Piloting an Outreach Program to Address Barriers to Neurodivergence in STEM

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INTRODUCTION

Neurodivergent individuals face barriers to participation and success in educational and vocational settings[1-3].

Twice-exceptional (2e) students are neurodivergent students who possess extraordinary cognitive, creative, or academic ability, while simultaneously facing challenges in the form of a developmental or psychiatric disability[4].

Although they have the potential for extraordinary achievement, many 2e students are not adequately supported in educational and vocational settings[5-7].

Despite several high-profile first-person testimonials, the experience of neurodivergent individuals in science, technology, engineering, and math (STEM) remains vastly understudied[8-12].

Many barriers influencing science identity, an individual's concept of their own place in science, contribute to the exclusion of systemically non-dominant groups from achievement in science[13,14].

Brief science outreach programs have been shown to improve science identity[15,16].

Here, we report the results of a survey investigating barriers to participation and success in STEM education and careers for neurodivergent individuals.

We also describe the twice-exceptional neuroscience day camp, an immersive science outreach program for 2e secondary students including a hands-on laboratory experience, and its impact on both the science identity of students and staff attitudes towards neurodiversity.

Figure 1. Inaugural twice-exceptional neuroscience day camp. The participants of the inaugural twice-exceptional neuroscience day camp on July 25th, 2022.

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Barriers to Neurodivergent Participation and Success in STEM

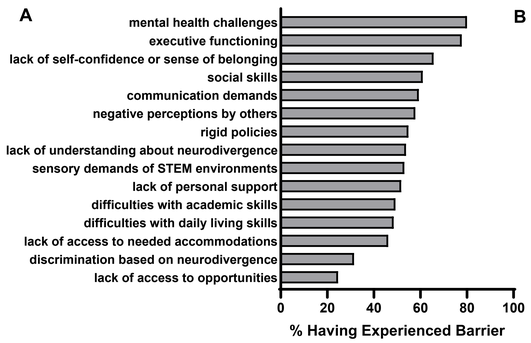


Figure 2. Neurodivergent individuals face barriers in STEM. A) Percent of survey respondents affiliated with the University of Iowa (n=147) that reported experiencing each barrier to participation and/or success in STEM education and/or careers. B) Thematic analysis of qualitive responses to the survey questions corresponding to the six most frequently indicated barriers revealed details about the challenges that neurodivergent individuals face in STEM. C) Demographic data obtained from survey respondents.

B

Describe your experience with mental health challenges (e.g., anxiety, depression, etc.) and how they have posed a barrier for you.

"Getting help from professors when you miss class is hard because you don't want to tell them you have depression and had a pretty bad episode and that is why you were out sick". Neurodivergent Identity: Depression, anxiety, panic disorder
"Sometimes my anxiety can create barriers for me to get tasks accomplished, grow in my career" Neurodivergent Identity: ADHD

Describe your experience with difficulties with executive functioning (e.g., time management, planning, attention, motivation, cognitive flexibility, etc.) and how they have posed a barrier for you.

"Time management and motivation have been the hardest aspects for me." Neurodivergent Identity: ADHD
"I have poor time management and motivation. I am not seen as a good student as a result" Neurodivergent Identity: ADHD, ASD

Describe your experience with a lack of self-confidence or sense of belonging (e.g., perceived difficulty, unsure of competence, imposter syndrome, etc.) and how it has posed a barrier for you.

"Imposter syndrome - constantly feeling like a fraud" Neurodivergent Identity: OCD, anxiety
"Perceived difficulty, think math and science should be hard so I make it that way for myself"

Describe your experience with difficulties with social skills (e.g., navigating social events, "getting along" or "fitting in," etc.) and how they have posed a barrier for you.

"I cannot form strong connections with my colleagues." Neurodivergent Identity: ASD, ADHD
"I would say working in STEM this is less of the case, because there are so many of us. But socially, this is true in general" Neurodivergent Identity: Dyslexia

Describe your experience with communication demands (e.g., modes of communication, expectations around expressing needs and advocating for supports, communication of instructions or expectations, etc.) and how they have posed a barrier for you.

""My field expects excellent social communication skills, and I am deficient in this area despite being competent and knowledgeable in other areas." Neurodivergent Identity: ASD, ADHD
"Communication expectations not clearly listed, everyone having different communication preferences, saying things out loud but not writing them down anywhere and being expected to remember" Neurodivergent Identity: ADHD
"I need written instructions/ reminders of new responsibilities if they arise in meetings spontaneously" Neurodivergent Identity: ASD, ADHD

Describe your experience with negative perceptions by others (e.g., stigma, presumed incompetence, assumed lack of caring/effort/motivation, etc.) and how they have posed a barrier for you.

"I have been assumed to have a lack of caring or motivation that can frustrate me. And sometimes people do call me weird or odd so it does hurt my feelings which makes it hard to feel motivated at the same time. It is kinda a cycle"
"may be forced to leave my PhD program due to perceived incompetence" Neurodivergent Identity: ADHD, ASD

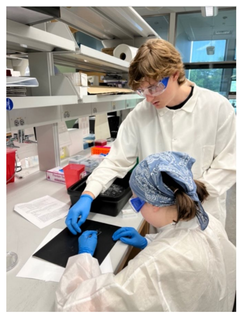
C

Barriers Survey Demographics

Neurodivergence	ASD 46 (31%)	ADHD 104 (71%)	Psychiatric 22 (x%)	Multiple 59 (40%)	Other/Unspecified 15 (10%)	-	-
Academic Standing	Faculty 10 (7%)	Research Scientist/Postdoc 17 (13%)	Graduate Student 30 (22%)	Undergraduate 32 (24%)	Healthcare 22 (16%)	Administration 9 (7%)	Other 15 (11%)
Gender	Man 36 (26%)	Woman 87 (64%)	Non-binary 8 (6%)	Prefer to self describe 4 (3%)	Prefer not to respond 1 (1%)	-	-
Race	African American/Black 2 (1%)	Asian/Pacific Islander 4 (3%)	Hispanic/Latino 8 (6%)	American Indian/ Native American or Alaska Native 2 (1%)	White 129 (96%)	Prefer to self describe 1 (1%)	Prefer not to respond 1 (1%)

Piloting the twice-exceptional neuroscience day camp

A



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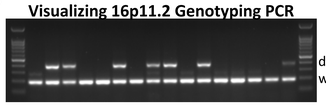

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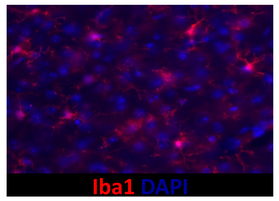

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Student Demographics

Neurodivergence	Yes 4 (50%)	No 3 (38%)	Unsure 1 (13%)	-	ADHD 3 (38%)	ASD 2 (25%)	Multiple 1 (13%)
Gender	Man 3 (38%)	Woman 5 (63%)	Non-binary -	Prefer to self describe -	Prefer not to respond -	-	-
Race	African American/Black -	Asian/Pacific Islander -	Hispanic/Latino 2 (25%)	Native American -	White 6 (75%)	Prefer to self describe -	Prefer not to respond -

Figure 3. Activities of the twice-exceptional neuroscience day camp. A) The camp centers around the completion of a mentored, hands-on science experiment. The second annual camp on June 12th, 2023, included an introduction and lecture, immersive laboratory experiences, and individual meetings with faculty. Laboratory experiments produced real-world data in the form of B) a DNA gel visualized using ultraviolet light to genotype a litter of 16p11.2 deletion mice following polymerase chain reaction (PCR) and C) fluorescent microscopy images of microglia, the resident immune cells of the brain, stained using the marker Iba1 (red) and the nuclear marker DAPI (blue). D) Demographic data obtained from 2e student participants.

Participation influences the science identity of twice-exceptional students

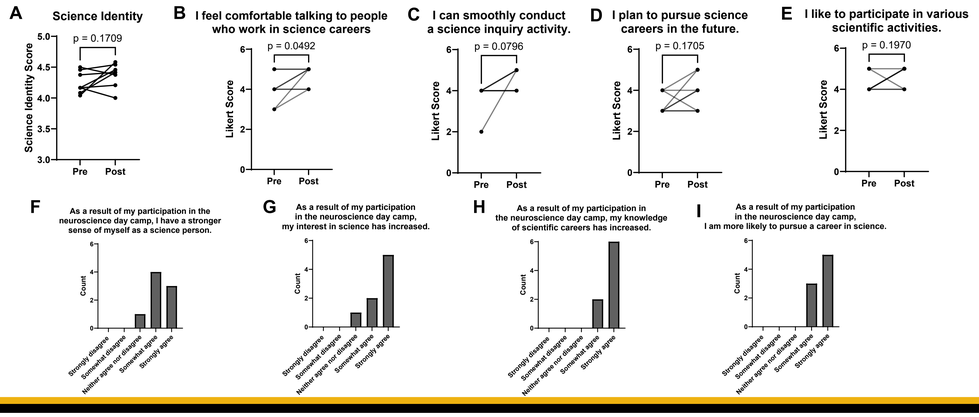
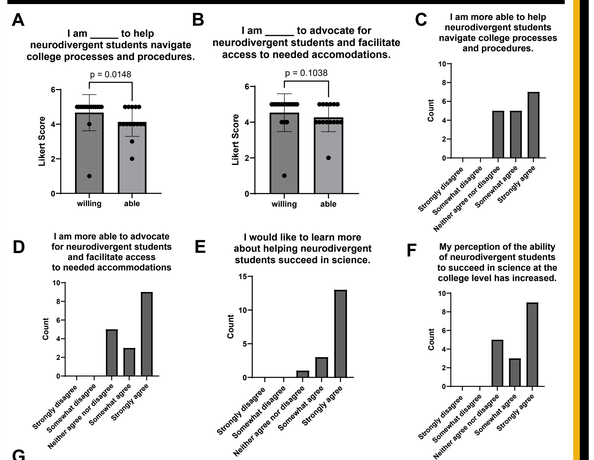


Figure 4. Science identity increases following participation in the twice-exceptional neuroscience day camp. A) 2e camp participants (n=8) completed a 24-item survey of science identity (modified from Chen & Wei, 2020)[17] both before (Pre) and after (Post) participation (paired t-test). B-E) Students Likert Score improved on specific items of the science identity survey (paired t-tests). F-I) Following the camp, students were asked to directly assess the impact of their experience on science identity, science interest, and scientific careers.

Impact on staff neurodiversity attitudes



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Staff Demographics

Neurodivergence	Yes 5 (29%)	No 11 (65%)	Unsure 1 (6%)	-	-	-	-
Academic Standing	Faculty 5 (29%)	Research Scientist/Postdoc 2 (12%)	Graduate Student 4 (24%)	Post-baccalaureate 4 (24%)	Undergraduate 2 (12%)	Other -	-
Gender	Man 4 (24%)	Woman 12 (71%)	Non-binary -	Prefer to self describe -	Prefer not to respond 1 (6%)	-	-
Race	African American/Black 1 (6%)	Asian/Pacific Islander 2 (12%)	Hispanic/Latino 2 (12%)	Native American -	White 9 (53%)	Prefer to self describe -	Prefer not to respond 2 (12%)

Figure 5. Staff attitudes toward neurodiversity. A,B) Prior to camp participation, staff volunteers (n=17) indicated the effect of verb choice (either "willing" or "able") on their agreement with the title statement (data analyzed using paired t-tests) (survey modified from Sniatecki, Perry & Snell, 2015)[18] C-F) Following the camp, staff were asked to directly assess the impact of the camp experience on their agreement with the title statements. G) Demographic data obtained from staff.

CONCLUSIONS

- **Neurodivergent individuals face a complex array of barriers to participation and success in STEM.**
- **Participation in the day camp positively influences science identity of 2e students.**
- **Staff participants report more positive attitudes toward neurodiversity following camp participation.**

FUTURE DIRECTIONS

- Continue collecting data from student and staff participants at future camps.
- Examine neurodivergent strengths in STEM.
- Longitudinal study of 2e participants' science outcomes.
- Expand to other academic and vocational settings.
- Implement and study the impact of specific interventions for neurodivergent individuals in STEM including executive function supports.

REFERENCES

References can be obtained using this QR code. Alternatively, a hard copy of references can be provided upon request.