Social-Emotional-Sensory Design Map for Affective Computing Informed by Neurodivergent Experiences

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One of the grand challenges of artificial intelligence and affective computing is for technology to become emotionally-aware and thus, more human-like. Modeling human emotions is particularly complicated when we consider the lived experiences of people who are on the autism spectrum. To understand the emotional experiences of autistic adults and their attitudes towards common representations of emotions, we deployed a context study as the first phase of a Grounded Design research project. Based on community observations and interviews, this work contributes empirical evidence of how the emotional experiences of autistic adults are entangled with social interactions as well as the processing of sensory inputs. We learned that (1) the emotional experiences of autistic adults are embodied and co-constructed within the context of physical environments, social relationships, and technology use, and (2) conventional approaches to visually representing emotion in affective education and computing systems fail to accurately represent the experiences and perceptions of autistic adults. We contribute a social-emotional-sensory design map to guide designers in creating more diverse and nuanced affective computing interfaces that are enriched by accounting for neurodivergent users.

CCS CONCEPTS • **Human-centered computing→Computer supported cooperative work**; **Empirical studies in accessibility.**

KEYWORDS: Emotions, interpersonal communication, social-emotional learning, autism, accessibility

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1 Introduction

Insights into diverse lived experiences have the potential to surface new design approaches—in the case of this work, for affective computing.

"I'm just really sensitive and the world is very intense, and I just take it all in, and I can't block it out," said our research participant, Sarah, during her interview. Alana, another participant, described a situation in which she *"ended up yelling and screaming and exploding, and that causes headaches and panic attacks...I'm just really irritated and frustrated because they just don't get it."* A third participant, Jack, described that when his feelings escalate to a burst of anger, it is similar to how he *"can numb my whole body to take the impact of a punch, but instead it's letting all the energy from all the punches out all at once with my fists. So basically, completely taking the energy from all the punches I have taken over the years and just let it all out at once."*

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These participants are on the autism spectrum[1], a neurological condition that impacts one's expression of emotions and desired way to establish social bonds [2]. They described to us the ways that they experience emotions within their bodies and within the context of social relationships. In this paper, we present the ways in which autistic young adults navigate their emotional and social lives. We argue that the emotional and social lives of autistic individuals are rich and nuanced and provide insights that should inform the design of affective computing systems. In 1995, Picard coined the term 'affective computing' as computing that "relates to, arises from, or influences emotions" [66:1]. Examples of affective computing systems include wearable devices that sense a person's emotional state (e.g., Feel [82], MoodLight [86] both shown in Figure 1), automobiles designed to support safe driving by tracking and responding to the emotions of drivers [24,42], and a chatbot that promotes self-compassion [50]. Inspired by Picard, we use the term 'affective computing' for digital user experiences and underlying algorithms that relate to, arise from, or influence affective phenomena. The Handbook of Affective Sciences identifies five major affective phenomena: emotion, feelings, mood, attitudes, and affective style [18]. Psychologists conceptualize moods as diffuse states and emotions as more specific states that are connected to stimuli and are time-bound [27].

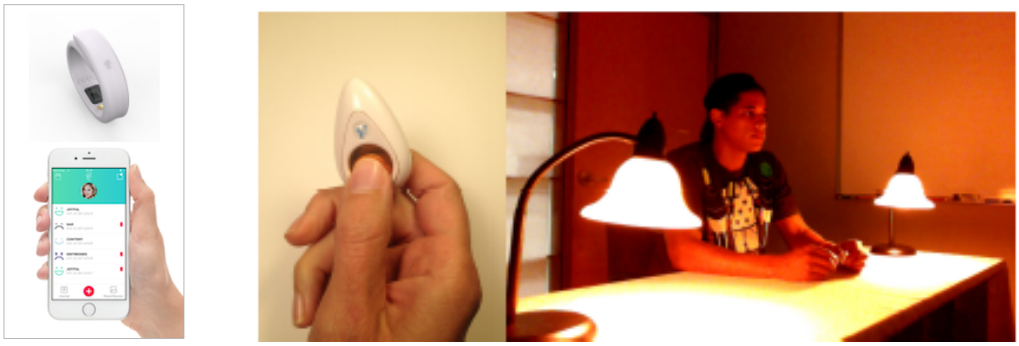


Fig. 1. Examples of affective computing. (a) Commercially available Feel emotion wearable and mobile application [82]. Copyright: Fair use. (b) Research artifact, MoodLight, Personal Input Pod and programmable LED lamp [86].

There are several key questions regarding human emotions that shape affective technologies. Do humans experience discrete emotions? Can emotions be consistently identified from physiological information? Psychologists, neuroscientists, and everyday experiences point to the ways that body language, especially facial expressions, are facets of expressing and perceiving emotions. Biometrics (e.g., heart rate, breathing rate, and skin conductivity), voice, and body language are all components of affective responses—physical and cognitive reactions to affective phenomena. Given the scientific basis of physiology on affect, technologists have pursued different techniques for modeling affective responses and emotions computationally by training machine learning algorithms on body language and biometric data. Affective modeling is in the same vein as technology (e.g., facial analysis technology) that attempts to classify people into constructs of human identity including gender and psychology. Such technologies have resulted in racial, gender, transgender, and intersectional bias [34,46,79]. Current emotion recognition systems are likely to produce bias due to the inequities of data sets [39], and as we argue in this paper, normative views of emotional experiences at risk of being encoded into algorithms.

Our work highlights variations and complexities of emotional responses by focusing on a community that has affective experiences that are viewed as non-normative. People on the autism spectrum are just one example of groups who have emotional experiences that do not always align with standardized taxonomies. Autism is a life-long neurological condition characterized by particular social, emotional, and behavioral

[1] We use the terms "on the autism spectrum" and "autistic" interchangeably in keeping with the terminology used by our participants (Table 1).

styles [2]. In disability studies, related literature, and self-publishing avenues (e.g., blogs and YouTube), autistic individuals describe experiencing difficulty communicating with others due to differences in verbal communication and interpreting non-verbal social cues. Autistic individuals describe sometimes having difficulty expressing or perceiving emotions. Autistic self-advocates describe "not being able to trust, feel, or control their bodies as they would prefer" [10:1]. Autistic individuals describe experiencing the world in part through hyper- and hypo- processing of sensations, such as bright lights and loud sounds, and physiological conditions of the body. Underscoring the newly recognized importance of sensory processing for autistic individuals, updates to the latest Diagnostic Statistical Manual-5 (DSM-5) added hyper- and hypo-processing of sensory inputs as potential indicators of autism [30]. Autistic individuals and their families may modify their environment and daily routines to decrease overstimulation and add calming sensory activities [78]. Autistic individuals may engage in repetitive body movements as pleasurable mechanisms for self-soothing and engaging kinesthetically with the world [40].

To build more ethically-sound and representative technologies, a critical lens can be used to challenge assumptions and stereotypes embedded in digital systems and suggest examples of more inclusive methods and data practices [22]. By contributing an expanded approach for designing affective computing, our study examines interconnections between embodied emotional experiences of autistic adults and interpersonal interactions. Theories of embodiment center people's physicality, cognition, and perceptual experience [19]. In the case of autism, self-advocates and theorists have explained that for autistic individuals embodied experiences inform their knowledge of, and interactions with, the world. As described by the cognitive scientist De Jaegher, autistic individuals engage in embodied sense-making composed of "emotion, knowledge, mood, physiology, background, concepts, language, norms, and crucially, the dynamics of the interaction process" [19:10]. This is the locus of a critical link between emotional and sensory (or embodied) experiences. To better support this connection in the design of affective computing systems, we ask:

RQ1: During daily interpersonal interactions, how do autistic adults conceptualize and share emotions and sensory experiences?
RQ2: In what ways do autistic adults use or respond to digital technologies within the context of their social, emotional, and sensory experiences?

To explore these questions, we conducted a contextual inquiry of the autism community comprised of community observations, outreach with autism community members, and interviews with 18 autistic young adults. During the interviews, we elicited feedback about visualizations of emotions that are currently used in autism therapy and mainstream affective computing. We learned that (1) the emotional experiences of autistic adults are entangled with their social interactions and their processing of internal and external sensory experiences, and (2) that conventional approaches to visually representing emotion are often overly reliant on standardized taxonomies and fail to incorporate contextual aspects of emotional responses. Findings support the need to broaden approaches to affective computing by revising standard models to explicitly consider the situated and embodied aspects of emotional experiences. We offer a social-emotional-sensory design map for affective computing in communicative contexts. In delineating the nexus of social, emotional, and sensory experiences of autism, we provide a blueprint or map to enable designers to navigate this site of design. By social, we refer to the interpersonal social interaction in which communication activities are being mediated by affective computing. As described above, emotional refers to emotional states that are connected to stimuli and are time-bound. And by sensory, we refer to internal and external sensations centered in an individual's physical body and processed by an individual's cognitive system. We argue that these aspects influence each other so deeply in the lived experiences of autistic individuals, that when affective computing considers each aspect in a silo, opportunities to engage

holistically with the end-user are missed. By focusing on experiences of a neurodivergent group of stakeholders, researchers and designers of affective computing can be more inclusive of diverse perspectives while critically mitigating potential harms introduced by concretizing neuro-normative bias into systems.

2 BACKGROUND

Situated at the intersection of affective phenomenon, autism, and technology, our study builds upon the prior theoretical understanding of affect and technological advancements in affective computing. To establish the conceptual framing for our work, we present a summary of affective phenomena from a psychological perspective and as manifest in autism. We provide an overview of affective computing user experiences and research focused on mainstream and autistic populations.

2.1 Dominant Theories of Affective Phenomena

Human emotions have long intrigued scientists in fields, including psychology and neurology. Our conceptual framing of emotions begins with the overarching concept of affect that covers "all experientially nonneutral, hedonic or value-laden states or stimuli" [27:37]. Core affect, as defined by psychologist Russell, is "that neurophysiological state consciously accessible as the simplest raw (nonreflective) feelings evident in moods and emotions" [75:148]. Russell posited that affect is the blend of two fundamental neurophysiological systems related to pleasure and arousal [74]. Depicted as the circumplex model of affect (Figure 2), dimensions of valence and arousal map the space of possible emotional states.

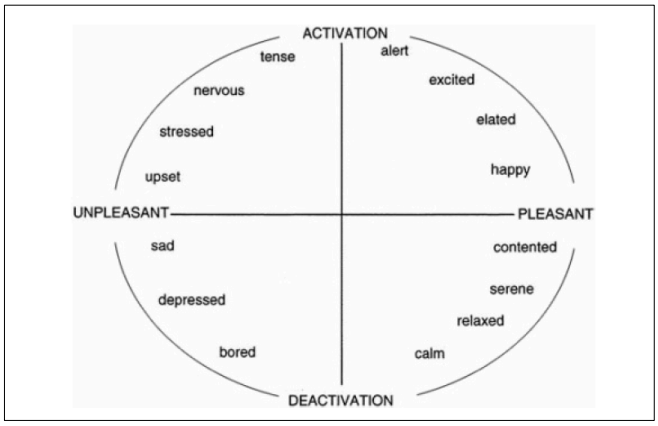


Fig. 2. Russell's circumplex model of affect [68] showing valence on the horizontal axis and arousal on the vertical axis. Emotional states are mapped onto the two space.

Five major affective phenomena are prominently studied: emotion, feelings, mood, attitudes, and affective style [18]. Humans experience affective states as "psycho-physiological constructs used for characterizing emotions (short-term) and moods (long-term)" [92:1]. Examples of emotional states are mapped onto the circumplex model of affect shown in Figure 2. The connection between emotions is a topic of conceptual and empirical inquiry. A dominant theory from Ekman posited that there were six basic, discrete emotions—joy, surprise, sadness, anger, disgust, and fear—experienced universally by all humans [23]. According to this theory of universality, our neurological and physiological systems express these emotions in reliable and predictable ways across cultures. For example, facial expressions of emotions are used to define precise positions and movements of facial markers including eyebrows, facial lines, and lip position. A body of research has substantiated this theory, sometimes expanding to seven basic emotions to include contempt, as shown in the research image in Figure 3 [52,53]. In this image, six actors of different genders and races demonstrating pre-defined facial expressions of basic emotions. Data sets of facial

expressions are currently used by technologists to develop computational models of emotional expression and recognition, at risk of embedding cultural, gender, and racial bias [39].

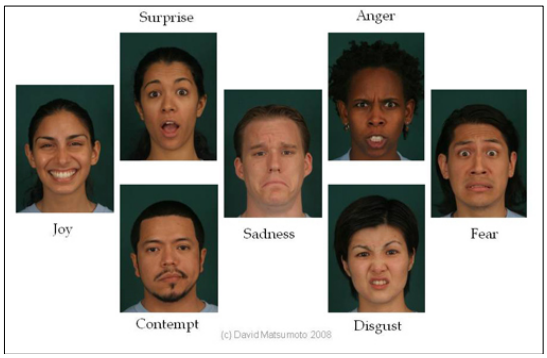


Fig. 3. Facial expressions of emotions (joy, surprise, sadness, anger, fear, contempt, and disgust) as depicted in research on basic emotions [52,53].

One critique of the theory of basic emotions is its hypothesis that predictable "patterns of autonomic activation and facial innervation are specific to each basic emotion" [68:717] has not been consistently validated by research. In addition, the presence of a specific facial expression is not solely enough to classify an emotion, thus, disputing the reliance on facial expression to categorize emotions. Nonetheless, the notion of basic emotions as expressed through facial expressions remains a prevalent area of inquiry for neuroscientists and human-computer interaction researchers, as well as autism therapists as discussed later in this section. As opposed to the theory of basic emotions, theories such as the circumplex model of affect, are better aligned with advancements in neuroscience research and knowledge of clinicians and researchers that people have difficulty with emotional competencies such as discerning and describing their own emotions [76]. On the extreme end is alexithymia—affective and cognitive difficulties recognizing and describing one's feelings, including distinguishing between feelings and bodily sensations [29].

Some emotion theorists have explored the experience of emotions as sensations within the body, felt through one's sense of interoception. Interoception is awareness of internal senses, including temperature, heart rate, our sense of balance, etc. [21]. "Models of embodied emotion posit that we understand others' emotions by simulating them in our own bodies, meaning that we should be able to construct bodily representations of others' somatovisceral states when observing them expressing specific emotions" [63:648]. Biomedical researchers have explored how people associate bodily sensations with different emotions. For example, Nummenmaa et al. [63] created maps of bodily sensations as self-reported by participants responding to emotional stimuli associated with the six basic and seven non-basic ("complex") emotions plus a neutral state (Figure 4). Their findings suggested that people perceived both basic and complex emotional states and that people perceived different emotions as embodied in different ways. However, they found overlap in the bodily maps, with emotional states affecting the body in sometimes similar ways.

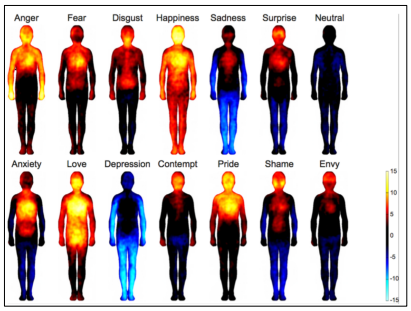


Fig. 4. Bodily map of emotions depicting self-described embodied sensations associated with anger, fear, disgust, happiness, sadness, surprise, neutral, anxiety, love, depression, contempt, pride, shame, and envy [63].

Psychologist Lisa Barrett argues that our understanding of emotions needs to change from the 'classical' view of emotions—in which our bodies reliably broadcast perceptible biometric signals that correspond to universal emotions—to a constructivist theory that emotions that are constructed both within oneself and socially [5]. From a constructivist perspective, one's emotional experiences are formulated based on one's neurology, access to related emotional experiences, and context of social actions. We explore this in our research as we investigate the lived experiences of autistic individuals within the context of emotional, sensory, and social interactions. We further unpack the complexities and idiosyncrasies of emotional experiences during interpersonal interactions towards enhancing the design of affective computing.

2.2 Affective Computing for Interpersonal Communication

The aforementioned affective theories, which conceptualize basic and complex emotional states and use biometrics as signals, are the dominant basis for affective computing models for classifying affective phenomenon. Technologists can use cloud-based emotion recognition services offered by cloud-based platforms. Google's Vision API, released in 2016, processes images to detect faces, landmarks, and objects [98]. It calculates likelihood ratings for emotional states (joy, sorrow, anger, and surprise). Microsoft's Cognitive Services includes the Emotion API for perceived facial expressions for six emotional states (anger, contempt, disgust, fear, happiness, neutral, sadness, and surprise) and a corresponding confidence level [58].

Affective computing systems have been targeted for settings including the workplace, healthcare, education [e.g., [26,60,94], and wide-spread use, such as Amazon's reported emotion-detection wearable [99]. Researchers have investigated the impacts of emotions on interpersonal communication and teamwork. Teams of information workers can experience enhanced productivity and positive affect, suggesting happiness, when using systems that mediate task transitions and breaks [44]. In the context of healthcare, physician empathy towards a patient and physician-patient communications about emotions can reduce patient distress and facilitate more caring treatment [33]. In the high-intensity setting of an emergency room, Mentis et al. [57] found that articulation work between healthcare personnel benefitted from professionals filtering or suppressing affective expression in order to exhibit what they felt were the appropriate types and intensity of emotions given the context. They argued that system designers should not assume that "(1) a person wants his or her emotional state to be perfectly and fully conveyed to communications partners and that (2) observers want or need to know all of the task-relevant emotions expressed by another" [57:34].

Researchers have investigated ways to provide emotionally-aware mental health socio-technical, such as a wellbeing chatbot that infers mood and adjusts its delivery of interventions accordingly [25]. Emotion recognition functionality is sometimes built into a platform without the express knowledge of the user. This has been used to detect distress in a social media user's online behavior [62] towards providing critical support. In another case, Facebook conducted an experiment in which content was shown or omitted from users' news feeds based on the emotional expressiveness of posts [48]. The Facebook experiment, which

was conducted with users without their consent, came under ethical scrutiny an example of algorithmic emotional manipulation. Andalibi and Buss conducted interviews with social media users about their attitudes regarding emotion recognition on social media platforms [3]. They found that people "view emotions as insights to behavior, prone to manipulation, intimate, vulnerable, and complex" [3:1]. They describe ways the complexity of emotions is difficult to define for the person experiencing them, let alone a computing algorithm. One challenge they note is how algorithms are often designed to classify an emotion as one of a set of universal feelings or moods; however, emotions are felt differently by each person. They found that participants perceived potential harms of emotion recognition at individual and societal levels. Concerns included that they and others, especially vulnerable individuals, could be manipulated and exploited based on their emotional state, there could be negative impacts on emotional and mental health, and there could be identity and digital image misrepresentation across time.

In our work, we investigate the holistic, constructed emotional experiences of autistic individuals. This perspective differs from prior work that considers emotions individually (such as emotion wearables). We build upon the work examining potential harm to people from hidden, inaccurate, and misrepresentations of emotions in technology.

2.3 Affective Phenomena in Autism

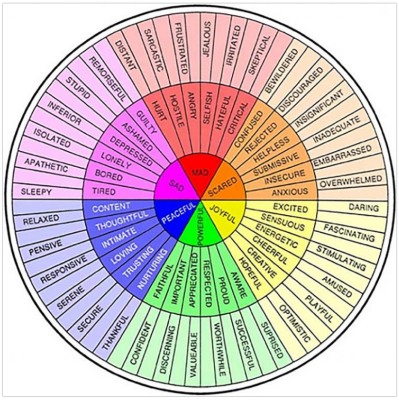
In our work, we explore the experiences and perspectives of autistic adults within the context of their emotional experiences. We present an overview of how affect and emotions are theorized and manifest in therapy and education related to autism. Evaluation of affective responses and emotions is used to diagnose and assess autism, stemming from when autism was first characterized as a psychological and behavioral condition. "The role of emotion in autism is still debated" in autism research, literature, and community discourse [91:1]. At a high level, emotional well-being enriches one's quality of life. In general, the quality of life of autistic children tends to be lower than that of non-autistic children, "with a majority having little or no social support, meaningful relationships, future employment opportunities or self-determination" [11:83]. Emotional well-being is supported by social-emotional learning and enacting skills, thereby building emotional competence [65]. Emotional competence are predictors of academic and social success, as well as gains in social aptitude [16].

A key emotional competence is the ability to identify and recognize emotions in oneself and others. According to a meta-analysis of emotion research in autism, Uljarevic and Hamilton [91], emotion recognition has been found to be difficult for autistic individuals; however, rigorous validation of the exact nature of emotion recognition difficulties has not been solidified by research. In their meta-analysis, Uljarevic and Hamilton found that emotion recognition can be difficult for autistic individuals, with no significant difference between difficulty in recognizing types of emotions such as fear and happiness. Difficulty with emotion recognition may be connected to alexithymia—as described above, entails difficultly identifying and recognizing emotions—since autistic individuals have been found to have a higher rate of alexithymia than non-autistic populations [59].

Another important emotional competency is self-regulation of emotions. "Emotion regulation involves modulating the temporal features, intensity, or valence of one's emotions in the service of adaptive or goal-directed behavior" [54:15]. Emotional outbursts, aggression, and self-injury can stem from ineffective management of emotional states in response to stress or overstimulation [47]. Sources of stress for autistic individuals include social pressure, feeling in discord with others, and trauma. Children and youth with autism have been found to have been exposed to trauma including abuse, neglect, and peer victimization (including physical, social, verbal, and cyber-bullying) [13]. Autistic children are exposed to traumatic events at least as often as their typically developing peers, with bullying found to occur more often against youth with ASD more often than non-autistic youth [38]. Research on the effects of these events on autistic people

suggests ostracism, loneliness, internalization of emotional symptoms, and suicidality. More research is called for, along with supportive interventions and policies.

Both of these emotional competencies-- recognizing emotions and self-regulation of emotions—are areas targeted by psychologists, social skill therapists, and educators. These professionals use traditional and modified social-emotional learning strategies when working with autistic children. To support multi-modal learning and to assess emotion competencies, professionals use a variety of visual aids, including those containing facial expressions and taxonomies of emotions [32,36,69]. Cognitive-based therapy (as opposed to behavioral approaches) sometimes use emotion taxonomies to teach autistic individuals emotion recognition and emotion regulation skills (Figure 5).



BLUE ZONE	GREEN ZONE	YELLOW ZONE	RED ZONE
"Running Slow"	"Good to Go"	"Caution"	"Out of Control"
Low Energy	Normal Energy	Elevated Energy	Extreme Energy
BLUE ZONE	**GREEN ZONE**	**YELLOW ZONE**	**RED ZONE**
Sad	Good	Excited	Mean
Tired	Calm	Frustrated	Mad
Sick	Thankful	Nervous	Angry
Bored	Relaxed	Silly	Aggressive
Shy	Content	Annoyed	Terrified
Exhausted	Proud	Confused	Out of Control
Depressed	Happy	Embarrassed	Elated

Fig. 5. (a) Feeling wheel used in psychological counseling with autistic adults [84]. Copyright: Fair use. (b) Feeling Zones curriculum designed for teaching teens to first identify their energy zone (blue, green, yellow, red) and then a corresponding feeling within each zone [49,97]. Copyright: Fair use.

Our work seeks to contribute empirical evidence of the emotional and affective lived experiences of autistic adults, including the reflections of autistic adults on their social-emotional learning as described in this section. We explore sensory experiences within the context of social-emotional experiences, as motivated by disability studies. Our work is motivated by the scholarship of critical autism scholars, who "attend closely to the views and voices of autistic people themselves" to counter traditional autism literature in which "it is not unusual…to encounter descriptions, indeed definitions of autism as an 'empathy disorder'" [17:131]. Critical autism studies offer alternative, more expansive perspectives. For example, Milton theorizes about a 'double empathy problem,' describing how challenges to empathy are not due to a "singular problem located in any one person. Rather, it is based on the social interaction between two differently disposed social actors" [61]. We draw from disability studies for perspectives such as Milton's and rich descriptions of lived experiences of autistic individuals, especially adults. These perspectives expand our understanding of autistic adults beyond research typically focusing on autistic children in psychology, education, and human-computer interaction (HCI) research (with notable HCI research exceptions including [9,12,37,55,96]). Next, we describe affective computing used in the autism domain.

2.4 Affective Computing for Autism

Affective computing systems for autism are primarily applications used in educational and therapeutic settings. In these programs, autistic children are instructed to complete computer application tasks that are "designed to elicit the affective states of liking, anxiety, and engagement that are considered important in autism intervention" [51:1]. Autistic children also use computer applications that teach the meaning of facial expressions. These emotional literacy skills are then the basis for learning a wide range of social skills that are contextualized based on the individual's age and communication goals. Researchers have found that

using video technology and virtual worlds to practice social skills for scenarios such as public speaking and job interviews has benefits for autistic individuals [35].

In autism technology research, the expression of emotions, emotional empathy, and emotional regulation have received significant focus (e.g., [8,43,93]). As an extension, empathetic artificial intelligence (AI), which strives to mirror and model human emotions, has been applied to autism scenarios. Empathetic AI, in the form of social robots and avatars, has been used with autistic children to promote social engagement and emotionally-aware interactions, specifically, "assisting in the diagnostic process, improving eye contact and self-initiated interactions, turn-taking activities, imitation, emotion, recognition, joint attention and triadic interactions" [68:1]. In other areas concerning physical interactions with digital systems, researchers have used wearables to detect stereotypical motor repetitive behaviors (e.g., [30]) and to attempt to predict emotional 'melt-downs.' This line of research focuses on understanding affective responses and repetitive behaviors to inform tools for parents, teachers, and therapists.

By exploring motivations and emotional connections to physical behaviors, we are guided by Picard's insight that "both brain and body interact in the generation of emotion and its experiences" [67:22]. In the vein of understanding the brain-body experiences of autistic individuals, Simms et al. explored the communicative practices of autistic individuals during stress [83]. The design team created a digital tracking system with squeezes of stress balls providing input into a mobile application that would text a trusted friend during a stressful episode. Ringland [70] also explored embodied digital experiences within the context of Autcraft, a Minecraft server for autistic players. Members of Autcraft created spaces and social interactions tailored to their needs, including sensory-aware spaces [72], enacting behaviors to manage emotions (e.g., killing monsters to release anger), and hosting an in-world fireworks show—an alternative to sometimes sensory-overwhelming firework displays in the physical-world [71]. Ringland argues that embodied experiences are also constructed and felt during digitally mediated social experiences. This includes the liminal "transitional space between two states of being or the threshold between two spaces" [70:5].

Recent research in the field of media studies has investigated the intersection of media use with the sensory experiences of autistic children. Alper [1] found that "media play a role in autistic children's sensory-seeking behaviors at home, the integrated ways in which they experience pleasurable stimuli, and how they learn to interpret their own sensoria." Children may listen to music while jumping on a trampoline or may hold up a tablet close to their face while tensing up their whole body. Autistic children may use media to create sensory-friendly experiences, such as creating a virtual fireworks show within Minecraft [71]. Alper proposes compelling directions for future research on sensory experiences, notably, on "the relationship between sensory regulation during media use and one's ability to process messages in those media" and "how might sensory regulation behaviors serve learning and other cognitive processes through media use?" [1:3574].

Our work contributes to research related to affective computing for autistic users by closely examining socio-technical sensory and emotional experiences of adults and the ways that these experiences are represented. In our research, we aim to deepen our understanding of the co-constructed, socially embedded nature of emotional experiences within the daily rounds and routines of autistic adults. An important dimension of this work is to explore how the material and visual representation of embodied emotions plays a role in social interactions. Our focus on autistic adults, rather than children, extends knowledge of the experiences of autistic individuals into adulthood. Autistic adults describe experiencing social anxiety and isolation that comes with negotiating often uncomfortable and ambiguous social norms and social settings. This is amplified by the transitions of emerging adults, which often include novel education, social, and work experiences [91,95].

3 METHODS

Our choice of methods aligns with the social model of disability, which rather than centering perceived limitations on individual attributes, examines barriers faced by disabled people on society norms and infrastructure [66]. The social model forefronts the voices of disabled individuals. In contrast, the medical model of disability focuses on the perceived deficits of the individual. Technological supports for autism have traditionally aligned more closely with a medical framing of autism, typically resulting in digital tools designed to be corrective prosthetics. This limiting approach has been critiqued as embodying "normative expectations of a neurotypical society" [88:10]. Towards countering that momentum, we maintain a commitment to forefront the voices of autistic individuals. This is especially important when researching marginalized groups and as part of our reflexivity as non-autistic researchers [6,80]. We recognize that as allies of autistic individuals with connections to the autism community in several avenues in our personal and academic lives, our lived experiences are from inherently different perspectives than those we seek to more deeply understand. Towards centering the lived experiences of autistic adults, we purposefully used qualitative methods that value staying close to the data and engaging in joint researcher and community reflection.

3.1 Grounded Design – Context Study

We are currently concluding what will be an 18-month Grounded Design project with autistic adults. Grounded Design [95] is a research approach that uses an iterative and collaborative design process to engage with a community of practice. As the name implies, this methodology allows researchers to become deeply familiar with a context of use, to work closely with stakeholders in the design process, and to continually validate conclusions and findings with members of the community of practice. The first phase of Grounded Design is a context study, which is reported in this paper. We focus here on methods of contextual understanding and insights provided by these activities. Future publications will focus on subsequent phases of the Grounded Design research, including our continuing CBPR outreach on emerging themes, technology co-design sessions, and findings from a technology appropriation study.

3.2 Community Observations and Participatory Research Design

To engage in current activities and issues important to autistic individuals, we began our research project by attending autism-related events. Building on previous interactions with the autism community in our region, the research team attended an advertised "Sensory-Friendly Day" at a local zoo. The zoo provided a sensory map of the grounds that marked quiet spaces and a sensory garden. At an indoor space specifically designed for those with sensory sensitivities, we informally spoke with zoo employees, one who self-identified as being autistic. We learned about the measures taken by both designers and program directors to make the zoo more accessible to neurodiverse visitors. Also during the initial phases of the context study, the first author attended a conference organized and presented by autistic adults hosted by a local college to better understand the values, priorities, and preferred terminology of at least one group of autism self-advocates.

Throughout subsequent phases of the context study, the research team participated in additional events including a webinar on autism and trauma, a conference on autism and employment, and conferences on autism-related technology research. The research team wrote research memos and discussed observations and learnings, iteratively building a more grounded, informed perspective on the autism community and current issues.

Based on networking during the autism and employment conference, the first author reached out to the autistic-lead organization Academic Autism Spectrum Partnership in Research and Education (AASPIRE) [100]. During a discussion about this research project, a representative from AASPIRE suggested that we follow their Community-Based Participatory Design (CBPR) approach for conducting respectful and socially relevant research and to facilitate alignment and collaboration between researchers and autistic adults [61]. Their CBPR approach identifies key points of alignment between researchers and autistic adults throughout a research project. For example, during the research development phase, community priorities should influence the research focus of inquiry and study design. Following

this CBPR approach, we gathered input on our research plan from autistic-lead groups, autistic self-advocates, and other representatives of autism service organizations. We met in person with a university-based autism center, a university leadership program for professionals entering autism services, and an organization that provides services to neurodiverse (those with autism and other conditions such as attention-deficit disorder) youth and young adults. During these meetings we gathered feedback on our research goals, research questions, study design, and recruiting plan. We also became more sensitized to the needs, perspectives, and challenges faced by autistic adults, adapting our language and approach to reflect this understanding.

3.3 Participants and Recruiting

Informed and influenced by these experiences, we recruited 18 young autistic adults for semi-structured interviews through the organizations we connected with through our CBPR outreach. Our recruiting message was an invitation to co-design autism technology relating to communication and collaboration. Participants were asked to commit to participating in a multi-step research project composed of "Discover", "Brainstorm," and "Evaluate" activities. In line with our position that the insights and experiences about the lived experience of autism constitute subject matter expertise, participants were paid $75 for participating in the first set of interviews of our Grounded Design research. This research was approved by our university's Institutional Review Board. To protect participant anonymity, we report summarized demographics (Table 1). All participants communicated verbally, were able to recall and describe their social interactions and responses to sensory inputs and had used a personal computing device (including a mobile phone or gaming console) in the past month.

Table 1. Self-described demographics of the 18 research participants

Attribute	Demographics
Age	18 – 31 (average 22)
Gender	6 female, 12 male
Race	White (15), Black (1), Asian (2)
Autism	All identified as "being on the autism spectrum" and/or "autistic." When talking about themselves, several said they "have a disability" and one described himself as "having a slowness"
Location	United States, living in a rural, mid-size city (12) or living in suburbs of large metropolitan city (6)
Living arrangement	Live with parents (13); live alone or with roommates (3); live with spouse (2)
Level of education	Transition program for life and job skills at a community college (12); Master of Music (1), PhD in statistics (1), medical residency program (1), Bachelor degree (3)
Current employment	Employed in technology, music, and education fields. Internships with local retail shops (bakery, feed store, pizza restaurant, computer repair)

3.4 Participant Interviews

After our community outreach and observations, we conducted face-to-face, semi-structured interviews with 18 participants to gain an understanding of their lived experiences, with a focus on their social interactions at work, school, and in their personal lives. Prior to conducting interviews, we piloted our protocol with an individual who identifies as autistic, and as a result we revised questions to use more direct language and more explicitly stated that participants could choose to not answer any questions, especially given the sensitive nature of questions about emotions and sensory sensitivities. While scheduling the interviews, the researcher instructed the participants to bring a 'personal comfort object,' which we described as "an object or written process that they turn to for comfort when they are dealing with strong emotions or sensory experiences (such as feeling bothered by bright lights or loud sounds)." In the interviews, we asked participants about their daily activities and their social, emotional, and sensory experiences. We inquired about (1) their experiences coming to know they were autistic and the strengths and frustrations that they connect to being autistic, (2) their experiences feeling overwhelmed by sensory inputs or seeking out sensory experiences, (3) ways in which they decode emotions of themselves and others. We discussed the

participant's sensory and emotional well-being practices, including a show-and-tell activity of the personal comfort object they brought to the interview. Throughout the interview, we probed into their technology and media use during the experiences they described. We then led the participants through an activity, described in the next section, designed to elicit responses to visual representations of emotions. To scaffold moving through interview topics, we used a visual schedule (Table 2), which is a best practice for supporting neurodivergent individuals during technology research [7].

Table 2. Visual schedule used during interviews to scaffold switching topics and managing time

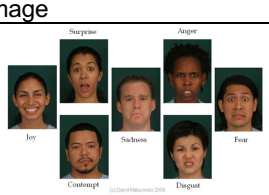
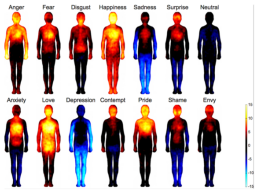
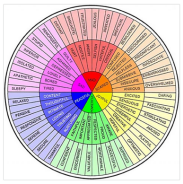
Step	Topic	Minutes
1	 Introduction	5
2	 Your background	10
3	 Sensory processing and emotions	10
4	 Well-being	10
5	 Visuals	20
6	 Wrap up	5

3.5 Method for Engaging with Visual Representations of Emotion

During interviews, we used a visual elicitation method designed to probe participants' perceptions of emotion recognition and expression. For this portion of the interview, the researcher asked participants to respond to existing visual representations of models of emotions and then to create a visual representation for their conception of a model of emotions. Visual elicitation research methods supplement the verbal aspect of typical interviews by introducing visual prompts or ways of responding to questions [7,28]. Visual elicitation methods often help participants articulate mental models associated with sensitive issues such as managing serious mental illness (e.g., [85,87]). In this case, we were also inspired by the prevalence of visuals used in the educational and therapeutic experiences of autistic individuals, such as the schedule chart shown above, reward charts, and communication aids [20,36,69].

The team prepared visual prompts by selecting four visual representations of emotions (Table 3). The criteria for the visual set was that they were a representative sample from (1) field (autism therapy and affective computing), and (2) image type (ranging from photographic, realistic images to simplified renderings to iconography). The first criterion is important because these are images that autistic individuals are likely to have encountered in therapy or as they are exposed to affective computing as described in the Background section. The second criterion was important because autistic individuals respond differently to images based on how realistic they are [15]; in addition, current affective computing uses both realistic and iconographic emotion imagery.

Table 3. Visual representations of emotions used in interviews

Image	Description	Settings	Realism Dimension
 Facial expressions [52]	Facial expressions	Autism therapy, emotion theory, affective computing. We chose an image of adults rather than of children since our research participants are adults and during our community outreach, autistic adults relayed that it was important to tailor the images and future design concepts towards adults.	Realistic
 Bodily maps of emotions [63]	Bodily map of emotions	Clinical neuropsychological assessments. Used in affective computing models for identifying emotions based on biometrics, especially changes in temperature and heart rate.	Realistic
 Feeling wheel [84]	Feeling wheel	Autism therapy and education; emotion taxonomy.	Iconographic
 Feel Emotion Sensor and Feel App from Sentio Solutions Inc. [82]	Emotion wearable and application	Emerging technology in areas of self-tracking and emotional literacy, emerging affective computing in marketplace	Iconographic

During interviews, the participants were asked to compare each of the four visual representations of emotions to their own experiences and mental models. Digital copies of images were presented on an iPad Pro with Apple Pencil, providing participants with the opportunity to annotate, alter, or otherwise visually register their responses to the images. First, the interviewer introduced the activity and gave a brief tutorial of an iPad Pro drawing application, GoodNotes[2]. The participant was given a few minutes to explore the brush styles and colors in GoodNotes. Next, the interviewer showed the participant the visual representations of emotion (Table 3) one at a time, asking the participant to reflect upon what the image made them think about in terms of emotions and to mark anything they would change or highlight in the image to better reflect their personal experience. The interviewer probed for elements in the images that fit or did not fit with how participants conceptualize and experience emotions. They were then asked to draw their own visual representation that shows how they think of emotions. They were asked to draw an image and annotate it with text. During the interviews, five participants stated that they did not want to draw, in which case, the interviewer drew images or wrote notes to match what the participant was saying, asking for verification from the participant along the way. Using the iPad for this activity provided participants with

[2] https://www.goodnotes.com/

the freedom to engage with the digital artifacts at will, including experimenting with different types of annotations. Interactions on the iPad were captured using the QuickTime Player[3], providing real-time recordings of additions, edits, and notations added to the digital images. By engaging our participants in an alternative, visual mode of communication, we were able to triangulate our findings between the narrative portion of the interview, the visual markings and responses to visual representations, and the vocabulary and attitudes evident in their words.

3.6 Analysis

Data from the context study consisted of research memos written soon after community observations, CBPR outreach meetings, and participant interviews; transcriptions of the interviews; and screencasts and edited images from the visual representation of emotions activity. We analyzed the data following an iterative inductive approach [77]. Using MaxQDA qualitative coding software, we conducted open coding of the textual data. Note that our analysis included coding both the textual data and the outputs of the visual representation of emotions activity in similar manners. This consistent treatment of the visual activity was informed by related work using interview and visual methods (e.g., [64]). We identified themes that captured connections between emotions, sensory experiences, and social relationships. We wrote memos on the emerging themes to remain close to the data and refine our analysis. We reported the themes back to the participants and community partners and asked for their feedback. They conveyed that they resonated themes relating to making interactions clearer, making it easier to understand emotions, and increasing independence during social interactions.

4 RESULTS

As described in the Methods section, our contextual inquiry consisted of community observations, outreach, and participant interviews. First, we briefly report on the outcomes of our CBPR outreach. The remainder of the Results section reports findings from participant interviews. To answer our first research question inquiring into how autistic adults conceptualize and share emotions and sensory experiences, we first describe the participants' reported daily 'rounds' [90], a description of the important factors of one's daily life as grounded by routine activities. We then describe the participants' accounting of how their emotional experiences were influenced by social-emotional awareness, recognizing emotions in themselves and others. Finally, we surface how emotional experiences are co-constructed in social relationships and include a component of attending to emotional and sensory needs. To answer our second research question inquiring how autistic adults use or respond to digital technologies within the context of their social, emotional, and sensory experiences, we include sub-sections to specifically report on socio-technical experiences. In our discussion, we will connect these findings to the design of affective systems by introducing a social-emotional-sensory map to guide the digital representation of emotions.

4.1 Social, Emotional, and Sensory Factors in Autism Community

Community observations surfaced issues relating to autism advocacy and considerations for neurodivergent ways of engaging in social and physical environments. Based on the college presentations by autistic youth and adults, topics of importance to the community included the right to be autistic; embodied and emotional considerations related to alexithymia and interoception; neurodiversity and the social model of disability; thinking with the autistic perspective; and respecting autistic ways of playing and interacting. Within the public spaces that our observations took place, attention was given to sensory experiences. The conference coordinators provided streaming for people who preferred to attend the event from home as well as streaming in another room at the conference building for people who wanted access

[3] https://support.apple.com/quicktime

to a low-sensory environment. In this low-lit room, sensory aids (e.g., squeeze balls) and bean bags for alternative seating were provided. Similarly, sensory processing was also a consideration at the zoo event with access to a sensory garden and hands-on exhibits with a limited number of attendees. Children could check out "sensory backpacks" containing exploration tools such as binoculars and checklists.

In addition to providing evidence of the importance of designing sensory-sensitive spaces, our direct engagement with autistic self-advocates and representatives from autism organizations raised three primary considerations related to our research: (1) community preferences to use "autistic individuals" rather than "individuals with autism," (2) limitations of clinical instruments designed to assess emotional literacy and sensory sensitivities, and (3) the importance of minimizing research burden on participants. We incorporated these insights into our research plan and protocols to reflect preferred terminology, use real-world visual representations of emotions, rather than instruments, and minimize extra communications and logistics required of participants.

4.2 Communication in Daily Rounds

During the participants' daily rounds, their communicative practices centered around home, job, and life skills courses; work; and entertainment. Thus, they primarily interacted with family, classmates, work colleagues and mentors, therapists, and online gaming communities. The majority of participants live with one or more parents and siblings, while three of the participants live with partners or roommates. Participants primarily interacted with people who were non-autistic. However, the interactions with other members of the life and job skills program were neurodiverse, meaning autistic and/or identifying with other neuro-atypical conditions such as attention-deficit disorder or schizophrenia.

The participants described their daily rounds as traveling to their workplace or school, then, for some, going to a second location such as a job, internship, or speech therapy. The majority of participants do not drive, instead relying on public buses or rides from parents and extended family. Some participants needed to walk long distances between transportation nodes. For evening activities, they coordinated with others regarding childcare, meals, sharing computers and video game consoles, and family rules for technology usage. Several participants discussed that they prioritize balancing socializing with regrouping in preparation for the following day, as described by Kyle, *"I do want to socialize with people. But I just want to relax. I don't want to do too much at once...because I get too tired...and if I do too much, I get overwhelmed."* Participants described spending time on weekends caring for children, doing chores, and pursuing interests such as job skills training or outdoor hobbies. They talked about valuing their imagination and rich inner worlds, cultivating these parts of themselves by reading books, envisioning imaginary characters, and contemplating alternate realities.

All of the participants described their social relationships as grounded in routine, periodic interactions with family, instructors or job mentors, work colleagues, and a small group of friends. The participants shared that they value these relationships because they can talk about and engage in common interests and have the support of someone who encourages and understands them. Some desire more friends and romantic relationships. Some participants are looking for more independence and autonomy, such as being able to take on more job responsibilities or live on their own. They discussed their steps towards independence, such as getting a job by passing an interview and getting their first paycheck, with a sense of pride. They look forward to future accomplishments, such as Kyle sharing steps he is taking towards moving out of his parents' home into an apartment, saying, *"I feel proud when I learn the skills to get ready to move to my own apartment, like cooking, shopping, laundry, pay bills. Okay, peaceful – I'll be peaceful when I'm in my own apartment and say I did it."* On the other hand, some participants instead felt external pressure from parents and grandparents to be more independent in daily lives, such as managing their medicines or planning their transportation.

To contextualize the participants' social relationships and emotional experiences, it is important to recognize that many of the participants shared past experiences of trauma. These experiences included bullying, feeling separated from peers in school (when in special education classes and mainstream classes), and varying forms of abuse. This finding underscores that "studies suggest that youth with intellectual and developmental disabilities are 1.5 to over 3 times more likely to be maltreated than their peers" [23:3476]. In our study, many of the participants who experienced trauma described memory loss, emotional numbing, and other feelings and behaviors that are psychologically recognized as traumatic stress. Several participants had a continual fear of getting picked on or being physically assaulted, habitually scanning their environment for unsafe people and situations. These traumatic experiences continued to impact their stress levels and apprehension about social interactions in their daily rounds. Next, we unpack the emotional experiences of the participants, as situated in interpersonal relationships and sensory experiences.

4.3 Learning About Emotions

All of the participants described their emotional experiences as rooted in their childhood. Some participants discussed *"hurtful"* or *"traumatic"* experiences from social interactions with family, teachers, and peers. As described in the following sections, they all engaged in interpersonal interactions in embodied ways that are informed by their cognitive styles; however, they faced misunderstandings and misperceptions due to disconnects in communicative and emotional styles with their conversation partners.

The participants described learning emotions in implicit and explicit ways. These early learning experiences stayed with them into adulthood as they reflected upon their emotional experiences. Some participants described learning about emotions from role models, such as parents and teachers. As described by Alana: *"When I was growing up [labeling my emotions] was an issue. Now I'm more in tune with my emotions, and I think as a kid, you just naturally learn from your parents more so than have a sense of your own emotions."*

Many participants discussed their personal emotional growth from their childhood to the present. When describing how they formed their ideas and mental models about their emotional states, self-reflection in the form of journaling was a method for Sarah to parse and interpret her feelings. She would "*be writing out "I don't know why I feel this way" and I'd be like "I guess this thing bothered me and maybe I'm angry about it. Oh, I guess I'm angry." It would be kind of more intellectualizing, before I realized how I felt."*

By describing the events of a day and emotions they had, participants formulated views on their emotional capacities and perspectives. For example, David had a strong philosophical stance towards how he cultivates a positive attitude for himself:

> *"There's drama that I can't control...because been there, done that. I'll stick with just being a peaceful fellow. I remember back then I was usually a big grumpy fellow who was always angry all the time and just roar...But since then, I'm becoming more calm. I pray a lot. I just think peacefully. Because there was this teacher that told me a lot about being positive...and if you're more positive, happiness grows better."*

For many participants, the primary role of technology is having social-emotional resources available through online and other digital media sources. For Alex, some characters in movies were role models for expressing emotions:

> *"This is what I like about Disney, especially the older generation, the Walt Disney movies aren't afraid to let out their feelings, even though it kind of scares people…[Some movies] basically sugarcoat it, don't let out the feelings, which bothers me because I like to not bottle it up, and sugarcoating, like being honest, I was raised up on honesty."*

A few participants talked about explicitly seeking out information about emotions from books and YouTube videos. These were sources for definitions of terms related to emotions and information about how people express and interpret social cues. Drawing from knowledge he gained from YouTube videos, David observed body language to pick up on emotions:

> *"Sometimes when I look in their eyes, I mainly focus on their pupils, actually. Because I watched this video about how to understand a person's view, how they feel, just by looking into their pupils, and I was like ooh, this is interesting. Even looking at their body movements, of how they move, how they act, which legs are they posing, how they use their arms, head, face, eyes, nose."*

David and Emily described their expression of emotions as a form of embodied acting. David said, "I try my best to use my acting skills. I never went into drama… I just watch a lot of movies, videos, try to copy what other people do. Then my expressing emotions from face pictures, like oh, holy cow, eyebrows raising, eyes moving." Sarah used an app, Brain Works [101], for connecting how she was feeling with recommended sensory, physical activities. The app calls this balance of sensory inputs and sensory processing as one's 'sensory diet.' Sarah, who was diagnosed as autistic in adulthood, said that the app was "helpful for ideas" as she learned more about autism.

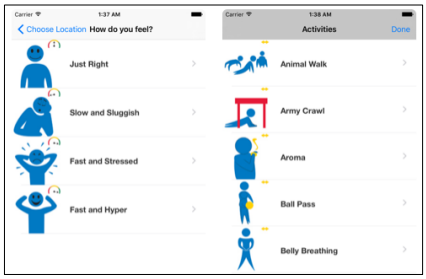


Fig. 6. BrainWorks mobile app for the user to track how they feel (e.g., just right, slow and sluggish, fast and stressful, fast and hyper) and follow prompts for recommended activities (e.g., animal walk, army crawl, aroma, ball pass, belly breathing) [101]. Copyright: Fair use.

The participants' descriptions of emotional learning demonstrate that their affective learning is entwined in their technology and media experiences. In contrast to therapeutic perspectives that emphasize that autistic individuals have difficulty learning from social modeling and self-reflection, our findings demonstrate ways that their learning is both implicit and explicitly detailed, and sometimes self-initiated to seek out knowledge about emotions. This also surfaces the hidden work autistic individuals do to attune to verbal and non-verbal, sensory cues.

4.3.1 Visual Representations of Emotions: Social-Emotional Learning

We observed that their childhood exposure to imagery of visual representations of emotions during social-emotional learning in therapy, school, or home influenced the participants' attitudes towards visual models of emotions. Their learning experiences with visual representations helped them formulate their conceptual models of emotions, and they had specific reasons why the imagery resonated or did not resonate, with their real-world emotional experiences.

During the visual elicitation activity, participants compared the visual representations of emotions to their educational, therapeutic, and social experiences. For Matthew, the general idea of using imagery to represent emotions reminded him of how emotions were represented as discrete characters with unique personalities in the animated Pixar movie, Inside Out. In the film, the internal emotional life of a young girl is depicted as an ensemble cast, including Joy, Fear, Disgust, and Anger, who live in her head and are

continually vying for control of her behavior. Like others, Matthew was familiar with the feelings wheel and illustrations of facial expressions shown in the visualizations we shared. Matthew said that he had seen it *"done plenty of times before, using colors to represent certain personalities."* He quickly noted that he is *"actually more in the yellow section – not energetic but more creative and optimistic."*

For Alec, when he was shown the facial expression image (Figure 1-A), he recalled, *"Oh yes, I remember in my high school life skills class, doing face recognitions."* In his reflection of the facial expressions, he wanted to see the facial expressions on women as well as men, and a wide variety of age groups ("*babies, toddlers, children, teens, adolescents, young adults, even senior elderly people."*) He shared that in his place of employment where the general public comes, he *"can't always know what they are thinking entirely which is why I am with behind-the-scenes type jobs that don't deal with customers. [I am in] slower-paced jobs which I know what some people are thinking, then this helps and this corresponds to the details (of facial expressions) matter."* These vignettes demonstrate that the participants' social-emotional-sensory experiences were constructed within the context of technology and media resources, conceptual models of emotions, and social interactions.

4.4 Identifying and Expressing One's Own Emotions

Feeling and expressing one's emotions is an important aspect of emotional literacy that can be difficult to tap into and describe [5]. Some participants described their baseline feeling being happy or optimistic, although others described generally being, for example, *"neutral"* or *"neutral or sad or anxious."* In this section, we include samples of the personal visual representations of emotions drawn by participants. As depicted in Figure 7, two participants focused on their neutral state when asked to draw a visual representation for how they experience emotions. The emphasis of their neutral state came across in the focus on a neutral emoji during the participant-generated images.

Fig. 7. (a) Emoji with two eyes and a flat mouth. (b) Neutral and angry emojis stylized as bears

Some participants relayed vivid accounts of their sensory, embodied experiences with emotions. For Alana, sadness is felt *"like a very physical pain in my chest."* David described his *"anger and upsetness coming from my heart. Because I can literally feel the inside of my ribs being either warm or cold."* We observed that many participants described feeling flooded by a sense of *"overwhelming"* emotions. For some participants, they experienced swings in both *"positive"* and *"negative"* emotions. Another participant, Sarah, described her tendency for being flooded with emotions as being *"just really sensitive and the world is very intense, and I just take it all in, and I can't block it out."* (Figure 8 (a)). Caylee had developed an imaginary creature, The Flabbergast, who *"was known as the guardian of feelings"* (Figure 8 (b)). Caylee described that The Flabbergast could, by opening her eyes, take *"control of an emotion,"* which are represented by different colors within and around her. The Flabbergast *"cares for emotions and loves them like her own children. She protects them, with all her might because she's afraid that they might take control of her."* In Caylee's case, she imagined the embodied experience of emotion as displaced into the character of The Flabbergast.

Fig. 8. (a) Visual representations of four key emotions: calm, anger, content, and confusion. (b) An imaginary character, The Flabbergast, who controls and protects emotions.

In contrast to swings in the full range of emotions, other participants said their emotional shifts were from neutral to angry feelings (Figure 9). They tended to suppress their anger towards others, and sometimes, on the other hand, could not control their emotional expressiveness. For Mitchell, he depicted his anger (Figure 9 (a) as a stick of dynamite, saying that he is usually a peaceful, happy guy, but *"once someone gets on my bad side, then all hell breaks loose."* When their feelings escalated to *"exploding,"* intense sensory experiences could result in headaches and panic attacks. Alana described a situation in which she *"ended up yelling and screaming and exploding, and that causes headaches and panic attacks...I'm just really irritated and frustrated because they just don't get it."* (Figure 9 (b).) Jack described that when his feelings escalate to a burst of anger, it is similar to how he *"can numb my whole body to take the impact of a punch, but instead it's letting all the energy from all the punches out all at once with my fists. So basically, completely taking the energy from all the punches I have taken over the years and just let it all out at once."* We report on these emotional shifts to highlight how aspects of time, sensations, and origins in traumatic experiences all contribute to these intense, emotional experiences.

Fig. 9. (a) Anger depicted a stick of dynamite. (b) Buildup of distress in body.

Participants considered how their social relationships have been impacted by misperceptions of their emotional needs and styles. For Ethan, he expressed that he *"does not get sad like other people do"* and that this was evidence for him that he *"has a different mindset"* than other people. In the case of Emily, she did not want to express her true emotions to her mother when her mother was asking about her decisions and actions. Rather than expressing her true motivations, she tried showing one type of emotion, hiding the different emotions she felt inside. To share emotions, participants needed to feel safe and comfortable. Then within that context, many participants expressed a desire to be able to more openly share their emotions, as described by Mitchell who wanted to improve "*how to express my feelings more and explaining how I feel about friends and family. (Emotions) in general – positive and negative."* This sentiment highlights that participants felt there were barriers in conceptualizing and verbalizing their inner emotional lives.

During the "show-and-tell" portion of their interview, participants described activities or showed the objects they brought with them that brought them a sense of comfort and pleasure. A sample of participant objects are shown in Figure 10.

Fig. 10. Sample of objects that participants turn to for comfort and relaxation. Top row: (a) Notebook for drawing characters from the animated show Steven Universe. (b) A flip phone. (c) A smart phone with applications for transportation and entertainment. (d) A DVD of a participant's favorite musician and musical educator Bottom row: (e) Support dog. (f) Two Nintendo DS consoles and (g) finger armor.

Many of the participants shared that technology devices and media (e.g., books, DVDs) were sources of personal satisfaction, happiness, and pride. For Jack, video games and playing card games were a reliable source of happiness, whereas other activities that *"try and make me happy don't really making me happy for too long. Usually, they make me happy for a few minutes, five at the most sometimes, and then it just – why am I doing this?"* The pure entertainment value of technology and media use should not be undervalued as a source of positive and contented experiences. Daniel viewed his video watching as purely entertainment, with no connections to education or his future goals, but a way to cultivate the *"entertainment period of my life"* in the midst of feeling *"passive"* about other aspects of his life. However, participants also associated boredom, stress, and family conflict with technology and media. Chase was an avid video gamer who was, as he described, *"what they call a toxic player"* because he talks bad about other players "for doing the wrong thing" in gameplay. In response, *"people are just like hey, calm down, it's just a game. For me, gaming has always been my life pretty much."* His self-described *"addiction"* to video games caused him to *"shrug off doing chores"* and fueled arguments between him and his parents and when he was made to stop playing, he felt *"a lot of emotions happening at once that I do not like."* These scenarios surface the participants' complicated socio-technical emotional experiences that elicited a range of emotions that could be difficult to discern into discrete emotional states.

4.4.1 Visual Representations of Emotions: Neutral and Simplified Emotion Taxonomies

As the participants engaged with the visual representations of emotions, they expanded upon and revealed new insights about how they identify and express their emotions. Visual representations that depicted many emotions—the feeling wheel and the bodily map of emotions—prompted many participants to talk about their primary emotions. Participants stated that the visual representations of the feeling wheel and bodily map of emotions were "*complicated*" and needed to be simplified. This was especially important for Alec who had emphasized his preference for simplification throughout the interview. In interpreting the bodily map of emotions visualization, he *"broke this into two simple categories...bad things would be shame, contempt, depression, anger, fear, disgust, sadness, and the happy things would be pride, love, and happiness."* Some of the participants were particular about how they would describe their emotions. While engaging with the feeling wheel, some participants found that some of the terms (e.g., powerful) did not seem like emotions but rather an attribute of someone. The words in the middle circle felt more natural to some participants as a way *"to really express"* emotions. Some participants did not want to use a term that they perceived as having a negative connotation. For example, Emily said, "*I think it is not a good idea to always say I'm scared because I'm afraid if it means something more of the negative, you should say I'm concerned, or I am confused...it sounds better."*

Most participants focused on the emotions they typically feel or desire to feel, often circling them as in Figure 11 A-B below. Many participants crossed out the emotions that do not resonate with them, as Alex did in Figure 11-A, crossing out what he termed *"the negative"* emotions stemming from sad, mad, and scared, stating he mainly stays happy and optimistic.

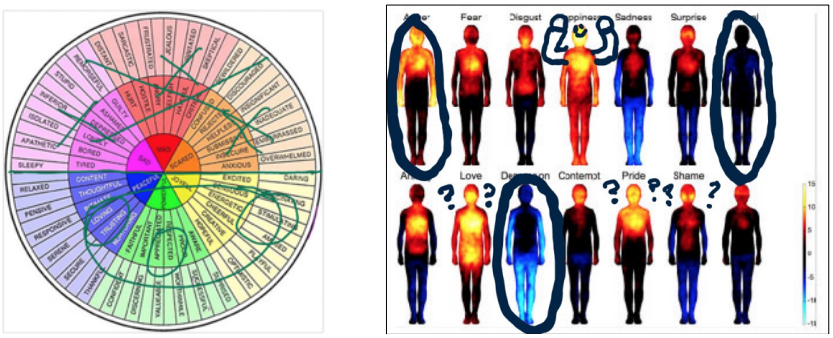


Fig. 1.. (a) A participant marked up the feeling wheel image, crossing out emotions he did not respond to and circles around emotions that resonated with him. (b) A participant circled the body maps for anger, neutral, and depression, indicating she agreed with those depictions. She added flexed arms on the happiness body map to show she felt strong when happy.

Several participants wanted the experience of feeling neutral to be better represented in the images, some of which omitted neutral altogether (i.e., the feeling wheel, facial expressions, and emotion wearable). Sarah's self-described baseline emotional state was "*neutral*," and she proposed that 'neutral' be added to the basic emotions in the center of the feeling wheel and colored grey.

Participants had a mixed reaction to using a wearable device and application like the Feel Emotion Sensor and Feel App, ranging from enthusiastic (as Joanie did with stars in Figure 12) to very reticent. Most participants were intrigued by the concept, as Joanie was, claiming that a device like this would help her be more confident about her emotions. Other participants were curious to know what the device identified as their emotions and how their feelings changed throughout the day.

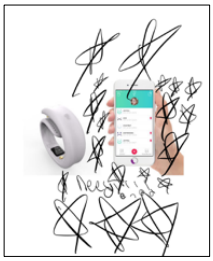


Fig. 12. Joanie wrote "need!!" among her stars of excitement for the Feel Emotion Sensor and Feel App.

However, many had concerns about a digital device attempting to access their emotional states, citing doubts about the technology accurately sensing and classifying their emotions. Emily was *"not interested (in such a device). I don't know how they define and analyze heartbeats [and how it] would go into emotions. I don't want someone to predict or analyze that part of the emotions [from] my body."* Another reason for doubting emotion-sensing technology was the lack of confidence that a device could track all the minute changes in biometrics and emotions, then relay that in a meaningful way to the person wearing it. Jack raised an interesting perspective that *"some people have nothingness (and the app) would literally be showing blank."* Participants also noted that changes in biometrics, such as temperature, depends on the context of the place they are in and who they are with. One participant shared that he has high blood pressure and expressed doubt that the device could accurately discern the meaning of his biometrics. Due

to these concerns, the majority of participants said that, if they used such a device, they would do so for their own experimentation and keep the application private from even close family members.

In summary, the visual representations we showed to participants failed to capture the embodied associations and expressions of emotions that they rely on in real life. The visual imagery and taxonomies were not tailored to the emotional states, embodied experiences, and terminology that resonated with the participants. To implement the strategies they have been taught, they need representations of emotions that are discrete but also nuanced and that make strong connections with sensory states.

4.5 Recognizing Emotions of Others

Recognizing the emotions of other people involves perceiving emotional signals and then interpreting those signals. A prominent sentiment among the participants was that they wished they could better understand other people's emotions. Kendall wished for a superpower to be a "*mind reader to know people's emotions. [I could] hold up a phone to their face and it would tell me what their facial expression is and what their emotion is."*

Recognizing emotions in others was not an all-or-nothing activity for many of our participants; rather, they were more attuned to certain signals over other signals. Several participants noted that they were more likely to notice and understand facial expressions over other emotional cues. Participants shared that they tend to miss emotional signals that were *"more subtle,"* such as tone of voice and the particularities of word choices. If they were unsure of how to interpret a non-verbal communication signal, some participants would be, like Alana, *"very direct in that way where I will ask, what's happening here."* Kyle described a recent conversation with his mother in which he could *"tell she is sad when she's crying. I get it...I was born very slow. When she is crying, I feel like I hurt her feelings by accident...I do get why she's crying, like she can't let go of her son."* This example exemplifies the open communication in which the participant and his mother are sharing an intense, emotional experience. We explore the phenomenon of the co-construction of emotional experiences further in section 4.6.

4.5.1 Visual Representations of Emotions: Calibrating Interpretations of Emotions

The visual representation that prompted the most conversation about reading the emotions of others was the facial expression image. Several participants noted that they have seen similar images used in life skills classes and at doctor appointments for *"reassessment of disability."* Daniel articulated the key attributes he noticed in the faces, saying, *"I do associate joy with a smile, surprise with wide eyes, slack jaw...Sadness, frowny face, I guess. Anger, baring teeth, low brow, yes. Disgust, scrunched back, yeah. And fear, wide-eyed."*

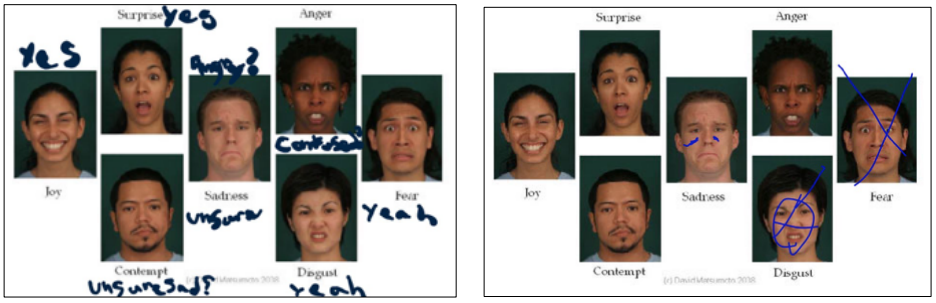


Fig. 13. (a) A participant edited the facial expression image to indicate they agreed with the depictions of joy, surprise, disgust, and fear, but not the other emotions. (b) A participant added tears to sadness and did not agree with the expressions for disgust and fear.

Most participants had a strong reaction to the facial expression image, proclaiming that the expression looked "*comical*" and "*over-exaggerated*." They were also not in consensus with the labels given to the emotions. Some felt that sadness looked more angry than sad or needed tears to truly be sad (Figure 13).

Many of the participants did not think the emotions of contempt and disgust were clear or necessary. Some participants asked the interviewer for clarification of what contempt meant and even after hearing the definition, did not resonate with that emotion. A few participants remarked on the unbalance of gender and racial representations of the actors. They noted the need for full representation of gender, ages, and races for all of the emotional states. Their responses demonstrated attention to patterns and tendencies to systemize, which is a common trait of autistic individuals [4,73] as well as attention to social factors in reading emotions. This perspective aligns with prior work, described in the Introduction and Background, calling for fuller representation for gender and racial representation in emotion AI and other algorithmic modeling.

4.6 Social Construction of Emotional Experiences

Last, we surface how emotional experiences are co-constructed in social relationships and include a component of attending to emotional and sensory needs. These findings contribute empirical evidence of the constructivist framing of emotions, which, as discussed in the Background section of this paper, posits that emotional experiences are constructed within a given context, which includes the social context. Most participants shared they were motivated to engage in social activities for their benefit (e.g., attending a dance) and to support close family and friends (e.g., going to an art show). Participants described that participating in social interactions is often heightened by an underlying emotional state of anxiety and stress. Social interactions could be exasperated by sensory experiences, such as a ticking sound in the background or a nearby hyperactive child that *"overwhelms all of your senses."* Social interactions could also be made uncomfortable due to a combination of sensory inputs and social pressures, such as being surrounded by people who want to talk with you. Participants were particularly aware of when their sensory and emotional needs were different than their close family, as conveyed by Alana:

> *"I just felt extremely alone even inside my family, and so that's another tough spot, because – sorry. [tearful] They would say things like oh, she's antisocial and I didn't know what it was. But I would literally go to a family function and just go to a room by myself with a book, and I would be fine. I didn't think anything of it, because I was happy. But to them I guess it was offensive or oftentimes I wouldn't speak, I wouldn't say hello or things like that. They would get upset."*

Participants also expressed discomfort due to being questioned by strangers. For example, Kendall described rocking and enjoying the music at a rave when organizers approached her, shined a flashlight in her eyes, and asked her if she was ok. Kendall perceived that they thought she may have been on drugs so she *"came out. I told them I am autistic. I'm fine."* Kendell felt embarrassed and anxious and left the event. As participants had experiences like Kendall's, they anticipated misunderstandings for future interactions and some took steps to mitigate potential confrontations. For example, Alec shared that he experienced sensory overload and stress when flying,

> *"I always have an autism card on me, I give it to the passenger next to me and also the flight attendant as well so that they know that I have autism. And it's served me very well because, in the past, air travel didn't go very well when I was younger because I became panicked and afraid of air travel."*

Writing as a communication strategy also resonated with other participants including Alana. When she was in a series of arguments with a close family member, she felt communication was *"better in writing. That way emotions don't get too high. When we're talking face to face, it's not good. So oftentimes we'll text or sometimes I'll write a letter."* Some participants expressed explicit ways they wished they could influence others' emotions and behaviors during social interactions. For instance, when describing conflicts he experiences with parents and teachers, Chase expressed that he wished he had *"ice powers. I would ice*

their mouths. I'd keep people I don't like away from me. Freeze them out...Not in a negative way – more like a positive way; a fun way." In a similar vein of keeping negativity at a distance, David was bothered that, *"whenever someone tells me about how their day went, it's usually negative. I want to be positive and for them to be positive, too."* By these actions, participants attempted to predict and impact the social-emotional experiences of other people. These insights add to the potential role of affective computing in not just reflective affective states, but actively shaping affective experiences.

4.6.1 Visual Representations of Emotions: Emotional Signals Between Social Partners

The notion of how emotional experiences are socially constructed raises the issue of functionally similar vocabularies. Differences in vocabulary or variations of interpretation among people can add to the difficulty in establishing a mutual understanding of emotions. This can be especially relevant for autistic individuals since "63% of children with ASD meet criteria for a language disorder and even those with large vocabularies and strong verbal abilities often struggle to communicate their emotional struggles and experiences to others" [45:3476]. Consistent with this tendency, during the visual representation of emotion activities participants regularly asked for definitions of descriptors (e.g., contempt, discerning) in the feeling wheel and the facial expression images.

Facial expressions, such as those in our visual representation, also did not resonate with all of our participants as predictable means of either expressing or perceiving emotions. Some participants described situations in which people questioned them about their emotions based on their facial expressions, which in turn created a feedback loop in which they were then uncomfortable for being questioned. A fairly common experience for the participants was that other people interpreted their baseline facial expressions as negative when the participants were actually feeling neutral. As Sarah shared, while looking at the facial expressions image,

> *"I don't always show these facial expressions when I have a feeling. I feel like I usually have a pretty blank expression. I will smile and laugh when I'm happy... but I don't think I make these faces all the time when I'm having these feelings...I notice that I tend to have the facial lines of sadness when I'm just neutral or when I'm concentrating...My concentration face looks sad, and I've often had people come up to me and say that I look sad."*

In terms of reading emotions, they also do not always attend to faces due to sensory and social overload, as found in other research [96]. When they do attend to faces, the participants' interpretation of facial expressions varied widely during our visual activity. In essence, based on the participants' engagement with the facial expression image, the emotional signals between participants and their social partner would be ascribed different meanings by each person. This misalignment led to feeling emotionally disconnected from their social partners and having misunderstandings during communication and coordination activities.

5 DISCUSSION

Our study demonstrates that autistic young adults have complex, layered, and situated emotional experiences that are influenced by (1) their internal sense of self, and (2) their perceptions of external—social and physical—worlds. Our findings provide empirical examples of the ways that these experiences are built from a combination of social, emotional, sensory, and technological factors. In our discussion, we situate our findings within knowledge about autistic adults pertaining to affective, socio-technical phenomena. We present a tool for charting affective computing design, which we term a social-emotional-sensory design map.

5.1 Affective Phenomena in Autistic Young Adults

Autism is typically characterized in terms of 'emotional deficit.' However, our participants described ways that they think about their own emotions, seek to learn how to recognize emotions in others, and practice expressing affective responses. At the same time, other participants discussed how it is difficult to know what they are feeling and described not having rich access to their emotions. As to the question of whether participants experience discrete emotions or a combination, participants described emotions in a variety of ways that do not fit neatly into one emotional theory or another. The notion of six basic emotions did not resonate with our participants, neither in number nor categories of emotions. Some participants described how they primarily feel positive emotions, others felt more negative emotions, and yet others described their primary emotional state was neutral. The diversity of participants' access to their own emotions resonates with aspects of alexithymia, and on the other hand, shows alternative routes and areas of sensitivity to, and interest about, emotions.

As young adults, their emotional experiences are poignantly rooted in their childhood experiences and, for those living with parents, are tightly integrated with their family. Many participants experienced traumatic events such as bullying and abuse, which result in long-standing emotional strain on individuals, consistent with other reports of trauma in the autism population [45]. The formative childhood emotional experiences of autistic adults, coupled with ongoing impacts of navigating social worlds centered on neurotypical social norms, contributed to an underlying sense of stress in the face of emotional situations and a desire to establish protective boundaries. Our work adds insight into the effects of exposure to traumatic events for autistic individuals, effects that are not well understood [38]. Participants relayed that trauma had influenced them to hide and dampen their emotions, tendencies to shut down, and the desire to avoid overly-emotional situations. In extreme situations, participants talked about how traumatic events in their past have influenced their desire to create rich internal, imaginative worlds.

Barrett's emotion theoretical framework of constructed emotions [5] informs the meaning of our findings. Our participants' emotional experiences were constructed in-the-moment as they anticipate, engage, and reflect upon social interactions. Their memories of experiences were sometimes crisp and visceral, and at other times, unclear as they pieced together the social, temporal, and embodied aspects of the interactions. For example, during social engagements, they focused on the activities that felt most comfortable to them, responded in their particular emotional style, and took social and sensory breaks when they needed them. However, the impact of these actions is dependent on the emotional and configurations of social engagements. They tried to mitigate social discomfort for themselves and others by employing diverse tactics, including distributing 'autism cards' and avoiding overstimulating crowds. The resulting social dynamics varied widely, with participants recalling situations in which they felt misunderstood and placed in the position of being different and 'othered' by family, friends, and strangers.

Our findings contribute knowledge about autistic adults to recent autism research on children highlighting connections between typical autism characteristics, such as research examining sensory over-responsivity, repetitive behavior, and emotional functioning [41]. Some participants readily recalled distinct connections between emotions and bodily sensations, thus, aligning with theories of embodied emotions and research into modeling emotions in affective computing. Some participants certainly wanted the opportunity to use wearable devices that identified their emotions as a mechanism for them to validate their emotions with themselves and others. More research is needed in this area to further understand the commonalities and differences between physiological affective phenomenon, and collaboration between neuroscientists and technologies to integrate findings from neuroscience about known differences.

Sengers calls for designers to reconsider typical approaches to affect in computing, which typically result in "inadvertently disenchant[ing] affective experience, rendering it explainable and categorical, and, in the process, reducing its richness to the simple kinds of categories available to a computer" [81:348]. The emotional experiences shared by our participants reflect more enchantment, using Sengers' term, than

given credit for in traditional autism literature. Given (1) the diversity of emotional experiences described by participants and (2) consistent themes in our data, including the communicative roles of embodiment, socially dependent contexts, and technology, our research indicates that there is value in developing models of affective phenomenon experienced by neurodiverse users. However, these models need to be nuanced and flexible. There is an inherent conundrum in attempting to universally, definitively categorize affective phenomena that is centered in diverse individuals and dynamic social groups. Hence, rather than claiming to delineate a framework, model, or stable design space, we offer a design map to help creators of affective computing systems identify, weigh, and prioritize different socio-technical dimensions of emotional experiences in communicative contexts.

5.2 Role of Technology and Media in Emotional Experiences of Autistic Adults

Participants made use of media-based technology, crafting their socio-technical toolset to both learn about emotions and to support their engagement with emotions in social contexts. Our findings build upon those of Alper in her study of autistic children and their use of media for sensory and emotional processing [1]. Technology and media use bridged the complex emotional lives of participants, which they sometimes guarded even from close family. We noted contrasting relationships with technology. At times, technology use involved conflicts with family and feelings of depression, anxiety, boredom, and stress. At other times, participants used technology and media as tools to bolster positive emotions and handle negative emotions and sensory sensitivities.

For autistic adults, the media and technology use was negotiated within the context of a family with an emerging adult. Thus, the young autistic adults were advocating for more autonomy and independence, striving to establish new boundaries regarding media and technology use. We found that autistic adults use technology and media as tools for engaging in activities they perceive as safe and bounded, which gives them a sense of security in its familiarity and predictability. This can take the form of re-watching a beloved movie to using an airplane flight tracker to provide up-to-the-minute information about their flight. When viewed within the context of trauma stress, these behaviors and the desire for security and predictability take on increased significance. Their coping strategies of immersing themselves in technology use and choosing when to disclose or reveal their emotions could be reframed as healthy, strategic moves similar to emergency room personnel's concealment of emotions for workplace norms [57].

All of our participants had been exposed to affective therapy and education. Emotion-related therapeutic strategies in autism typically use visual aids and computer applications that use visual representations of emotions [31,88]. We found that participants found these visual representations of emotions limiting because (1) the images did not adequately represent the emotional states that were most relevant to them, (2) the textual and visual taxonomies of the images did not match their mental models of emotions. It is important to note that this issue around language is not just one about language impairments. It is a fundamental issue with how humans connect to emotional states since "there is no way to ensure a consistent link between internal experience and the language or terminology to describe it" [57:42]. Further research should examine the use of language and vocabulary in affective computing when engaging with neurodivergent and other populations.

5.3 Social-Emotional-Sensory Design Map for Affective Computing

Given these technology practices and what we learned about challenges with affective systems, we argue that affective computing design would be enriched by examining the intersection of social, emotional, and sensory experiences of autistic individuals. To formalize this examination, we present a social-emotional-sensory design map, depicted in Figure 14.

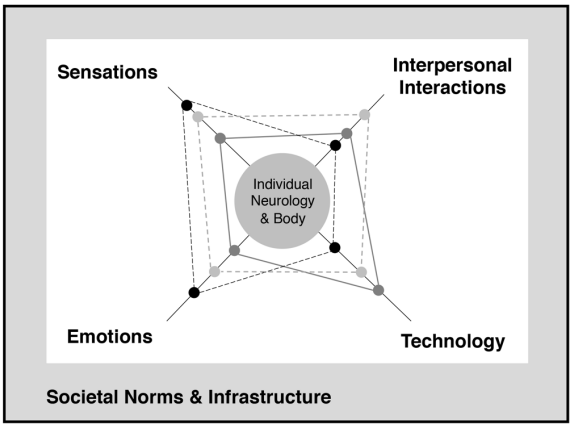


Fig. 14. Social-Emotional-Sensory design map for affective computing. ©A. Zolyomi and J.Snyder.

By using the concept of a map, we point designers and researchers towards a rich site of exploration. We offer the term 'design map' as an alternative to other conceptual design frameworks, such as 'design domain' or 'design space.' The urban planner and educator, Schön, advocated for reflective design practices and defined design domains as rich descriptions of particular design settings in terms of concepts, words, language, and notation [80]. A *design domain* typically represents a set of normalized and concretized practices, resulting from a formalization of a set of design problems and stakeholder groups. Similarly, a *design space* is a tool for design teams, often in technology and product design, that scopes a design exploration (e.g., [14]. The dimensions of a design space are commonly bounded by (1) a limited number of dimensions, often depicted on a grid, and (2) the priorities and technology afforded to the product development team. In contrast, we use the term *design map* to describe a tool to be used to navigate a dynamic, non-normative, or less clearly delineated problem space. By depicting a set of influences with varying impact on a design space, a design map does not represent an unequivocal definition, but rather captures a set of sliding measures to be considered during the design process. Similar to an equalizer or mixing board, we offer this tool as a means for designers to visualize the ways in which social, emotional, sensory, and technological factors impact the space in which they are working.

The phenomena pointed to by the social-emotional-sensory design map are not set in stone, but rather, are dynamic, emerging from current experiences, perceptions, and activities of people—in our case, autistic adults. The social-emotional-sensory map has several key aspects: (1) emotional landscapes of individuals and groups, (2) communicative practices and social norms enacted by the group, and (3) sensations, constraints, and opportunities presented by the physical infrastructure and environment. The setting occurs in a particular environment (virtual, real-life, augmented) at a particular time and place. The design map is viewed within the lens of the social model of disability. Thus, the map is embedded within an individuals' lived experiences with disability and barriers imposed by society and infrastructure.

This design map moves the focus of affective computing from the classical goal of segmenting and classifying the emotional experiences of an individual to creating constructed, personalized models of emotional experiences. The social-emotional-sensory design map acknowledges people who experience emotions in different ways, creating an alternative to affective computing systems that presuppose or dictate normative measures and representations of emotion. Normative measures are a means to, as described by Sengers, "inadvertently disenchant affective experience, rendering it explainable and categorical, and, in the process, reducing its richness to the simple kinds of categories available to a computer" [81:348]. The design map reimagines the connections between mind-body-emotions, allowing for unique expressions of interoception, including those that experience disconnections and mixed signals.

To see how the design map supports this shift, let us construct an imagined affective wearable device designed according to this approach. Our imagined affective wearable device is a fictional alternative to currently available wearable devices that show pre-determined emotional states through a daily log populated with emojis. In contrast, our imagined wearable device situates an emotion *event* within a *particular location*, *timeframe*, and *social activity*. Our imagined affective wearable device scaffolds interpretation of affective experiences. Prior affective computing research has highlighted the importance of co-interpretation of affect, which our work supports, although prior work has focused on joint interpretation between humans and machines [81]. In contrast, our work highlights the importance of emotional *co-construction* within a social group. Importantly, this act of co-construction applies not only to the present interaction but interpretations of past experiences and anticipation of future ones. Therefore, our imagined affective wearable device would help the wearer make connections between *patterns of social-emotional-sensory experiences*. The device could support the wearer in working through emotional experiences that they view as difficult, rather than the device automatically classifying experiences as positive or negative. An extension to the wearable could be an application that scaffolds verbal, such as scripts or prompts, and non-verbal communication according to the preferences and strengths of members of the social group. The design map also allows for the reconstruction and reconfiguration of emotional experiences through individual and shared memory, which can be aided by affective technology. Some technologies have considered ways to support the recall of emotional memories [56]. Our imagined affective computing device would be an emotionally-supportive tool for autistic adults as they recall and anticipate social-emotional experiences.

Given the potential pervasiveness and opaqueness of affective computing, individuals unknowingly engage with affective computing, such as on social media. Similar to our participants' concerns about privacy, agency, and potential harm of these systems, the general population has been found to want these systems to be more accountable to their concerns and values [3]. As highlighted by Andalibi and Buss, when emotional information is encoded, stored, and shared by affective computing systems, we must recognize that emotional data is highly sensitive. There is a risk to autistic individuals, as a marginalized population, to be targeted for emotional manipulation and exploitation. Further research is needed to explore protections to emotional data and experiences of autistic and other vulnerable populations.

5.4 Limitations and Future Work

Our work does not represent the full diversity of the community of autistic young adults. For instance, all participants in our research communicate verbally, thus our work does not include the perspectives of autistic individuals who are non-verbal. Future work could explore the emotional experiences and communication of non-verbal autistic individuals, including those who use augmentative communication tools. To deepen our understanding of language in connection to emotions, future work could examine the vocabulary, metaphors, etc., that is available to verbal, non-verbal, and autistic individuals who experience selective mutism [89].

Another methodological limitation is that we selected four specific visual representations of emotions based on criteria regarding source (autism therapy and affective computing) and realism (realistic to iconographic). There is a range of images that could have been chosen meeting these criteria, or the criteria could be altered for another dimension, such as gender and race matching that of the participant. Future work could select other specific images or alter the selection criteria, which may result in different insights from the participants.

Since we centered on understanding the lived experiences of autistic adults, our work thus far did not include observations or interviews with non-autistic members of neurodiverse social groups. In the next phase of our research, we will interview trusted social partners of autistic adults to gain a more holistic perspective on the co-constructed nature of emotional experiences. We acknowledge that our social-emotional-sensory design map is emergent, and as is the nature of maps, is not the actual territory. We

resist “reifying the map as unitary, fixed, coherent, or encompassing of all aspects of the territory” [25:174]. Therefore, to further explore, and apply our social-emotional-sensory design map, we will conduct participatory design and technology appropriation with autistic adults according to the grounded design paradigm.

6 CONCLUSION

Our research provides empirical evidence that the affective experiences of autistic young adults can diverge sharply from the theoretical, computational, and visual models encoded in therapy, media, and affective computing systems. We found that technology influences the ways in which autistic individuals learn about, emulate, and enact affective responses and emotional states. We argue that, by examining the embodied and co-constructed nature of emotions, affective computing would more richly support the affective experiences of autistic adults, and other marginalized groups perceived as having non-normative emotional experiences due to communication, cognitive, and cultural differences, including people with aphasia or dementia.. We contribute a social-emotional-sensory design map that formalizes the examination of the embodied and co-constructed phenomenon of neurodiverse social groups. In practice, applying the design map for affective computing carries with it a commitment to design affective computing that explicitly supports diverse, non-normative expressions and perceptions of emotion. The design should account for ethical considerations to protect privacy, vulnerabilities, and disclosure, especially given that the data is even more vulnerable because it captures personal, emotional states and information about location, social groups, and infrastructure. Our work is a step towards making affective computing more inclusive and enchanted—and critically, not introducing harm—by accounting for situated and embodied emotional experiences of autistic individuals.

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