Intimacy at a distance: An autistic approach to wearable design

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Abstract

What might internal perspectives bring to the design of wearables for autistic people? In this report, I first explore how wearable designs are created and used in relation to autism and autistic people through a small literature review. From this, I propose autobiographical approaches as a way of challenging the status quo. Through an autobiographical design process, I continue the development of a wearable compression garment for symmetrically showing affection through hugging at a distance. I center my work in my own autistic social and sensory experiences to explore how an autistic approach to designing wearables might look. While the resulting prototype is comfortable for longer term wear, it had several technical limitations making its compression insufficient.

Introduction

In HCI, as elsewhere, autism has traditionally been regarded from an allistic (non-autistic) perspective. This has recently been criticized from within, as being patronizing and othering, disregarding the agency, needs and desires of autistic people to instead correct and align with allistic expectations [26,43]. This criticism mirrors a broader sentiment, which argues for autistic knowledge creation, both as distinct fields, e.g. critical autism studies [53], and within existing fields such as psychology [5]. Essential to this development is the sharing of autistic experience. From a philosophical perspective Hacking regards the relatively recent appearance of autistic autobiography as prototyping new language for describing autistic experience [20]. I argue that extending this process to HCI is essential to challenge current conceptions and further the field.

The specific design context for this project is autistic co-habitation and affection. One common experience among autistic people is touch aversion, feeling significant discomfort at physical contact [48], often as a result of high sensory load. This may be challenging for co-habitation, as expressing care and affection is often physical. At the same time, the use of compression may have a calming and comforting effect. Building on a previous design, this project proposes mutually activated compression as a method of hugging at a distance.

The goal of this project is to concurrently demonstrate an autobiographic design approach to autism [35], while iterating on a design for autistic co-habitation. In this report I first present a review of papers concerning wearables and autism, and discuss tendencies, limitations and blind spots of these, to argue for autobiographic approaches. From here I document the development and preliminary evaluation of a muscle-wire based compression wearable, for mutually showing care and affection.

Finishing up the section, I recognize that I probably need to support my claim of touch aversion as a common trait. This feels odd for something that seems like general knowledge to me and the autistic people I know. To live up to my learned expectations of rigor I scan through papers to find a medicalized validation of my experience described as disorder.

Throughout the work, I make personal reflections on the process.

Related work

In this section, I review the current state of wearables targeted at autistic people, and look into wearable designs making use of compression in general.

Wearables and autism

At the beginning of this project, I conducted a small literature review using the search term (*autism* or *asd*) and (*wearable*(*s*) or *worn*) on the ACM digital library. This resulted in 41 papers. Of these, four were deemed irrelevant and four were papers referencing an already included project. The remaining 33 were thematically categorized along three themes: *Behavior analysis and intervention*, *Therapy* and *Assistive technology*.

Behavior analysis and intervention

One focus of these papers concern technologies for recording, detecting and analyzing autistic behavior (exemplified in fig. 1): Goodwin et al. propose a system for "detecting stereotypical motor movements" (colloquially known as stimming, a self calming behavior), to inform intervention [19]. Both Chong et al. and Ahn et al. propose systems for screening for autism by detecting autistic behavior [1,9]. Albo-Canals et al. and Ward et al. propose systems for detecting progress in the social behavior of autistic children. They do this by video recording behaviors with a robot, and sensing synchronous movement during theater performances respectively [2,51]. Takano and Suzuki propose a system for explicating autistic facial expressions using lights on a head-worn device [46].

Finally, two papers discuss design implications for designing these kinds of systems: Bell et al. explore how to get autistic children to wear wrist-worn accelerometers for collecting behavioral data. The authors conclude that the biggest challenges with wearable technologies are children's familiarity with the devices, comfort wearing it and fashion. They suggest having a period of desensitization with the devices, and considering more discrete locations than the wrist, to keep attention off the device, minimizing play and removal [4]. Sharmin et al. conduct an extensive literature review of "ASD-support smart technologies for children". From their review, they identify limitations in the field, among these a lack of studies collecting data in natural environments and/or over longer time periods. [41].

A smaller group of papers (exemplified in fig. 2) discuss technological interventions for changing autistic behavior. These include teaching autistic children to maintain social distance using a stomach-worn sensor and a smartphone interface [22], using electronic bracelets to encourage physical touch [45], smart-watch notifications for instructing behavior [54], or robotic wearables integrating AI for measuring, reporting and correcting autistic behavior [8].

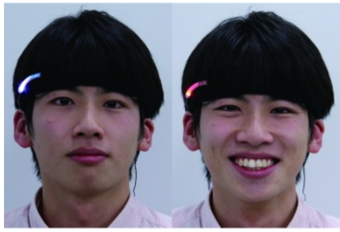

Fig. 1: Explicating autistic facial expressions with LED lights (left) [46]. Prototype accelerometer wristbands for children (right) [4].

One tendency among these papers is the conflation of autism and autistic behavior, and seeing its visible reduction as a success criteria: Goodwin et al. aim to support interventions in stimming behavior [19]. Jiang et al. aim to teach autistic children interpersonal distance [22]. Chen et al. propose a system reporting daily percentage scores of how autistic a child is with automated interventions to reduce it. To me, this reflects a desire to make autistic individuals appear normal and fitting to allistic society, possibly at the cost of autistic life quality and individual autonomy.

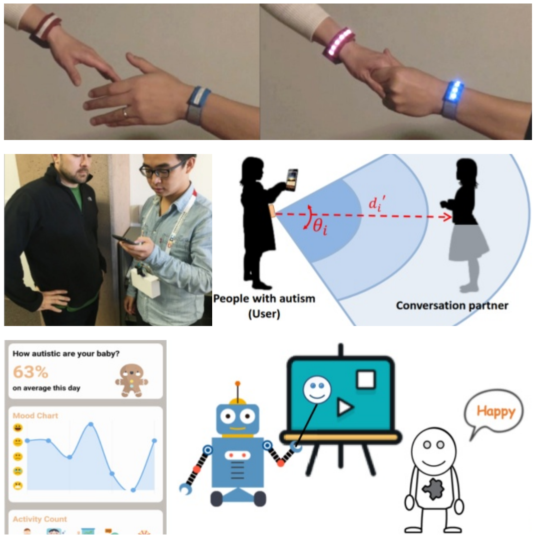

Fig. 2: Wristbands for detecting and encouraging physical touch (top) [45]. Teaching interpersonal distance with a stomach-worn sensor: Prototype, scenario sketch (middle) [22]. Using a robot for reporting and intervening autism: App interface, scenario sketch (bottom) [8].

Reading through the papers, I come across a remark on an autistic kid who refused to wear a motion tracker stating that he's not a criminal [4]. I feel a mild kinship, being reminded of my own occasional distrust of authority figures through my childhood. Then the discomfort hits me of a project making its participant, even if only one, feel like a criminal.

Therapy

The second group of papers (exemplified in fig. 3) discuss the creation of technologies for supporting existing therapy practices to give autistic people greater agency in their lives: Multiple papers discuss using VR and AR for practicing social stories (e.g. learning the steps involved in taking the train) [15,49], or for augmenting therapy sessions [14]. Giocondo et al. and Ozcan et al. both develop interactive soft toys for learning social practices with a caregiver [16,36], while Koo develops interactive clothing to encourage autistic children to express themselves [27]. Cibrian et al. (2019) explore how a smart watch interface can support transition from emotional co-regulation with a caregiver to self regulation [10], while Cibrian et al. (2018) documents a pilot study into the sound preferences of autistic children, for music-based therapy [11].

Fig. 3: Interactive clothing for self expression (left) [27]. Interactive toy for encouraging interaction (top right) [16]. AR social stories for practicing daily tasks (bottom) [49].

Worth noting is that all but one paper in this theme focus children [49], which is the highest proportion of all three. This suggests a lack of representation of autistic adults in therapy. This would especially affect late diagnosed autists, who are disproportionally women [3].

Assistive technology

The final theme of assistive technologies focus on creating technology to empower autistic people in their daily lives. One subcategory of these technologies involve analyzing interaction: Multiple papers document the creation of smart glass software for helping autists identify the facial expressions of others (fig. 4) [30,50,52]. el Kaliouby and Goodwin propose a different approach in using a wearable to support the wearer in capturing, quantifying and analyzing their interactions with others [24].

Two papers propose technologies for facilitating better communication and understanding between autistic children and their parents. Koumpouros and Toulias use a smartphone or smartwatch app to let parents monitor their child's location and heart rate while providing quick contact methods [28]. Marcu et al. use a body worn camera to let parents see the world from their autistic child's perspective (fig. 4) [32].

Boyd et al., create a user controlled heads-up display for notifying their user if they are speaking too loud or tonally flat in conversations [6]. Two papers build assistive tools for non-verbal people, creating soft communication boards for horse riding (fig. 4) [38] and classification models for non-verbal vocalizations [33].

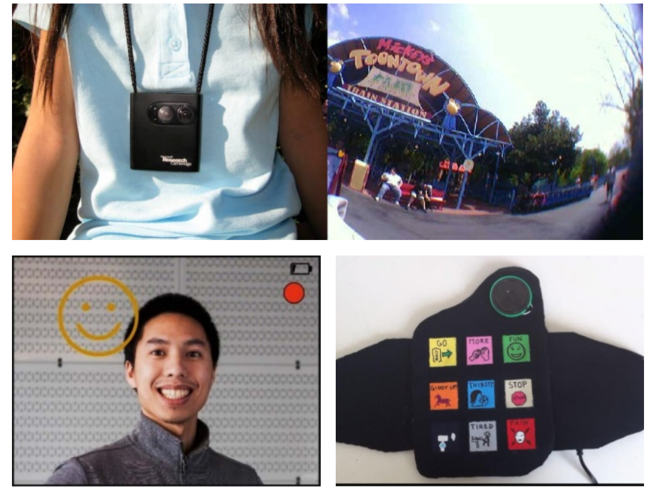

Fig. 4: Recording experiences from autistic kids perspective (top) [32]. Smart glass facial expression recognition (left) [30]. Soft communication board for horse therapy (right) [38].

Three of the papers develop garments for pressure therapy (fig. 6). Duvall et al. create a pressure vest for children with sensory processing disorder (SPD). Using shape memory alloy (SMA) springs, contraction is activated remotely through an app [12]. Goncu-Berk et al. establish design requirements for a pressure vest, based on an analysis of online discussions and sales pages related to tactile products for people with dementia, Alzheimer's SPD and autism. These design requirements include the location and amount of compression (gradual pressure on shoulders and back and sides of torso), comfort (must be breathable and not restrict movement), visual style (must blend in), and user experience (ease of donning and doffing different among groups). From this, they produce an undershirt with embedded air bladders to provide compression [17]. Goncu-

Berk et al. follow up on this a year later with a similar pressure vest that is activated automatically based on measurements of heart rate variability and respiration rate [18].

In a final subcategory, a few papers aim to support self-analysis (exemplified in fig. 5): Simm et al. document a co-design process of creating a bracelet for emotional self-tracking to manage anxiety [42]. In a co-design process with autistic children, Spiel et al. develop examples of "companion technologies" that are intrinsically meaningful to the kids instead of embodying external expectations [44].

While this theme shows a focus on empowerment instead of correction, some of these papers still regard allistic practice as the assumed default. E.g. both the facial expression recognition and vocal notification papers aim to augment their autistic wearer to perform better in allistic conversation, rather than identifying this as a mutual task between those involved [6,30,50,52]. A deeper critique of this is made by Kender and Spiel [26]. While absolutely better than outright correction, this thinking still betrays an expectation of conformity. It should be noted that this is not universal among papers in this theme. The two above-mentioned self-analysis papers indeed approach assistive technology from autistic interests first.

Fig. 5: Iterations of a co-developed anxiety management wristband (top) [42]. A co-designed device for exploring sounds (bottom) [44].

Compression wearables

The use of electronically controlled compression wearables exists beyond the context of autism (exemplified in fig. 6). Generally, most of these wearables are used for reducing anxiety [7,17,18,21,37], with exceptions like communicating affection [47].

Many existing compression garments for anxiety management use bio-sensing as their method of activation, based on respiration rate [18,37], heart rate [17,18], and/or electrodermal activity [7,17,37]. Jensen et al. critique self-management approaches as potentially leading to increased anxiety, and instead propose shared management of anxiety by involving a close peer in monitoring and intervening experiences of anxiety. This approach is demonstrated through a contracting compression wearable, activated by a support person touching their shoulder. [21] As previously mentioned, the wearable demonstrated by Duvall et al. is controlled remotely through an app by a parent or support person. In the context of showing affection at distance Teh et al. similarly demonstrate a compression vest for children, activated through a touch sensitive doll by their parents [47].

What these three projects share is an asymmetrical interaction between the controller and the wearer. As Jensen et al. highlight in their evaluation, this inequality between users might be problematic [21]. With this project I argue for a shared interaction and extend it to be mutual in its expression. By ensuring both parties actively engage in the interaction, equality and consent is ensured and the mutuality of a physical hug is maintained.

Fig. 6: Current wearable designs using compression.

Approaches to autism-wearables

Viewed together, papers on autism and wearables seem to share a set of common tendencies (visualized in fig. 7): A majority of papers explicitly focus autistic children [1,2,4,8–12,14,15,22,24,27,28,32,36,41,44–46,51,52,54], whereas adults are only the focus of 7 papers [6,17,18,25,30,42,49]. Since autistic children eventually grow into autistic adults, this indicates a significant gap in representation. This discrepancy may further contribute to the problem of involvement as discussed later.

Many papers do not report the gender of their participants. Of all that do [1,4,6,9,22,25,28,32,33,45,46,49,51,54], all but one [51] primarily involve boys or men, two exclusively [22,33]. This reflects the fact that autism diagnoses are biased towards assigned male people [29]. However, this observed gender difference has shrunk in recent years. At the same time, existing theory and diagnostic criteria have been criticized for being biased, creating an under-representation of autistic women [34]. While the argument can be made that gender representation should and does reflect existing demographics, these biases risk getting uncritically reproduced. It should be further noted that of the four papers that reported ethnic data on its study group [1,9,25,46], all were biased towards white/Caucasian groups. This suggests that the ethnic disparities that exist within autism research and diagnosis too may be reproduced within HCI [31]. As autistic people are a highly heterogeneous group, and autism is expressed in social context, focusing representation is essential for questions of generalizeability, limitations and intersectionality.

Only 7 papers report actively involving autistic people in shaping the research or design process [6,10,11,24,28,42,44]. These include the two self-analysis papers that engage autistic adults and children respectively in designing tools for their sensibilities [42,44]. 9 papers elicit feedback from autistic people, or from people personally involved with them (e.g. parents, caregivers) [2,4,30,32,33,36,45,49,52]. These include papers like the expression recognition glasses [52] and the physical touch bracelets [45]. 10 papers only record data on autistic people or collect information from third parties [1,8,9,14,19,22,25,38,51,54]. This level of involvement is common in the themes of Behavior analysis and intervention. Finally five of the papers simply have no form of involvement of autistic people [12,17,18,27,46].

Worth noting is the way autism is regarded in a substantial amount of these papers: Multiple papers explicitly regard autism as a disease for which the symptoms can be treated. Goodwin et al. sees the self-calming practice of stimming as behavior which should be intervened [19]. Chen et al. claims that ASD is “seriously endangering the physical and mental health of children” [8]. More implicitly, papers like [51] and [45] suggest reducing autistic behavior in favor of allistic behavior improves quality of life. As documented by Monique Botha in the field of psychology, there exists a pervasive tendency of regarding autistic people as being fundamentally incapable of understanding or representing themselves, e.g. dismissing personal insights on the claim that autistic people lack a theory of mind [5]. This leads to a dehumanization of autistic people, enabling researchers to dismiss autistic perspectives outright. It seems to me that these views pervade parts of HCI too.

One argument can be made that some groups of autistic people are practically more difficult to involve in traditional research or design practices. Autistic people with intellectual disabilities or who are nonverbal may have greater difficulty being understood in a scientific context. I argue that this argument once again mirrors the dismissal of autistic experience, displacing this challenge of

As part of my autism assessment, I’m asked to fill out a questionnaire based on theory by the same researcher I see repeat again and again in the references of these papers. It’s the author they use to claim people like me can’t empathize with others. The questionnaire includes questions on my interest in trains, cars, stamps, politics and strategic board games. The spreadsheet scores my autism based on how well I answer. In the following session, I spend most of the time drawing parallels from the questions to my actual experiences.

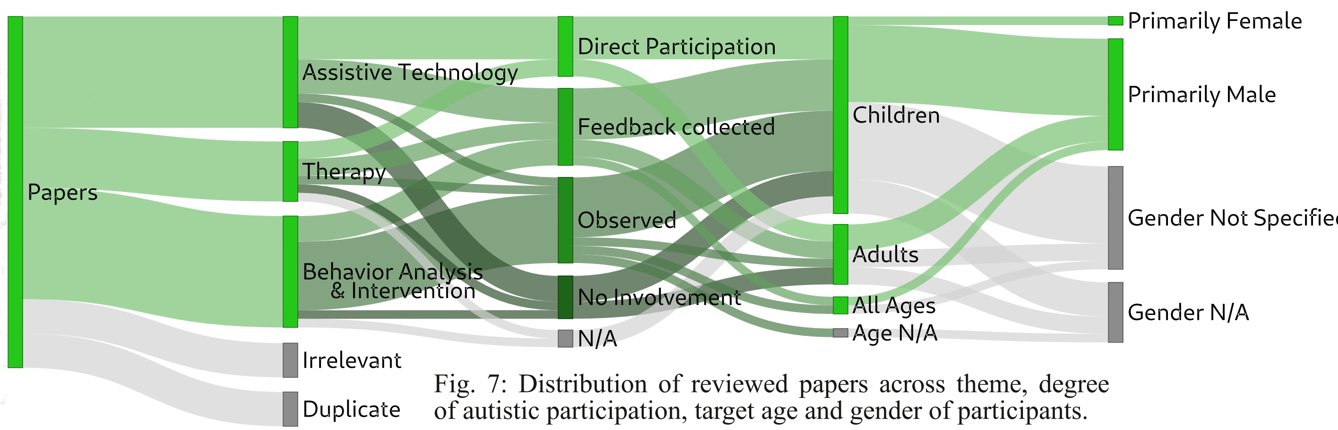

Fig. 7: Distribution of reviewed papers across theme, degree of autistic participation, target age and gender of participants.

communication from researchers onto to their subjects [26]. Narain et al. demonstrate one approach in using caretakers or close family as representatives for nonverbal autistic people [33]. However, this still carries a layer of interpretation. In an essay on the development of a tactile language for deafblind people, John Lee Clark explains how American sign language interpreters are taught to be a neutral party, relaying their surroundings as objectively as possible, and how this causes problems for deafblind people in actually understanding the world. Instead of adapting to this existing norm, Clark documents his and his communities efforts to create new modes of deafblind communication independent of a sighted, hearing norm. [23]

I argue that to address the issues identified in existing literature on autism and wearables, this field needs a deeper reflectivity on the understandings of autism we construct. To instigate this, I too suggest that we as autistic researchers and designers work from our autistic experience instead of allistic norms, i.e. autobiography.

Working through this literature review is tough. Reading through the texts, I can't help but read myself into these descriptions, conceptions and solutions. Its a constant barrage of tragedy: Autism as disease, disorder, pandemic. Something to be caught early, objectively measured, and intervened to avoid problem behavior. At their worst, these articles seem to regard autistic people as barely capable of conscious thought and without use for personal agency. At best, troublesome kids incapable of knowing what's best for them. I feel my brain twist to make sense of it all. These authors are clearly invested in autism and yet describe us so othered. After a while I start doubting my own fundamental experiences. Is this actually how the world sees me? Am I delusional in thinking that I have a meaningful inner life and understanding of the people around me? Am i somehow fundamentally broken in a way that i am incapable of recognizing? My mind is reset by an article actually taking its outset in the premises of their autistic participants. I breathe.

Design process

The design of this compression wearable takes its outset in an earlier prototype called the NonHug [40]. This prototype demonstrated a self-activated compression based on pneumatic inflation. The project further proposed a symmetrical interaction between wearers. Due to time limitations, this interaction was not implemented, and the prototype was not fit for long term wear or evaluation. Continuing its autobiographic approach, my process started with a sensory reflection on the experiences of wearing the earlier NonHug prototype. From this, I began an iterative process of refining the design to be more appropriate for long term wear.

Reflections on early design

Taking the form of a leather chest-plate, the NonHug provides pressure on the sternum using pneumatic inflation activated though touch (fig. 8). While showing promise, the prototype had some general issues making it unreasonable for daily wear:

The general fit of the prototype made it uncomfortable to wear for longer periods of time. As the leather chest plate was stretched out between the shoulders and a ribbon around the stomach, activation and movement would pull this ribbon upwards, putting pressure on the ribs. Further the electronics of the prototype were bunched up in a pouch on the back, making it impossible to comfortably lean back in chairs. The aesthetic of a leather chest-plate with a shiny copper motief made it quite attention grabbing, which could be a social concern.

During the development of the first prototype I started gesturing affection with my partner by pressing one or two hands against the sternum. In situations where one of us was touch averse this proved useful. Casual discussions on the project has let us to be much more explicit in our interaction. While maybe seeming stilted to outsiders, explicating our intentions have become a way of showing care. I signal and receive a hug through the kitchen window as I'm headed out.

The prototype used leather to provide a rigid surface on which to mount the inflatable. While leather does not significantly stretch, it does flex. This resulted in limited pressure being applied, and the previously mentioned discomfort. At the same time the leather was mildly discomforting in its smell, texture and source of production.

The prototype made use of an air pump and a regulator to safely inflate a silicone inflatable. This resulted in an audible buzzing and subsequent hissing every time the prototype was activated. With the prototype intended for situations of high sensory sensitivity, this was not appropriate. As highlighted by [12] this noise may also be socially undesirable.

Fig. 8: The NonHug prototype [40]

Finally due to time limitations, only one prototype was produced, and no wireless communication between prototypes was implemented. I set to work developing a new prototype to address these issues.

Reworking form and fit

Discarding the previous method of attachment to the body, I explored alternative methods for putting pressure on the sternum. I found that attaching over the shoulders and around the torso just below the armpits allows for a tight comfortable fit without obstructing breathing or other identified concerns [40]. From this I sketched a new design, fitting the upper torso (fig. 9). In this design, a chest plate is tied to a back plate over the shoulders and under the arms. Instead of inflation, pressure is applied by a contracting force across the torso. Similar to the previous prototype, interaction occurs on the chest plate.

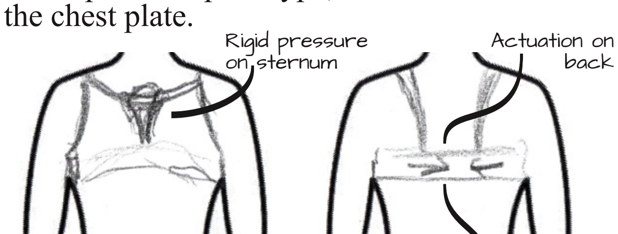

Fig. 9: Early sketch of new design.

Method of compression

To move away from noisy and bulky inflation, I explored using the shape memory effect of nickel titanium (nitinol) alloys to create contraction. An example of this is demonstrated in [12] where shape memory alloy (SMA) wires are trained to coil up on heat, providing contraction. Another approach is to use muscle wire, which is a special annealing of nitinol, that contracts length-wise when heated above a set temperature [13]. While muscle wire has a proportionally smaller shape change compared to trained SMA, it is capable of applying significant force. It further does not require training which involves heating above 500 °C. Due to this ease of access, I decided on using muscle wire to provide the pulling force.

As I wanted to focus the contracting force on the sternum, I took inspiration from auxetic materials to create a 3d printed mechanical element that expands when parts of it are pulled outwards (fig. 10). I first used rigid PET-G plastic for the parts. This made long-term wear uncomfortable as it dug into my skin. To alleviate this, I replaced non-mechanical parts of the design with softer, flexible parts printed in TPU, and added form-cut foam padding between the prints and body.

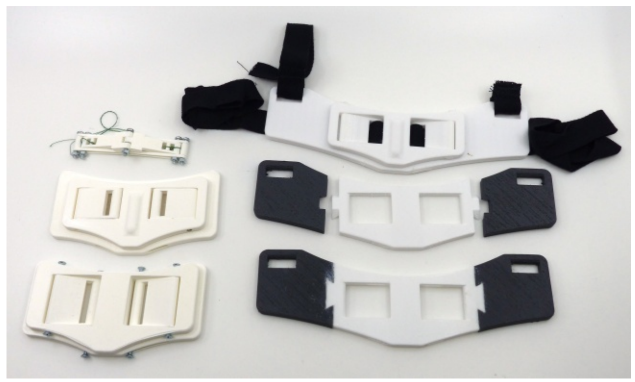

Fig. 10: Iterations of the mechanical element.

Embroidery sensing

With the switch away from leather to stretchable fabrics, using form-cut copper tape to sense touch input was no longer an option. As an alternative, I experimented with embroidering touch surfaces from conductive thread. While the thread used has a much higher resistivity than copper tape or stainless

Fig. 11: Test embroidery (tl). First fabric enclosure and embroidery prototype (tr). Hidden steel thread attached to conductive embroidery (bl). Final chest-plate components (br).

steel thread, embroidery alleviated this issue by layering the thread to reduce actual resistance. Using a test embroidery, I observed a change in surface resistance from >50MΩ to <10MΩ on the touch of a palm. This is sufficient for resistive touch sensing. I proceeded designing an embroidery pattern for the touch surface (fig. 11).

Managing Actuation

Actuating low temperature muscle wire involves heating it to 70 °C [13]. To avoid risking burns, the wire must be kept away from skin contact. This is a challenge as the wire must also have significant length to contract a usable distance. The wire can not be folded (i.e. have more than one attachment point at each end), as this will halve the length of contraction while doubling force. In an iterative process, I designed a cassette for rolling up the wire in a manner that would still

allow full contraction without producing a twisting force, and that wouldn't unroll (fig. 12). The cassette was printed in PETG. With a heat deflection temperature of 78 °C [39], the printed part in practice proved just able to hold the wire without warping.

Managing electronics

To minimize discomfort and restriction of movement, I mounted the rigid muscle-wire cassette and electronics onto a flexible frame on the back. From experiences with the previous prototype, comfort requires keeping the parts as flat and flexible as possible. I initially designed the back mount to house the electronics on one side, and battery on the other. However, as flat, lithium batteries of a fitting size and current delivery capacity are not readily available, a high capacity pack was assembled to be worn on the hip. (fig. 12)

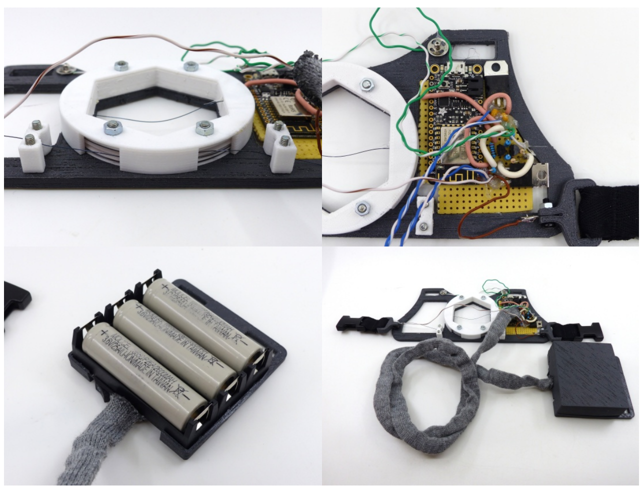

Fig. 12: Muscle wire casette (tl). Prototype electronic circuit (tr). External battery pack (bl). Complete back assembly (br).

1) Available at https://gitlab.com/painlessMesh/painlessMesh

Technical implementation

Power

The circuit (fig. 13) is powered by three in-series 18650 Li-Ion batteries. These provide the ample current required to drive the muscle-wire. To avoid brownouts because of high surges from powering the wire, the electronics and wire are run off separate circuits, attached directly at the battery pack. To provide further isolation, the electronics are driven off of a properly decoupled LM7805 voltage regulator.

Input

Similar to the original prototype [40], the wearable uses resistive touch sensing for its simplicity and reliability. The circuit uses two NPN transistors in a Darlington configuration to amplify the small current across the skin when touching the embroidered contacts. To bring the output voltage of the sensing circuit within specification of the microcontroller (MCU), a voltage divider is used.

Output

The particular muscle-wire used contracts at 70 °C, shrinking in length by roughly 4% [13]. With a length of 1m, this gives a contraction of around 4 cm, just enough to accomplish a noticeable squeeze. The wire is actuated through resistive heating. It is driven by a single NPN power transistor, shorting it across the battery.

Control

The actuation is controlled by an Adafruit Feather Huzzah board. Using the painlessMesh library[1)], the MCU creates a mesh with any other devices nearby. The board then repeatedly starts reading the touch sensor, broadcasting its status on the mesh. When all boards in the mesh report being touched at the same time, the wire is powered, causing it to

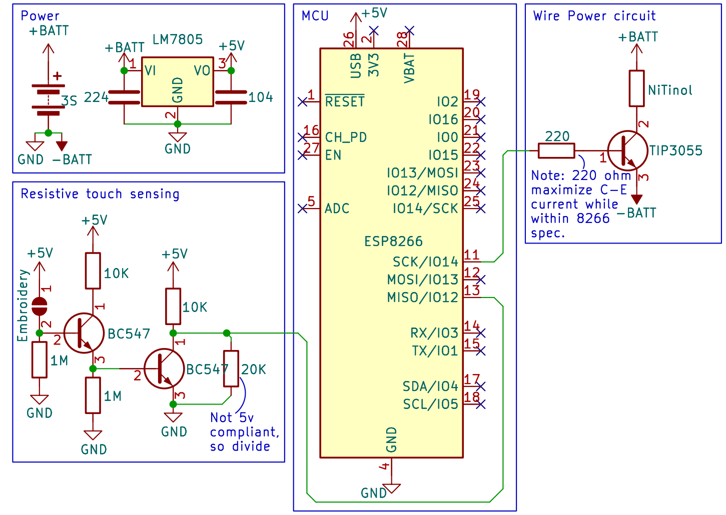

Fig. 13: Circuit schematic of the prototype

actuate. To avoid risking damage from overheating, the wire is limited to stay powered for six seconds at a time.

Preliminary evaluation

To evaluate the longer term use of the wearable, I wore it on a regular basis throughout two weeks. I report the experiences below:

Putting on the wearable alone is quite troublesome, as it requires the wearer to reach around themselves to close the buckles on their back (fig. 14). This makes the decision to wear it an active choice. Putting it on with another person makes this much easier. Fitting the buckles to be the right size takes a while initially, but is easy to adjust.

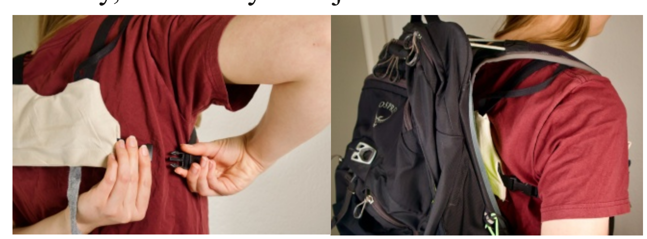

Fig. 14: Trouble closing the buckle. Prototype fitting under a backpack.

With the battery pack mounted on the hip, the prototype can be worn with good comfort, as long as the foam padding is used. The wearable is thin enough to fit underneath a jacket or backpack without discomfort (fig. 14), and even works for some physical exercise like biking. One issue with exercise is that the straps of the wearable must fit close underneath the arms. Sweating from exercise makes this uncomfortable. The current season revealed another limitation: As resistive sensing requires direct skin contact, wearing the prototype underneath a jacket or wearing gloves at the same time makes activation impossible. This is a significant problem as the bustle of being outside can be a significant source of anxiety, and a relevant situation for activating compression. Finally, the battery pack is sufficiently large and heavy to be noticeable, even when worn on the hip.

Fig. 15: Having exposed wires grabs attention.

I put on an early revision of the prototype as I'm heading out the door. My partner makes a joking comment on the mildly odd look of wires strapped to my body. As I bike to the hospital for a blood test, I start to worry. Heading in, I become painfully aware that I will have to take off my jacket for the nurse. I feel the need to explain the situation to avoid problems. We strike up a short conversation about it, and my worries prove unwarranted. The nurse asks if I'm bad with needles. I explain that its just because I'm sweating from bicycling.

On a social level the wearable is not particularly inconspicuous. Being outside wearing an early revision of the prototype, I became highly conscious of how the exposed wires could be interpreted. This led me to revise the prototype to hide away all wires completely (fig. 15).

In use, the compression was weak but noticeable when tightened sufficiently. In practice, the limited travel distance and almost complete lack of elasticity in the wire made for a prototype that either restricted taking deep breaths or would only sit tight when activated. While moving freely while not being worn, the high friction and inwards force of the ribbons were too great to actuate the mechanical part. During actuation, it would simply stay flat. The heat produced by the circuit and wire was noticeable. If not for the connotations of warm prototypes, this was actually a rather comfortable sensation.

A short evaluation together with my partner revealed that the compression was simply too weak to give meaningful results over a longer period of time. Instead we found other issues with fit and comfort: My partner was wearing an oversized hoodie, which the under-arm ribbon dragged up in an awkward fashion. From this, we concluded that general wear on the outside of clothes is impractical. This has implications for the use of resistive touch sensing. After a short while of wearing, they noted the buckles and front 3d print pressing in a painful manner. I noticed the padding of the front print had shuffled down, exposing the rigid parts. Activating the compression, the weak force my partner did notice was focused towards their back ribs. Also recognizing the issues with elasticity, they proposed a redesign in the materials of a sports bra, its only rigid parts being collected on the back. For long term wear, they argued that it should sit loose, though for the current prototype this was impractical due to its weight.

Future work

Many of the current practical issues with the prototype have reasonable solutions for future revisions:

The heat produced by the circuit is enough to risk damaging it. Due to the low current rating of the MCU, the power transistor used stays in its linear mode. This results in the transistor having a significant resistance while conducting, therefore producing significant heat. A solution to this would be to switch to a MOSFET with a sufficiently low drive voltage. As fitting devices are not easily available, a circuit redesign to drive the power transistor would be more reasonable.

To increase the length of contraction, an approach would be to simply use a longer wire. By switching to a material with higher thermal resistance for the cassette, and to a better printing method, the wire could be layered closer, maintaining shallow depth, and the issues of internal friction could be reduced. Similarly to reduce friction around the body, the contracting ribbon could be kept within a low-friction tube. To handle the issue of elasticity elastic ribbons could be embedded in the assembly.

Finally, the pressure mechanism needs to be reworked or replaced. From experiences of wearing the non-functioning mechanism, just having a semi-rigid chest-plate may be sufficient to redistribute the pressure.

Conclusion

In this report, I document my experiences with autism-focused research as an autistic person, through an autobiographical design process of a compression wearable.

In a review of 33 papers on wearables and autism, I categorized these into themes of *analyzing and intervening* autistic behavior, augmenting existing *therapy* methods and building *assistive technologies* for empowerment. Based on the literature review, I identify several tendencies within existing literature: Most authors seem to focus on a specific subset of an otherwise highly heterogeneous group. Further, a significant amount of the work seems to disregard autistic input and agency, mirroring tendencies in other fields. I argue for conducting autobiographical design, as a way of challenging these current perceptions and approaches.

In the space of compression wearables, this project aims to move away from either automated control based on bio-sensing or asymmetrical control by a second party, to symmetrical control where control is a mutual, consenting practice.

Taking outset in an earlier prototype, I designed a compression-wearable using muscle-wire, allowing wearers to give mutual hugs at a distance. The design process focused sensory experience, giving attention to material choices, long term comfort, and social appropriateness.

In evaluation, the prototype showed reasonable comfort for long term wear except during physical exercise. The prototype had technical issues with its strength of compression, location of force and heat dissipation. This made it unfit for longer term evaluation with my partner. From these results, future improvements are suggested.

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