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Diverging nonlocal fields: Operationalizing critical disability physics identity with neurodivergent physicists outside academia

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(Received 28 April 2023; accepted 25 October 2023; published 29 February 2024)

Science, technology, engineering, and mathematics (STEM) education research and physics education research, in particular, are currently struggling with a dearth of research into understanding the experiences and identity development of neurodivergent students. In addition, an even larger gap in research exists looking into nonacademic members who have left the field and still strongly identify with their disciplinary identity. As valued members of our physics community, these colleagues provide a unique perspective as to how identity and participation are nurtured and developed, particularly among rising disabled physicists. To resolve these current issues and aid in future research, we operationalize our new Critical Disability Physics Identity framework and present results from interviews with three neurodivergent post-baccalaureate nonacademic physicists (those who have left physics and retain a strong affinity toward their identity as a physicist). As the first paper in a four-part phenomenological study into the identity development of neurodivergent physicists, we also present an analysis of each interview through a Critical Disability Physics Identity lens and discuss the implications of their Critical Disability Physics Identity development. We find that neurodivergent students experience very little outright discrimination and violence but experience structural ableism in the form of assessment that is not constructed for how neurodivergent physicists perform physics-related tasks. Additionally, we find that neurodivergent physicists seem to ground identity in having a strong interest in physics, something that is only shaken by professors and others in power being neutral toward the discrimination experienced by neurodivergent people. We find that there are very large power imbalances between professors and neurodivergent students and that only when professors and others in power are actively anti-ableist is this power imbalance remedied and neurodivergent students begin to feel that they are physicists.

DOI: 10.1103/PhysRevPhysEducRes.20.010111

I. INTRODUCTION

The neurodiversity and neuroqueer movements [1–3] have gained a lot of traction in recent years and have garnered the attention of higher education researchers and educators [4]. This attention is for good reason, as neurodivergent [autistic, dyslexic, attention deficit hyperactivity disorder (ADHD), obsessive compulsive disorder (OCD), etc.] students are entering college in greater numbers than previous years and are increasingly being open about their identities [5]. Very little research has gone into understanding these students' identities [6], nor into how their neurodivergent identities intersect with their disciplinary or career identities. What research does exist shows a severe lack of accessibility services for neurodivergent students in higher education [5] and calls for systemwide changes to support structures and diversity, equity, and inclusion initiatives that highlight disability [7]. One way to remedy this lack of research is to introduce a theoretical framework to be used by researchers which describes intersecting disciplinary and disability identity and can examine resources and supports that disabled folks access in and out of academia. This research serves in part to introduce such an intersectional framework, the Critical Disability Physics Identity (CDPI) framework.

Intersectional frameworks for studying physics are not new and are being discussed more and more frequently [8–10]. What ones we have are powerful tools for understanding how people from historically marginalized communities interact and find belonging in our physics community, each with their own merits. Taking an intersectional approach to our research is imperative to understanding power dynamics in physics and critical to informing just and equitable education practices [9]. Johnson's [11] Intersectional Framework, which posits a four-domain physics identity (from Patricia Hill-Collins's Domains of Power [12]) populated with interpersonal, cultural, structural, and

disciplining domains for analyzing the identity development of undergraduate women of color in physics through ethnography, is one such framework. One which informs our work is Hyater-Adams *et al.*'s [13] Critical Physics Identity (CPI) framework, which initially was used to examine the narratives of Black physicists, and has since been used to examine the performing arts as a mediator of the identity of Black women in physics [14], and the identity of Queer folks in mathematics [15], among others. These frameworks, however, do not fully encapsulate and explain the experiences of being disabled in physics. Because of this, we expand on Hyater-Adams *et al.*'s [13] CPI, itself an expansion of Hazari *et al.*'s [16] physics identity framework, and combine the constructs and resources of CPI with the domains of Putnam's [17] Political Disability Identity (PDI). This framework, we believe, gives us a powerful tool for examining the intersection of disability and physics identity. Much as Hyater-Adams *et al.*'s seminal work on their CPI framework, we present in this paper this operationalized CDPI framework, demonstrating methods for which the framework could be used, analysis which marries well with CDPI, and results which can be gleaned from using it with a post-baccalaureate nonacademic physicist demographic.

Learning and doing physics is a social act [18], and it is important that as we do research to improve learning, we are constantly reimagining the social and cultural landscape in physics and reimagining physics itself [19]. We are always reanalyzing how sociopolitical forces affect current and future physicists and their development in the field. By opening discussion and listening to the narratives of neurodivergent physicists who have left academia and identify as physicists, we can construct and strengthen our Critical Disability Physics Identity framework. These discussions, here brought to the forefront, combined with critical disability physics identity, can help us engage critically with the current environment of physics as it relates to disabled physicists and point us in the directions necessary to reshape the classroom, the lab, and the field as a whole.

The next few sections will provide a brief review of contemporary literature examining neurodivergent and neuroqueer identities and the neurodiversity and neuroqueer movements. This will be followed by an in-depth review of the theories which inform our CDPI framework that we operationalize in this paper.

A. Use of language

Throughout this paper, we will be using the terms neurodivergent and neuroqueer interchangeably. This is because being neurodivergent implies diverging from normative neurotypical structures via subverting, questioning, and talking back to the structures at hand; whereas being neuroqueer implies subverting, questioning, and talking back to the structures at hand through diverging from neurotypical norms. They are two sides of the same coin and imply each other.

We believe it is important to define what we mean when we use the word "neutral." We use the word neutral to mean, politically, neither preferring one side over another. We also mean neutral, in the context of neurodiversity being a neutral thing, to mean neither good nor bad. Science is not a politically neutral thing, and the doing or performing of science and scientific identity is not politically neutral either. Science and knowledge creation are not done neutrally, and the privileges and marginalization of those who construct knowledge impact the knowledge itself [20]. Furthermore, we regularly use the word "normal" in this paper. We do not mean normal as in correct or right, and instead, we use the word to mean aligned with societal norms. There is no such thing as a normal way of being, instead, there are only ways of being that are in line with hegemonic ideas of how to "properly" exist.

We also will be conscious of how we refer to our subjects and to members of the neurodivergent community. We will most often use *identity-first* language (such as the phrase "autistic person" as opposed to "person with autism"), so as not to pathologize people's identities. This is in line with how all subjects referred to themselves and their identity and how the authors also refer to themselves with regard to identity. However, there are some instances in which the use of identity-first language is not necessarily proper. These situations arise with identities still colloquially referred to as disorders, such as attention-deficit hyperactivity disorder (ADHD), or obsessive-compulsive disorder (OCD). Again, subjects with ADHD referred to themselves as such, and as of the writing of this paper, there does not exist a widely accepted identity-first way of referring to these identities. We want to be clear, however, that this does not mean that we approach these identities with any form of pathologizing view and instead celebrate these identities as natural human variation.

B. Neurodivegent/neuroqueer identity

Coming from Australian sociologist Judy Singer's 1998 work [21], neurodiversity, in short, is the diversity of minds [22]. Similarly, neuroqueerness is the queerness of minds [23]. There has been much research in the past decade regarding these topics [24–26], and this paper aims to be in conversation with these insightful contributions to the field of neuroqueer studies.

Neuroqueer is a social identity. Developing a strong neuroqueer identity is linked to personal wellness and student success [6]. This identity, like all other identities, is not one-size-fits-all and encompasses a wide variety of folks. Much like disability identity, neurodiversity is incredibly internally diverse, and discussions on what "counts" as neurodivergent are ongoing and contentious [27]. We, however, commit to the broadest possible definition for being neurodivergent [28] that anyone belongs in the neurodivergent community regardless of

diagnosis or sensory-cognitive disability identity. If a person identifies as neurodivergent, they are neurodivergent. This is because we believe the neuroqueer movement becomes stronger, and identifying as neurodivergent becomes a stronger political tool, when we acknowledge the common causes we all have to dismantle neurotypical-normative and otherwise ableist structures. Everyone is welcome underneath the neurodivergent umbrella, as there is always room.

Traditionally, neurodivergent identities include anyone who experiences sensory-cognitive differences, which are otherwise nonharmful and are consistent throughout the life course [22]. However, this excludes folks who identify with bipolar depressive disorder (BPD) as the depressive aspect of BPD constitutes something outwardly harmful and can exclude folks who are dyslexic as they may have issues reading, especially in an academic setting, which can be detrimental. We worry that a strict border on neurodivergent identities promotes the exclusion of those who may benefit from being under the neurodivergent umbrella due to the medicalization of their identity. Furthermore, this strict border excludes folks with multiple sclerosis (MS) or like author McDermott who has traumatic brain injuries (TBIs) (author McDermott is recovering from a concussion), which onset later in life. This is especially worrisome from author McDermott's perspective as his TBI has caused delayed speech and he would otherwise benefit from the social protections that neurodiversity provides.

Therefore, we are defining neurodivergent identity as *any identity that is grounded in differences in minds.* That is to say, *any identity that falls in the union of sensory and cognitive disability identity.* These can include, but are certainly not limited to, autism, ADHD, MS, dyslexia, BPD, TBIs, Tic Disorders, epilepsy, etc.

C. The neurodiversity/neuroqueer movement

The neurodiversity movement is the result of the broader neurodivergent community coming together due to shared political needs and experiences [1,3]. A very important aspect of neurodiversity is that the community is remarkably heterogenous [29]. The neurodiversity community includes folks with low accessibility needs, high accessibility needs, those who are verbal and nonverbal, those who were born disabled, and those who were not. Our community is multifaceted, creating a variety of countersocialities and queered literacies [30] in response to neurotypical-normative structures. As the adage goes: *if you've met one neurodivergent person, you've met only one neurodivergent person*.

Despite the incredible heterogeneity of our community, many of us share experiences. These experiences range from common misunderstandings of our identities to common educational experiences to common day-to-day experiences with ableism. These common experiences have led to the neurodiversity movement as a political movement, with Neuroqueer folks rallying around common goals of dismantling ableist structures.

Like any political movement, the neurodiversity movement is not above critique. For instance, the neurodiversity movement has a very strong autism bias. Much of the movement is centered on specific autistic experiences when the community at large is not only autistic [31,32]. This can lead to factionalization of the community into smaller groups at odds with each other. There is also the aforementioned issue with defining the in-group and out-group under the neurodiversity umbrella [32]. We remedy these issues by centering many diverse voices from the neuroqueer community, this paper specifically includes the voices of folks who are dyslexic, epileptic, and have ADHD, depression, and anxiety. Further, we allow the folks whom we interviewed to self-identify what about them makes them neurodivergent. It is our hope that by answering these critiques, we aid in creating a stronger neuroqueer movement.

D. Neurodiversity/neuroqueer model of disability

There exist many models of disability, each generally coming from either a medical or a social model of disability [33]. However, many neurodivergent folks, authors included, hesitate to categorize their identity exclusively socially or medically, finding themselves somewhere in between. Dwyer *et al.*'s [34] neurodiversity approach to disability offers a solution for modeling neurodiversity. This approach grounds itself in the idea that disabilities are relational, a result of the interaction between a disabled person's innate characteristics and the society that they exist within. This model is centered on the belief that neurological differences are things to be celebrated and embraced, not cured. With this mode of thinking, diversity of minds is something to be celebrated, not cured or forced to conform, and those with sensory-cognitive disabilities should be accepted for who they are.

The approach calls for a shift in methodology, from a deficit-based approach to a strengths- or assets-based one. It states that while neurotypical-normative aspects of society are detrimental to the success of neuroqueer folks, there are various other aspects in which they excel that are often overlooked. In addition to this, the neurodiversity approach calls for researchers to recognize that research is done as a social act, and thus researcher positionality has a pronounced effect on the research, from the gathering of data to the drawn conclusions. The scope of this approach is vast, and different individuals have different opinions on what constitutes as the neurodiversity approach. For clarity, therefore, we will be modeling disability through Dwyer *et al.*'s neurodiversity approach as a relational thing based on inherent characteristics of a person interacting positively, negatively, or neutrally with neurotypical-normative structures.

In conversation with the neurodiversity approach, we expand on it to say that neurodiversity is diversity in full.

Neurodivergent identity is a queer thing [22], and as such, there we assert that focus on typicality or atypicality in terms of neurotypes obscures the full picture. Everyone has their own personal way of thinking, concept mapping, and sense making. We, as physicists, should aim to cater to all equitably. All people have room to be protected under the neurodiversity umbrella [28], and neurotypical folks may find they benefit from the recommendations we put forth in this paper. Our approach asserts all persons, regardless of mental type, as equals through and through, just different. The important thing to note is that these differences make a difference in our neurotypical-normative society. With the neurotypical-normative structures queered in this way, it may even be discovered that many of those who currently identify as neurotypical share many traits, experiences, and common causes with neurodivergent folks.

II. POSITIONALITY

How we analyze and draw conclusions from data is dependent on how the researchers see and experience the world. It is therefore important for the presentation of social-scientific results that researchers are upfront and clear about their identit(ies) and thus how they frame their analysis above even their conceptual framework. This section serves to do just that.

Author McDermott is a neurodivergent and hard-of-hearing physics graduate student and researcher focusing on physics education research (PER). He is also a queer white person. Because of his neurodivergent identity, he was the one to conduct the data collection via interviews, as establishing a rapport could be done quicker and adjusting questions based on nonverbal neurodivergent-specific cues was easier and more likely to be correct if author McDermott was conducting the interviews.

Author Mosley is a nondisabled undergraduate physics student and researcher, who has been working in PER for 4 years. He also identifies as Black, agender, and pansexual. Author Mosley worked with author McDermott on transcribing interviews, analysis of data, and condensing conclusions from the analysis. Author Mosley was an immensely important part of our research and data analysis, as he provided insight into the experiences of Black physicists, highlighting biases and oversights caused by McDermott's white identity.

Author Cochran is a multiply marginalized, differently abled, queer, Black woman. Cochran conceptualized combining Critical Physics Identity with Political Disability Identity, contributed to the design of the study, and provided multiple, critical reviews of McDermott's conceptualization of the four core themes expanding Political Disability Identity.

As we do not identify with every demographic of the folks we interviewed, nor do we share the same life experiences, we engaged in member checking. This took place after conclusions were summarized and the first draft of this paper was complete.

III. CONCEPTUAL FRAMEWORK

Much like intersectionality, physics identity is not a new research topic in physics education. Much has been said on the matter since its conception [16], ranging from gendered patterns in physics identity construction [35,36] and effects of learning assistants on physics identity [37], to the effects of teacher positioning on physics identity development [38] and the relationship between physics identity and career outcome [39]. This concept of physics identity was expanded by Hyater-Adams *et al.* [13] into a CPI, establishing a connection between race and physics identity through a critical lens. Further research has since validated this CPI framework [40,41] and has been developed further into other disciplines [15]. Since its conception, CPI has proven to be a powerful tool for understanding the ways people from historically marginalized communities, especially physicists of color and physicists from marginalized ethnic backgrounds find success in their field. However, when it comes to examining the successes found by disabled physicists, it appears that CPI would benefit from some adjustments. These adjustments, we assert, can be found within Putnam's [17] PDI framework.

Disability is a political thing [42]. Choosing to openly or internally identify with a disability identity can be a powerful choice for an individual, which then leads to establishing and further strengthening their political agency in their community [43]. In our case, this environment or political sphere is found in the physics classroom, the physics department, the academic institution at large, and in the countless spaces in between which connect them. These spaces, too, are political things [44], and thus it is pertinent that a framework be established, which to date does not exist, which reflects this fact. To remedy this gap in theory, we here put forth a Critical Disability Physics Identity (CDPI) framework that marries these CPI and PDI frameworks for use in physics (and potentially other disciplines) settings.

A. Political Disability Identity

Political Disability Identity is a very useful framework for understanding disability identity in a political sphere [42]. In disability studies, it has proven to be a very useful tool for examining the political agency of disabled individuals and communities [42]. While PDI has been traditionally used in research concerning broader disability rights movements, there is promise for its use in education [42,45]. In this vein, PDI has been successful in its use in education to design recommendations for praxis [45]. While author McDermott has already discussed PDI in a physics context [42], we discuss PDI in depth in this section due to its novelty in PER and to highlight the changes we

make within the disability-specific constructs in the finalized CDPI framework.

1. Domains

In her 2005 seminal work, Putnam [17] used contemporary research on disability justice and disability identity to conceptualize six domains that describe the political identity development of disabled people. These domains are self-worth, pride, discrimination, common cause, policy alternatives, and engagement in political action (here shortened to political engagement). Further research by author McDermott [42] further organized these domains into three internal and three external domains. The internal domains are those that involve internalized conceptions about disability and community which are affected by external sociopolitical forces. The external domains are those that involve externalizable and actionable beliefs about disability which are realized due to internal beliefs and conceptions about disability and one's place in a broader disability community. We here develop these internal and external domains based on Putnam's [17] work and center them in an academic context.

Internal domains. The internal domains consist of self-worth, discrimination, and pride.

Self-worth—This is a person's belief that being disabled does not make them lesser than nondisabled people. It is also an understanding that disability is a social construct based on natural human difference and that difference is an inherently neutral thing. Moreover, self-worth can manifest as something akin to a resistance or resistant capital [46], in which a disabled person rejects internalized negative beliefs about disability. Putnam further establishes the following subdomain qualifications for self-worth: "(a) belief that persons experiencing disability are of the same worth as persons not experiencing disability, (b) belief that persons with disabilities can be productive contributors to society, and (c) belief that persons with disabilities are undervalued in society" [17] (p. 191).

Discrimination—This is a person's understanding that people, based on disability status, are "widely and frequently discriminated against by other members of society" [17] (p. 191). As a corollary to this, a disabled person thus has less access to traditional resources as compared to their nondisabled peers. Coming from queer theory [47], and developed in tandem with crip theory [48], discrimination as a domain can also mean a person's understanding that the medical model of disability leads to negative treatment of disabled people, whether in a search for a "cure" for disabilities or through medical and social violence due to misunderstanding of disability or belief in and enactment of social hierarchies and power dynamics which place disabled people lower than nondisabled people. Further, discrimination is the understanding that disability violence is normalized in society and this violence is hegemonic, metaphorically baked into communication, physical environments, etc. Putnam further establishes the following subdomain qualifications for discrimination: "(a) a belief that people with disabilities are negatively stereotyped, (b) a belief that persons with disabilities are typically treated differently (often negatively) in comparison with persons without disabilities, and (c) a belief that discrimination results in inequality of opportunity and access to social and economic resources" [17] (p. 192).

In our academic political space, discrimination can be hidden, or less blatant, than discrimination is often visualized. Traditionally, we imagine disability violence as a lack of access to ramps as an alternative to stairs or as actual physical violence like those once codified by the "Ugly Laws," laws which banned disabled people from appearing in public [33]. However, in academia, discrimination can manifest as a student performing poorly due to a professor's perception of extended time on assignments being akin to cheating.

Pride—In this context, "the demonstration of pride … stems from being able to identify as part of a collective group of individuals who have both struggled within and contributed to the development of their home nation" [17] (p. 191). One can think of the pride domain as equivalent to queer pride. In essence, the pride domain is a person's belief in a larger disability community and their sense of belonging to that community in spite of negative associations of disability held by themselves or others. In fact, like queerness, pride is the radical rejection of moral and medical models, that because a person is disabled, they add to the vibrant tapestry that is a diverse humanity. Moreover, pride also consists of working from inside their disability community to make it better. Putnam further establishes the following subdomain qualifications for pride: "(a) claiming disability by acknowledging oneself as a person with a physical or mental impairment who experiences disability; (b) believing that impairment and disability are not unusual but, rather, are a common human condition; (c) believing that impairment is not inherently negative but can become so in certain cultural, social, and physical environments; and (d) recognizing this characteristic as engendering membership in a cultural minority group" [17] (p. 191).

External domains. The internal domains consist of common cause, policy alternatives, and political engagement.

Common cause—This domain is a person's understanding that disabled people, as a constituency group, share similar political goals. This understanding leads to the enactment of political action to drive change and to organize into an active political group. Common cause can be thought of as a person's existence along the path from understanding similarities between smaller disability communities to their eventual organization into a "shared political agenda" [17] (p. 192). Like the political engagement side of queerness, this domain is centered on coalition

building. This domain involves quantitatively or qualitatively assigning value to certain experiences, i.e., certain experiences faced by disabled people are negative or positive and turning them into a political agenda. Putnam further establishes the following subdomain qualifications for common cause: "(a) the belief that persons with disabilities share similar experiences, (b) the belief that some of these experiences should be modified or changed, (c) the belief that the contributing factors to these modifiable experiences are similar, and (d) the belief that addressing them as a group issue involves the development of a common political agenda" [17] (p. 193).

Policy alternatives—Philosophically, PDI is grounded in the social model of disability, in which disability is recentered away from medicalization and impairment-focused models to describing disability as a result of sociopolitical forces. This recentering implies that the root causes of marginalization can be isolated and addressed. How do we address these causes? Policy. Policy alternatives is a person's understanding of this sociopolitical nature of disability, their understanding that change can come from policy, and their drive to change policy. Putnam further establishes the following subdomain qualifications for policy alternatives: "(a) belief that disability is not characteristic of the individual, (b) belief that contributors to the disability experience can be identified and addressed, and (c) belief that opportunities to reduce or eliminate disability and to condition the disability experience are influenced by public policy" [17] (p. 194).

Political engagement—Critical to PDI is the idea that no person belonging to a historically marginalized group attains liberation without some form of political action. These actions can be in the form of legislating change, participating in protests, writing to representatives, engaging in debate, self-advocating, etc. Thus, political engagement is exactly that—taking action to change policy. Putnam further establishes the following subdomain qualifications for political engagement: "the beliefs that (a) people experiencing disability are a political constituency group, (b) disability constituency groups represent political minority groups, and (c) engagement in political action by, for, and on behalf of these constituency groups can effect policy change" [17] (p. 194).

2. Themes

Author McDermott [42] has also developed PDI further to include four core themes that serve to guide research using PDI. These themes are not necessarily to be used as codes like PDI's domains. Instead, they guide study design and recommendations for praxis which comes from the research. The themes are social model, multidimensionality, variance in outcomes, and fluidity and inevitability. They are as follows:

Social model. As stated, PDI is grounded in the social model of disability. However, the social model of disability is not the only sociopolitical model of disability. There are many to choose from, such as the strong social model, the identity model, the limits model, and the diversity model, just to name a few, each with its own merits for specific research [49]. For instance, this research uses the neurodiversity model [34], as a sibling to the diversity model. What is important is that research which uses PDI conceptualizes disability as sociopolitical in nature and rejects the medicalization of disability.

Multidimensionality. Disability is an incredibly heterogeneous thing. No one person experiences disability in the exact same way as another. While a deaf person may have very little in common with an amputee by way of impairment, they are alike by way of shared political goals and can share a political identity. Research using PDI should thus be cognizant of these differences and shared goals. A broader disability community may be made of many smaller disability communities (i.e., an autistic community, a deaf community, etc.), each with its own cultures and shared experiences. Furthermore, disability identity intersects with many other identities. One can be Black and disabled and thus experience disability very differently from someone who is white and disabled. Research using PDI must also take this intersectionality into account.

Variance in outcomes. Corollary to the multidimensional nature of disability, any recommendations for praxis should take into account that a "one-size-fits-all" approach to policy is not always feasible or helpful. Instead, recommendations for praxis should, where possible, provide multiple avenues for accessibility. Furthermore, it cannot be expected that one specific research design will be accommodating to all research participants or subjects. Researchers need to be cognizant of this and thus provide multiple ways for people to engage with their work at any stage of research.

Fluidity and inevitability. Critical to Putnam's [17] research, disability is incredibly contextual. A person can be disabled due to certain sociopolitical factors in one location or time which may be absent in another. For instance, author McDermott, being hard of hearing, is not disabled in an empty office, yet becomes disabled the moment he steps into a noisy one. Additionally, one can make the (albeit naive) claim that due to the contextual nature of the disability, there exists some hypothetical way for a person to navigate their life never experiencing a context in which they are disabled. This is not the case, however, as due to aging, sickness, accidents, genetic variation, etc., everyone will experience disability at some point in their life. Disability is an identity some people claim their entire lives and others step into and out of regularly. Both experiences are equally valid, and

acknowledging this contributes to a much more vibrant and accepting disability community. Research using PDI thus must be designed with these facts in mind and philosophically grounded in these four themes.

B. Critical Physics Identity

Marrying Hazari *et al.*'s [16] physics identity framework with Nasir's [50] racialized resources, Hyater-Adams *et al.* [13] provide a critical framework for understanding how members of historically marginalized communities develop and construct their identities as physicists. This is an incredibly powerful framework and since its conception, Hyater-Adams *et al.*'s CPI has contributed to many important research topics in PER. The CPI framework combines physics identity constructs with racialized resources and describes the interplay between these two in developing physicists' conceptualization of self. Because CPI is a far more physics-specific framework and has been regularly used in PER, we will spend less time discussing the constructs and resources involved in this framework. This allows us to spend more time going in depth into how CPI and PDI marry to form our CDPI, and what alterations we made in these frameworks to make them compatible, and what alterations we made to them to update them *vis-á-vis* recent research. Figure 1 shows the model, in which Hyater-Adams *et al.* [13] devised, and updated to reflect current research on physics identity.

1. Physics identity constructs

Hyater-Adams *et al.* [13] outline three important physics identity constructs, recognition as a physicist by self and others, interest in physics topics and in learning more about physics, and competence or performance in physics related tasks. However, considering additional research into neurodiversity in physics [51], it is clear that with disabled populations, competence in physics topics does not necessarily equate to performing well with given physics related tasks. Because of this, we initially separated this third construct into competence—one's feeling of mastery over physics topics and belief that they possess adequate knowledge of physics, and performance—one's actual physical success in doing physics related tasks.

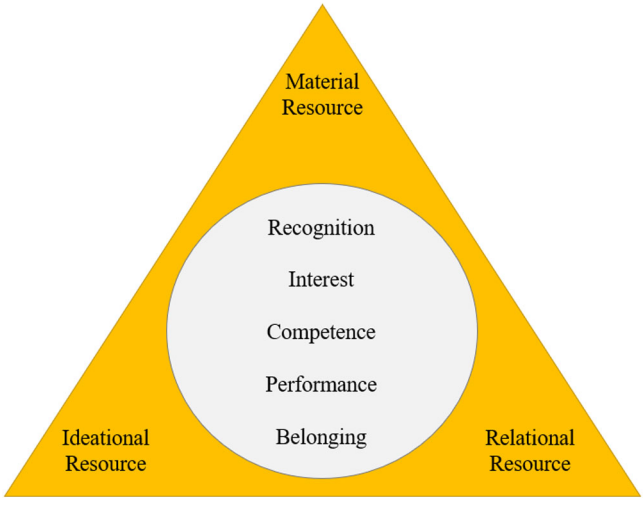

FIG. 1. The CPI model [13], adjusted for our purposes.

Additionally, recent research [52] indicates that there is an additional useful physics identity construct—belonging. This belonging construct we define as a person's sense of membership to their physics community. This can come from a person's network making them feel that they are important members of the community, a person's own beliefs about where they belong or any other resources a person may have that contribute to their sense of personal membership to their community.

These five constructs, recognition, interest, performance, competence, and belonging, make up the physics identity part of our Critical Physics Identity framework. Combining these with Nasir's racialized resources, we arrive at a complete CPI.

2. Racialized resources

In conversation with the physics identity constructs, Hyater-Adams *et al.* [13] use Nasir's [50] racialized resources. These three resources consist of material, ideational, and relational resources, which describe the resources people who belong to historically marginalized communities use to navigate institutional oppressive systems, such as academia. Material resources are physical or otherwise tangible things that contribute to success in physics. Ideational resources are ideas or beliefs about oneself or one's relationship in their field which contribute to their success in physics. Relational resources are any relationships that contribute to success in physics. Hyater-Adams *et al.* [40] further break down ideational resources into subcodes of "positioning in physics, what is valued in physics, perceptions of physicists, and personal characteristics" (p. 3) and divide each resource into positive and negative subcodes.

C. Initial development of the critical disability physics identity constructs

Initially, and perhaps naively, author McDermott constructed the CDPI framework in what was thought to be the simplest possible fashion. This construction of the CDPI was to effectively add the PDI domains to the CPI resources and constructs. The hypothesis was that the domains and constructs would be interlinked. The construction of both would thus be mediated by the material, ideational, and relational resources, as visualized in Fig. 2. Combining our PDI domains with our CPI constructs and resources, we arrive at the initial structuring of our CDPI framework. This framework was initially conceptualized as composed of six disability domains—self-worth, discrimination, pride, common cause, policy alternatives, and political engagement, five physics constructs—recognition, interest,

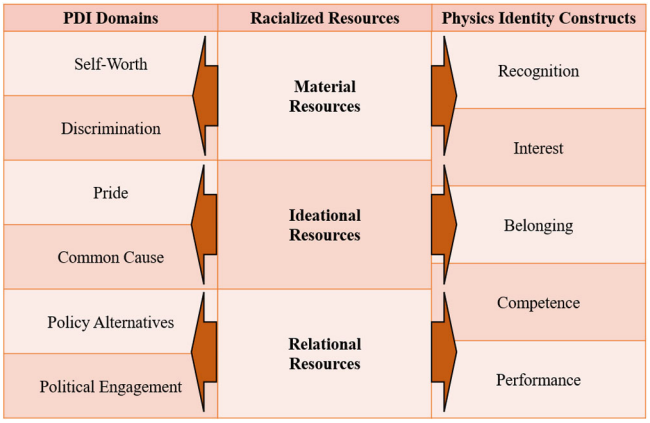

FIG. 2. An initial working model of the CDPI constructs. Resources develop disability-specific and physics-specific identity constructs.

belonging, competence, and performance, and three resources—material, ideational, and relational.

The process of coding Sky's, Catalina's, and Henry's interviews was an iterative process, as all coding is. Initially, we coded these interviews in accordance with how the CPI and PDI constructs and domains are outlined in their seminal works, with the addition of a belonging construct from newer work into physics identity [52]. There are two issues, however, that cropped up by doing this. First, 14 CDPI constructs, while on paper manageable, proved to be unwieldy in practice. Second, and in synergy with the unwieldiness of 14 constructs, by marrying CPI and PDI and applying them to interviews, the lines between certain constructs blurred or were removed entirely.

The minutiae that separated recognition by others and feelings of belonging to the physics community or that separated understanding that there are policy alternatives and actively engaging in politics were not large enough to warrant meaningful distinction and took away from the quality of our analyses. Because of this, we recoded the data with 11 CDPI constructs, each with its own subcodes. The political disability domains become self-worth, discrimination, pride, common cause, and political acts. The racialized resources remain the same as material, ideational, and relational. The physics identity constructs become recognition-belonging, interest, and performance-competence. Notice that in our initial description of these constructs, we explained that for neurodivergent folks, we cannot make the assumption that performance and competence will be linked, and thus should be separated. The recombination of these two codes takes a new form in this framework. Instead of linking them in the assumption that competence in physics leads to performing well, this construct examines the orientation of performance relative to competence. We provide a table (Table I) that defines each construct and resource. We include tables (Tables II–XII) which provide examples of each construct and resource found in the interviews.

IV. DATA COLLECTION AND METHODOLOGY

Data for this paper are part of a broader study examining neurodivergent identity formation and development and application of political agency by neurodivergent physics practitioners. While data collection discussed here is generalizable to this larger study, the specifics discussed are particular to this paper.

TABLE I. The CDPI constructs and resources in full, with their respective definitions.

Critical Disability Physics Identity constructs and resources	
Disability-specific construct	*Definition*
Self-worth	Belief that oneself holds equal value in society to abled persons.
Discrimination	Belief that disabled people are held at a lower value in society due to ableist norms and prejudices.
Pride	Belief that one belongs to a disability community and that belonging is a good thing.
Common cause	Aligning oneself with the needs of others. Seeing that what uplifts others, uplifts us all.
Political acts	Understanding that change can and should be made in society and engaging in intentional acts to create that change.
Physics-specific construct	*Definition*
Competence-performance	The alignment or misalignment of one's performance of physics tasks with their competence in understanding physics.
Interest	Interest in the subject of physics, and in doing and performing physics-related tasks or study.
Recognition-belonging	Recognition as a physicist by oneself or others and feeling of belonging in a physics or physics-related community.
Resources	*Definition*
Material resource	Physical things which one has or has access to which affect their relationship with physics.
Ideational resource	Beliefs about physics and one's relationship to physics which affect their relationship with physics.
Relational resources	Relationships with people which affect their relationship with physics.

TABLE II. The self-worth subcodes: Positive and negative, and examples from the data corresponding to each subcode.

Self-worth	
Subcode	Example
Positive	"I'm like, well, maybe that makes me cool, too, like maybe other people think that way about me."
Negative	"… That definitely made me think my brain wasn't correct- my brain is bad at doing physics. That's literally what it equated to. I thought I was bad at physics, because of how I solved problems."

TABLE III. The pride subcodes: Acknowledgement of difference and disability is a good thing, and examples from the data corresponding to each subcode.

Pride	
Subcode	Example
Acknowledgement of difference	"Being probably not a typical physicist, I don't know if I know the answer to that question. I would say, I just know that I'm not one."
Disability is a good thing	"[Being neurodivergent is] spicy. You add some spice, the flavor, so I think that's why I think better. I don't know if I would say [better], but I do think it makes me valuable."

TABLE IV. The discrimination subcodes: Normative-oppressive, normative-resistant, outright-oppressive, and outright-resistant, and examples from the data corresponding to each subcode.

Discrimination	
Subcode	Example
Normative-oppressive	"I just got the sense that it wasn't made for me. And that's why it was so much more difficult, and some professors, I think, have trouble understanding that. Academia isn't necessarily made for people who are quote unquote 'different,' you know?"
Outright-oppressive	"there were a couple of people who are like, 'Okay, well, that sucks for you. Why are you here?'"
Normative-resistant	"[I have] the perseverance to keep going. Like the attitude of 'alright. Can't do this, therefore I will.'"
Outright-resistant	"I have described myself as an astronomer before, and I have gotten the response, like 'you're not in school anymore. You're not doing research,' which is why I, at least in that identity- Identity is saying, you know, 'I'm an astronomer.'"

TABLE V. An example from the data corresponding to common cause.

Common cause	
Subcode	Example
No subcodes	"Having things in common with people, is massively helpful, because when I entered physics I was like 'I'm different. I don't need no support,' and then I join the society of women in physics and astronomy, and I was like 'wow! There's a lot of barriers to women in physics!'"

A. Data collection

Author McDermott conducted three semistructured interviews with neurodivergent physicists who self-identify as "postbaccalaureate nonacademics," or physicists who, after achieving their bachelors, voluntarily or involuntarily left academia. Subjects were asked questions regarding their experience as physicists and their experience being neurodivergent. Subjects were recruited based on their relationship with the researchers, their identity as physicists, and their identity as neurodivergent. This sample consists of Sky, a cis-heterosexual woman, Henry, a cis-heterosexual man, and Catalina, a cis-heterosexual woman.

TABLE VI. The political acts subcodes: Personal and external, and examples from the data corresponding to each subcode.

Political acts	
Subcode	Example
Personal	"It's kind of like a thing of acceptance. Because if you accept that you are neurodivergent, I think you are a lot easier on yourself."
External	"[Dr. Haruti] was a saint, and I was like, I am struggling massively, and she was like, 'would 15 min help you more on the exam?' and it turns out that yes, it does, in fact, massively help."

TABLE VII. The material resource subcodes: Positive and negative, and examples from the data corresponding to each subcode.

Material resource	
Subcode	Example
Positive	"That summer between semesters, I took a math class online to catch up and I just kept getting better."
Negative	"I went back to do like a- I don't wanna say like an evaluation, but like, I was a part of like the talented and gifted program. So they asked us to come back and like, say, 'do you think this program prepared you for physics?' I roasted them alive, I was like 'absolutely not. I was not ready.'"

TABLE VIII. The ideational resource subcodes: Positive and negative, and examples from the data corresponding to each subcode.

Ideational resource	
Subcode	Example
Positive	"[Mrs. Klause], of course, a queen. Sometimes, when I'm really sad, I'm like '[Mrs. Klause] wouldn't want me to be sad.' So I gotta, you know, I gotta get on it."
Negative	"It's also partially my fault, because once I didn't get it, I didn't want to ask questions I was like, 'I'm just fucked.' Like, 'no questions here, guess I'll just die.'"

TABLE IX. The relational resource subcodes: Positive and negative, and examples from the data corresponding to each subcode.

Relational resource	
Subcode	Example
Positive	"Dr. Yoshmitsu forever is hero to me. He's the reason he is the reason I graduated with a physics degree, because so he was the head of the department, and he was my physics professor for my first, my intro to Physics classes."
Negative	"I think once you start to get beat down in the higher classes, and professors didn't recognize that this was OK and this happens to everyone, then you could start to feel not included in the club, so to speak."

All subjects self-identified as white. In terms of education, all subjects received their bachelor's degrees. Sky received her from a smaller private university, and Henry and Catalina both attended public universities.

Subjects were given the choice between participation in either a virtual or written interview. Virtual interviews were conducted over 1–2 h in 1 h chunks and were conducted over Zoom. Virtual interviews were transcribed first via Zoom's transcription service, and these transcriptions were validated against audio recordings and transcribed by Author Mosley. Author Mosley then further simplified the interviews by cutting out filler words, introductions, conclusions, and nonresearch questions (i.e., demographics questions placed at the end of the interview). Written

TABLE X. The recognition-belonging subcodes: Positive and negative, and examples from the data corresponding to each subcode.

Recognition-belonging	
Subcode	Example
Positive	"I identified with being a physicist because of [Dr. Grayson], for so long that, well, I practice physics. I do physics so therefore I am a physicist."
Negative	"I didn't have that kind of relationship with any physics professors. And I don't know if that was me or if that was them, but… Yeah, leave it there."

TABLE XI. The interest subcodes: Positive and negative, and examples from the data corresponding to each subcode.

Interest	
Subcode	Example
Positive	"I think my interest. That's always what's carried me through is my just, my want to understand."
Negative	"What it came down to was: I lost interest in the topic and I didn't see it as being a long term career for me. So, I don't know if I did want to make it my career, and I stuck with it maybe, I would have made it through the harder classes and given a little more effort than I did."

TABLE XII. The Competence-performance subcodes: Competence aligned with performance and competence unaligned with performance, and examples from the data corresponding to each subcode.

Competence-performance	
Subcode	Example
Competence aligned with performance	"Typically, I think I've seen with ADHD where I can do school work really well if I can get into the head space to focus on it. So, I think that's something a lot of people have experienced with actually who are neurodivergent. Then there's stuff like teaching communication. Where some people see things in a different way and can explain to kids really well, versus others who really can't break down a complex topic."
Competence unaligned with performance	"The testing, not helpful. And I think, yeah, I think a lot of the way the current academic structure works is kind of frustrating and hindering. But I could. Yeah, that's just a whole big mess."

interviews were conducted via email. If subjects chose to partake in a written interview, they were sent the interview protocol and asked to answer the questions therein. Only one subject, Henry, chose to partake in a written interview, after conducting the first half of his interview due to scheduling conflicts.

Regarding the ethical care taken throughout the research process, subjects were repeatedly informed of their rights regarding control over their own data and repeatedly assured that they may revoke their consent at any time during the research process. In addition, many subjects referred to people by name and they were assured that these data would be held confidential in the same way as their own information. After the data collection was complete, subjects were informed that the authors engage in member checking and that they would be asked to review the draft of any disseminated work and were free to make any changes they felt necessary regarding their representation, without fear of retribution or retaliation. We have no reason to believe that subjects had any incentive to simply agree with the results of their work or to agree with the authors. Subjects were given multiple weeks to respond to the authors with desired changes.

B. Data analysis

Interviews were coded deductively using an *a priori* coding scheme based on the newly developed Critical Disability Physics Identity framework. After the interviews were transcribed, we used NVivo software to qualitatively code each interview. Codes were then compared to find instances of agreement and disagreement. When disagreements were found, the codes were again discussed until an agreement was reached. We washed, rinsed, and repeated this method multiple times per interview until a consensus on coding was reached throughout the interviews.

We found that our initial coding schema (Fig. 2) was not sufficient in coding Henry's, Catalina's, and Sky's interviews, as can be expected when operationalizing a framework. Because of this, throughout the wash, rinse, and repeat coding cycles, we combined certain codes together and expanded on the defining characteristics of certain codes. For instance, we expanded the *material resources* code to include assessment materials like homework and tests or quizzes. It is also in this process that we developed our subcodes indicated in the Tables II–XII.

To analyze our data, we examined code connections. We defined these connections as any place in our transcribed interviews where codes overlapped. Specifically, as we are examining how neurodivergent physicists develop physics and disability identity through resources, we pared down our sample to instances in which all:

1. Any physics-specific construct was coded.
2. Any disability-specific construct was coded.
3. Any resource was coded.

This paring-down method yielded 234 individual references with 1334 instances of codes.

This paper is part of a larger phenomenology study, comprising the bulk of author McDermott's dissertation study, gauged for understanding what it means to be a neurodivergent physicist. This means that during analysis, we not only view each interview individually but we also examine the similarities across the totality of interviews. This allows us to gain insight into best practices for educating neurodivergent physicists and assess commonalities that can give us, as a community, a better understanding of where we fail and where we succeed in creating a just and equitable space for our colleagues.

V. USING THE NEWLY OPERATIONALIZED CDPI FRAMEWORK

Figure 3 displays a bar graph of the code counts, in total and divided into each subcode. Figure 4 displays a bar graph of the code counts, in total and divided into the code counts of each interviewee. As can be seen in Fig. 3, we discussed, in depth, subjects' experiences with discrimination, their relationship with resources, and their alignment or misalignment of competence and performance. Note that in Fig. 4, the total number of references per interview does not line up with the total number of references. This is because certain references in interviews were split up and coded under different subcodes, creating an additional reference. Additionally, note that in Fig. 4, Henry takes up a much smaller percentage of references than Catalina or Sky. This is because the length of Henry's interview was much shorter than either of the other interviewees. Given this difference, the coverage of codes for Henry is comparable to the coverage of codes for both Catalina and Sky.

A. Code connections

One way to analyze data using the CDPI is to analyze code connections. Code-code links or code connections help us, as researchers develop theories about qualitative

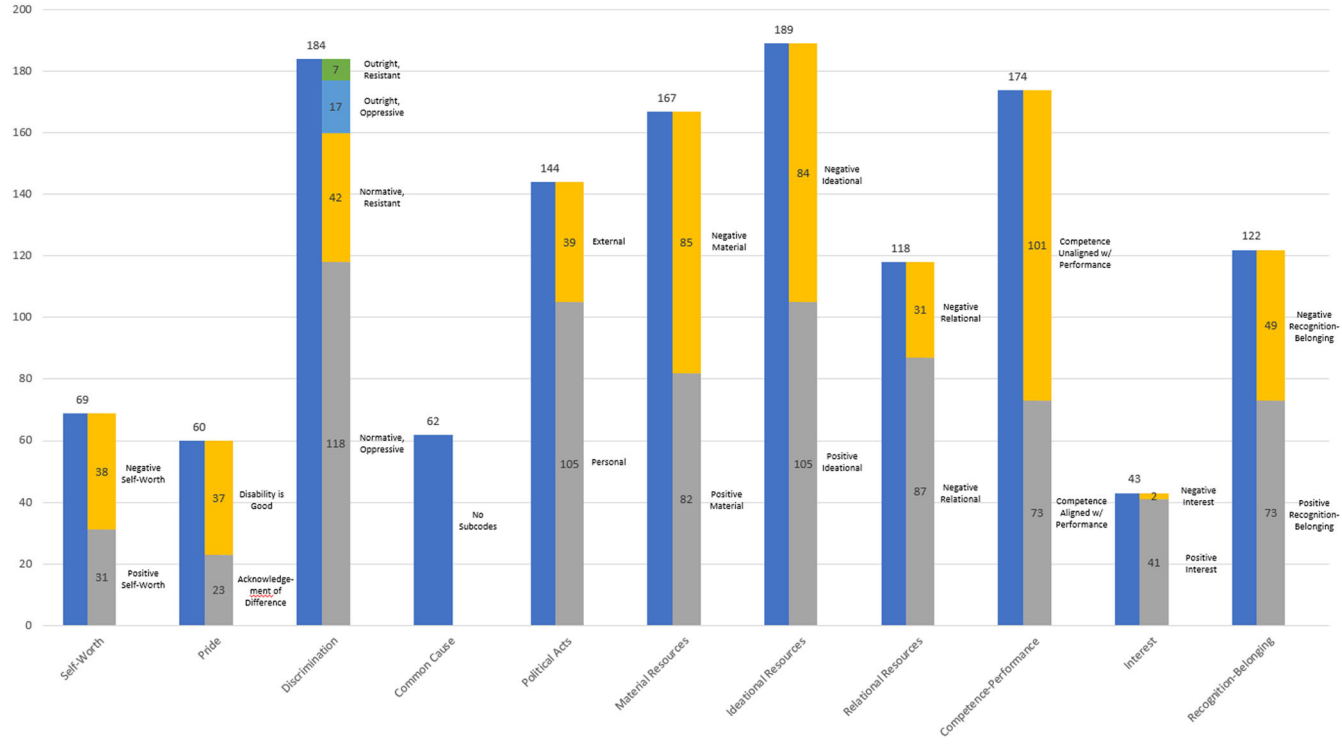

FIG. 3. A bar graph with the number of references per code (left) and number of references per subcode (right).

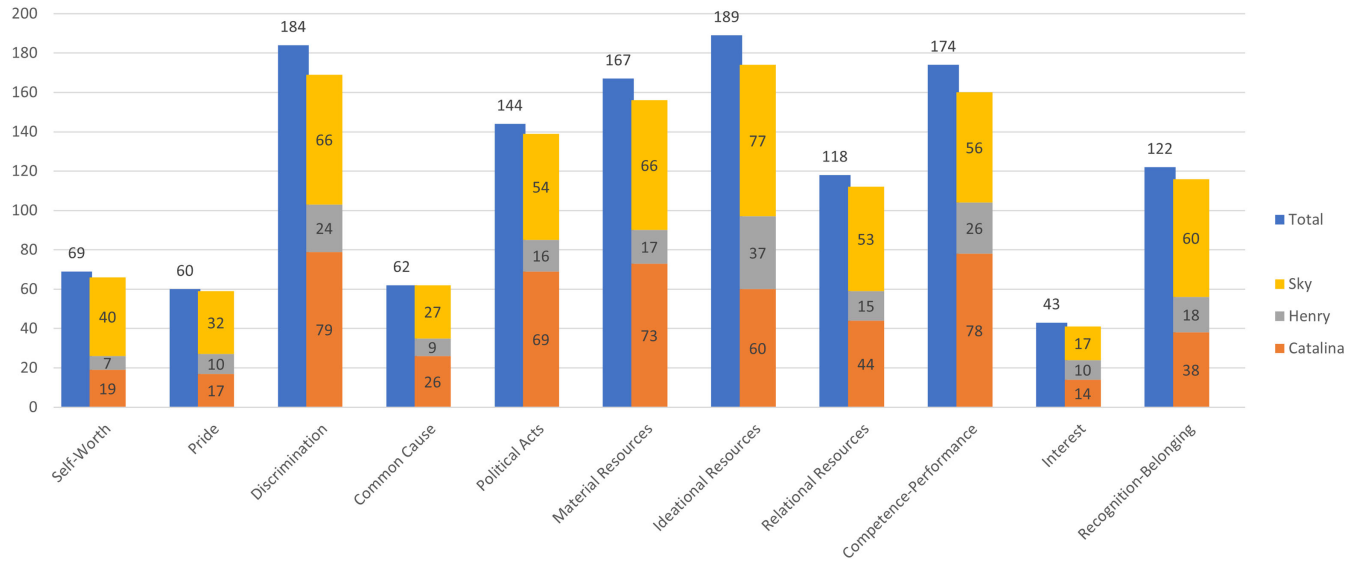

FIG. 4. A bar graph with the number of references per code (left) and number of references per interview (right). Note that the total number of references per interview does not line up with the total number of references. This is because certain references in interviews were split up and coded under multiple different subcodes, creating an additional reference.

data, and help us glean a better understanding of the relationships between aspects of our conceptual framework when applied to real-world data [53]. For a framework with as many moving parts as our CDPI framework, analyzing code connections can make the daunting task of developing relationships between many identity constructs and resources much easier to understand.

The way to analyze code connections that we found most easy was on a microlevel. That is to say, examining the CDPI subcodes as they relate to one another. We found it made sense to split the analysis into groups based on construct or resource types. Figure 5 shows code connections between constructs and resources as a percent of total references and Fig. 6 shows similar code connections between constructs and resources but as a percent of total resource references. Figure 7 shows code connections between physics-specific and disability-specific constructs as a percent of total references and Fig. 8 shows code connections between physics-specific and disability-specific constructs as a percent of total physics-specific construct references. In analyzing data in this manner, we use microlevel connections to examine mesolevel (broader codes) and macrolevel (constructs and resources) trends [53]. By analyzing code connections between constructs, we also get to see broadly how each disability-specific construct subcode is leveraged as a resource to strengthen each physics-specific construct subcode and vice versa.

We also found that taking coding references as a percent of total references (as in Figs. 5 and 7) is only part of the full picture when it comes to understanding how subjects leverage constructs and resources to develop their identity. We found it incredibly useful to also take coding references

% of total reference	Positive Ideational Resource	Negative Ideational Resource	Positive Material Resource	Negaitve Material Resource	Positive Relational Reesurce	Negative Relational Resource
Common Cause	4.12	2.47	4.12	2.06	5.35	0.82
Structural Oppressive	2.88	16.05	2.88	19.34	3.29	4.12
Structural Resitant	5.76	0.82	6.17	2.06	2.47	0.00
Outright Oppressive	0.00	2.47	0.00	2.06	0.41	0.82
Outright Resistant	0.41	0.00	0.00	0.41	0.00	0.41
External Political Acts	0.82	0.41	5.76	2.88	8.23	0.00
Personal Political Acts	11.11	3.29	14.81	5.35	7.41	1.23
Belonging to Disability Community	2.88	1.23	2.88	0.82	0.41	0.00
Disability is a Good Thing	6.58	0.41	2.06	0.00	1.65	0.00
Positive Self Worth	6.17	1.65	1.23	0.00	3.29	0.00
Negative Self-Worth	1.23	5.35	0.41	2.06	1.23	1.23
Performance Aligned with Competence	10.29	0.41	13.17	2.47	6.17	0.00
Performance Unaligned with Competence	4.94	14.81	7.00	18.93	3.70	1.65
Positive Interest	4.53	1.65	3.70	0.00	3.29	0.00
Negative Interest	0.00	0.82	0.00	0.41	0.00	0.00
Positive Recognition Belonging	9.47	2.47	6.58	0.41	13.58	1.23
Negative Recognition Belonging	4.12	8.64	0.41	5.35	0.41	3.70

FIG. 5. A table showing code connection as a percent of total references, between resources (x) and constructs (y). Darker colors indicate higher code connection and lighter colors indicate lower code connection.

% of resource reference	Positive Ideational Resource	Negative Ideational Resource	Positive Material Resource	Negaitve Material Resource	Positive Relational Reesurce	Negative Relational Resource
Common Cause	9.09	5.45	8.70	4.35	18.84	2.90
Structural Oppressive	6.36	35.45	6.09	40.87	11.59	14.49
Structural Resitant	12.73	1.82	13.04	4.35	8.70	0.00
Outright Oppressive	0.00	5.45	0.00	4.35	1.45	2.90
Outright Resistant	0.91	0.00	0.00	0.87	0.00	1.45
External Political Acts	1.82	0.91	12.17	6.09	28.99	0.00
Personal Political Acts	24.55	7.27	31.30	11.30	26.09	4.35
Belonging to Disability Community	6.36	2.73	6.09	1.74	1.45	0.00
Disability is a Good Thing	14.55	0.91	4.35	0.00	5.80	0.00
Positive Self Worth	13.64	3.64	2.61	0.00	11.59	0.00
Negative Self-Worth	2.73	11.82	0.87	4.35	4.35	4.35
Performance Aligned with Competence	22.73	0.91	27.83	5.22	21.74	0.00
Performance Unaligned with Competence	10.91	32.73	14.78	40.00	13.04	5.80
Positive Interest	10.00	3.64	7.83	0.00	11.59	0.00
Negative Interest	0.00	1.82	0.00	0.87	0.00	0.00
Positive Recognition Belonging	20.91	5.45	13.91	0.87	47.83	4.35
Negative Recognition Belonging	9.09	19.09	0.87	11.30	1.45	13.04

FIG. 6. A table showing code connection as a percent of total *resource* references, between resources (x) and constructs (y). Darker colors indicate higher code connection and lighter colors indicate lower code connection.

% Total Reference	Performance ↑↑ Competence	Performance ↑↓ Competence	Positive Interest	Negative Interest	Positive Recognition Belonging	Negative Recognition Belonging
Common Cause	2.88	4.53	2.47	0.00	8.23	0.41
Structural Oppressive	2.88	30.04	0.41	0.41	3.70	10.29
Structural Resitant	4.94	5.35	1.23	0.41	2.88	1.23
Outright Oppressive	0.00	1.23	0.00	0.00	0.00	4.94
Outright Resistant	0.00	0.00	0.00	0.00	0.82	0.41
External Political Acts	5.76	4.94	0.00	0.00	5.35	1.23
Personal Political Acts	13.58	10.29	4.53	0.41	9.47	1.65
Belonging to Disability Community	1.65	2.06	0.41	0.00	2.06	1.23
Disability is a Good Thing	4.94	0.00	2.06	0.00	4.53	0.00
Positive Self Worth	2.47	1.65	0.41	0.00	6.17	1.23
Negative Self-Worth	0.00	4.94	0.41	0.00	1.23	6.17

FIG. 7. A table showing code connection as a percent of total references, between *physics-specific constructs* (x) and *disability-specific constructs* (y). Darker colors indicate higher code connection and lighter colors indicate lower code connection.

as a percentage of each code. As an example, the total amount of references for ideational resources was 174. Therefore, to construct Fig. 6, we divided the total references of each ideational resource subcode by 174. We did similar for the material ($N = 156$) and relational ($N = 112$) resources as well.

Using solely code connections to analyze data does not a good analysis make, however. There are inherent limitations to using code connections to analyze our data and construct our theories. Especially given CDPI's assertion that constructs act as resources to strengthen one another. For instance, analyzing code connections does not show if certain resources are purely resources, as in access to extra class material being a material resource or are constructs acting as resources, as in a student believing that disability is a good thing and using it as an ideational resource. It is therefore critical that research using CDPI digs deep and critically analyzes the textual data, and not just the connections, and instead uses the code connections to supplement or to complement the analysis of qualitative data; in our case, interviews.

B. Using code connections to supplement textual analysis

Code connections only tell us that certain constructs or resources were regularly mentioned together throughout an interview. As we collect more interview data, we gain a more certain idea that certain constructs (and subconstructs) and certain resources are related. However, this is not a very full or rich picture. For this, we must dig deep into the text. It is critical when using CDPI that researchers uplift the voices and the narratives of their subjects. To do this, given our small sample size, we found it best to generate a profile for each subject and discuss each in depth.

We understand that not all research using CDPI will have a small sample size, however, and fortunately generating profiles is not the only way to communicate results. We assert that it is, if not necessary, highly, highly suggested that researchers generate profiles of each subject to aid in examining data critically. Specifically, we suggest examining these profiles to gain a better picture of *how* resources are used, *what* resources are used, and what constructs are used as resources and how they are used. We include in our results section examples of these profiles with key points gleaned from our data.

VI. RESULTS

In this section, we provide profiles of the three interviewees, with key points we drew from each subject's respective narrative. We also provide an analysis of the commonalities throughout the three interviews and a discussion of what insights we can draw from the collection of interviews. Further, to assure the accuracy of our analysis, we engaged in member checking with each interviewee, asking each subject to review and verify that we have represented them and their views accurately.

A. Sky

Sky identifies with ADHD, anxiety, and depression. She is also a cis-heterosexual woman. Above all this, first and foremost, Sky identifies as an "atypical physicist," something which came up a lot in our interview. She is an atypical physicist, she says, for a number of reasons: she places an emphasis on the communication of physics concepts to nonphysicists, she received poor grades throughout her physics education, and she finds "numbers are hard for [her]," especially when comparing herself to her peers. These differences, Sky says (and the authors concur), certainly do not disqualify her from being a physicist, though we discussed her often feeling that she is not a true physicist. "Just because I'm slightly different than what I would categorize as a typical one doesn't mean I'm not one," she says. "If an apple is orange colored, that doesn't make it not an apple. It just makes it a really weird apple, like a really weird physicist." As we dug deeper into this discussion of her "atypicality," one thing repeatedly came up: Sky is atypical for a physicist because despite her being incredibly competent in physics and certainly on par with her classmates, she regularly performed worse when her skills were assessed by others.

In our conversation, Sky cites two people as critical to her success: her mom, and a specific professor in her undergraduate institution, whom we have named Dr. Yoshimitsu. Dr. Yoshimitsu was the head of her physics department and the instructor of both introductory physics classes at Sky's undergraduate institution. She tells us a story about an interaction she had during her time in Dr. Yoshimitsu's introductory physics class.

> "he's the reason- he is the reason I graduated with a physics degree… That first semester in his class, I got a 'D,' and I was mortified! I came into office hours to him and I'm like, 'oh, my God I am failing, what am I doing wrong?' … And he would be calm as clay. Just like, 'oh, you're fine, just- it's just the math. We just need to work on your math. It's

> okay.' Just like, 'don't worry, don't freak out, it'll come. Just practice, it'll come.' "

She explains that this response from Dr. Yoshimitsu was a distinct anomaly compared to every other interaction she had had with teachers up until then. Up until this interaction, every other teacher had been freaking out alongside her when faced with this struggle. Something making this moment markedly important is that receiving poor grades in these classes, being introductory physics, were an affront and direct challenge to her burgeoning identity as a physicist.

> I, as someone who had never really gotten bad grades, was like 'oh, my gosh! This is mortifying. I can't be a physicist. I can't do what I want, [what] I have known my whole life I want to do.' And he just, every single time, would help me through and would give me confidence. And so I got a 'D' that first semester. Next semester with him. I got a 'C,' and he goes 'see? You're getting better, it's okay'.

Sky explains that, while she can't be 100% sure (she cannot read minds), she suspects that Dr. Yoshimitsu's support came from a place of respect and encouragement for her atypical identity. The fact that she was very active in the Society of Physics Students, that she was interested in aspects of science outside of physics, *vis-á-vis* communication, public relations, etc. Sky recalls that Dr. Yoshimitsu went so far as to refuse her quitting physics when broached with the subject. He told Sky, "you can choose to leave being a physics major, but I don't want it to be because you don't think that you can do this." In her words, "he made me feel part of the community there, and like, I was really important … that meant a world of a difference to know that somebody saw a physicist in me when I didn't, and so that was empowering."

In addition to Dr. Yoshimitsu's reassurance of her, at the time, fragile identity, Sky cites her mother as an incredibly critical resource in her success in becoming a physicist, establishing her disability identity, and combining her disabled and disciplinary identities. In fact, Sky mentions her mom 11 times throughout our conversation, far more than any other person in her life, and 5 times more than Dr. Yoshimitsu. About her ADHD diagnosis, Sky tells us, "I was lucky enough that my mom—ADHD kind of runs in our family, and so she knew what to look for." She explains that her mom was the one who took her to the doctor to get tested. However, simply getting an ADHD diagnosis does not necessarily mean organically developing coping mechanisms, nor does it mean getting accommodations right away. For that, Sky says, her mom was critical to her success. As an example, "she taught me… if you have questions about what they're saying, you can ask these questions, and maybe your brain will stay on topic," something which neurodivergent traits like rejection sensitivity dysphoria [54] can make incredibly challenging. In addition, Sky talks about how her mom helped her deconstruct her imposter syndrome, even from a young age. Upon being placed in the Talented and Gifted program at her school, Sky immediately began questioning her belonging, saying, "I was like 'Mom, I'm not that smart.'" Her mom immediately shut any questioning of Sky's intelligence down. "She's like 'well, (1) you are smart, but (2) it's because you think differently. It's because you can problem solve in a way that you're gifted because of it. You have a gift of how you think.'" Sky explains that in doing this, her mom laid the seeds for establishing a stronger physics and disability identity.

For Sky, her relational resources are critical to her success in physics. However, when it comes to her cohort and to professors who maintained the *status quo* in their physics classes, these relational/material resources also serve to poke holes and deepen weaknesses in her identity. She tells us about consistently comparing herself negatively to her peers. "At least for me, it was hard … not to focus on some of the differences that we had." Sky explains that two close peers, in fact, the only other people in her year excelled at the performance aspect of physics. They thought linearly about problems (McDermott, 2023), they solved problems quickly, and received excellent grades. This was reinforced by professors who taught in a normative way (specifically for her peers). Of this, she states

> I really struggled with that, and thought that I was in the wrong; that because … the way the professors taught, the way everything was very linear, [I was in the wrong]. So to me, what that showed me is that my way of thinking about a problem and going about solving it was not the correct way. And so that was something that definitely made me think I was—My brain wasn't correct. My brain is bad at doing physics.

Sky was not able to organically develop her skills in performance to match normative practices in physics, and so when constructing her place in the community, she effectively was rejected; not by her peers, but by the linear structure that physics is taught. As Sky watched the "correct" successful performance of her physicist peers reinforced by her physicist professors, comparing their successful practices to her own, her identity as a physicist was challenged. Her recognition of herself in relation to others challenges and counteracts the positive resources of her mom and Dr. Yoshimitsu.

B. Henry

Henry is an epileptic cis-heterosexual man who identifies with ADHD and anxiety. In our conversation, we discussed how his identity as epileptic directly informed his decision to leave physics, and how his identity has developed as a

physicist postdeparture from the field. In describing his neurodivergent identity, he states

> Obviously that means my brain is screwed up in ways that caused me really terrible health problems. And then I take drugs to, you know, cover for that, to treat it. And those drugs actually adjust the way my entire brain works, not just localized to where I have problems with my epilepsy. So honestly, who knows what I would be like if I wasn't taking those drugs? I don't know.

Henry describes how he was first drawn to physics due to how physics is performed and how physics processes are conducted. He says of introductory physics, "I found a lot of satisfaction in the way that math, like the logical process of math, combined with real-life applications. Like math didn't seem so abstract at that point. It wasn't just numbers." In fact, Henry still cites the applicable nature that physics brings to mathematics as a reason he still enjoys recreationally exploring physics. However, as the math behind physics became less immediately applicable, and more abstract, these warm feelings toward physics did not stay. "The problem for me was once I hit quantum level stuff and atomics, and I couldn't assign meaning to the numbers as much anymore. That was when [physics] started to lose me a lot."

Henry describes the fact that the general abstractness of higher-level physics, specifically atomic physics, made him lose interest in the subject as ironic. "It's funny to say because I work with DNA and I studied genetics, but I understood that kind of atomic level stuff way better than I did when you incorporate math into it. Because I couldn't link the math to the topics anymore." He states that this unlinking of math and physics, accompanied by decreasing perceived grades (we specifically discussed how receiving grades in the 40% range and receiving A's and B's in class was detrimental to Henry's mental health), were distinct reasons he lost interest in pursuing physics professionally. Whereas, Henry found none of these issues in the biological sciences. Henry tells us that he expects this disconnect and loss of interest to be due to the differences in his brain relative to his neurotypical peers. When asked about whether others are drawn to physics in the same way as him, Henry tells us:

> I think so, yeah, for sure. And I think some stick through it a bit better once it becomes re-abstracted as you said. Maybe their brains work a bit differently than mine did, and they. [They] can still see the physical meaning behind all of it, but I lost it.

Further, Henry explains that this disconnect, both with how classes were taught for his peers and with the subject itself, combined with his own journey of self-discovery about his epileptic identity, led him "ending up finding [physical meaning] in biology instead."

> [my epilepsy] actually directly impacted [my decision to leave physics]. Because part of discovering and thinking over everything I'd been through led to me wanting to do something other than physics. I wanted to do something biologically related or something in the medical field. So that was the major factor that controlled my career decision to not study physics for the rest of my life.

Henry's interview elucidates something that we discuss fervently as a field: students are not *tabula rasa*. They come into our classes with their own experiences and their own ideological resources regarding their relationship to physics. Moreover, students are experiencing their own journeys parallel to the path that we guide them along in our brief time with them. It is, in fact, a thing to be celebrated that our students find themselves stronger in their identity when traveling along this parallel path, whether they stay in physics or not.

C. Catalina

Catalina is a dyslexic cis-heterosexual woman who identifies with ADHD, depression, and anxiety. She identifies strongly with being a physicist and spoke a lot about how varying the process of her identity development was throughout her undergraduate studies and the 2 years since graduating with a physics degree and astronomy minor. Like Sky, she specifically cites the relational resources she found within her professors. Unlike Sky, Catalina spoke extensively about the resources her well-established undergraduate community provided; she spoke very little of the resources her family provided. She explains that there was a distinct push-and-pull between her sense of self in physics and her neurodivergent identity. "I suffered from depression for many years for the majority of my college experience," she says. "And that very much [negatively] altered my view of myself for a really long time." Contrary to this, Catalina also repeatedly refers to her being neurodivergent as a very good thing. Catalina tells us that because she is neurodivergent she learns "a lot more in depth about topics, instead of just having a surface level understanding… I never got these surface level understanding. I had to have the whole thing or literally nevernothing ever made sense." She also tells us that as a child, she learned that NASA actively hires dyslexic people, likely a reference to statistics like how 50% of NASA employees are dyslexic [55], which led her to "make that a part of [her] identity." That "I'm dyslexic so I'm cool 'cause NASA only hires people who are dyslexic." Catalina summarizes this experience: "so while I do think that there was a period of time where I was like 'haha! I'm definitely neurodivergent, that makes me cool.' There was also a

large period of time where I was like 'why can't I just be normal?'"

In our conversation, Catalina spoke extensively about two professors, whom we named Dr. Haruti and Dr. Grayson. Dr. Grayson, who taught the first part of Catalina's introductory physics course, and was the first physics professor she met in her undergraduate institution clearly left an indelible mark on Catalina's physics identity, oftentimes by doing the simplest of actions. "I identified with being a physicist because of [Dr. Grayson], for so long. I practice physics. I do physics, so therefore I am a physicist." In our conversation, she notes the power of Dr. Grayson's sentiment. "It's been years," Catalina says. But, "he would come in and be like 'as long as you're practicing physics, you are a physicist.' Like, 'we're all physicists here. It's the first day of physics, but we're all choosing to engage and practice physics. So, therefore, we're all physicists.' That was a huge confidence booster when I was already feeling very nervous about it." It is clear from Catalina's interview that Dr. Grayson's simple, yet ardent and repeated sentiment of unconditional recognition was critical to her identity as a physicist.

At the exact opposite end of Catalina's undergraduate physics journey, Dr. Haruti taught both instances of quantum mechanics at Catalina's undergraduate institution, the last two physics classes that she took. In our conversation, Catalina spoke extensively of her negative experiences with learning quantum mechanics, so much so that she withdrew herself from Quantum Mechanics II, and how these negative experiences were mitigated by an incredibly vigilant professor. "[Dr. Haruti] was a saint," she tells us. "I was doing really really great on all the homeworks, but [Dr. Haruti] noticed that in my exams I would get all of the questions except for one. Every single time, and she was like 'what's going on?' And I was like, 'I simply do not have the ability to finish every single question in the given time.'" In fact, Dr. Haruti's radical assumption of her students' competence appears to be a driving force in Catalina's success. Catalina indicates as such, "the thing is, it's not that I was struggling, or that I found the material particularly hard. It was physically impossible for me to do the exam in the given amount of time." Much like the simplicity of Dr. Grayson's encouragement, Dr. Haruti's unquestioning and unwavering support of Catalina is simple, yet incredibly effective. In Catalina's own words, "I was like 'I am dyslexic like I just—I need—like I need the help.' And she was like, 'okay, I got you.' "

Catalina states she definitely lacked material resources in physics, and where material resources were had, they rode the line of being discriminatory themselves. She states, "things [in class] that are barriers [to neurodivergent people]… [are] a lot more sneaky." She contrasts neurotypical-normative barriers in textbooks to a textbook she used which only referred to the student as "he." She tells us that there are very few overt instances of discrimination based on her neurotype that she can point out; most discrimination she faced in undergrad was normative or structural in nature. But where the institutional and discipline-based structures created negative material resources, it is clear that Catalina's relational resources, in the form of supportive professors, served as a grassroots support structure to mitigate the damage neurotypical-normative instruction and assessment causes.

D. What is learned from experiences of neurodivergent postbaccalaureate nonacademic physicists?

Initially, we had hypothesized that the CDPI would be modeled as in Fig. 2. However, after coding and analyzing interviews, we have arrived at a model that more accurately reflects reality, as given in Fig. 9. Something unexpected came up repeatedly during our interviews, and was reified by examining the connections between codes, was that subjects used physics constructs as resources to reinforce their disability constructs and vice versa. For instance, using prior experiences of having competence aligning with performance as a resource to improve their self-worth and advocate for themselves (political acts) or using their belief that disability is a good thing (pride) to inform their belief that they belong in physics. When constructs are used as resources, it appears from our data, that more often than not these constructs become ideational resources. We conclude that, in fact, disability- and physics-specific constructs become resources to strengthen each other. This, we believe, may become a beneficial cycle in which student identity with regard to disability is reinforced by a strengthened physics identity and vice versa.

Examining coding connections in our sample extracts additional meaning from our interviews. To help visualize this, we constructed Figs. 5–8. Examining the figures we gain some remarkable insight into the identity development of neurodivergent physicists. We see in Figs. 5 and 6 that having misaligned competence-performance and experiencing normative oppressive discrimination is highly connected with negative ideational and material resources. Similarly, we see a high connection between aligned competence-performance and positive ideational and material resources. We do not see as high of a connection because normative

% Physics-Specific Reference	Performance ↑↑ Competence	Performance ↑↓ Competence	Positive Interest	Negative Interest	Positive Recognition Belonging	Negative Recognition Belonging
Common Cause	4.58	7.19	21.43	0.00	19.23	0.96
Structural Oppressive	4.58	47.71	3.57	3.57	8.65	24.04
Structural Resitant	7.84	8.50	10.71	3.57	6.73	2.88
Outright Oppressive	0.00	1.96	0.00	0.00	0.00	11.54
Outright Resistant	0.00	0.00	0.00	0.00	1.92	0.96
External Political Acts	9.15	7.84	0.00	0.00	12.50	2.88
Personal Political Acts	21.57	16.34	39.29	3.57	22.12	3.85
Belonging to Disability Community	2.61	3.27	3.57	0.00	4.81	2.88
Disability is a Good Thing	7.84	0.00	17.86	0.00	10.58	0.00
Positive Self Worth	3.92	2.61	3.57	0.00	14.42	2.88
Negative Self-Worth	0.00	7.84	3.57	0.00	2.88	14.42

FIG. 8. A table showing code connection as a percent of total *physics-specific construct* references, between *physics-specific constructs* (x) and *disability-specific constructs* (y). Darker colors indicate higher code connection and lighter colors indicate lower code connection.

resistant discrimination and positive ideational and material resources. However, we conjecture that this is because of the lower rate of normative resistant discrimination being coded in the interviews (Fig. 3). That being said, we do see a higher rate of connection between normative resistant discrimination and positive ideational and material resources as compared to negative ideational and material resources. While we cannot speak on correlation, we can conjecture that this may be because performing poorly, perhaps due to neurotypical-normative assessment structures (McDermott, 2023), makes neurodivergent folks (who are already more likely to experience rejection sensitivity [54]) view themselves and their relationship to physics poorly. We also see in Figs. 5 and 6, that positive material resources connect highly with personal political acts. We conjecture that this may be because seeing alternative assessment, as in Sky's case, can open the door to viewing assessment as nonfixed, thus encouraging self-advocation.

The strongest code connections we see from this analysis are between positive recognition-belonging and positive relational resources, between positive interest and personal political acts, and between misaligned competence-performance and normative oppressive discrimination. We conjecture the strong connection between positive recognition-belonging and positive relational resource to be a result of positive allies, in the form of professors and peers, making neurodivergent folks feel safe and validated as physicists. We also conjecture that the high connection between positive interest and personal political acts could be because neurodivergent folks who are highly interested in physics, whether the topic being taught or the specific field of research, are more likely to have their identity reinforced (thus making the choice to say "I am a physicist"), and more likely to advocate for themselves to continue pursuing the subject. Finally, we conjecture that the strong connection between misaligned competence-performance and normative oppressive discrimination may be because performing assessment counter to their competence in physics is a result of structures in place that marginalize neurodivergent folks. This last strong connection reinforces our conjecture because performing poorly could be due to neurotypical-normative assessment structures.

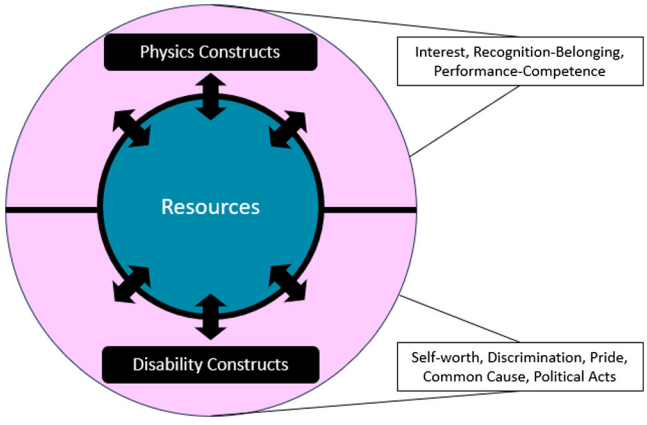

FIG. 9. The operationalized model of the CDPI framework.

There is very important information to be found in the negative space as well. Initially, we considered combining the discrimination subcodes into simply "oppressive" and "resistant" upon seeing that outright discrimination had very few codes. However, we realized that the fact that outright discrimination was so minimally coded reinforces what Catalina describes as "sneaky" discrimination. This lack of outright discrimination indicates to us that the practices that marginalize neurodivergent folks are *structural*. That neutral educators, who may otherwise not commit ableist acts toward students, are still complicit in enacting ableism and upholding structures that exclude and reject neurodivergent folks. Additionally, we see negative space in regard to negative interest. We conjecture that this may be because the folks that we interviewed see themselves as physicists and thus are interested in physics. This may also be because, as Catalina, Sky, and Henry are out of academia, they have less requirement to engage with "uninteresting" aspects of the field, only engaging with what they are interested.

From Figs. 7 and 8, we see that having aligned performance and competence is highly connected with taking personal political acts, i.e., self-advocation. We see this in Sky's interview, where she states that performing well in Dr. Yoshimitsu's class (due to positive material and relational resources) led to her advocating for herself in other classes. Performing in line with competence helped Sky develop the ideational resource that she is worth self-advocation. We also see that having a positive interest and being positively recognized as a physicist by self or others also connects highly with personal political acts. Sky provides an example of how she consciously makes the decision (a personal political act) to turn her perception of what being a physicist means outward and uses this act to create an ideational resource to spur her radical act of self-acceptance and self-recognition as a physicist, saying "I have to kind of force myself to identify as one cause I believe I should. If it was anybody else, I'd say 'yes, you're a physicist,' so I have to turn that back on myself." Catalina provides an example of her positive interest being used as an ideational resource to navigate her classwork: "Choosing to engage in [physics] allows me to not look at it as a chore, but to look at things that I think are interesting, which in turn makes it easier for me to continue to consume materials. Because if I think that it's boring, I'm not gonna want to do it." It seems to be that constructs reinforce each other by becoming or acting as ideational resources. This is a very important thing to note, as in Fig. 5, ideational resources are the most regularly connected resource (and the most regularly referenced), and thus, potentially, the resources that are leveraged most readily to strengthen CDPI.

Digging more into the textual data, each subject, Catalina, Sky, and Henry, spoke extensively about the power dynamics present in academia and the physics classroom. These power imbalances, at least for these three physicists, come in the form of universities having seemingly sole power to administer accommodations and "allow" accessibility, and certain professors acting as the sole arbiters of success, while only allowing for neurotypical-normative thought processes and knowledge construction, though we are certain there are many others present that were not discussed in our interviews. They also spoke about how keenly aware they were of said power dynamics. Each subject shared at least one anecdote of professors who took action to break down the power imbalance for them, either doing something as simple as taking extra time to explain concepts in a way that aligned with how their minds conceived of physics topics (as in Sky's case) or something as radical as sidestepping traditional avenues of assessing accommodations (as in Catalina's case). They each allude to how the breaking down of these power imbalances by professors, specifically. Furthermore, as these power imbalances break, it seems, so too does the illusion that our subjects are bad physicists. Instead, the reality of structural ableism in the form of neurotypical-normative assessment becomes apparent to our subjects.

VII. LIMITATIONS AND RECOMMENDATIONS FOR FUTURE WORK

This article concerns research regarding a very unique population in PER, people who have left academia and identify as physicists. Working with this population, therefore, involves taking a unique perspective when understanding potential limitations. To begin with, all three subjects self-identify as white. This means that the data collected comes from a place of white privilege. It is therefore imperative that future research involving CDPI is cognizant of this fact, conducting research with larger, racially diverse populations, and including researchers of color in the research process. It should be noted, however, that the CDPI framework comes from the CPI [13] framework, a Black feminist framework for use with racial minorities. We believe that as CDPI comes from CPI, CDPI would still describe the identity development of a more racially diverse population. We encourage further work to confirm this hypothesis.

We highly suggest that future studies using CDPI develop it further by working with a more racially diverse, gender diverse, sexuality diverse, and ability diverse subject population. We also suggest that future studies analyze the intersectional nature of identity and examine how belonging to other historically marginalized groups intersects with being a disabled or neurodivergent physicist, as these identities are strongly intertwined with neurodiversity and disability [56–58]. In fact, future work in author McDermott's dissertation study will examine a much more gender, racial, and sexuality diverse population of neurodivergent physicists, along with neurodivergent physicists at various stages of their physics careers. We also suggest that future work examine successful and unsuccessful ways to construct classrooms and institutions that support CDPI development for neurodivergent students, faculty, staff, and community members.

VIII. CONCLUSION

As more neurodivergent students enter higher education [6], it is of the utmost importance that we interrogate and reevaluate our teaching practices and the normative structures in place which could be used to oppress new (and those who have been here a while) neurodivergent physicists. Our conversations with Sky, Catalina, and Henry elucidate some very interesting aspects of the phenomenon of being a neurodivergent physicist. While it does, critically, still exist, the violence that neurodivergent students face in physics comes not from hypothetical bad and evil ableist professors but from those who accept and uphold ableist norms in education. Good people can still be ableist, and from our interviews and analysis, those are the people who can do the most harm to students marginalized for their neurodivergent identity.

It is important that marginalized students find allies. Allies that are especially important for neurodivergent students are those who have control over material resources in class, such as testing, homework, lectures, etc. These interviews, especially Sky's, also show that we are not necessarily creating communities of practice that benefit disabled students in the long term; we are instead creating communities that these students use to compare themselves to, compounding doubts about belonging and issues with self-recognition. This is especially worrying because where students *did* find positive relations, they felt like they belonged, and they advocated for themselves and made the choice to identify as physicists.

It is also important to understand that many neurodivergent identities are grounded in differences in communication. Physics may be presented as objective and obtainable from first principles. However, this cannot ever be true for students if the subject is not communicated to them in ways that are understandable or sustainable. For instance, many neurodivergent folks, like dyslexics and folks with ADHD, have non-neurotypical automaticity (the ability to learn without focusing on learning) [59]. Keeping up this focus (not to mention the toll that masking takes on neurodivergent folks [60]) requires payment in the form of energy. This is next to impossible to keep up for hours at a time, like the expected length of lectures or labs.

Finally, having and maintaining positive interest, whether in the form of consistent interest in physics, providing resources and opportunities for student-led

research, or funding and supporting physics clubs, appears to help neurodivergent folks self-advocate, see common cause, and view being disabled in physics as a good thing, things which all also connected highly to feelings of belonging and recognition.

ACKNOWLEDGMENTS

This work was conducted under approved IRB Protocol 2022000074. This work was funded in part by LGBT Tech's PATHS STEAM Education Grant.

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