PKI: Crafting Critical Design

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ABSTRACT
In this paper we discuss the value of an open, responsive research structure in the context of a multi-faceted, critical design project that has participation at its core. Problems with data delivery rendered our original design research structure unviable. Turning to the crafts that underpinned our research enabled the emergence of a new–open and responsive–structure. As a direct result, we arrived at a number of unexpected, highly valuable outcomes. The contributions of this paper are fourfold: 1) we provide a ‘live’ story from research practice, within which, 2) we argue the usefulness of a core provocative question to ensure saliency of critical designs, 3) we demonstrate the value of unresolved prototypes in eliciting participant engagement, and 4) we discuss how craft can serve as method, technique and tool to scaffold an open, responsive research structure. A number of researchers have highlighted the need for documentation and reporting of design process [9, 20, 37, 42] including, specifically, in the context of critical design [6]. We respond to these calls.

Author Keywords
Critical design; participatory design; in the wild; design process; craft; embodied interaction; textile design.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
In their 2012 paper, Bardzell et al. identify some of the many challenges with conceiving and developing critical design projects [6]. They make a call for contributions to understand the design process in the context of critical design that is socially and politically engaged to provoke shifts in attitudes or viewpoints. We describe here a project–PKI: the Poetic-Kinaesthetic Interface project–that uses the body as a point of departure to provoke shifts in attitudes and viewpoints around notions of body-typical, ability and disability.

PKI aims to challenge and enrich the constrained norm of body-typical to include hypermobility, physical disability, and the evolving abilities of the mature or ageing body. The project interweaves embodied creativity, choreography, motion capture, structured textile research, material and spatial explorations, garment and object construction, myotherapy and public engagement in an emergent co-design process. In doing so, we seeks to understand how we might give people the experience of being in someone else’s body, with different abilities and constraints.

Using design frameworks for embodied engagement, PKI gives participants access to alternate ways of connecting with the moving body, ability and disability. Each framework disrupts, transgresses or destabilises social and cultural norms around movement and ability, including idiosyncratic notions around the idea of what may or may not be considered ‘normal’. They do this by supporting ‘shared’ physical and sensorial experience, and thereby encouraging empathy. These ‘shared’ experiences are with another–absent, alternately-abled–person’s movement experience. The frameworks are informed by physical experimentation and motion capture of hypermobile, disabled and mature aged choreographer/movers.

The structure of PKI is being shaped as an open, responsive structure that allows for a dynamic relationship between conceptual, technical, material and design concerns, as well as research concerns. This paper presents an overview of the project and our intended research structure. It discusses how and why a new–open, responsive–research structure was set up, how it is evolving, and why we found this approach ideal for a complex, multi-layered critical design project, such as PKI. We describe the development and deployment of three design frameworks: Green Knits, Blue Cushions, and Sleeves, to demonstrate how our research is unfolding. In particular, we demonstrate: the usefulness of a core provocative question to ensure saliency of critical designs; the value of unresolved prototypes in eliciting participant engagement; and craft as method, technique and tool to scaffold open, responsive research.

Importantly, the need for an open, responsive structure was not planned. Yet, the shift proved to be extremely valuable. It led to salient outcomes and informed research thinking in unexpected ways. The breakdown of our initial structure prompted us to use our expertise and practice of non-digital crafts to inform decision-making and develop a new–emergent, open and responsive–structure. As Rosner et al
assert [32], how a craftsperson plays with their materials leads them towards finding what it is they want to make. In our case, treating the concepts, materials and techniques at play in the PKI project as material elements of our craft practices led us to understand what we wanted to do. Furthermore, we found the social and performative nature of craft to be a rich site for inviting and opening up exchanges of ideas [30], in complement of the discursiveness already afforded by critical design [6]. Our craft practices provided an inclusive and non-threatening space for people to engage. They also emerged as the ideal way to scaffold an open, responsive research structure.

In the following sections, we provide project background; and describe how our craft practices supported discovery of the most appropriate way forward, coherent with our aims and intentions, as well as emergent concerns.

PKI
The PKI project aims to understand how to give people the experience of moving in someone else’s body, with the associated abilities and constraints. The project is highly ambitious, with intended contributions to smart textiles and materials research, wearable technologies, design research, live performance, HCI, health and disability, as well as cultural contributions in the form of performances, still and live performance, HCI, health and disability, as well as materials research, wearable technologies, design research, live performance, HCI, health and disability, as well as cultural contributions in the form of performances, still and live performance.

PHASE 1: motion capture of disabled, hypermobile and mature aged choreographer/performer/movers. Analysis of data and development of techniques to transfer this data into structures for embodied engagement, including 3D, seamless knitted structures and other modular and mechanical structures.

PHASE 2: development of design structures and artefacts at a range of scales – graspable, wearable and body-able (able to be engaged with by the entire body), using a range of techniques and materials.

PHASE 3: Development of custom garments and/or choreographies using a design-choreographic process (based on [19, 40]) to flatten the hierarchy between design and choreography, and arrive at unexpected outcomes.

PHASE 4: Production of a large-scale, participatory event combining the different design and performance outcomes. Neural and cognitive testing of attendees, to evaluate the impact of the discovery afforded by the different outcomes, and understand whether discovery with them shifts notions around body typical, abilities and disabilities in a scientifically measurable way (building on 38).

Importantly, participation is key through all four phases. In-process tests with our hypermobile, physically disabled and mature-aged choreographers and movers are scheduled in each phase, as are open studio events and experiments with a diverse public.

Participation
Participation has a long tradition in HCI (see [28]). In PKI, participation with disabled, hypermobile and mature aged choreographers and movers, informed by design-choreography [19, 40], is used to support reflection around our core question, development of our design prototypes, and the kinds of conversations we are having with a diverse public. Participation with the public is used to enable discursive exchange in-process, with the dual intention of provoking shifts in attitudes and viewpoints around notions of body-typical, ability and disability, and informing the ongoing, emergent research.

The beginning and the breakdown
Design research structures need to be fluid to support a reflective conversation with materials and resources in an ongoing and iterative process [35]. Nonetheless, a structure must be clearly articulated to enable researchers to engage fruitfully and ensure timely outcomes. Unexpected delays are not uncommon when working with technology, and need to be allowed for. Despite being mindful of these concerns, our original structure broke down completely in PHASE 1. In this section, we describe what happened.

PHASE 1 began with three motion capture sessions at Deakin University motion.lab [10] using their 24 x Eagle 4 camera Motion Analysis optical system. Motion.lab is the premier motion capture lab in Oceania. They have extensive experience capturing people, animals, uncommon motions in dance technology research, and undertaking exploratory work with performers with physical disabilities [5]. We had no reason to anticipate delays in data delivery, yet the system was unable to interpret the bodies and motion of three of our four movers, and we encountered conceptual issues interpreting the data from the fourth.

Our first session was with Benjamin Hancock, a 27-year-old hypermobile choreographer whose contemporary dance practice has a strong focus on partitioning and segmenting the body to find new movement possibilities beyond common pathways. Ben has natural hypermobility in his spine, shoulders and legs. During the session his movements were adjusted to enable the system to capture his more complex motions. Post-capture, additional articulations were added to his virtual skeleton so that the system could better interpret what it had captured, and provide us with usable data. These adjustments complicated and delayed delivery.
As a key collaborator, Benjamin was present at all three motion capture sessions to assist and inform the explorations of the other movers. His expertise proved invaluable, dealing with the limitations of the system when faced with bodies outside the norm, and reflecting on the movement input when data delivery was delayed.

The second session was with a choreographer, performer and creative collaborator, in her mid 60s, who has been crafting dance performances for more than four decades. To provide an inroad into thinking about bodies of different ages and abilities, we captured comparative data in this session from Ben, our 27-year-old, hypermobile, choreographer, and a 46-year-old who is not a professional mover. We were able to use Ben’s existing virtual skeleton, so encountered no major technical difficulties. Nonetheless, working with an extremely agile ageing body proved challenging because more subtle than working with distinct dis- or hyper- or devolving abilities. The challenges in interpretation here were conceptual – researcher-related, rather than related to the motion-capture system.

The third session was with a physically disabled theatre artist, and a contortionist. The theatre artist, Sarah Mainwarine, is a 32-year-old professional performer who has an acquired brain injury, from a serious car accident when she was 6 years old. Sarah is a dancer with Weave Movement Theatre [41], a full-time company member of Back to Back Theatre [5], and devises and performs solo works of physical theatre. She has reduced mobility on the left side of her body, and varying spasticity in her right arm and hand, which she makes use of in her performances as an expressive attribute. Sarah’s marker set required significant tweaking in order for the system to be able to map her body to the limited range of normal with which it had been programmed. This complicated and delayed data delivery. Sarah is also a key collaborator, and her expertise, experience and contribution has been key in working out how to move forward.

Our final mover was a computer scientist, life-long martial artist and trained contortionist in his early 30’s, able to dislocate his joints at will. Daniel has Ehlers-Danlos Syndrome (EDS), an inherited connective tissue disorder that leads to enhanced elasticity of the skin, joints, muscles, ligaments, blood vessels and visceral organs. His range of motion proved highly challenging for the system. In particular, some of his larger arm flex sequences went beyond the mathematical limitations of the solver elements (eg. the gimbal lock), and required significant adjustment to enable the system to interpret and understand his movements and provide a useable data set.

The delays in data delivery and the conceptual challenge interpreting the data from our agile mature choreographer effectively put a hold on development. We understood that delays are not atypical when working with technology, but our delays were significantly longer than we had allowed for. Our PHASE 1 design explorations were predicated on the motion capture data, and we had a confirmed date to test emerging experiments on the public – a date which was too soon for us to be able to do the necessary development. In the next section we describe the conditions of our immanent prototype testing – the final element of the landscape in which we found ourselves stuck.

PKI Lab in the Wild

Our PHASE 1 testing of design prototypes was scheduled within a design residency during Melbourne Now [24], a major exhibition at the National Gallery of Victoria, International (the NGV), in Melbourne, Australia. The NGV is a significant national museum, Melbourne Now is the largest exhibition held to date at the NGV, and was extremely well attended (>100,000 attendees in the first 6 weeks). Our residency was during Summer school holidays, just after Christmas. We could expect families and children, in addition to a more typical gallery-attending public; seniors would attend, as would international and interstate visitors. Access to such a broad demographic would be very useful to us, on condition we had prototypes to test.

In our favour, the design residency was aimed at giving the public access to how design happens. This construct allowed us to conflate the notions of exhibit, work-in-progress, open studio and lab to create a kind of Research Lab in the Wild. Prototyping in the wild can be understood as an evaluation set up where objects, artifacts, and other inventions are assembled and then tried out in the settings for which they are envisioned. [31] Within this methodology physical and social context has a critical effect on usage [31]. Just as in the lab, the experimental context can impact results. Participants have expectations about what the investigators are looking for and this can affect the way they behave [8]. Creating a research lab in the wild, in the context of an exhibition, enabled us to play with participant expectations. The Lab was an exhibit. The exhibit included the researchers, the methods in process, the ideas driving the investigation and the prototypes. This construct enabled us to engage participants in the research in a way that freed them from the need to believe or behave in a particular manner. The construct of the exhibit allowed attendees to suspend disbelief and engage in our research “as if it were real”. The whole afforded discursive exchange that was authentic.

The Lab in the Wild also enabled us to consider presenting prototypes that were equally resolved or unresolved, and to investigate the impact of demonstrating that resolution along a spectrum. As discussed below, we would discover that this spectrum was useful. It enabled us to seek out a wide range of ideas within the scope of the parameters of our research question and to test these ideas on the public in different ways, catering for individual strengths and preferences in thinking and engaging. The attendant openness of different artefacts seemed to encourage people to participate and contribute quite freely – the more open
artefacts operating as a point of entry for the more highly resolved, and seemingly more provocative works.

At this point, though, we had no prototypes. With the motion capture data not sufficiently developed to directly inform prototype development in time for the NGV residency, we needed to think creatively about other ways of working. In the crisis, it became apparent that craft could act as the catalyst to elicit an alternate pathway to move forward. With our research question at the forefront, we began to consciously craft an alternate, emergent structure informed by the process of crafting materiality.

THE ROLE OF THE RESEARCH QUESTION

Arguably, all research is guided by a research question or defined problem space. One of the challenges Bardzell et al raise as first-time users of critical design, is how to design something with just the right “slight strangeness” to be provocative [6]. They point to the centrality of Dunne and Raby’s definition of a successfully provocative design: “A slight strangeness is the key – too weird and they are instantly dismissed, not strange enough and they’re absorbed into everyday reality” [11, p.63]; and highlight the fact that there are no heuristics in the literature that might assist less seasoned critical designers to develop the tacit knowledge to design provocatively. The first author studied under Dunne and Raby, and Gaver¹ – who champions the importance of ambiguity in leaving space for meaning-making [14] (also relevant), and has been using critical design as a key component of her research for more than a decade. In PKI, we found that seeking solutions to a clear, simple, provocative question enabled us to ensure saliency of our outcomes.

Our question: “How can we give someone the feeling of being in somebody else’s body, with different abilities and constraints” forced us to seek practical solutions, rather than respond to, enrich or resolve a problem space. The specificity of the question, along with its provocativeness, was key, as was leaving sufficient space for meaning-making. By constantly referring back to the question we were able to check the relevance of our experiments, along with their saliency. By ensuring a certain ambiguity in the resulting prototypes we could feel confident that we left room for participant interpretation and contribution.

This approach was particularly useful for developing a responsive, open, emergent structure. It allowed us to not close things down too readily, yet be confident about the choices we were making as we crafted our way forward. Our research question effectively gave us something to hold onto in our impasse. As we experimented wildly, it helped to ensure our experiments were relevant to the larger research project, and our design directions appropriately provocative.

The role of the body

When discussing User Enactments [26], a design approach that aids design teams to investigate radical alterations to technologies’ roles, forms and behaviors in uncharted future-focused design spaces, Odom et al speak of how a matrix of ideas can provide a map of the identified design needs; and how tacit knowledge accessed in the generation process can help designers understand which aspects of the design space might be more addressable than others. They also note that the design space of critical design is sometimes ambiguous. In our experience, this ambiguity is a strength. Particularly when creating frameworks for embodied engagement. When designs are focused on the body and the broader context remains undefined, the context for use can shift or change at the will of the participant. Room is left for the participant to discover, construct, or configure context through and around use, making the guiding question invaluable. The approach leverages the sometimes emergent, inaccessible nature of context in design [21], and allows participants to bring their own values and experiences to bear on their reading of the artefacts. Being able to refer back to a single question as the driver and point of verification of appropriateness of the artefacts helps ensure they function consistently in their provocative intent.

CRAFTING OUR WAY FORWARD

As mentioned: in our impasse, with our research question at the forefront, we began to consciously craft an alternate, emergent structure informed by the process of crafting materiality. McCullough [22] speaks of the importance of craft as “the condition in which the inherent qualities and economies of the media are encouraged to shape both process and products”. For the PKI project craft was as much a research process as it was our means to explore and develop ideas into tangible products regardless of how resolved the artefacts were. In considering craft as a method for research, we looked specifically towards the craft of textiles as offering richness in language and conceptual ways of thinking to elucidate the complexities needed to grapple with such a multilayered interdisciplinary project. Rosner et al speak of how a craftsperson playing with their materials is led towards finding what it is they want to make [32]. Craft and working with one’s materials provides an openness of enquiry. Such a process permits using the materials and tools to think with. What emerges is a research process that is a “speculative and indeterminate progression (...) reminiscent of what Tim Ingold [17] terms wayfinding in comparison to navigation: feeling one’s way rather than using a map” [7]. This way of thinking creates a continual feedback mechanism within the research structure that is open, flexible and responsive. Just as craftspeople calibrate the motions of their work in direct response to the work just performed [2], researchers also need to be open to where the data, research, design enquiry, and participant reactions might lead them.

¹ Interaction Design, Royal College of Art, 2001-2003
By treating the concepts, materials and techniques at play in the PKI project as craft elements, we were continually discovering what it is we would like to do. Engaging with craft techniques (the craft of knitting, sewing, textile materials and the simplicity of techniques such as a paper folding) we looked to where these would take us. At the same time we were continually referencing back to the body as a site for enquiry; discoveries made during the motion capture sessions with our disabled, mature aged and hypermobile choreographer/movers; and our core research question. Through the interplay of these exchanges we were able to prompt deep reflection around notions connected to disability, hypermobility and the ageing body, and to find coherent ways forward with our inquiry. As we worked, we quickly prototyped emerging ideas in material form so we could bring them into a collision with a relatively undefined (unprofiled) public. Working quickly was important as it left little room for the inner critic to interfere. It forced us to trust our process and work instinctively. The design residency, as Lab in the Wild, provided a structure for ongoing experimentation and allowed for risk-taking with our research framework. We were able to continue crafting prototypes on site, make adjustments to pieces, and create new prototypes in response to what was happening. This process led us to revalue the unresolved prototype, our fluid and emergent engagement with process and, eventually, with the public.

At the NGV, there was much curiosity in the act of observing us crafting on site. Comments such as “my mother knitted” led to conversations that might not otherwise have occurred. Seeing us at work with our hands was highly accessible. It blurred boundaries between making and testing. Craft, when thought of as a verb [30], offers a dynamic, sensory and performative way to enable engagement that is inclusive and non-threatening. Drawing on the constant interplay between tacit knowledge and self-conscious awareness of craft [36] enabled us to reach out and connect with participants. Within this context, the social dimension of craft proved highly valuable.

Significantly, we discovered that it was the least resolved prototypes, the Knit Structures that served as the most accessible entry point for a broader research dialogue. The openess drew people in who might not have otherwise engaged, gave permission to make suggestions and triggered the imaginations of possibilities. The unresolved prototypes also became an important point of entry for the more highly resolved, and seemingly challenging works, such as the Sleeves, which must be worn. They enabled a greater range of participation with all three design frameworks. Bardzell et al speak of the need for time to develop relationships with participants when deploying Critical Designs [6]. We posit that involving participants in a stage of the research where at least some prototypes are open and relatively unresolved, within a spectrum of resolution, may fulfill the same purpose.

THREE CONSTELLATIONS OF ENQUIRY

For the design residency we set out to work with three broad constellations of design enquiry, each responding to the core research question: “how can we give people the experience of being in someone else’s body, with different abilities and constraints?” Each enquiry involved a different level of resolution. In this section, we discuss the three design frameworks beginning with the least resolved: (i) Green Knits, (ii) Blue Cushions, and (iii) Sleeves.

(i) Green Knits: frameworks for emergent enquiry

With the core research question in mind, the intention of the Green Knits was to enable participants to ‘feel’ a particular movement by prompting them to make that movement; a secondary intention that emerged during development was to prompt different levels of cognitive engagement and support neurocreativity. As discussed in [38], the neuroscience of creativity cannot yet claim to be an operational research domain [27], yet Mednick [23, p.221] provides a neurologically sound extension of the standard definition of creativity that is useful: the forming of associative elements into new combinations which (...) are in some way useful. The more mutually remote the elements of the new combination, the more creative the process or solution. For more, see [38 and 1].

While considering our guiding question, the second author’s knowledge of knitting techniques enabled us to take advantage of the properties and inherent ‘soft’ logic of different knitted stitch architectures, such as the shift between the balance of an all-needle rib structure to a single jersey, which results in a natural fold: a form with an internal memory (Fig. 1(i) & (ii)). Complex forms of fabric origami were developed to form the Green Knits (Fig. 1(iii) and (iv)). These artefacts act as a guide to lead participants through a relatively simple movement such as of two hands.
coming together and moving apart in a spiraling form. The spiraling motion developed out of an investigation into tensegrity structures, structures that maintain a stable integrity through a set of discontinuous compressive elements, and a set of continuous tensile elements [29].

Crafting Biotensegrity
Significantly, the body is a series of tensegrity structures. This can best be understood when considering the way the spine can collapse and expand, depending on posture and muscular tension. Referred to as Biotensegrity [34], this notion reverses the idea that the skeleton is the frame upon which soft tissue is draped. Rather, the body consists of an integrated fascial fabric with “floating” compression elements (bones), enmeshed within the interstices of tensioned elements (muscles and fascia) [34]. When this notion is applied to the knitted prototype, the knit acts as the tensile structure and the short wooden skewers act as struts. The result is a dynamic prop for engagement.

Embodying Neurocreativity
The Knits were meant as an open exploration, a way to move forward while we waited for the motion capture data. They ended up being an unexpected vehicle through which to consider the amount of cognitive engagement the participants suggested a relation between structural openness and neurocreativity, linking Wilde’s proposal about embodying neuroplastic change [38]. This potential will be investigated in future phases.

Socially Crafting Engagement
The Green Knits enable physical interaction with material that leads to direct involvement with the research (“what’s this about?”), in part through facilitating social sharing. As groups gathered to watch what we were making and how we worked with our materials, we prompted them to “Have a go: try to unfold and refold the knit structure.” Immediately, someone in the group would be nominated and nudged forward (“you try it”), while others looked on, to see how it was done. Working out how to fold and unfold the structures emerged as a highly social activity and effectively became the entry point for the other artefacts and the research as a whole. It alleviated a level of anxiety of “I don’t want to look foolish” or “I can’t do that.” The activity provoked conversations, laughter and enabled everyone to get involved – “that doesn’t look too hard, let me have a go”; “no you’re doing it wrong, let me try”; “my turn”. Engagement that may have begun with some hesitation, quickly shifted to direct dialogue with the core of the research. The knit structure prototypes thereby acted as a readily accessible point of entry for participants to engage with the other, more highly resolved works.

As Belford suggests, craft’s sensory and emotive state is a way to open “the seemingly hard world of science to a wider audience, by using the ‘softer’ textile-making processes” (p80)[30]. In the PKI Lab in the Wild, exchanges were varied and considered, as people made connections back to their own lives and their own situations. Discussions drawn from experience and personal stories covered topics such as the aging body, children with autism and how to keep active – all valuable insights for our research. Additionally, crafting emerging artifacts on site enabled us to reflect and respond to people’s engagement dynamically. It also provided a useful method to facilitate our emerging research structure.

(ii) Blue Cushions: invisible, internal prompts
The Blue Cushion prototypes (Fig.2) were developed, in response to our guiding question, to work with the body’s capacity to enable or disable its own affordances. This series drew from the third author’s expertise in myotherapy; observations of our movers during the motion capture sessions; and previous work by the first author in wearable technologies [3]. The Blue Cushions act on the mechanical, cognitive and sensory elements of the body. Each serves as a pressure point to shift posture or stimulate nerve paths and send messages to the brain. Significantly, they don’t noticeably change the way a person moves. Rather, they shift perception of movement, bringing reflection to internal changes. As with the Feldenkrais Method [12], they change how making a movement feels. All of the current cushion-sets were developed in advance, and modifications made during the residency when the need became apparent. There are currently four cushion-sets that function as follows:
1. **Scapulo-Humeral Rhythm**: (Fig 2(i)) places pressure around the scapula (the shoulder blade), to impact the way it feels to lift the arm.

2. **Hip & Butt**: (Fig 2(ii)) places pressure over the lateral border of the Lattisimus Dorsi (the muscle that joins the lower thoracic, lumbar and sacral vertebrae to the humerus, (the upper arm)). It also places superficial pressure over the femoral cutaneous nerves, from the 3rd lumbar vertebra, through the quadratus lumborum muscle, towards the iliac crest (the hip); butt places pressure over the sciatic nerve. They are used together, to impact the way it feels to walk or sit.

3. **Excessive Kyphosis**: (Fig 2(iii)) applies gentle pressure over the first to third cervical vertebrae, along the neck towards C7, to give the wearer the feeling they have excessive kyphosis, or “a studious hump”.

4. **Varus (Trendelenberg)**: Varus mechanically interferes with the body as a person walks. It may be worn in two ways: (1). Fig 2(iv) behind the thigh, with the bulbous section over popliteus (the back of the knee); or (2). Fig 2(v) over the adductors (between the thighs). In (1), the cushion places pressure on the varus, and interferes with knee bend while walking. In (2) it mechanically tilts the pelvis and separates the thighs, to alter the gait in a different way. Despite operating mostly mechanically, the impact of this cushion on the experience of walking is felt internally rather than perceived externally.

Notably, Varus (Trendelenberg) was designed to place pressure on the side of the torso and under the arm, but this placement felt too similar to the common experience of carrying a bulky bag over the shoulder. Through embodied-storming [33], the cushion’s aptitude for gait interference became apparent. Though not designed for this purpose, it is extremely effective. While mechanical interference with the body was not the initial intention of the series, this cushion remains conceptually aligned. Externally it does not appear to have much impact. Yet the feeling of its effects, in both use cases, is dramatic for the wearer.

As people engaged with the cushion-sets modifications took place and iterations were identified and constructed. For example, modifications were made to enable better fit for people with bodies way outside the norm, and in the case of *Excessive Kyphosis*, an additional insert was made. Excessive kyphosis is a common phenomenon among the ageing, and computer users who do not maintain good posture. In excessive kyphosis, the cervical curve at the neck and down the thoracic spine becomes accentuated due to changes in posture: the head moves forward and a hump develops. When participants already suffer from excessive kyphosis the impact of the cushion is negligible. To compensate, a small insert was constructed to increase the pressure delivered. This insert enabled people with excessive kyphosis to feel what it would feel like to be them, from the perspective of someone who does not have this particular postural deformation.

(iii) **Sleeves**: *external pathways or movement mazes*

Of the three design frameworks, *Sleeves*, was the most resolved and provocative, requiring a participant to literally enter into and wear the artefact. Two sleeves were created prior to the residency as fully resolved pieces (Fig 3). The intention was to mechanically impact freedom of movement, coherent with a range of physical pathologies. They were also inspired by Hancock’s explorations using hypermobility to segment the body.

1. **Yellow Sleeve**: (Fig.3(i)) A soft felt maze that constrains forward flexion and extension of the arm. It acts as both a guide and constraint for upward reach, constricting the gesture into deformed positions as the person reaches upwards. The maze itself is internal to (hidden within) the material structure of the garment. Participants are able to move through it at their own pace, exploring the movement possibilities it affords. Importantly, *Yellow Sleeve* is made of very soft felt, comforting to the touch, not unlike a baby blanket. Yet the movement this garment affords is not typically thought of as soft, gentle or desirable. The inherent conflict destabilises values attributed to movements that may be considered disabled or outside the norm.

2. **Black & Red Sleeve**: (Fig.3(ii)) This sleeve constrains and reframes abduction, adduction, flexion and extension (different kinds of reach), by transforming the movement affordances of the arm into a shifting maze. The segmenting, created by the stocking straps, create different constraints and possibilities depending
The only element present at the outset of our research project was our core question: How can we give people the experience of being in someone else’s body, with different movement abilities and constraints? This question, in its direct, open provocativeness, leaves room for context building and interpretation, yet simultaneously provides grounding. When our structure broke down, our question effectively gave us something to hold onto. It ensured our experiments and prototypes were relevant as we sought to craft a new, emergent structure.

By shifting our focus to our crafts we were able to consider how our different practices might serve as methods for structuring a way forward. Textile practices might be used as material and method for developing ways of engaging the public through unresolved prototypes. Inspired, in particular, by the notion of weaving, we dynamically placed prototypes, representing a warp—the structural threads of the weave—in relation to each other in our exhibit space. We then considered the public’s engagement as weft threads—the nuanced, expressive elements of our weave—and adjusted our warp elements (the prototypes) to dynamically respond to their engagement. This approach afforded development of ‘fabrics’ that privileged different responses.

With this approach, the ambiguity of the Lab in the Wild proved useful. We were able to position our presence at the NGV as exhibit and research in process, and while the level of resolve of the prototypes was far from what we had initially imagined, our craft practices enabled us to scaffold an emergent structure to provide coherency. Rather than struggle to develop ‘finished’ prototypes with limited material and time, we could show prototypes in progress. The experience was about the public having access to design (in our case, design research) in process. We wore lab coats and played dual roles of designers and researchers—testing ideas, observing what took traction and what might emerge. We continued working: making material and time, we could show prototypes in progress. The openness gave participants permission to discover what each prototype might be, and to propose possible uses, while still connecting back to the research question. The range of responses was diverse: Reflection by the older generation might emerge as a powerful research tool for engagement. The openness gave participants permission to discover what each prototype might be, and to propose possible uses, while still connecting back to the research question. The range of responses was diverse: Reflection by the older generation was one of intrigue and self-analysis in regards personal health and life experience. Many expressed relief that we were promoting a discussion around the ageing and evolving body. A number of children made acute observations about older people when wearing the cushions, e.g. a young girl wearing Excessive Kyphosis said “old people who stand like this don’t even know they do”: a simple, yet pertinent observation that seemed to prompt self-reflection in the adults around her. Health professionals
redo the structures with ease. Yet after playing with them, many expressed surprise that they were unable to undo and redo them up and put them down without too much commitment. They were not designed to be worn: participants could pick them up and put them down without much commitment.

As discussed, the Green Knits were the least resolved of our prototypes, and the most open of the three enquiries. People seemed drawn to them as a point of departure. These structures seemed less threatening, less provocative and, as a result, easier to engage with than the cushions and sleeves. It was unclear if this was due to the fact that they were more clearly crafted – knit may be thought of as a familiar and friendly activity. Or if it related to the fact that they were not designed to be worn: participants could pick them up and put them down without too much commitment.

Engaging with the knit structures was not straightforward. Many expressed surprise that they were unable to undo and redo the structures with ease. Yet after playing with them, participants showed increased ability, as well as increased interest in the sleeves and cushions, and became willing to try the other prototypes. The Knits thus acted as an unexpected entry point to the more resolved works.

Over the course of the four days, the depth of participant engagement varied, and we were constantly confronted with surprising levels of openness and sharing by participants that we encountered only once. Bardzell et al speculate that deep relationships between participants and researchers might be a requirement of successful critical design research [6]. Gaver et al speak of such relationships emerging out of repeated interactions [15]. From our experience as researchers, evaluating the processes at play led us to understand that it was the openness of the prototypes, with their apparent contextlessness, as well as their varying levels of resolution that afforded this openness in the participants. The first author had similar experiences with critically designed wearables developed for her doctorate [39]. We are curious to discover what may be possible as the research evolves.

Importantly, our approach reinforces the concept that craft is a powerful site of connection and communication [30]. Our crafts offered entry points for participation: dynamic, sensory and performative means through which to enable engagement that is inclusive, non-threatening and instrumentally valid. Shifting our process at such an early stage of the research afforded alternative ways of working that are flexible in structure, yet robust enough to be trusted to lead to useful outcomes. Drawing on the constant interplay between tacit knowledge and self-conscious awareness of craft [36] has thus enabled us to reach out and connect with participants and craft a robust structure.

CONCLUSION
What began as an ambiguous experiment that might be considered tangential, became integral to the research project, and grew to form its evolving structure. Possibilities for where the research goes now are still unfolding, however this does not alter the value of the process to this point. Based on our experience we offer four contributions for Critical Design: 1) a ‘live’ story from research practice; 2) the usefulness of a provocative core question; 3) the value of working with prototypes at varying levels of resolution; and 4) using craft as method and way of understanding, as well as developing, a robust open, responsive research structure.

Many designers and researchers speak about the benefits of engagement as an integral element of the research (for a discussion, see [4]). Yet, set boundaries and define structure quite quickly. Such an approach may limit the range and depth of possibilities. Our experience demonstrates that a spectrum of openness can be beneficial. Boundaries become fluid, and space is left for interpretation, as well as meaning-making. As Gaver et al also discuss [14], the openness affords a richness of response.

In closing, while we are speaking to the challenges of Critical Design, we are responding to calls across design research for documentation and reporting of process (eg [9, 20, 37, 42, 6]). We hope that our contributions may be seen as relevant, more broadly, to other design research areas where participation and co-design are considered key.

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