) familiarizing yourself with your data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report" (p. 87). The raw data was examined for patterns to be systematically categorized and developed into themes that we then connected to existing literature and used to suggest new findings.

Incorporating reflexivity into our methodological approach, we used individual memos and weekly research team discussions to reflect on the ways in which our own backgrounds, experiences, and biases might influence the research process. Recognizing our

positionalities, we engaged in self-reflection throughout the research process. This approach allowed us to remain aware of how our perspectives and experiences could shape the data collection, analysis, and interpretation.

Participatory research emphasizes the active involvement of neurodivergent individuals in the research process (Fletcher-Watson et al., 2021). This approach aligns with inclusive research principles, ensuring that the perspectives and experiences of neurodivergent individuals are incorporated and reflected in the study findings (Gourdon-Kanhukamwe et al., 2023). While in the current study, we did not directly involve neurodivergent study participants in the formulation of research questions or interpretation of data, multiple neurodivergent researchers contributed to all phases of the research, including the study design, implementation, and analysis.

Given the limited knowledge about neurodivergent graduate students' writing experiences in STEM, we used inductive coding to let patterns emerge naturally. Two researchers coded independently, then reviewed codes collaboratively. Initial codes like "Blank Page Syndrome," "Procrastination," and "Past Experiences" were examined, redundant ones combined, and the rest organized into four categories: Experiences, Strengths, Challenges, and Strategies and Resources.

Each quote was also coded for the participant's specific neurodivergent group or condition. Finally, the research team used an iterative analysis cycle, reorganizing the data within these four categories to identify overarching themes centered around the cognitive, behavioral, and environmental factors related to neurodivergent students' unique writing experiences in graduate STEM programs. Figure 1 illustrates how Social Cognitive Theory helps understand the cognitive, behavioral, and environmental factors influencing these experiences.

5 Findings

5.1 Cognitive factors – "sometimes my brain just works differently"

Many participants attributed their unique writing experiences to individual cognitive differences. They noted that their distinct ways of thinking, processing, and communicating often differed from academic writing expectations. For instance, Alexis, an autistic participant, discussed the challenge she faced in clearly communicating with a neurotypical audience, saying:

FIGURE 1
Examples from the qualitative data, seen through a Social Cognitive Theory framework.
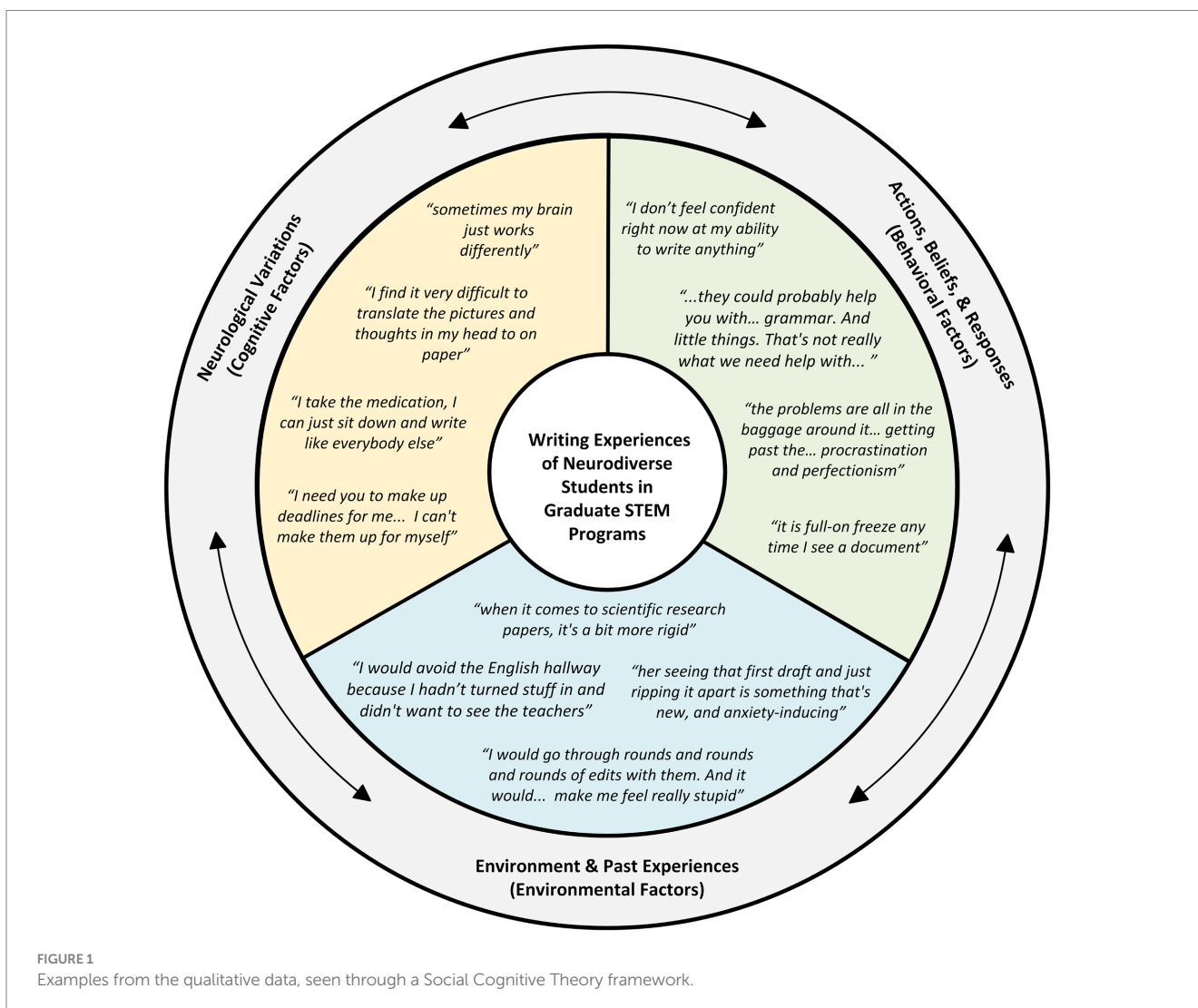
…and sometimes my brain just works differently. And so, I have noticed when neurodivergent people read my papers, […] they immediately get it, but sometimes neurotypical people, they're like, oh, like, I don't see the link. Like, they don't see the link as quickly. And so, I have to add, like a little bit of not like fluff, but like, […] transitionary statements.

Brianna, a student with ADHD and anxiety, echoed this sentiment, stating she had to learn "how to articulate [herself] to neurotypical people in the way that they expect." This suggests that neurodivergent students perceive a need to adjust their natural communication styles when writing for a neurotypical audience. Joseph, a dyslexic student, discussed how his visual thinking style, a strength that allows him to create supporting graphics for his written work, can also pose challenges. He said, "…I like to talk around pictures… I'll make a figure. And I'll write around that figure… sometimes I'll just make a figure per paragraph…" This aligns with previous literature that indicating visual strengths in students with dyslexia (von Karolyi, 2001; Lambert and Harriss, 2022). However, he also suggests that his visual thinking style may intensify challenges related to expressing himself in writing, saying, "I find it very difficult to translate the pictures and thoughts in my head to on paper."

Grace, who has ADHD, explains that for her, oral presentation in combination with visual representations of ideas come more naturally than writing a technical paper, which she does not enjoy. She says, "Ugh. I do not want to. I would much rather verbally talk out what I want… to communicate.… if I have to formally write stuff down, that makes it 10 times harder for me to communicate in… Whereas, paper writing, for me is definitely the – probably the least enjoyable…". The language used by several participants with ADHD suggests a perception of writing as a nearly impossible task. Brianna, who has ADHD, describes this challenge, saying:

> I can barely do it without medication. Unless I'm on like some sort of I'm in like, some sort of magical zone of like, you know, comfort and like, like, really, really interested in what I'm doing. And also, there's an extremely pressing deadline, with immediate and extremely visible and embarrassing consequences. Otherwise, yeah, I don't think my writing really changes, you know, with or without the stimulant medication. It's just getting it out or actually doing it is the problem.

Similarly, Dustin describes his frustration, negative self-judgments, and comparisons with neurotypical peers as he notices the difference between attempting to complete a writing assignment with and without stimulant medication for his ADHD:

> And I think part of what comes with the writing anxiety is almost a sense of self-loathing. … And so, you know, dealing with ADHD for a long time, it's why can't I just sit down and write this 500-page thing, and there's a bit of like a not just guilt, but just kind of like self-directed negative, like… I should be able to write a one-page thing. I'm a scientist. And I found that it was almost worse because I… for a while I was on ADHD medication. And when I would take it, it's like, oh, suddenly that – it's gone, I can just write. But then, you know, I had side effects from the medication. And then once that was gone, it became even more

salient to me that there's just something missing in my ability to sit down and do what would otherwise be a very simple task. Like I take the medication, I can just sit down and write like everybody else. And then once it's gone, it's I – It's like, I'm trying to drive with no feet. Like, why can't I just hit the pedals?

Abby, who reported ADHD and anxiety, experienced negative feelings that made writing feel impossible, despite the fact that she perceived herself as a good writer. She says:

> …for me, it's kind of like a mixture of anxiety, dread and like annoyance, because the thing about writing is, is that I know I can do it well. But the problem is that it takes work for me to do it because writing is one of the things where like, if I don't break it down into like, smaller pieces […] write a whole manuscript is a very large task, even though it's made up of smaller tasks and I have to do the mental work to like, cut it up into those things before I can even actually start doing the writing itself…That is a thing that I've had to learn through… being in therapy for ADHD and having to talk about because before, it was like getting blood out of a rock to get me to get a writing assignment to someone…

Many of the neurodivergent graduate students in this study felt their preferred modes of communication were not valued in academic STEM fields. They perceived traditional academic papers, journal articles, and dissertations as the accepted means of sharing work in their field. However, they often expressed a preference for alternative communication modes that utilized their visual, social, or verbal strengths. They believed these alternative formats could make their work more accessible to a broader audience. One participant, when given a choice, preferred to express her learning through video format, despite acknowledging that a written dissertation would be more accepted in academia. She says,

> Um, well, given that I am pretty sure I want to pursue academia, it would be better if I did a dissertation and I recognize that and like, wrote it, and like published it, and like did that. But I would prefer if I could just not have to do that and do it, go do a presentation. I like visuals and explaining and talking to people and showing movies and things like that.

Wendy, a master's student with ADHD who did not intend to pursue a career in academia, also believed that disseminating findings through a journal would limit who might read her work. In contrast, she perceived that sharing findings in a documentary format might be more accessible to a wider audience.

> Yeah, accessibility, I feel like is the main one, like, the cost to publish in an open access journal is so ridiculously prohibitive. And then who even reads those papers, like, the general public is not reading those kinds of papers. So, the knowledge isn't really being disseminated in the same way that, like [incomprehensible] like a video or something like that would be. So, I've tried to do both, like, my undergrad thesis was, you know, like a paper, but also, we did like a mini documentary that was, I feel like a lot more accessible … So, I feel like doing both if it's an option is definitely cool.

Wendy also expressed that she would consider sharing her research findings in both written and visual formats, if she had the option to do so, despite the fact that this would require an investment of significantly more work on her part. Multiple participants expressed a strong preference for an oral defense of their research in place of a written dissertation, in part because it would reduce writing anxiety and eliminate the dreaded process of producing a lengthy piece of technical writing, but also because the format allows for social interactions that facilitate the clear expression of information in a mode that feels more comfortable or natural for them. Abby emphasized that the interactions with audience members would offer some flexibility for her as a communicator as it provides an opportunity to clarify points for her audience in real time.

> I would much rather do an oral presentation. Because there's more back and forth. I feel like it's not as judged in the moment like, and I think I come across a lot clearer when I can have that back and forth of being like, you know, are you asking this? Or like, What do you mean by that? I would 100% rather do a oral presentation over writing a document, hands down.

Joseph, who has dyslexia, stated that posters and presentations make "room for pictures," allowing for his visual and social strengths to shine while also engaging him in something that he loves. We found that many students attributed their unique experiences with writing to their individual cognitive differences, noting that their natural ways of thinking, perceiving, processing, and communicating were not in line with the expected norms of academic writing, thus creating additional challenges. Additionally, they expressed frustration toward the lack of flexibility and acceptance of their preferred modes of communication in the academic STEM field.

5.2 Behavioral factors — "that's not what we really need help with"

We found that the graduate STEM students tended to not make use of the supports available to them at their campus writing center, as they perceived that the peer tutors, while skilled in grammar and other writing mechanics, did not have enough technical knowledge of graduate STEM fields to provide useful feedback. They also perceived that tutors at the writing center would not be able to help with some of the common challenges that they faced. It should be noted that these perceptions may not be accurate, as many writing centers can and do provide support related to the writing process, goal setting, strategies, and emotional and motivational factors. These perceptions are seen in this dialog between Samantha, who identified with both ASD and ADHD, and Stevie, who reported mental health concerns and identified as neurodivergent:

> Samantha: …I definitely resonated with like, some things other people have been saying. Writing's definitely, like, a struggle for me also. […] sitting and writing, I find is much more difficult to like, taskify for myself… I don't think we have any really departmental, like writing resources, really. I mean… my advisor is helpful, you know, in the ways that he can be, but we don't really have any like……I've never I've never actually been to the writing center. Maybe I should, but I don't know if it's like -

> Stevie: I honestly think that they wouldn't be that helpful because I think it's all staffed by undergrads.

> Samantha: Oh, okay. And they might not know about STEM writing specifically.

> Stevie: Yeah, I mean, like they could probably help you with like grammar. And little things. That's not really what we need help with, I think in most cases. Like, how do I structure this? How do I get started? So.

Gia, a student with ADHD, points out that the nature of scientific writing leads her to seek help from others who have direct knowledge about her field of study and her specific lab work.

> And for me, um, I feel like I don't have a problem with like regular academic writing. I haven't used the Writing Center. But I do agree that when it comes to scientific research papers, it's a bit more rigid and the only people you could sort of get advice from there are like your lab mates or like your advisor that you're working under, because they have the most experience and they have the most like technical knowledge on how to structure it properly and to convey the results in a way that the readers could understand best.

One exception to this pattern was Tara, a student with ADHD who had attended virtual writing retreats for graduate students through the campus writing center. She describes her experience as follows:

> Um, I know the Writing Center… they have like workshops that help you write, which I've done a few of them. And it's like, you get to meet a bunch of other grad students that are also struggling to do the same thing you're struggling with. So, it's kind of that misery loves company mindset. But yeah, that usually there's like a break in between. And I think it also works for me because I don't know them. So, it's a lot easier for me to not talk to them and be distracted.

Many of the students described challenges related less to the mechanics of writing and more to navigating the emotions related to writing. Of the 31 participants, 20 specifically described states of anxiety or panic induced by their graduate-level writing experiences. Exceptions to this pattern were found in a few participants who used words like "excitement," "anticipation," or "intrigued" to describe their feelings about starting a writing assignment. However, despite having some positive feelings about writing, there were still significant challenges related to procrastination on writing tasks. For example, Stevie, who identifies as neurodivergent and reports struggling with mental health and self-harm, says that she enjoys writing and describes getting into a "state of flow" when engaged in a writing task. Even so, she identifies "logistical brain stuff" and "baggage" related to writing as a barrier to getting started:

> … I get to the same sort of cycle of like feeling like I'm worrying about something that I know I don't want to do and then you want

to do a really good job but feel like you can't do a good job, so you just don't do it and then it gets to be big problem… So, for me if I can get past the sort of like, logistical brain stuff of like, can I sit down and start working, if I can get there, then I'm in good shape, like I really enjoy writing. It's like, probably my, like, one of my favorite ways to like, express myself. And I feel like it's a good way for me to like, communicate my ideas. But for me, the problems are in all the baggage around it. So, like, you know, getting past the sense of like, procrastination and perfectionism and making sure that I'm actually sitting down to do the work.

Few others mentioned positive feelings and experiences with writing. Rather, most described their feelings with words like "trepidation," "dread," "overwhelmed," "hate," "frustration," and even informal expressions like "ugh" that convey disgust or revulsion. Dustin's response uses imagery that conveys a painful and terrifying experience, and highlights an alarmingly low sense of self-efficacy related to writing, which he connects directly to his ADHD-related challenges getting started on writing tasks:

Is there a term stronger than horror? I would say the idea of writing in isolation is probably the most daunting and horrifying thing of my graduate experience… Oh, man, it's like pulling my tooth out… I consider it one of the greatest threats to my career is the fact that I don't feel confident right now at my ability to write anything.

Some participants described experiencing physical states similar in nature to trauma responses. These include hyperarousal states referred to as "fight or flight" and hypoarousal states that may include "freezing or numbing" (Tayles, 2021, p. 300). Nancy, who reported an auditory processing disorder and anxiety, says, "I get very anxious. Like the heart racing, the palms sweating. And then I avoid… I'm very avoidant," while Robin, who has ADHD, depression, anxiety, and PTSD says, "…I write things in my head. But the second I sit down at a computer, and I open up the document, I forget what sentences are… Like it is full on freeze every time I see a document."

The data shows that addressing the writing challenges of neurodivergent graduate students in STEM requires a nuanced understanding of their experiences, emotions, and perceptions. Discomfort and anxiety are common reactions to writing tasks, with some students experiencing even more extreme reactions, such as feelings of dread or horror. However, the feelings are not all negative; some students expressed feelings of enjoyment when fully engaged in a writing task.

5.3 Environmental factors – "rounds and rounds and rounds of edits"

Several students connected their present writing anxiety to environmental factors including the high pressure to publish, the rigidity of scientific writing, and negative past experiences with receiving criticism of their writing in their pre-college and undergraduate years. For example, Joseph remembers how his dyslexia-related challenges with writing contributed both to the belief that he was not intelligent and to the desire to avoid these unpleasant feelings through procrastination. He says:

I remember a lot of procrastination… I would make my mom and dad read everything several times. And it would be very frustrating, because I would go through rounds and rounds and rounds of edits with them. And it would… make me feel really stupid. But I would always get A's and B's because of that. So I guess I'm not…

Grace, who reports ADHD, describes previous negative experiences in school as a driver of the avoidance and procrastination that impedes her writing process in graduate school:

I will forever remember one of my high school English teachers telling me that I write essays like I'm writing a math equation. And that, that was like, not good enough, or whatever. […] But in high school, like I would avoid the English hallway, because I hadn't turned in stuff and didn't want to see the teachers. And yeah, it's always been a problem… And so, it's just always been a panic situation of if I don't get this turned in, bad stuff is going to happen.

Several students refer to "red edits," "a bunch of red marks," and comments in "red pen" in their descriptions of stressful and anxiety-producing writing experiences in which their mistakes were highlighted in red, both in their early years and in their graduate programs. As neurodivergent graduate students adjust to a feedback-intensive writing process, they appear to grapple with high levels of anxiety about receiving criticism. Nancy, who has an auditory processing disorder and anxiety, describes the graduate writing experience as follows:

[…] when you're preparing something for publication, or for a conference, you go back and forth with your advisor a lot. And you see their red edits on the Google Doc. And it's just, it's a relationship I haven't gotten used to. And so I have this anxiety about trying to make it perfect, so that my advisor spends less time editing it. But, you can always be better, and she's never gonna spend less time editing it. And it – I don't know, it's a different experience than I've ever had before graduate school with this one-on-one very intense editing writing process. And I think that's just added to my anxiety that how much, how much feedback, how much change, like her seeing that first draft and just ripping it apart is something that's new, and anxiety-inducing.

Graduate students' past negative experiences related to writing combined with the extreme pressure of the "publish or perish" culture may contribute to the perception that the writing process itself poses a distinct threat to the student's success and even their scholarly identity. In Dustin's experience, the criticism of his writing only highlights his perceived deficiencies, leading him to compare himself with his neurotypical peers, who he perceives are "getting it done," while he continues to struggle. He says:

… a lot of it's an ego threat of, you know, especially dealing with an advisor, that's someone where it's more than having their opinion of us be valuable to us. It's – it's structurally important… And writing is a manifestation of our work at that point. And so if there's critique on the writing, it's, you know, is this critiquing me as a scientist, as a professional, as a person? […] And I know

that I can just turn something in and get the feedback and make it better. But sometimes when I get the feedback, I sit on it because I have struggled with writing, and everyone else is getting it done, but I can't get it done. And then like what's wrong with me?

Interestingly, students expressed that in some cases, environmental factors supported them in their writing. For example, it was easier to start a writing task when faculty advisors encouraged them to approach writing as an iterative process and actively challenged perfectionism. Joyce, who reported anxiety and depression, spoke of how others helped her to challenge perfectionistic tendencies that might hold her back from completing a writing task:

Yeah, I definitely struggled with that, actually, prior to coming to grad school. But then I had this one boss, that she was really adamant about being like, Listen, I don't care what it is you bring in, like, get something on the page, and we will work through it together. Like having it be more of a collaborative type thing really helped and really emphasizing, Listen, you're never gonna reach perfect, just be okay with good enough. And just like having somebody you know, especially having somebody who is a supervisor, who's somebody that I have to answer to, so to speak, you know, having them be like, No, I'm not looking for perfection. Like, I'm just looking for something – just good enough, and we will get it closer to perfection together. And just not having that weight of trying to be perfect was really, really helpful.

Abby's awareness of her need for social supports translates into an active request to her advisor to provide compassionate support and affirming feedback for an imperfect work in progress:

The other thing is that because now I've been with my advisor for like, seven years, I have been able to kind of get rid of thinking that she's going to judge me for how good my writing sounds. Although, whenever I am stressed, and I am less able to like work on that on my own, sometimes I just have to have a meeting with her before I hand it in, I need to be like, Look, I need you to tell me that you're not gonna think I'm an idiot, for what I'm about to send to you. […] And so I just have to like, have her be like the affirming person for me whenever I like can't do it enough to be able to just send the thing out. So it kind of, I just kind of make it into like a social thing and use like all the social supports I can to make this happen for me.

A multitude of environmental factors, including pressure to publish, rigid academic writing structures, intense feedback loops, and past negative experiences significantly contributed to the writing challenges encountered by the neurodivergent graduate students in this study. These factors often augment the writing anxiety and avoidance these students experience due to their ingrained self-perception and belief, deeply rooted in past criticism and perceived failure.

5.4 Collaborative strategies – "someone else is relying on my work"

Many of the graduate students in this study described themselves as good writers. For example, Grace, who reports having ADHD,

says, "…I know that I'm not a bad writer… I know how to write pretty well, and I'm decent at it. It's just the – I absolutely loathe it part. That's the – the sticking problem." Despite perceiving themselves as generally good writers, the students reported a variety of challenges that impeded their writing productivity, including procrastination, avoidance, and anxiety about receiving negative feedback. As previously noted, most of the participants did not rely on the writing center for support. Instead, they often relied on informal collaborative strategies to address their challenges. We broadly define "informal collaborative strategies" as strategies that involve other people in the writing process in some way but are not part of formal institutional or departmental structures that are intended to support writing. The graduate students in this study integrated fellow students, faculty advisors, family members, and even unknown individuals in their environment, with varying levels of active participation in the writing process. The involvement of others in the writing process appears to increase motivation and enhance executive function to support neurodivergent graduate students' writing productivity.

Peers were considered one of the most helpful resources for graduate-level writing, especially in the context of providing feedback on early drafts that students might not want to show their faculty advisor. Joseph describes an informal network of peers, who he met through working in a lab or taking common courses, who provide feedback on each other's work much in the way that his parents did in earlier years.

I have or had, you know, a close group of friends and colleagues that – we're all willing to read each other's work and stuff. And we're pretty harsh on each other. But in a good way, so that we can continue to get better and progress. I always ask people that are reading my stuff to not hold back, they see a spelling mistake or grammar mistake, do it. Don't be afraid to make me feel stupid, otherwise, I won't be able to learn. And it's a safe environment at the same time. So, I'm not expecting them to you know […] make try to make me feel better, but you know, try to make me better.

Other informal strategies involving others relied on more passive participation by others in the writing process. For example, José who has OCD and ADHD, tackles the challenge of getting started on a writing task by talking out his thoughts, explaining his ideas to someone else prior to writing. In his words:

I, all the time, was needing to explain to other people to try to write because if I didn't try to explain to other people, I can't write or I can start my process to procrastinate it. That was my, my particular solution for the problem. Try to explain to others. And after that, try to write.

Others maintained momentum by working in the presence of others, whether it was in the graduate student office space, in informal writing groups, or even coffee shops, where other unknown individuals were working. Students took varied approaches to this, depending on their tolerance for external distractions and environmental noise or activity. Abby describes using this technique purposefully, referring to it as "doubling" or "mirroring," a strategy frequently recommended (Quinn, Patricia, 2022) to support task completion for individuals with ADHD:

> One is I know that I usually benefit if someone else is in the room with me who also is even if it's not exactly writing is also like having to work on their computer in like basically silence so I kind of make doubling and mirroring work for me. I just like try and see if I can have someone be like a working presence and I have a couple colleagues where I can like, say that outwardly to them and be like I just need you to know I need to use you and your presence for like a minute. So can we just like kind of work in silence for a bit.

Several students, especially those who reported ADHD, experienced a challenge with making progress on their writing in the absence of a pressing deadline. Many of these students recruited others to support their executive function by creating artificial deadlines, establishing accountability checks, and essentially creating a sense of urgency strong enough to push the writing forward. Riley, who has ADHD and depression, says "meetings often help me, whether it's a meeting that I have to write to prepare for, so that forces you to write, or it's a meeting where the whole point is that I'm writing in the meeting. Just saying there's like some accountability there, too." As Wendy describes this strategy, she refers to her challenges with executive function, specifically with setting goals and managing her time to advance toward her goal of completing a writing assignment:

> I'll echo the time management stuff. I – the most effective thing I've learned in grad school is tell my PI [Principal Investigator], I need you to make up deadlines for me. I know they're not real deadlines, but I can't make them up for myself. So, you need to make them up for me. So now I have like, like, Okay, you need to tell me to give you the paper by Friday, and it works. But yeah, I don't do anything until the very last minute ever. And then I just panic about it. And then it magically gets done. I haven't figured out what the like magic part is yet.

Working on a writing task as a group was noted to be helpful in assisting with motivation because of the pressure to be accountable to others who were depending on them to complete the task. Marnie, who reported ADHD, says, "I definitely struggle with like prioritizing things when it's just for my research alone." Having others depending on her work was helpful for Grace, even when the people depending on her were not her advisor. She describes this when she says:

> I've also found that I tend to do better if somebody else is relying on my work also. […] if there's another person that needs my stuff, it will get done. […] that's sort of a caveat that I've started trying to take advantage of is hold myself accountable to other people. Because they also need my, whatever work I'm doing.

At times, even with a supportive advisor and open communication about executive function challenges related to writing, students may experience difficulties that impede the writing process. In one example, Grace has openly discussed her ADHD with her advisor, who has agreed to provide a schedule of deadlines to break a large writing task down into smaller chunks. Even so, she struggled to make progress, experiencing a familiar pattern of avoiding writing tasks.

> … I had talked to my advisor about how like, if you give me just a big, long, massive deadline, that that's not gonna happen. Like,

I can't, I can't break stuff down into chunks very easily by myself. So, she did that part. We've made specific deadlines through the semester… And then, but I also at the same time, just like don't like writing. And so, like all of spring break, I was here working and she would check in almost every day, like how was the section coming because we were supposed to be working on like the big meat main section. And I kept telling her that I was working on it and all of that and I wasn't. But I didn't want to tell her that I wasn't, because I was embarrassed that I wasn't.

Thus, an approach that focuses primarily on mitigating individual challenges with executive function without examining environmental or social influences (i.e., previous experiences) may not address underlying issues that cause anxiety and result in avoidance of writing tasks. Our findings suggest that neurodivergent graduate students employ various informal collaborative strategies to enhance their writing productivity. From creating artificial deadlines to establishing accountability checks, these students engage their peers, faculty advisors, and family members to bolster their self-regulation and time management skills. Participants also found value in articulating their thoughts verbally to others before embarking on the writing process. This interactive tendency to engage others in the writing process both mitigates individual challenges and increases motivation.

6 Discussion

This study sheds light on the unique writing experiences of neurodivergent students in graduate-level STEM programs. Within higher education, and especially in STEM programs, neurodivergent graduate students face a culture that values perfection and intellectual ability while stigmatizing any sign of weakness (Dolmage, 2017). This, coupled with the high pressure to publish, creates a perfect storm of high anxiety for students who may have experienced challenges in traditional or standardized educational environments. Indeed, the findings from this study suggest that many of the students' struggles with writing were not related to the mechanics of writing. Rather, many of the students described themselves as generally good writers who experienced significant challenges related to the emotional and psychological "baggage" associated with the graduate writing process, which is perceived as high-stakes and thus may be perceived as a threat to the writer's career and even their scholarly identity. For many of the graduate students in this study, their feelings of anxiety were tied to internalized negative self-evaluations and negative past experiences. This suggests that any departmental or institutional programming that aims to address writing productivity should avoid a default focus on instruction in technical aspects of writing or the language of "improving writing skills" and instead foreground the emotional, social, and/or motivational factors that play such an important role in mediating writing experiences. Some literature suggests that a focus on emotional regulation by building strategies to manage emotions more effectively may address academic procrastination, especially in writing (Eckert et al., 2016; Mohammadi Bytamar et al., 2020).

The idea that some of the writing-related challenges of neurodivergent graduate students are related to negative past experiences with writing is supported by recent literature. Wilmot et al.'s (2023) study included a sample of children with dyslexia,

approximately half of whom had additional diagnoses of ADHD, dysgraphia, dyscalculia, autism, auditory processing disorder, and processing or working memory difficulties. The neurodivergent students in the sample experienced shame, stigma, embarrassment, anxiety, and stress; these emotional experiences connected to their performance on reading and writing tasks in school were found to be related to poor self-esteem and anxiety (Wilmot et al., 2023). This suggests that many writing challenges may be tied to emotional responses to past experiences which lead students to experience feelings of self-doubt and low confidence in their writing abilities.

In addition to navigating anxiety and self-doubt related to writing, neurodivergent students may experience writing challenges related to the need to "translate" or standardize their thoughts in order to "write for a neurotypical audience" in a rigidly structured style that varies by scientific discipline. This finding is supported by Tomlinson and Newman (2017) which found that one of the notable writing-related challenges for autistic students may be the need to translate their unique ways of thinking and knowing as they adhere to the norms of communicating with a neurotypical audience. Molinari (2022) argues that "standardization is exclusionary and this can lead to a range of epistemic losses and gains" (p. 3). This raises the question of what scientific contributions may be lost due to the adherence to rigid standards of and almost exclusive reliance on written communication. The students in this study reported that their visual, social, and oral presentation skills are marginalized in favor of the scientific writing required in their fields, with losses in productivity and enjoyment on the parts of the students. Additionally, the students suggested that the overreliance on standardized scientific communication may make the findings less accessible to a wide audience. We argue that broadening the conceptualization of what qualifies as scientific contributions or scholarly products may allow the scientific community to benefit from the unique strengths, approaches, insights, and creative potential of neurodivergent students.

7 Limitations

Inclusion of participants in this study was based on self-reports of neurodiversity and/or diagnoses; no formal measures were used to confirm self-reported diagnoses. While self-reports may yield some inaccuracies, no diagnostic process is entirely foolproof. As previously noted, there are disparities in diagnosis and supports across gender identity and racial and ethnic groups. Thus, relying on an official diagnosis for inclusion in this study might further limit the participation of racially or ethnically marginalized students who also identify as neurodivergent. Another limitation is that the majority of participants were White female doctoral students, which may limit our understanding of how experiences of neurodiversity may vary across social groups. The intersection of gender, race, and neurodiversity is outside the scope of this work, and should be further explored to gain insight into how these factors influence neurodivergent students' feelings of belonging and the impact of overarching power dynamics in graduate education.

Additionally, as this study relies on the self-identification of students as neurodivergent, the interpretation of the data depends on the assumption that the participants have unique experiences related to the ways in which they (a) understand themselves as neurodivergent and (b) interact with and make meaning of their graduate programs. In the absence of clear boundaries between neurotypical and neurodivergent student experiences, there is likely to be some overlap between student experiences. In other words, students who understand themselves as neurotypical may experience some of the same concerns related to graduate writing experiences.

8 Implications

8.1 Implications for practice

Existing support services may not fully meet the specific needs of neurodivergent graduate students in STEM fields. Although faculty advisors and institutional writing supports may be available, the participants were more inclined to seek and receive aid from informal, self-identified networks. This suggests that while individual cognitive abilities are crucial for writing, the social context, and environmental interactions in which writing occurs play a critical role in shaping and supporting the writing process. We noted that strategies such as active challenge of perfectionism, a collaborative approach to the writing process, and supportive, affirming feedback can ease anxiety and contribute to a more inclusive environment for neurodivergent individuals. Focusing on collaborative writing processes and strategies may be key when developing programs and methods to support the academic writing productivity of neurodivergent students in graduate programs. Peer writing groups may improve accountability, motivation, and productivity (Steinert et al., 2008). We suggest that writing groups specifically designed for neurodivergent students may also reduce stigma and isolation, allowing students to discover shared experiences and learn from the strategies and approaches of their peers. Additionally, the misperception that writing centers do not provide these types of social and collaborative writing supports highlights the need for writing centers to more clearly communicate their values and practices to graduate students.

Additionally, students should be encouraged to consciously select writing interventions that fit their cognitive profile rather than rely on standardized strategies. Writing interventions aimed at supporting a wide range of individual cognitive variations should normalize non-traditional writing habits such as writing in different physical environments (van den Berg and van den Berg, 2011; Amoly et al., 2014), using varying technologies such as speech-to-text or different writing tools, employing strategies to manage time and improve accountability, testing the efficacy of visual narratives and diagrams, and modeling mindfulness practices differences (Dunn, 2018; Jackson, 2020; Wenger, 2022). While not a major finding of our study, the final round of focus groups did yield some discussion of artificial intelligence (AI) writing tools such as ChatGPT. Most of the participants who discussed ChatGPT perceived that, despite its potential usefulness in some scenarios, such as overcoming writer's block, evaluating written passages, or structuring a scientific document, the use of such a tool might add to the bias and stigma that neurodivergent students already face within academia. This suggests that neurodivergent students may choose to not use this technology, despite its potential to support writing productivity, in order to avoid negative perceptions.

8.2 Implications for researchers

The findings from this study underscore the untapped potential of neurodivergent thinkers to generate and communicate scientific knowledge in nontraditional ways. Many of the participants mentioned strong preferences for alternative modes of communication while perceiving that written work is highly valued in academia. Current, deficit-based research approaches that focus solely on student weaknesses increase the stigma related to neurodiversity and limit our understanding of the ways in which neurodivergent students may use their strengths to contribute to the scientific community. Further asset-based research is needed to explore the cognitive and communication strengths of neurodivergent students.

9 Conclusion

The purpose of this article was to investigate the nature of the challenges that neurodivergent students face related to their writing tasks in graduate STEM programs and to learn about the strengths and strategies that they use to enhance their writing productivity. We used a Social Cognitive Theory lens to analyze the qualitative data in a way that situates neurodivergent students' writing experiences within the context of graduate STEM programs. This lens highlights the interactions between neurological variations (such as those that impact attention, motivation, goal setting, and communication style), behavioral factors (such as actions, beliefs and responses), and environmental factors (such as past experiences, relationship, and the culture and norms of academia). We found that many of the writing challenges faced by neurodivergent graduate students are related to behaviors and beliefs that emerge in response to environmental factors. These include prior experiences with writing assignments, perceived and experienced stigma around their nontraditional approaches, and other adverse experiences within educational environments. The neurodivergent students in this study leveraged self-awareness related to their strengths and challenges to activate a range of collaborative and situational strategies to support and enhance their writing productivity. This study fills a gap in the literature by focusing on the experiences of an underrepresented and marginalized group in graduate STEM programs. This work has the potential to inspire supports that leverage the unique perspectives and assets of neurodivergent students to enhance writing productivity.

Author's note

The experiences and strategies shared by the graduate students in this study supported me in my writing, reduced my sense that I was struggling alone, and inspired me to leverage collaborative strategies to push this work forward. I thank them for their generosity in sharing their time and experiences.

Data availability statement

The datasets presented in this article are not readily available because the datasets used to produce this article are not publicly available. As they are qualitative in nature, we aim to maintain the anonymity and confidentiality of the participants. The data may be made available from the corresponding author on reasonable request. Requests to access the datasets should be directed to CS, connie.syharat@uconn.edu.

Ethics statement

The studies involving humans were approved by University of Connecticut Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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