Design for Togetherness: Neurodiverse conversation in interactive praxis

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Abstract 350 words maximum: (PLEASE TYPE)

This doctoral thesis describes a practice-based design inquiry into sensory methods of communication for neurodiverse children. It identifies the agential role of responsive design artefacts in facilitating first-person participatory experiences to inform the design process, particularly in relation to interactive objects and environments for autistic children. The interaction design research employs critical and disruptive methods of participatory engagement to elicit feedback from populations that are typically under-represented in practice-based research and in turn, examines methods of involving these people in the design process. This is developed from the author's experience in designing embodied and sensory-focused interactions, including media art installation and personal responsive objects for autistic children. The design and use of interactive artefacts in this thesis are described for their interventional potential and how resulting 'conversations' can be used as a tool for increasing participatory engagement and understanding, leading to co-creative partnerships and the inclusion of neurodiverse voices in the design process.

The thesis examines the author's interaction design practice and the sensitivities this brings to making processes and materiality. Reflective practice is employed to examine how these might be applied to exploring unique sensory interactions that neurodiverse people have with the world. This is seen in the development of the *Responsive Dome Environment* (*RDE*), a space in which a neurodiverse group of children and their parents interact with a multisensory feedback system. The author's position and assumptions as a designer are challenged throughout interaction with autistic and neurotypical children, both in the *RDE* and subsequent interviews used to inform iterative development. This practice is located by the author interviewing expert practitioners to compare and contrast related fields of inquiry.

Participatory engagements are reflected upon in an 'open studio' format to identify and establish the author's 'conversational' practice, a framework through which neurodiverse perspectives can be elicited and described to inform an iterative design process. The unique features of this practice are formalised in response to working with participants in the *RDE* and is presented as a creative approach for interaction design practitioners working alongside complex populations with the aim of embracing human diversity to inform design praxis.

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Appendix and practice-based documentation

As a practice-based doctoral project, there is significant material and iterative design output that accompanies this document. The bulk of this practice-based component was generated in parallel to the literary research in an 'open studio', where participants were invited to experience interactive artefacts and provide feedback for further design iteration. The importance of this to the discussion in this thesis is to look at the design process; there was no singular artefact or exhibition for the reader to experience.

To help frame much of the discussion in this thesis around materials, artefacts and participatory experience, hyperlinks are provided to reference additional material available on an accompanying website, that functions as a supplementary appendix. Some of this material is publicly viewable, while other documentation is password protected to ensure the privacy of participants. The latter is provided for examination purposes only.

The hyperlinks in this thesis will direct the reader to specific material, however the website is structured so that documentation may also be navigated on a chapter-by-chapter basis, or by method of feedback: expert interviews; practitioner interviews; and observational video.

Contents

Thesis/dissertaion sheet 2

Originality statement 3

Copyright statement 4

Inclusion of publications statement 5

Appendix and practice-based documentation 6

Contents 7

List of figures 10

List of tables 14

Terminology 15

About this thesis 19

Publications 20

Acknowledgements 21

1 Introduction: A Practice-Based Approach 23

1.1 Background and motivation 29

1.2 Evolution of practice 37

1.3 Responsive Dome Environment (2014—2015) 45

1.4 An Exhibition of Process (2015) 49

1.5 The role of practice-based research 51

1.6 Thesis structure 52

2 Literature Review: Interaction Design 54

2.1 Experience-centred design 57

2.2 Embodied interaction 63
2.3 Situated interactions 67
2.4 Precedents in autism research 70
2.5 Expert interviews 81
2.6 Interview: Occupational therapist 84
2.7 Summary 88

3 Making: RDE Design 89
3.1 Foundations 90
3.2 Design framework 104
3.3 Development 112
3.4 Specifications 129
3.5 Interview: Body-focused HCI practitioner 136
3.6 Summary 139

4 Action: RDE Open Studio 141
4.1 Experiment space 144
4.2 Study population 145
4.3 Role of the participant 147
4.4 Iteration 1: Initial probe 151
4.5 Iteration 2: Establishing control 160
4.6 Iteration 3: Clarifying conversation 175
4.7 Disrupting conversation 183
4.8 Interview: Interaction design and media artist 185
4.9 Summary 188

5 Findings: Conversational Practice 191
5.1 Interview: Interaction design and HCI practitioner 193

5.2 Participating in conversation 195
5.3 Significance and findings 200
5.4 Features of conversational practice 206
5.5 The visual model 211
5.6 Summary 215

6 Future Work: Looking Forward 218
6.1 Looking forward 221
6.2 Concluding remarks 226
Bibliography 228

List of figures

Figure 1.1 - External view of the *RDE* with first iteration of tangible interface 27

Figure 1.2 - *All Is Domain* (Brown, 2010) 30

Figure 1.3 - *Device 2* from Honours study (2011) 33

Figure 1.4 - *Device 1* (2011) (video screen capture) 40

Figure 1.5 - *Device 2* (2011) (video screen capture) 41

Figure 1.6 - *Device 3* (2011)..... 41

Figure 1.7 - Lighting system inside the binaural dome model..... 44

Figure 1.8 - *Binaural dome* model at *Mighty Healthy* exhibition 44

Figure 1.9 - External view of the *RDE* with first iteration of tangible interface .. 46

Figure 1.10 - Internal view of the RDE with third iteration of tangible interface, during exhibition..... 46

Figure 1.11 - *An Exhibition of Process* (2015) exhibition flyer (front and back)..... 49

Figure 1.12 - Panorama image of exhibition/open studio (stitched from multiple images) 50

Figure 2.1 - Fields in relation to interaction design (Preece et al. 2015, p. 9) 56

Figure 2.2 - Influences on experience using 'participant' and 'artefact' terminology, adapted from (Forlizzi & Ford 2000, p. 420) 60

Figure 2.3 - The dynamics of experience in interaction for individuals and in social interaction, from (Forlizzi & Battarbee 2004, p. 264) 62

Figure 2.4 - The interior of the *MEDIATE* environment (Parés et al. 2004, p. 7)...74

Figure 2.5 - The *ReacTickles* MAGIC iPad application (Anon 2012) 77

Figure 2.6 - *ECHOES* evaluation setup (Alcorn et al. 2013, p. 486).....79

Figure 2.7 - Stages of practitioner interviews 83

Figure 2.8 - Connecting stages of my process by mapping across the floor (black tape) 84

Figure 3.1 - A single-loop (first order) self-regulating system (Dubberly et al. 2009, p. 72) 93

Figure 3.2 - A (second-order) cybernetic learning system (Dubberly et al. 2009, p. 72) 94

Figure 3.3 - Pask's *Colloquy of Mobiles* displayed at *Cybernetic Serendipity* (1968) (Reichardt 1968, p. 99) 98

Figure 3.4 - The *Musicolour* machine installed at Churchill's Club (Pask 1968, p. 86) 100

Figure 3.5 - Conversation as a means to convey concepts and to confirm agreement (Dubberly & Pangaro 2009, p. 25) 103

Figure 3.6 - Projecting onto a 1:5 scale dome to test shadow casting 116

Figure 3.7 - Completed dome structure, before insert of doorway 117

Figure 3.8 - Testing light colours for 'hotspots' 119

Figure 3.9 - Inside RDE during lighting test (video screen capture) 120

Figure 3.10 - Representing 15 light heads in 3D grid space using Max 6 121

Figure 3.11 - Testing a prototype camera-based interface to control lighting (screen capture) 122

Figure 3.12 - Testing play-doh conductivity to trigger lighting 124

Figure 3.13 - Testing a LightBlue Bean to track box movement 125

Figure 3.14 - A fiducial box, which would be used for the first participatory study interface 126

Figure 3.15 - Hexagonal table surface for RDE interface (all iterations) 127

Figure 3.16 - Light position on RDE (left) mapped to block or peg position on table-based interface (right) 128

Figure 3.17 - Flow of input/output in the *Responsive Dome Environment* (Iteration 1) 130

Figure 3.18 - Frame and flooring of RDE 133

Figure 3.19 - RDE frame and flooring with IP cameras surrounding 134

Figure 3.20 - Lighting stands, as viewed from outside the RDE (not visible to participants) 135

Figure 3.21 - Mapping the stages of practice of Body-focused HCI Practitioner (04p_05) 136

Figure 4.1 - Complete *Responsive Dome Environment* with iteration 1 interface 141

Figure 4.2 - Floor plan of *RDE* experiment space 143

Figure 4.3 - Child as tester from (Druin 2002, p. 7) 148

Figure 4.4 - Extension of Druin's tester role through active artefacts 149

Figure 4.5 - First interface iteration, using the reacTIVision object tracking framework 152

Figure 4.6 - Video still from study 01n_02 153

Figure 4.7 - Pre- and post-observation questionnaire from study 01n_04 (left and right respectively) 155

Figure 4.8 - Boy climbing under side of RDE in study 01n_01_a 157

Figure 4.9 - Iteration 2 of the RDE tangible interface 160

Figure 4.10 - Internal camera tracking positions (left) and hole positions on table surface (right) 161

Figure 4.11 - Exposed holes in the second iteration allowed light from the RDE in, feeding the system false triggers 171

Figure 4.12 - Third interface iteration 175

Figure 4.13 - Video still from study 03n_04 177

Figure 4.14 - Mapping the stages of practice of Interaction Design and Media Arts Practitioner (04p_03) 185

Figure 5.1 - Dubberly and Pangaro's 'Process of Conversation' tasks 195

Figure 5.2 - Dubberly and Pangaro's conversational tasks, disrupted 197

Figure 5.3 - Dubberly and Pangaro's 'conversation to learn' model, in the *RDE* case study context 210

Figure 5.4 - A disrupted conversation between child and artefact 212

Figure 6.1 - The UNSW Autism Research Group at the Autism MeetUp event, April 2016 221

Figure 6.2 - Rear of early lighting module prototype 223

List of tables

Table 4.1 - Questionnaire feedback results from study 01n on child's temperament state, pre- and post-study 156

Table 4.2 - Questionnaire feedback results from study 01n on child's interaction understanding and engagement, post-study 156

Table 4.3 - A summary of Bødker's "Checklist for HCI Analysis through Focus Shifts and Breakdowns" (left) and relevant observations from Iteration 2 in the RDE open studio (right) 173

Table 4.4 - Use of Dubberly and Pangaro's 'Process of Conversation' tasks in analysing study 03a_02 182

Terminology

There are several specific terms used regularly throughout this thesis which are deserving of their own examination. This includes ideas and language around perceptions of ability, diagnosis, and my own relationship to related fields of research. Some of these terms are potentially emotionally and politically charged. To warrant their use, I must take a position on what can be contentious issues. Like many of the decisions that inform my practice, these choices have been made after reflecting on conversations with people who are directly affected by the attitudes they describe.

Autism and identity-first language

I recognise that the person-first/identity-first (i.e., 'person with autism' vs 'autistic person') debate remains highly contentious. When working with a young population for whom parents are still responsible, it is important to consider the parents' feelings when it comes to the relationship between autism and their child. Many parents of autistic children see their son or daughter as human first and foremost and will therefore prefer the use of person-first language (i.e., child with autism). On the other hand, self-advocacy groups are often seen to push for identity-first language (autistic child), as they believe

autism to be so much a part of their identity as to be inseparable from it. By taking ownership of the previously diagnostic term, autistic people — sometimes referring to themselves as Autists — see their own symptoms as a strength rather than a deficit.

Taking a cue from the radical Deaf community, members of the self-advocacy group Autism Network International (ANI) began to refer to themselves as "Autistic" instead of saying that they were people with autism. Jim Sinclair, cofounder of ANI, observes that 'saying "person with autism" suggests that autism is something bad — so bad that it isn't even consistent with being a person' (Sinclair 1999). Relatedly, Steve Silberman argues that 'it is only when someone has decided that the characteristic being referred to is negative that suddenly people want to separate it from the person' (Silberman 2016, p.441). While I recognise the need to remain open to the different language used among stakeholders, I have chosen to use identity-first language in this thesis to keep with its position of advocacy.

Interaction design and human-computer interaction (HCI)

As this is an interdisciplinary study, some of the methods and methodologies used throughout are not strictly from a single field, but may have slightly different approaches or usage, depending on the background of the researcher who uses them. One place that this arises significantly is the positioning of interaction design and human-computer interaction (HCI).

My own approach to interaction design focuses primarily on creative responses to constructing embodied sensory experiences between people and responsive systems. Preece et al. suggest 'the main difference between Interaction Design (ID) and Human-Computer Interaction (HCI) [is] one of scope' (Preece et al. 2015, p. 9). The sprawling, interdisciplinary nature of interaction design certainly overlaps with the human factors and ergonomics history of HCI, however for the purposes of clarity in relation to my own practice, I separate these terms in this thesis.

Neurodiverse / neurodivergent and neurotypical

In an effort to avoid the binary of normal/different or autistic/non-autistic — which sets up a dichotomy suggesting lack in the other — the term neurotypical is used throughout this thesis to describe anyone from the mainstream population who does not have an autism diagnosis. The term was popularised by ANI in the mid-1990s, recognising the power of labels not only to change perception, but also to highlight the absurdity of definitions at all. Steve Silberman's book NeuroTribes is a call to arms on this very issue and describes ANI's decision to begin using the term:

> The most enduring ANI neologism was the term neurotypical, used as a label for nonautistic people for the first time in the group's newsletter. With its distinctly clinical air, the term (sometimes shortened to NT) turned the diagnostic gaze back on the psychiatric establishment and registered the fact that people on the spectrum were fully capable of irony and sarcasm at a time when it was widely assumed that they didn't "get" humor. (Silberman

2016, p. 441)

The term neurodiversity was first used by sociologist Judy Singer in 1998, who herself was diagnosed with Asperger Syndrome (Jaarsma & Welin 2011, p. 21). As a concept that sees use throughout disability rights movements, neurodiversity is not specific to autism. The underlying premise of neurodiversity is that the many neurological conditions that receive diagnostic labels are in fact 'natural variation on par with for example homosexuality' (Jaarsma & Welin 2011, p. 20). This, while a potentially problematic comparison, produces a useful approach to understanding neurological states as a broad spectrum, and is in recognition that autism is far more nuanced than the current diagnosis affords. In my own attitude to research, the concept of a neurodiverse spectrum underlines the approach of treating each participant as having individual knowledge, regardless of diagnosis.

About this thesis

The choice of typeface in this thesis is based on accessibility considerations of similarly located design theses (Pullin, 2013). I have used wide margins to allow for written notes and annotations, and provide hyperlinks to an accompanying website that includes documentation which is more exhaustive than is required in this document. The structure of this thesis is broadly chronological, in that it represents the path that I took throughout my PhD research, foregrounded by a literature review to locate my practice and summarised by my reflection and contribution drawn from the work.

Publications

The following publications have resulted from the research described in this thesis:

- Brown, S.A. & Gemeinboeck, P., 2017. Sensory Conversation: An Interactive Environment to Augment Social Communication in Autistic Children. In J. Huber et al., eds. *Assistive Augmentation*. Cognitive Science and Technology. Singapore: Springer Singapore, pp. 131–150.

- Brown, S.A. et al., 2016. The Case for Conversation: A Design Research Framework for Participatory Feedback from Autistic Children. In OzCHI 2016 the 28th Australian Conference. New York, New York, USA: ACM Press, pp. 605–613.

- Brown, S.A. & Koh, J.T.K.V., 2014. Responsive multisensory environments as a tool to facilitate social engagement in children with an autism spectrum disorder. In SIGGRAPH Asia 2014 Designing Tools For Crafting Interactive Artifacts. New York, New York, USA: ACM Press, pp. 1–4.

- Brown, S., 2013. Autism and theory of mind in interactive spaces. In K. Cleland, L. Fisher, & R. Harley, eds. 19th International Symposium on Electronic Art, ISEA. Sydney, Australia, pp. 1–4. Available at: http://hdl.handle.net/2123/9702.

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pursuit, and being the catalyst in making it possible.

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My parents, who have unflinchingly supported me in every endeavour.

My children, Theo and Toby, who remind me what is really important.

My partner Lauren, without whom this PhD would never have started, let alone been finished. Your strength and selflessness has made this all possible, and your enduring belief in the potential of others has inspired me to cultivate empathy throughout my research.

Finally, the parents and children who were generous enough to take part in my research. While I am not able to thank you here by name, none of this would be possible without your voices.

1 Introduction: A Practice-Based Approach

> In the practice of design, the purpose is not to represent what is out there but to imagine what is not and to bring into existence what is imagined. Creators are fabricators of possibilities embodied: They both make and make-up things! Important here is the notion that a designer's projections emerge through a conversation with—and through—their own and other people's externalizations. The nature and quality of this conversation are a key to all forms of learning, and paramount to intelligence itself. In Schön's terms, learning is designing, and designing is a conversation with—and through—artifacts. (Ackermann 2007, p. 2)

This research explores the possibilities in interaction design to engage in conversations with neurodiverse peoples. This takes place between people, as well as through the material artefacts developed in response to my ongoing

learning about human experience. I ask the question: how can the agential potential of responsive design artefacts facilitate first-person feedback to inform the design process? At the outset of this doctoral study, I embarked on a research project to understand the potential for enriching non-verbal communication with autistic children based on their sensory preferences by observing their engagement with an interactive environment. My research aims changed, however, through my own interaction with participants in and around a responsive multisensory environment that I designed for autistic children. My research became more self-reflective, uncovering the tacit aspects of my practice that led to increased participatory input in my iterative design process. I explore this change throughout my thesis, defining my practice as emergent and cooperative, examining how creative and empathic research methods might support neurodiverse experiences for co-creation in the field of interaction design.

In this thesis, I will make the case that my responsive design artefacts have played an agential role in eliciting feedback for cooperative inquiry (Druin, 1999) where first-hand experiences inform the design process. I have built upon this idea through my personal practice-based experimentation, in order to affect the behaviour and social interaction of participants. I argue that my approach to designing for neurodiverse experiences can inform iterative interaction design praxis by supporting participatory feedback, and contribute to developing assistive technology for neurodiverse children.

Over the past 15 years, I have developed a creative practice that is situated in human activity and experience: this includes electronic music events, live theatre sound, and embodied interactive installation. The sensory aspect of these activities has coalesced my interest in how design interventions might contribute to some of the issues identified in relation to autism, including difficulty with pre- or non-language interactions and sensory preferences in personal expression. The present research explores these ideas through participatory engagement with a material design practice and several iterations of interaction and feedback with a large-scale responsive space, which I refer to as the *Responsive Dome Environment* (RDE). My practice aims to bring participants into the design process in a cooperative partnership, framed by their 'conversation' with and in response to a design artefact. To define what I will present as my 'conversational practice', I draw on my skills and sensitivities as an interaction designer to inform the development of embodied experiences with sensory design artefacts and responsive spaces.

'Conversation' in this thesis is used to describe an act of communication that is not limited to verbal or written expression, and relates to definitions taken from the goal-seeking systems of cybernetics. I will put forward the case that my responsive design artefacts were able to elicit these kinds of conversations and lead to reflective feedback opportunities for a range of research stakeholders (autistic and neurotypical alike). I will also argue that the role of the artefact in my research practice is to facilitate and situate human participation, which becomes the driver of the iterative design process. This reframes the emphasis

on functionality that can be seen in many approaches to assistive technology and instead promotes an open and playful exploration in interactive experiences where children and their parents are able to express themselves in a non-directed manner. Furthermore, I examine my own development throughout this project as an interaction design researcher and acknowledge the role that participatory experiences of embodiment and sensory expression plays in this journey.

The work that I present in this thesis centres around several iterations of participatory engagement with responsive artefacts I developed in an open studio environment. Key to this is a series of three design interventions, situated by participatory engagement with the *RDE*. This structure, built much like a large dome-shaped camping tent (Figure 1.1), provides autistic children and their parents with an opportunity to engage with audiovisual (light and sound) feedback based on their physical interaction with a table-based tangible interface. As I discuss the development of the *RDE*, I draw from precedents and reference points in interaction design, cybernetic/systems theory, education, and therapy to map out a problem space and inform my material approach to working with autistic children. The result is a responsive design artefact that draws on the first-hand knowledge and experience of participants to reflect on its efficacy in creating a space which supports a range of sensory expression. Participatory engagement with the design artefact itself is the "key means in constructing knowledge" (Koskinen et al. 2011a, p. 5) and I use my interaction design practice as a foundation for reflecting on the experience of participants

and capturing their feedback as a means of generating new understandings of designing for neurodiversity.

Figure 1.1 - External view of the *RDE* with first iteration of tangible interface.

I will investigate the design, development and deployment of the present interactive design artefacts as situated sensory interventions. This will primarily be in relation to my RDE and another work I developed during this research, *Binaural dome* (2014), which critically explores some of the issues faced by some autistic people when negotiating the world. These artefacts are presented to reflect upon the experience of participants (in the case of the RDE, as a driver of iterative design) or exhibition audiences (in the case of the *Binaural dome*, to challenge audience perspectives of autism) while observing sensory experiences and first-hand knowledge. In working with autistic participants, I address the complex challenges faced by researchers and other stakeholders (parents, educators, and therapists) and I introduce my practice in response to this, as a

catalyst for conversations that can be held up against my own bias and assumptions as an interaction designer.

Through my human-centred approach to interaction design, I examine the way that 'wicked' problems can be disentangled by reflecting on experiential feedback of participants or stakeholders.[1] As a result, at every stage of this research participation has been aimed at being a path to agency. By involving the experiences of underrepresented or marginalised populations, the contributions of my research aims to empower people through participation in order to change the negative perceptions of ability perpetuated by normative pathologising. In much the same way that the design of assistive technology can pave the way to widespread acceptance of a condition (for example, the evolution of eyeglasses from medical appliance to fashion accessory), engaging an autistic population as co-creators may lead to design that can be applied to broader human contexts. Responding to this notion, I posit that the approach to participation in the conversational practice that I present in this thesis can be applied in praxis where empathic cooperation with stakeholders is important to the researcher.

Drawing on my understanding of situational contexts and materials in the production of events and interactive interventions, I argue that the sensory expressions of autistic children through embodied interaction is an area that requires further attention. I will examine this notion as an example of emergent

[1] Wicked problems are those that have no clear 'best' solution or straightforward approach (Frauenberger 2015).

behaviour through designed sensory interactions (Brown 2013) and reframe this design problem to be viewed through the lens of situated first-person contexts (Brown et al. 2016). This builds on a rich history of creative practitioners contributing to areas of perceived disability with a sensitivity to the human at the centre of the issue, rather than maintaining the pathology-centric lens applied to marginalised groups by positivist approaches to research.

To explore these ideas, I will examine how I arrived at explorations of neurodiversity from my own background as a designer. Through reflection on my present motivations in relation to embodied interaction and formal interviews with other experts in the field, I will frame the ways in which I believe my practice-based approach can help designers draw upon neurodiverse experience and feedback to inform the development of interactive artefacts. These insights on the tacit dimension of my practice will unpack the relevance of my material and participatory experimentation working with neurodiverse children.

1.1 Background and motivation

One of the key challenges I brought to this project was how to engage feedback from participants who may not be willing or able to express themselves through written or verbal language. In addition to the methods I describe throughout the open studio surrounding the development of the *RDE*, this includes

facilitating feedback from participants after their interaction with artefacts, as well as interview dialogues with experts and stakeholders related to autism education and therapy. The story of how I arrived at this PhD project begins with an informal discussion between myself and an autism service educator. As I introduced her to my interactive installation All Is Domain (2010) produced for exhibition in 2010 (Figure 1.2), she commented on the potential for this kind of tangible sensory interaction to be applied in her own educational work with primary school-aged autistic children.

Figure 1.2 - *All Is Domain* (Brown, 2010).

This interactive installation was shown at Carriageworks[2], and used a tangible interface to allow participants to 'unearth' local histories beneath the visible surface. As the participant dug through translucent granular material, the projection-mapped topology would reflect their interactions and, in effect,

[2] Carriageworks is a contemporary multi-arts centre in inner Sydney.

create a record of their experience. If a key location was revealed by the participant on the surface of the table, a spoken audio history of the local area (in this case, the Eveleigh area of Sydney that is home to Carriageworks) would be activated along with dynamic lighting changes. The sensory nature of the system feedback (light and sound) combined with an exploratory style of interactivity appealed to the autism educator as an experience that some children with particular sensory sensitivities (common with autism) might find engaging.

My interest in physical and sensory experience was tacit at this point (likely a result of my background in live performative events), however, in the doctoral research I describe in this thesis, my interest in embodied interaction developed further. Computer and social scientist Paul Dourish notes that embodied interaction is concerned with the philosophical problem of being in the world; we are revealed and reflected through phenomenological encounters within it (Dourish 2001, p. 107; Rokeby 1996). Dourish describes embodied interaction as being central to the effectiveness of tangible and social computing, as a result of our actions being 'embodied elements of the everyday world' (Dourish 2001, p. 100). My focus for *All Is Domain* was to explore the richness of sensory experience afforded by an embodied interaction and explore whether these experiences can lead to 'conversations' with systems, spaces and other humans. Sparked by the above discussion with an educational expert in autism, my interest in deploying an interaction design practice to explore the sensory and social engagements of autistic children began to emerge.

I continued this interest into a year-long study with a two-year-old autistic girl in 2011 (Brown 2013), providing me with my first research experience working with autistic children, their parents and therapists. Conducted in the home environment of the child, I carried out an iterative design project (titled the *Device* series) in conjunction with the therapeutic activities of an occupational therapist from Building Blocks (Autism Spectrum Australia's early intervention service). This speculative design exploration looked at the potential for tangible interactive devices to capture the aesthetic interest of autistic children, and serendipitously found its greatest success with a seemingly simple glance between mother and child. This act, recognised as 'joint attention' by the occupational therapist present during the study, was a sign of social interaction—an area of perceived deficit for this particular child. In this moment of joint attention, the girl displayed an awareness of her agency in generating the sensory feedback in the device (Figure 1.3), and turned to her mother to ensure that she was also sharing the experience. I will examine the *Device* series further in relation to my material prototyping methods in this thesis.

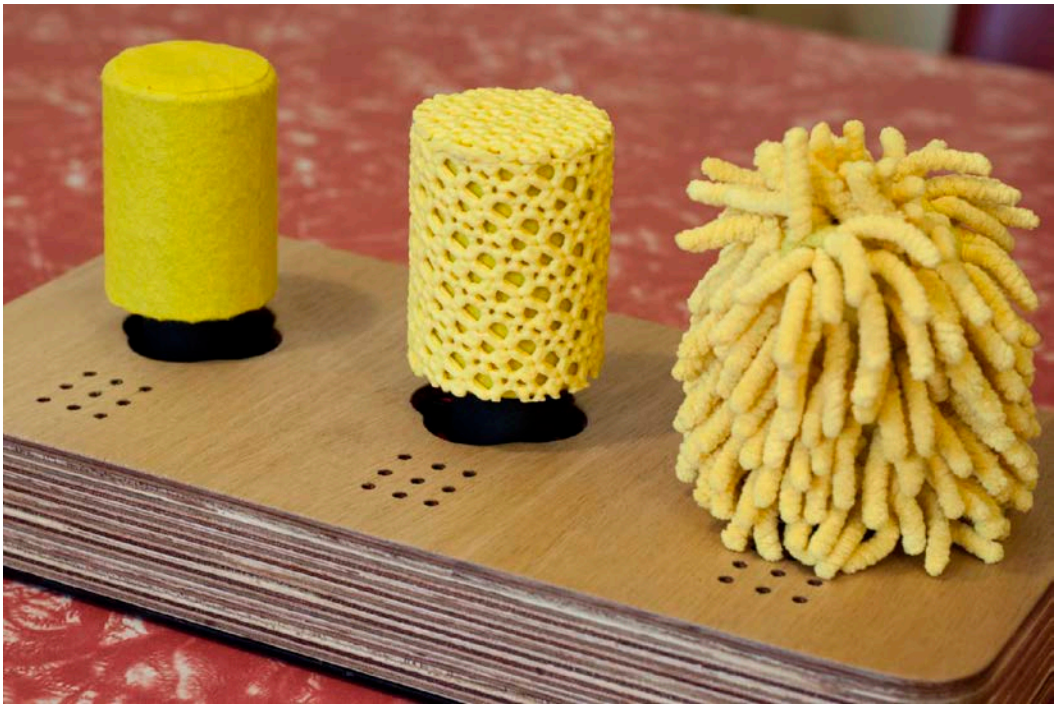


Figure 1.3 - *Device 2* from Honours study (2011).

Opening channels of interaction and conversation between the many stakeholders involved with a marginalised population like autistic children became a key motivation of my practice. Working in a way that places first-person experience at the centre of my research encouraged me to continually question my own design assumptions and open my practice to participatory exchange. My use of constructivist methods and accessible technologies aims to empower participants by providing avenues for their first-hand perspectives and feedback, engaging with them in a collaborative process of co-creation.

Exploring the relationship between myself as a design researcher and the participants and stakeholders that engage with this project, I develop interactive technologies to facilitate social communication, and highlight the opportunities afforded by a creative practice to address issues specific to neurodiversity and children. Taking the above works as inspiration for this project, I depart from a

commercial focus for design objects and explore the material and sociocultural influences on creating experiences for non-directive and sensory expression. My practice facilitates emergent feedback and provides autistic and neurotypical children the opportunity to engage in conversation using modes of communication with which they are most comfortable.

1.1.1 Autism and neurodiversity

> Once autism had no name. It is useful to remember this when crafting a theory of autism because it underscores the obviousness of autism's central defining feature: social disconnectedness. The name "autism" derives from the Greek word "auto" for self, and proclaims the apparent mental involution or self-absorption of autistic people (Yates 2002).

An autism diagnosis is generally made early in life (Iarocci & McDonald 2005). However, autism presents as a vast spectrum of behaviours rather than a singular condition. Identified by a therapist, the diagnosis is given based on three broad observations: impaired social development, resistance to change and repetitive mannerisms, and impaired language and communication skills (Volkmar & Reichow 2013). All of these identifying features are addressed in my approach to interaction and the concept of conversation described in this thesis. While I do not take a position on the perceived increasing prevalence of autism, it is worth noting that the condition impacts a notable proportion of the population. A diagnosis rate cited in 1985 was '4 in every 10,000' (Baron-Cohen et al. 1985, p. 37). Contemporary estimates are closer to 1% of all children

(Maglione et al. 2012, p. 170).[3] Regardless of the figure, autism does have a profound effect on the social interaction of many families and continues throughout the lifespan.

Difficulties around social interaction was an early focus of my research. Historically, one of the precursors to the development of communication skills, Theory of Mind (ToM), was said to be lacking in autistic people by psychologist Simon Baron-Cohen, an idea most notably reiterated during the mid 1980s (Baron-Cohen 2000). ToM is generally acquired during a child's developmental stages through to seven years of age (Malle 2002), and allows us to attribute thoughts, beliefs and desires to other individuals: without it, we cannot imagine the subjective perspective on the world of others and, in turn, any impetus to share personal feelings or intentions is limited (Tager-Flusberg 2000).

More recently, some autism advocates such as Amanda Baggs (Baggs 2007) have suggested that this limited view of communication is misdirected. In Baggs' video *In My Language*[4], her exploration of physical surroundings through all of her senses is presented as a unique form of communication and experience with her physical environment. Baggs (Baggs 2007) describes her sensory language as "being in a constant conversation with every aspect of my environment," rather than based in the codified structures of linguistic language. In the video, Baggs explores her home surroundings through stereotypical 'stimming' behaviours, such as flicking, tapping, patting and shaking. This expression is more attuned

[3] These statistics reference US national rates.
[4] *In My Language* video: www.youtube.com/watch?v=JnylM1hI2jc

to making physical connections with her situation space. Whether this communication can be viewed as an effort to connect outwardly with others or serves only as her internal dialogue is an area of current debate (De Jaegher 2013).

1.1.2 Opportunity for research

Through the background works I describe here, my research perspective on autism and neurodiversity aims to examine methods for facilitating sensory-based conversations using methods and frameworks from the field of interaction design. As I foreshadowed in the beginning of this thesis, the way I approached this idea evolved significantly across the duration of my doctoral project. This reflects what is at the core of the contribution of my work: by structuring my practice around the feedback and knowledge of a neurodiverse range of children, I opened myself to the possibility of emergent research trajectories.

Much of the research I have touched on thus far in relation to autism treats the autistic person as an object of study, and the autistic voice is lost or marginalised in that process. In allowing my practice to be open to the voices of participants in the action of my research, I am recognising the importance of these voices. This is an opportunity to not only recognise the people at the centre of my design process, but to explore what makes my approach of benefit to autistic people and strengthen this aspect of my practice.

1.2 Evolution of practice

My interaction design practice looks to elicit contingent moments of experience which emerge from designing artefacts for human use. This speaks to my interest in the potential for embodied interactions to be a driving force for new knowledge in a design process. The 'communication and learning' that occurs in situated actions with humans (Giacomin 2014, pp. 608-609) results from my particular understanding of materiality and the sensory experiences afforded by first-person embodied interaction. I trace this understanding to my background in music, theatre and live events, however, it is most clearly seen in my work which uses ephemeral media (light and sound) as feedback to embodied interaction. The tacit knowledge I have gained from each of these experiences guides my design approach in the project I present in this thesis. In the live event space feedback from an audience is important in shaping the performance; in this practice-based thesis, feedback informs my iterative approach to design.

My human-centred approach to working with a complex population does open this project to 'messiness' or 'wicked problems' (Frauenberger et al. 2012, p. 2377), in that the design problem was not framed at the beginning of the project. Rather, it emerged through practice-based material explorations as well as interactions with, and feedback from, participants. As described by Rittel and

Webber, “find[ing] the problem is thus the same thing as finding the solution; the problem can't be defined until the solution has been found” (Rittel & Webber 1973, p. 161).

I enter into what I will describe as my ‘conversational’ practice of interaction design, referencing the cybernetic Conversation Theory of Gordon Pask. Indeed, the title of this thesis was chosen in acknowledgement of Pask’s work (Pask 1980), which studies how goal-oriented systems (humans and machines alike) might understand and learn from one another, leading to closer social relationships:

> The popularised word “togetherness” aptly captures a general notion of human proximity, of meeting and speaking, or dancing together at a festival. Social groups, be they families, urban communities or the older universities, have institutions which promote togetherness; the dining table, a market, or a cafe as the case may be. On more or less ritualised occasions, and in the traditional places, humans converse; either verbally, or by image and gesture. I submit that the conversation which occurs, debate and sometimes agreement, is the stuff of civilised life and togetherness is essential to it (Pask 1980, p. 999).

Like Pask, I do not equate understanding or communication with the linguistics of words and speech, but look to make explicit the ability for materials to facilitate conversational exchanges. This opens up the potential for a range of modes of communication and neurodiverse experiences that may arise during interaction with an artefact. This is ideal for a constructive approach to design research, where the material object serves as the site of knowledge development

and exchange between the designer and participants, helping to make sense of a situation, rather than attempt to solve a perceived problem (Koskinen et al. 2011b, p. 17). Moreover, I structure my design practice to reflect upon the situated experience of the participant, for whom embodied interaction is at the centre of conversation in its many forms.

By framing my practice as conversational, I aim to encourage empathic engagement with participants, to express themselves freely as part of the iterative development and deployment of design artefacts. In my practice, conversation informs the design of the *RDE* and other artefacts to facilitate moments of experience and reflection by participants, as well as informing the methods I use to capture feedback between myself and study participants. Throughout these processes, I consider the situated perspectives and sociocultural contexts of autistic and neurotypical children, their parents, and stakeholders such as educators and therapists. Using conversation as both driver and anchor point in designing for neurodiverse experience, my approach to embodied interaction recognises the 'messiness of everyday life' (Frayling 2015) and embraces unexpected moments of intervention, often through the tacit knowledge I have developed during my background in theatre, music and embodied interaction. Cooperative inquiry as a result of reflection on these experiences is the personal approach I bring to bear on interaction design.

1.2.1 *Device* series (2011)

Although the work described in this section precedes my doctoral studies, the *Device* series of responsive objects informs the research project I present in this thesis. The experiences I drew from this project closely informed my current motivation to working with autistic children and interactive technologies.

The purpose of this study was to explore the potential for tangible interactive devices to afford aesthetic agency, and to allow the participant to express her personal interest in particular sensory experiences, thereby giving me feedback on my design as useful (or not) in her personal context (Brown 2013).

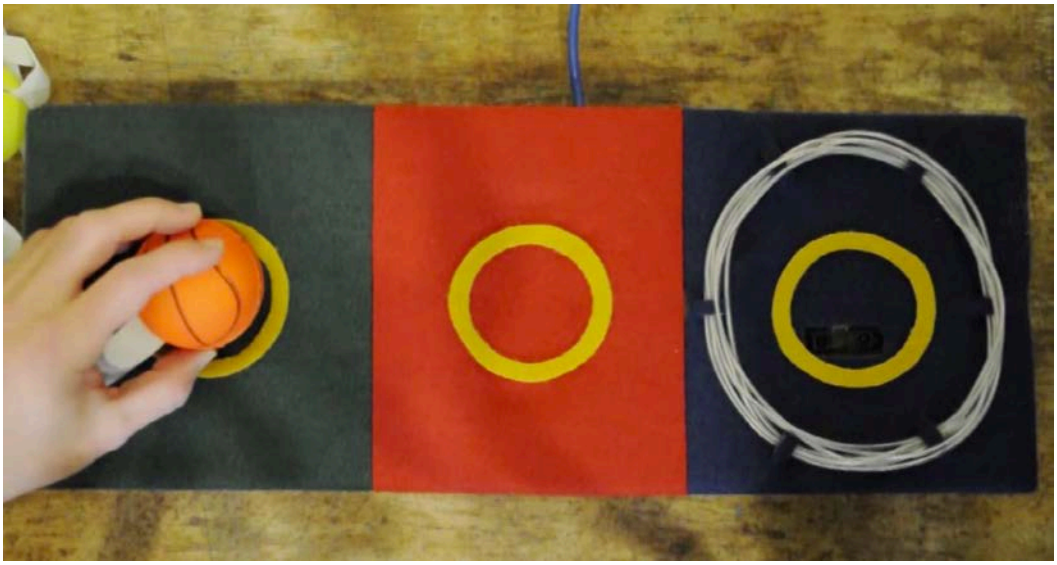


Figure 1.4 - *Device 1* (2011) (video screen capture).

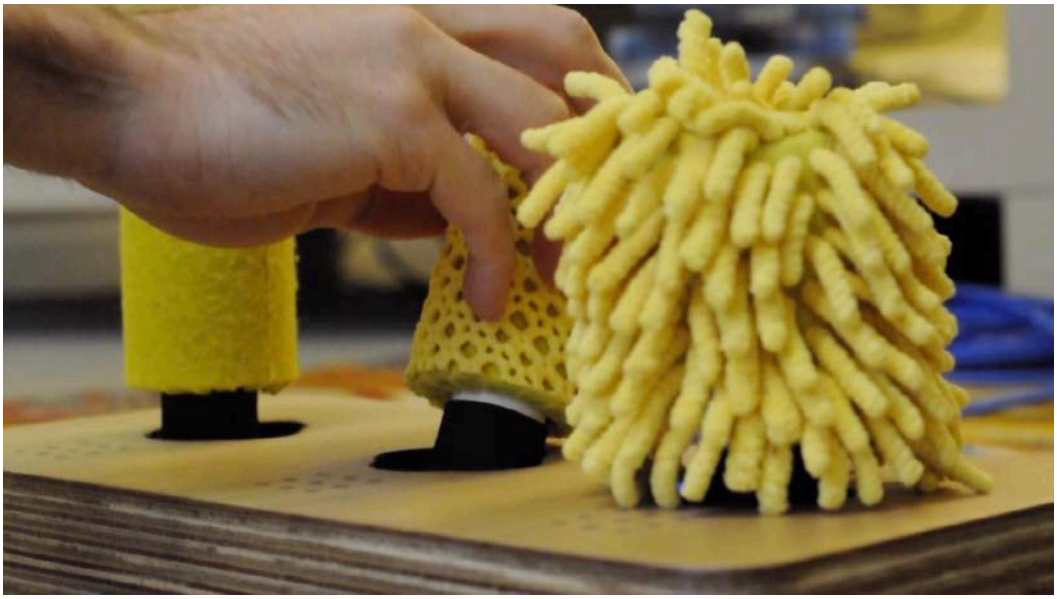


Figure 1.5 - *Device 2* (2011) (video screen capture).

Figure 1.6 - *Device 3* (2011).

Although the progression and development of the design artefacts (Figures 1.4 – 1.6) was the original focus of the study, it was the unanticipated moment of joint attention between mother and daughter with the second device (Figure 1.5) that motivated the project I describe in this thesis.

1.2.2 *Binaural dome* (2014)

I present the *Binaural dome* (Figure 1.8) here as a critical design artefact, developed during material exploration and prototyping studies conducted for the participatory open studio project in my doctoral research: the *Responsive Dome Environment* (*RDE*). Development of the *Binaural dome* gave me the opportunity to test my tacit exploration of materials (specifically the lighting technologies and dome surface) at a small scale, while also exploring important conceptual ideas around autistic sensory experience within a critical frame.

Structurally, the *Binaural dome* is a scale version of the *RDE*: it is a small (60 cm diameter) dome-shaped object, covered in a translucent material that allows coloured lighting beneath the dome to light its surface. The *Binaural dome* is triggered by push buttons located on a supporting plinth and includes the addition of binaural headphones to make the viewer hyperaware of their auditory sense within the environment.[5]

Unlike the *RDE*, the *Binaural dome* was required to function as a gallery object, where it would be competing with other artefacts for the viewer's attention in the gallery space. I used the binaural headphones to take advantage of this context, giving the viewer a highly sensitised experience of the sounds around them, some of which they might not usually pay attention to. One of my

[5] I use the term 'binaural headphones' here to describe a set of stereo headphones with a discrete, highly-directional microphone attached to each earpiece. Separating recording and playback of sound in this way gives the listener a heightened sense of where sound originates from, with certain frequencies being picked up more than others (e.g. shuffling of feet on the floor, doors opening and closing). As our ears naturally filter much of this environmental noise, this can be a disconcerting or disorientating experience.

interests in developing this artefact was to engage the gallery visitors (whom I assumed the majority to be neurotypical) in an alternative way of experiencing the space and their engagement within it. From this position, I framed the *Binaural dome* as a critical design artefact, aiming to challenge viewer perceptions of autistic experience while investigating what might it be like to be hypersensitive to sound.

The technology employed in the *Binaural dome* was very similar to that used in the *RDE*, particularly in regard to the lighting system and outer material of the dome (Figure 1.7). This gave the design artefact a dual purpose, providing the viewer an opportunity for critical reflection while allowing me to test the technologies planned for the *RDE*. For the *Binaural dome* installation, the gallery space was often busy with people moving and talking all around the viewer. By amplifying the sound of chattering voices and shuffling feet, an overwhelming auditory experience of the space was created for the viewer, providing them with an opportunity to reflect on what experiencing a gallery might be like for someone with a hypersensitivity to sound.

Figure 1.7 - Lighting system inside the binaural dome model.

Figure 1.8 - *Binaural dome* model at *Mighty Healthy* exhibition.

When one of the buttons placed in front of the dome model was pressed (Figure 5.7), a sequence of lighting and sound would be triggered, playing out a pre-

programmed audiovisual composition. Therefore, experience of the *Binaural dome* was broadly passive for the participant; rather than being designed as an interactive system, the object served as a situating experience for reflection on sensory hypersensitivity.

1.3 Responsive Dome Environment (2014—2015)

The central practice-based component of my project can be found in Chapter 4 of this thesis, where I describe a series of design iterations in a participatory open studio conducted with children and their parents. These interventions are conducted within the primary design artefact that was developed for this research, the *Responsive Dome Environment* (RDE) (Figure 1.9). I introduce the RDE here briefly, to contextualise much of the literature and precedents that are relevant to the project and discussed throughout Chapters 2 and 3.

As an interaction designer with a background in developing tangible and sensorial experiences, I bring a particular set of sensibilities to this research that inform the material explorations represented in the RDE, which ultimately serve as the first step in a conversation with participants. My interest in non-directed sensory interaction as a form of personal expression was one of the pathways that led me toward working with autistic children. This interest also informs the way that I approach experimentation with materials and space, even before engaging participants in my research practice. The result of this background was

the construction of the *RDE*, a responsive space designed to facilitate conversation with participants, by allowing them to engage with an audiovisual feedback system using one of several iterations of a tangible interface.

Figure 1.9 - External view of the *RDE* with first iteration of tangible interface.

Figure 1.10 - Internal view of the RDE with third iteration of tangible interface, during exhibition.

I describe the *RDE* as a 'constructive design artefact' and explore this concept in detail during Chapter 3. My framing of the *RDE* in this way leads me to position the material aspect of my practice as the locator for generating new knowledge: a situated catalyst to elicit feedback from participants on their experience during interaction. Throughout the participatory case study, in which I invited children and their parents to interact with the *RDE* (Figure 1.10), I explored ways of drawing out and reflecting on first-person experiences through my approach to the project as participatory action research. Some of the methods I use are the result of my tacit knowledge as an interaction designer developing sensory experiences. Other methods evolved and emerged during the case study that I will focus on as central to this thesis. I will reflect on my own experience in this practice-based approach to working with children and formalise the contribution to the field from my practice in Chapter 5.

1.3.1 Open studio

The development of the *RDE* occurred over several months and three design iterations. It was necessary to this process to lay bare my practice and be open to emergent directions identified by children and their parents interacting with the *RDE*, as well as through interviews and unplanned discussions with other practitioners in and around the material artefacts. With regard to the latter group, it was hugely useful to be working in a space that afforded unexpected conversation while situated by the *RDE* or other materials under construction. This opened the 'black box' of my practice and allowed critical reflection to take

place with other experts and peers.[6]

The final iteration of my open studio approach to developing the *RDE* coincided with a public exhibition, which I discuss in the following section. I separate these events not as an effort to claim a 'finished' work or artefact for exhibition, but to describe the different intents of these processes. The open studio was necessarily structured, in order to allow me to focus on the feedback from participants in relation to the development of the *RDE* and then bring this influence back into the iterative design process. The exhibition, on the other hand, was an opportunity to display my practice in its entirety, looking at the project as a whole.

[6] The term 'black box' is used here in the same way as the colloquial term found in many computing-related fields to describe a process that is hidden.

1.4 An Exhibition of Process (2015)

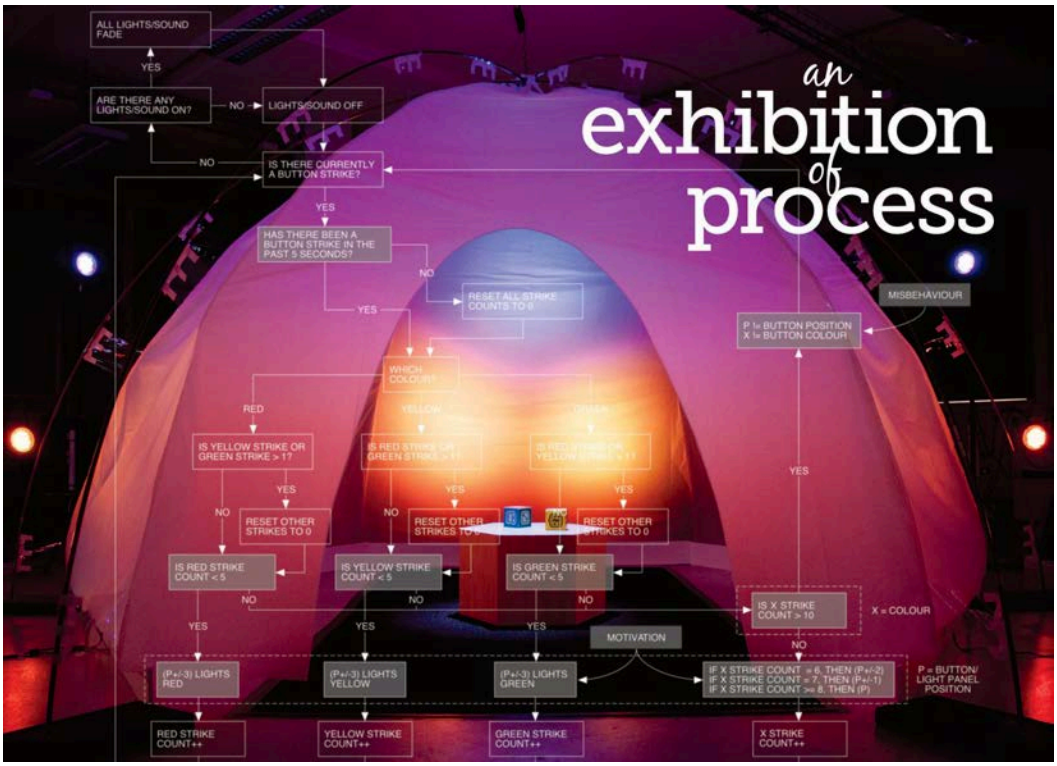


Figure 1.11 - *An Exhibition of Process* (2015) exhibition flyer (front and back).

Following the iterative participatory engagement with the *RDE* that I have outlined above, I presented the process work and artefacts generated throughout my PhD in an exhibition, titled An Exhibition of Process (2015). This event had the dual purpose of putting my practice on display to the public, as well as being a space in which I formally discussed my process with a series of academic experts from related fields (interaction design, media arts, HCI and occupational therapy). Throughout this thesis, I will refer to my semi-structured interviews with these practitioners to locate my own practice amongst existing fields and contrast my own way of working against established practices and expertise. As my reference to these interviews is distributed throughout the thesis, I will foreground these discussions by briefly describing the exhibition and interview setting in this section.

Figure 1.12 - Panorama image of exhibition/open studio (stitched from multiple images).

In creating a physical space that facilitated the semi-structured interviews, process artefacts and research materials were laid out within the Creative Robotics Lab (CRL), a cross-disciplinary research space at the University of New South Wales, Sydney, for approximately two weeks during September 2015

(Figure 1.12). This is the same experiment lab space that was used for the participatory studies described in Chapter 4. The approach to these interviews was such that emergent ideas or tangents in the discussion were encouraged, while still situating the interview around specific research issues (Wright & McCarthy 2010, p. 88).

The themes explored with each practitioner were a reflection of the phase at which I found myself in the research process. That is, these questions reflected some of the design and research problems I was working through at that stage of the project. As such, the expert interviews are presented at key points in this thesis, as they relate to aspects of my research and practice. Drawing upon these interviews helps to 'step outside' the tacit approach I bring to much of this project, gaining a different viewpoint and framing it in the larger field to bring my practice into sharp relief.

1.5 The role of practice-based research

In this chapter, I have begun to outline what I see as a gap in knowledge in relation to autism research. This is not framed as an attempt to address autism in a way that reaffirms the traditional pathologising of the diagnosis, but to explore the neurological diversity of human experience, which autism is part of. I will describe my creative, practice-based approach to this idea throughout the thesis, and make a case for why I believe that my conversational framing is

particularly well-placed to address wicked problems such as this.

I look at neurodiversity research through the lens of other creative approaches, particularly those with inclusive technology and embodied interaction at their heart. I draw from a range of fields to reflect on methods that I believe fit well within studio-based creative praxis that benefit from rapid responses to participatory feedback. Therefore, the practice-based approach that I present here is an exploration of how human experience can drive the design process, in a very personal way. It is both a reflection on my own development as a creative practitioner and an attempt to bring the voices of autistic people as co-creators into the design process.

1.6 Thesis structure

This thesis is presented in a structure that describes the development of my practice as it evolved primarily through the *Responsive Dome Environment* (RDE) project. This decision has been made for clarity and coherence of the overall argument. Chapter 2 and 3 form the literature review component of my research, examining at theories and precedents from interaction design and conversation respectively. The latter chapter explores how I bring cybernetic and design-based approaches to conversation into the development of the RDE, as both are relevant to describing my approach to interactive experiences.

Chapter 4 sets forward the participatory open studio that is central to my

doctoral research. I combine practice-based approaches to constructive material practice with a creative and reflective perspective to working with participants in a process of cooperative inquiry. From this study, I describe my practice in Chapter 5 as a way of working with marginalised or under-represented populations using conversational design interventions. Chapter 6 looks at the contributions from this doctoral study and forward to future applications of my practice.

2 Literature Review: Interaction Design

> Designers coming from the art school tradition have many ways to deal with the "halfway" between people and things. People negotiate their way through this halfway with their eyes, ears, hands, and body, as well as their sense of space and movement and many kinds of things they are barely aware of. (…) Designers trained in the arts are capable of capturing fleeting moments and structures that others find ephemeral, imaginative, and unstable for serious research. They are also trained in reframing ideas rather than solving known problems. (Koskinen et al. 2011, p. 8)

As an interaction designer, I take a holistic approach in this thesis to improving or intervening in relationships between interactive artefacts, humans, and the contexts in which interaction takes place (Fallman 2008, p. 4). My interviews

with expert practitioners throughout this thesis[7] will show that approaches to the field may come from a strongly technical and positivist perspective or, at the other end of the spectrum, are the result of creative practitioners exploring the speculative and critical relationships between humans and interactive experiences. Most often, like myself, interaction designers draw from a range of skills and interests across this gamut of practice and theory.

In the handbook *Interaction Design: Beyond Human-Computer Interaction* (Preece et al. 2015), Preece, Rogers and Sharp illustrate the interdisciplinary nature of interaction design by mapping some of the influences on the field (Figure 2.1, below). This image is not presented here as an exhaustive account of interaction design, but rather an example of the multiple perspectives that are often brought to bear on the field. Preece, Rogers and Sharp broadly categorise these perspectives under 'academic disciplines', 'design practices' and 'interdisciplinary overlapping fields'.

[7] I draw upon semi-structured interviews that I conducted with practitioners to situate my practice and reflect upon the artefacts developed as part of this research. Later in this chapter I will describe the format and methods of analysis for these interviews.

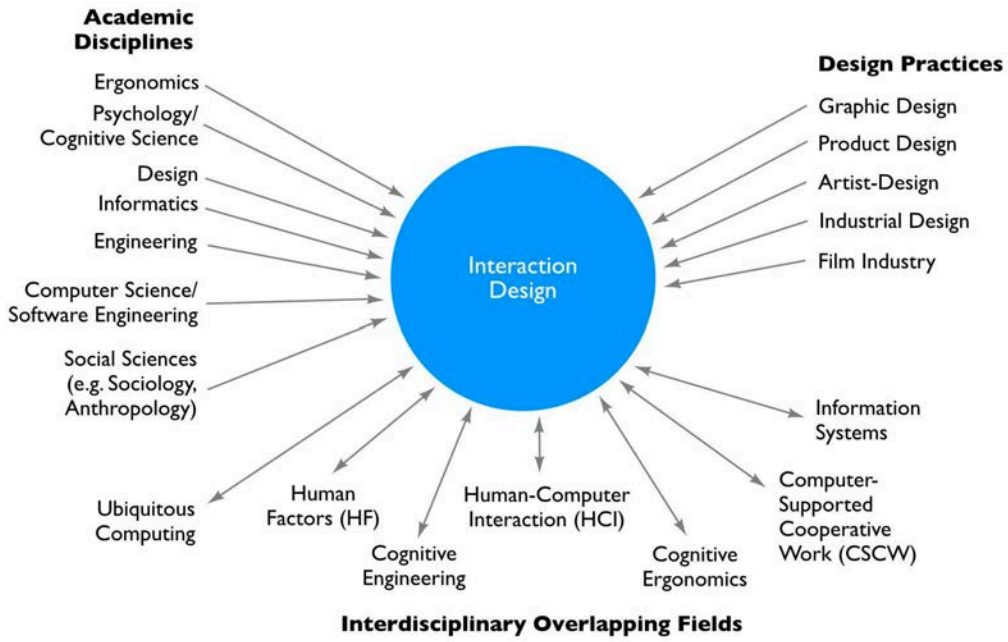


Figure 2.1 - Fields in relation to interaction design (Preece et al. 2015, p. 9).

The primary point I make here is that depending on the practice under examination, interaction design draws from a range of disciplines to contend with often wicked problems in human and/or machine interactions. The wickedness of the problem may even arise from contesting disciplines or practitioners, where there are manifold expectations for the outcome of a single project. Viewing the world from alternative perspectives, therefore, is hugely important for an interaction designer.

My own contribution to this field is in structuring my practice as 'conversational', resulting in a useful framework for designers working with a neurodiverse population. I propose that one of the strengths of my conversational approach to design is that it produces dialogue between the different fields that I draw into my practice and in turn offers channels for feedback from underrepresented participants. In this chapter, I will describe

some of the key interdisciplinary terms and influences on my own relationship to interaction design, namely embodied and situational design approaches. I will then examine precedents from key researchers working in relation to autism, each of whom overlap with the sensitivities and interests of interaction design.

2.1 Experience-centred design

In the previous chapter, I pointed to the role of embodied interaction in my practice as a method of supporting non-directed sensory expression through interactive technology. Here I connect this idea to 'experience-centred design', a humanistic approach which has come to prominence in HCI and interaction design practices, where artefacts are designed to enhance, augment, or facilitate the richness of individual lived experience (Wright & McCarthy 2010, p. 2). Facilitating individual experience is the foundation on which I build this thesis. I use experience-centred design as a frame for remaining empathetic to alternative human perspectives by designing for experience, and for maintaining a sensitivity to engage in human-centred conversation:

> The job is to understand the experience, not to apply the method. The method is a tool that can help you understand the experience, and it should be used with sensitivity to the situation, people, and experiences in question. This requires 'entering into' the situation and participating with the people whose experiences are being studied, perhaps, participating in activities with them and having them participate in research and design activities with you, minimally, participating in a dialogue that can take the

> form of meaningful, sometimes intimate, conversations with them over time. (Wright & McCarthy 2010, p. 94)

The role of experience-centred design in my practice is manifest in my interest and effort to reflect on the perspectives of participants. Like Peter Wright and John McCarthy point out in the quote above, I tacitly draw from my own sensitivities as a designer to create situations and activities for engaging participants in a rich conversation both with and through a responsive design artefact. There are stages to this process: the designing and materialisation of an experience, the interaction experience of participants, and the reflecting upon the experiences of both myself and the participant to situate the work. Each stage informs the others, but it is the situated and ephemeral experience of participants that is of most interest to me in this project. It is this element that I aim to draw out through participatory interaction with a responsive artefact. In so doing, my research practice moves between research through design and research into design (which I will explore further in the constructive design research section in Chapter 3).

By reflecting on the participatory experiences that take place in the *RDE* open studio, I will look at the role of conversation and first-hand experience in practice, so that these reflections may be instructive for others working in human-centred and interdisciplinary design. My practice—like experience-centred design—finds value in the interlinked relationship of designer and participant. As Wright and McCarthy note, designers and participants are different, but equally important 'centers of value in the process of design'

(Wright & McCarthy 2010 p. xiii). Exploring the experience of participants as well as that of myself as a designer recognises the role of personal knowledge in disentangling the wicked problems encountered when engaging a neurodiverse population.

Jodi Forlizzi's interaction-centred framework for understanding participatory experience (Forlizzi & Ford 2000) is useful in bringing some of the sensitivities of an experience-centred approach to praxis relating to interactive media art (Khut 2006, p. 31). Jodi Forlizzi and Shannon Ford consider experience in three categories: conscious experience or 'self-talk' that occurs through daily interaction with the world (simply 'experience'); a singular or memorable experience that we refer to in isolation, such as a helicopter ride or deep sea dive ('an experience'); and communicated experiences, which play out through social interactions with others ('experience as story') (Forlizzi & Ford 2000, p. 419).

In the experiences I designed in this project, I considered the role of the first two of Forlizzi and Ford's categories in informing the third co-experiential category of social interactions. In doing this, I encouraged or elicited co-creation between myself and participants. This connects back to my motivation to include the first-person perspectives in conversational interactions and is of particular interest in examining neurodiverse experience, for example an autistic child whom may have specific sensory interests or aversions. The sensory inclinations of a participant will inform their experience in an

interactive environment, such as the way that they interpret or respond to light, sound, and the formal design qualities of a space. In the *RDE* open studio, I looked to these life experiences to help reflect on conversation and social interactions. Forlizzi and Ford recognise the uniqueness of experience in their framework, as shown in their diagram below (I have replaced the term 'user' with 'participant' and 'product' with 'artefact' to more closely align with the terminology I am using in this thesis).

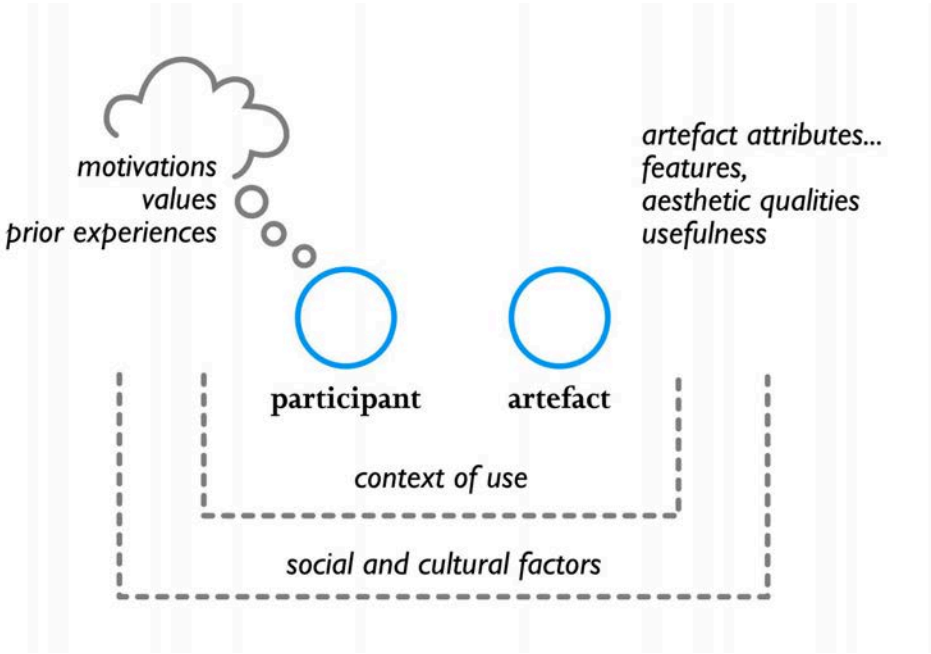


Figure 2.2 - Influences on experience using 'participant' and 'artefact' terminology, adapted from (Forlizzi & Ford 2000, p. 420).

When designing for experience, I recognise that the situation or context created by the designer is only one aspect of a participatory experience. The participant will bring with them a range of sociocultural influences that will colour their interaction and are beyond my influence or control. Rather than working against this, I open my practice up to unexpected or emergent experiences that arise from a participant's motivations and values. This is particularly pertinent

when working with a neurodiverse population who by definition will have very different responses to the aesthetics and function of an interactive artefact.

The quality of a participant's experience in my work is important, as it relates to their ability to reflect upon it in a way that can feed back into the design process. Forlizzi and Battarbee describe interactive experiences as falling into three categories: 'fluent' (automatic and skilled), 'cognitive' (difficult, which may result in new knowledge or confusion and error), and 'expressive' (develop a relationship between the participant and artefact) (Forlizzi & Battarbee 2004, p. 264). Media artist George Khut reflects on the relationship between Forlizzi and Ford's interactions by considering how a participant interacting with an artwork might have 'meaningful and potentially transformative experiences' (Khut 2006, pp. 35-36) and how transitions between types of interactive experience centre around the notion that a participant is able to reflect on their own actions, potentially triggered by the feedback of the artefact. For example, Khut posits that developing knowledge of the behaviour of a system will transition the type of interaction from cognitive to fluent, and when expertise of an interaction leads to subconscious actions, there is potential for an experience to shift from fluent to expressive.

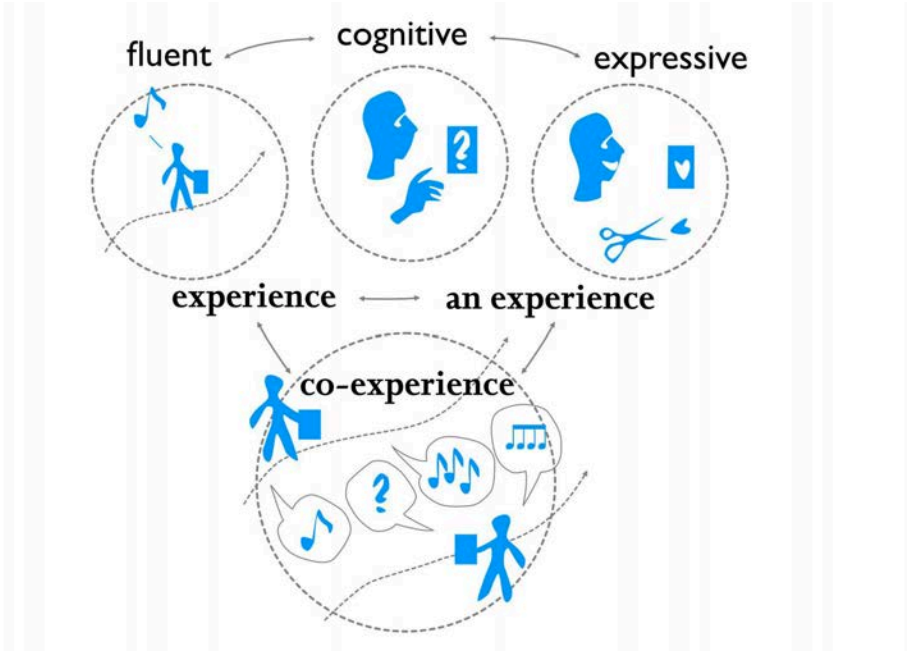


Figure 2.3 - The dynamics of experience in interaction for individuals and in social interaction, from (Forlizzi & Battarbee 2004, p. 264).

Of most interest to my work with neurodiverse children is a reversal of the fluent-to-expressive progression, which is the result of the participant reflecting on their own actions, and the interaction shifting from fluent or expressive to a conscious or 'cognitive' act. This creates an opportunity for the participant to be self-reflexive, either of their own volition, or through prompting in regard to their experience.

In this project, I worked with a study population of 6 children (2 autistic and 4 neurotypical), all under the age of 5. As a result, reflecting on first-hand experience using only linguistic feedback (written or verbal language) was not always straightforward. This presents an interesting research challenge. One of the practical ways I responded to this problem was through the reflection of the parent or carer of the child. As a person with a close relationship with the child, the parent provided a valuable perspective in establishing a rich picture of the

child's experience and their own (co-)experience of the interaction. The feedback of the parent also helped to place the experience of the child in a broader sociocultural context. My approach to designing interactive experiences thus supports a complex and rich narrative of experience, rather than a metric of artefact use, success, and quantitative data.

2.2 Embodied interaction

> Embodied Interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artifacts. (Dourish 2001a, p. 126)

My orientation toward interaction design is the result of my interest in embodied human experience; the way that interaction can transform understanding of our bodies, and bodies can transform our understanding of interaction. Informed by my background in live performance, the potential for embodiment to situate a performer or the audience within the world has affected my design practice. The dynamic relationship between body, responsive artefact and space has shaped my intentions as a designer and my belief that embodied interaction can uncover personal histories, knowledge, and meaning making.

According to Paul Dourish (Dourish 2001a, p. 99), embodied actions are central to tangible and social computing, 'unavoidably enmeshed in a world of physical facts.' While this quote would seem to point to the commonly accepted notion

of physics as a science of gravity, mass, and so on, Dourish takes a more relativist position on embodied interaction. Embodied or phenomenological experiences in the world are understood from the perspective of each body; our sociocultural histories shape the way that we exist within and understand our world, and are the lens through which we interact with it (Dourish 2001a, p. 99). From this position, my interest in embodied interaction is twofold: firstly, to reflect neurodivergent ways of knowing, expressing and engaging with the artefacts which I design, and, secondly, as performative expressions of sociocultural histories that communicate experience and understanding of the world.

The value I place on first-person accounts of experience is key to my approach to design. I focus on embodied interactions to position the design artefact as a facilitator of experience and meaning making, 'turn[ing] our attention away from the artefacts themselves and toward the ways in which people engage with them' (Dourish 2001b, p. 184). However, the purpose of embodiment in my practice is not simply as a tool for observing human behaviour or usability; it is to bring the participant's attention to their own actions, making interaction cognisant and reflexive, and providing an experiential foundation to feed back into a co-creative design practice.

This characterisation of self-directed participation in my research parallels David Rokeby's description of interaction in 'Transforming Mirrors':

> A technology is interactive to the degree that it reflects the consequences of

> our actions or decisions back to us. It follows that an interactive technology is a medium through which we communicate with ourselves... a mirror. The medium not only reflects back, but also refracts what it is given; what is returned is ourselves, transformed and processed. To the degree that the technology reflects ourselves back recognizably, it provides us with a self-image, a sense of self. To the degree that the technology transforms our image in the act of reflection, it provides us with a sense of the relation between this self and the experienced world. (Rokeby 1996)

In Rokeby's exploration of embodied interaction, participants are encouraged to appreciate their personal agency for changing an environment through sensory feedback of a responsive system. He surmises that interaction with technology gives something back, something to identify with and reflect our selves in the world. In Rokeby's interactive installation *Very Nervous System* (1986-1990), the participant is able to effect change in a musical instrument-like system, using camera tracking on a single body in space to manipulate auditory feedback. On a technical level, this style of interaction is now more commonplace, with depth-sensing cameras (such as those used to create the Microsoft Kinect) becoming a familiar technology. However, *Very Nervous System* was highly advanced for its time. The novelty of Rokeby's system during the 1980s and 1990s lay in his use of cutting-edge technologies to 'hide' the computer from participants (Rokeby 2010). By using the body as interface, Rokeby aimed to make the interaction natural and immediate through an intuitive, physical, human-scale, and personal experience.

Rokeby's foregrounding of human movement-as-interface is recognition of the

role of the body in meaning-making and cognition. This tactic can be seen more contemporarily in Lian Loke's 'making strange' approach to embodied interaction design (Loke & Robertson 2013), which explores a mapped relationship between human actions and computer feedback. However, unlike Rokeby's work, which was driven by his fascination with the different experiences of the novice and the expert, Loke's premise assumes a certain level of physical and sensory capability, suggesting that not all bodies are able to experience these works (at least until they are no longer novice). While Loke does acknowledge the importance of first-person ability, most users of the 'making strange' toolkit are highly capable performers, such as trained dancers.

My work—deliberately—assumes little to no knowledge of how an embodied interaction should play out, or the bodies that will experience them. This is because the interactive artefacts I develop have been brought to bear on a neurodiverse population, with a broad range of sensory hyper- and hypo-sensitivities. My practice-based approach to embodied interaction is not an effort to measure or understand the experiences of an autistic person, but is instead a critical and speculative exploration of uniqueness found across neurodiversity, elicited by conversation with and through responsive design artefacts.

The role of the interactive design artefact in my practice is to facilitate reflexive moments between the system, participant(s), and myself. This is achieved by providing space for critical reflection in response to interactive experiences: if

the system did not respond as expected, how does that change a participant's expectations and understanding of self? If a participant does not interact as I expected, how does that change my assumptions as a designer? This opportunity for reflection also leads to meaning-making through experience. As described by Anthony Dunne and Fiona Raby in their book *Speculative Everything* (Dunne & Raby, p. 35), the material object affords 'thinking through design rather than through words.' This is to say that the function of the artefact is to engage people in a conversation through materiality. I will unpack this idea further in Chapter 3 in regard to my constructive design research practice, in which I engage with participants by reflecting with them during experiences with the *RDE* open studio—a site of knowledge acquisition for both participant and myself. My approach to working alongside neurodiverse groups by reflecting on embodied interactions allows me to engage with participants in a way that remains sensitive to their ways of being in the world in which written or spoken language may not be appropriate.

2.3 Situated interactions

My role as an interaction designer is to create situated activities in which a participant can reflect upon their own experiences, leading to meaning-making. This places participants at the centre of knowledge production in my project and recognises their unique understanding and experience of the world. The locating of experience in my practice is an important step toward creating

opportunities for conversation.

In this thesis, I look at the ways in which my practice—and notably the *RDE*—use aspects of embodied interaction and experience-centred design to support first-hand experiences, which are situated by the interactive artefact. This follows a long tradition of tangible computing in interaction design. For pioneering designers, such as Bill Verplank, physicality is an important mediator of interaction that guides the creation of seemingly simple technologies, like buttons and levers, to facilitate embodied interactions (Tarakajian 2013). However, this simplicity belies the close understanding Verplank has for the role of the computer in situating interactive experiences. In his *Interaction Design Sketchbook*, Verplank (Verplank 2009, p. 18) asks the reader to consider 'the essence of computers: representation for manipulation.' Put another way, an interactive experience can facilitate a participant in locating their worldview; their expectations and perceptions—based on sociocultural histories—can be reflected or challenged through manipulation of a physical experience with a computer or machine.

Likewise, human-computer interaction (HCI), a field that has much in common with interaction design, has evolved from its task-oriented and efficiency focus of the 1970s and '80s into a field that now examines a spectrum of human-computer concerns, such as social and situated 'everyday life' interactions with machines (Muller 2008, pp. 69-70). For example, Lucy Suchman's *Plans and Situated Actions* (1987) was a notable departure from the quantitative approaches

of HCI at the time. As the title suggests, Suchman's contribution lay in placing human experience at the centre of HCI, asserting that meaning-making occurs in the situated act and a participant's goals emerge through acting in the present moment (Suchman 1985, p. 37).

The relevance of this idea to my thesis can be seen through my approach to the material artefact as a facilitator of participatory engagement—the purpose of the *RDE* in eliciting feedback from participants as a result of their interactive experiences. For the contemporary 'third paradigm' of HCI, focusing on human-centred experience is of particular interest in challenging the mainstream patriarchal gaze (Harrison et al. 2011) and exploring HCI's 'growing emphasis on the contexts, motivations and experiences of real people rather than abstract and generalised "users"' (Muller 2008, p. 70).

In the RDE open studio I describe in Chapter 4 of this thesis, I reflect upon the embodied and 'situated perspectives' (Harrison et al. 2007, p. 1) of children and their parents interfacing with a responsive audiovisual artefact. I propose that through facilitation, observation, and reflection on the experience of participants in the space, layers of reflection on conversations take place, piecing together a picture of first-person knowledge and experience. Paul Dourish uses a Heideggerian framing to describe this approach to understanding through an embodied situation: rather than trying to understand the world through an objective lens, Heidegger asked, "How does the world reveal itself to us through our encounters with it?" (Dourish 2001a, p. 107). This

aligns with my argument for embodied experiences to be described as conversations. It also locates agency with the participant—a proposition that is under-explored in neurodiversity research and one that creative practices can contribute. My framing interaction in this way affords the participant an opportunity to express themselves on their own (non-directed) terms, and informs my praxis as an interaction designer.

2.4 Precedents in autism research

> Oliver [Sacks] was interested not just in studying what deficits and impairments his patients had, but also in what gave them joy, resilience and a sense of purpose. He would then ally himself with these sources of strength so they could learn to use their potentially devastating conditions as opportunities for adaptation, renewal, reinvention and growth.
> (Silberman 2016)

In his book *NeuroTribes: The Legacy of Autism and How to Think Smarter About People Who Think Differently* (Silberman 2015), Steve Silberman references not only the medical research of neurologist Oliver Sacks, but also the sensitivity he brought to the people he worked with—most importantly, Sacks' appreciation for the individual. Like Silberman, I highlight the work of Sacks here in contrast to much of the historical research carried out in relation to autism. For a condition that is highly complex and individual in its symptoms, a great deal of the work in this area attempts to treat autistic people as a homogenous group. This runs counter to the premise of neurodiversity, which embraces individual difference.

In this section, I identify a range of technology-based autism interventions, each of which has recognised the importance of the individual either in their design or methodological focus.

According to the *Australian Bureau of Statistics*, there were 164,000 people in Australia with autism in 2015 (AU et al. 2017) and difficulty with social interaction and communication remains one of the key indicators of the condition. The perception that autism is a solitary existence has persisted for as long as diagnosis; embedded in its etymology is the Greek word *autos* meaning 'self' (Yates 2002). It is unsurprising, then, that many autism therapies and interventions focus on encouraging social communication through joint attention and co-operative interactions. The examples of interactive technology I present here frame my own research project and place the *RDE* within a lineage of embodied sensory interactions designed to facilitate neurodiverse social experiences.

2.4.1 Snoezelen and multi-sensory environments

The *Responsive Dome Environment* (*RDE*) I developed as the artefact central to this doctoral research is a spatial environment in which children can interact through a variety of sensory modalities. At the outset of this project, my interest was to use a responsive space to locate interactive sensory experiences between autistic children and their parents, moving away from the personal (1:1) relationship of the *Device* objects I describe in Chapter 1. Use of multi-sensory

spaces in therapeutic contexts is not a new phenomenon, and can be traced back to the Snoezelen room of the 1970s. Developed in the Netherlands, 'Snoezelen' is a portmanteau word formed from two Dutch words: *snuffelen* (to explore or sniff out) and *doezelen* (to doze or relax), created to describe the act of "exploration in a relaxed state" (Botts 2008, p. 139). The Snoezelen room was originally developed by therapists working with people with developmental disabilities (McKee et al. 2007, p. 305) and was designed to allow people to relax through interaction and/or passive immersion in a non-directed sensory space.

This non-directed and relaxing intent of the Snoezelen parallels with my *RDE*, despite its contentious historical association with therapy and education (McKee et al. 2007). Sidestepping this debate, I reference Snoezelen here for its historical significance and use of non-directive embodied interaction. In the Snoezelen and other multi-sensory environments (MSEs), coloured lighting, projections, bubble tubes, ball pits, and bean bags are installed primarily in institutions like schools and hospices, to create spaces for respite and relaxation for clients.

The aims for these spaces are diversional (well-being focussed) rather than therapeutic or educational.[8] Similar to these intentions, the *RDE* is designed to allow children to engage with sensory experiences on their own terms. In the *RDE*, interaction is non-directive, and behavioural observations (by parents or myself) aim to highlight actions or patterns of activity for first-person

[8] In Australia, Diversional Therapy is a wellbeing-focused practice that uses client-led activities in a range of health-related contexts (Anon n.d.).

reflection, rather than confirm predetermined goals or hypotheses. This approach keeps the direction of the practice-based research led by 'what children want to do as opposed to what adults expect of them' (Druin 1999).

Following Amanda Baggs' thoughts on what constitutes communication and personal expression (Baggs 2007), my own analysis of MSEs is that they successfully address two main challenges in embodied interaction. Firstly, MSEs provide a broad enough range of sensory experiences that facilitate interest from a range of participants (for example, neurotypical children). Secondly, MSEs also create situated spaces that are immersive enough to mitigate what Oliver Grau (Grau 2003, p. 13) describes as a 'critical distance'. By increasing 'emotional involvement' between the participant and artefact, the observer is placed strongly within the experience. This is key for engaging participants in conversation with an artefact, rather than thinking about the interaction on a technical or conscious level; it allows participants to express themselves naturally and with 'increasing emotional involvement in what is happening' (Grau 2003, p. 13).

2.4.2 MEDIATE

The *RDE* open studio I present in this thesis describes an opportunity for neurodiverse participants to engage with a responsive space without being directed by the aims or objectives of a study. Indeed, I was interested in observing the agency of participants and looking at how this might guide

conversational engagement. Another project which combines the immersive sensory potential of MSEs with explorations of autistic agency is the *MEDIATE* environment.

Developed at the Universitat Pompeu Fabra, Spain, *MEDIATE* is an immersive, responsive environment with stated goals of 'control to achieve a sense of agency' and the ability of the system to 'adapt to each child' (Parés 2005, p. 110-111). When participating in the *MEDIATE* environment, autistic children are able to interact with a large projection wall that responds to physical movement by animating an array of geometric shapes (Figure 2.4). The self-directed approach to interaction is designed to afford many different modes of physicality and adapt to each participant's mode of sensory dialogue.

Figure 2.4 - The interior of the *MEDIATE* environment (Parés et al. 2004, p. 7).

The motivation for this responsive interaction is to give children an awareness of their agency in the space and provide an opportunity for creative expression. While the ambitions of Parés et al. suggest that interacting with the environment will be an enjoyable experience for autistic children, being within

the space is a solitary encounter and the project researchers do not make a stated attempt to understand how participants are expressing themselves, their thoughts, or feedback into the design process. In this way, *MEDIATE* uses technology as a functional end in itself, which is unlike my own *RDE* open studio and the other practice-based work I describe in this thesis. Unlike the *MEDIATE* project, I develop responsive design artefacts to not only create, but also situate an experience for reflexive feedback. This is a key area for creative contributions to neurodiversity research through interaction design.

2.4.3 ReacTickles

There are limited examples of interaction designers using design artefacts with neurodiverse participants to generate principles for other designers to work with similar populations in better ways. One researcher that is working in this space is Professor of Technology and Inclusion, Wendy Keay-Bright. Keay-Bright takes a human-centred and inclusive approach to designing technology-based interventions for people that may be marginalised by mainstream perceptions of disability and a lack of access to assistive technologies.

In their paper *Is simplicity the key to engagement for children on the autism spectrum?* (Keay-Bright & Howarth 2011, p. 129), Keay-Bright and Imogen Howarth argue that using technology for purely functional ends misses an important opportunity for emergent 'untapped ability' from autistic children. Keay-Bright and Howarth suggest that children can be better engaged through the kind of

simple interaction that can lead to 'fluent' or 'expressive' modes of interaction (described earlier in this chapter). Keay-Bright's *ReacTickles* screen-based applications (2012) are examples of work that attempts to engage participants in a flow-state, to reveal novel channels of participant feedback.

The *ReacTickles* suite of applications (Figure 2.5) looks at giving autistic children and adults an understanding of their ability to control cause-and-effect interactions through a screen-based format, 'demonstrating positive impact on concentration and flow, expressive communication and creativity and self awareness' (Keay-Bright 2012, p. 3). Using touch, gesture and audio input as forms of interaction that reward users with animated feedback, *ReacTickles* allows the participant to use their preferred style of sensory engagement and reduces the need for specific skills or knowledge (Figure 2.5). The creative and expressive interface used in the *ReacTickles* project allows for non-verbal conversations to take place between the participant, system and design researcher.

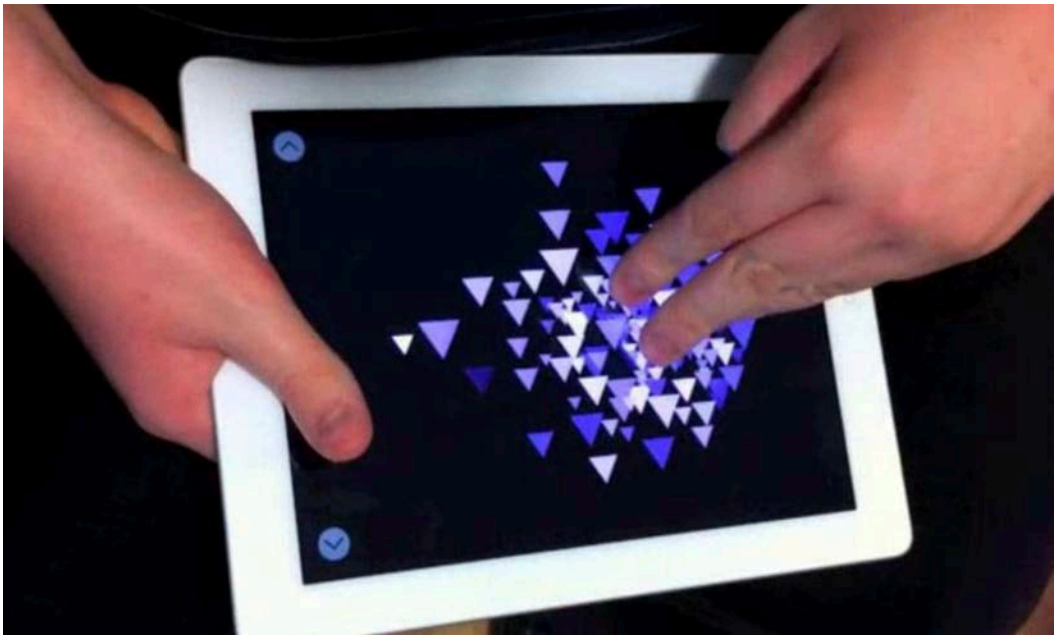


Figure 2.5 - The *ReacTickles MAGIC* iPad application (Anon 2012).

While developing this project, Keay-Bright created several design principles that are reflected in the software, which are also useful for designers and researchers working with interactive and assistive technologies:

- Avoid making assumptions about interest or cognitive ability—participants will create their own meaning through action;
- Simplicity in design can allow the participant to have novel experiences, open to interpretation and avoiding perceived errors in use;
- Providing rich sensory opportunities for interaction and feedback should stimulate, but not overburden participants; and
- Repetition and flow elicits curiosity in the participant, affording self-directed choreography to their experience (Keay-Bright 2012, pp. 3-4).

Each of these principles can be seen in my own approach to interaction design, although used tacitly in my earlier work with tangible interfaces (see Section 1.2), before becoming intentional in the neurodiversity-focused design of the *RDE*. For the *RDE*, I have developed experiences that are straightforward yet rich enough to encourage the participant to explore the experience through the lens of their own values and expectations. This can be seen in the use of bold colours as signifiers in the *RDE* interface, combined with some ambiguity in the way that interface position or location is mapped to the visual feedback of the *RDE*. The result of this ambiguity in *RDE* often led to emergent behaviours that I had not consciously designed for—experiences that were unexpected and created new meanings for participants that we were able to reflect upon and I could feed back into my practice.

2.4.4 ECHOES

As pointed out by Keay-Bright in her work and design principles, and key to my own practice, observing interactions between participant and system can provide valuable feedback for informing design decisions. However, it may be difficult to understand through observation alone what a participant is experiencing during interaction with an artefact without active reflection or feedback from that participant. Identifying ways of overcoming this difficulty is central to the contribution of this thesis and I explore related fields that also consider how to encourage participants to externalise their internal thought processes—for example the 'breakdown' (Winograd & Flores 1986, p. 36) and

'making strange' (Loke & Robertson 2013)—in the next chapter. Here I introduce a work which speaks to this idea within the scope of autism research: the interactive game project, *ECHOES*.

The task-focused game play of *ECHOES* project, developed at the Department of Culture, Communication and Media at University College London, originally aimed to look at screen-based interactions of an autistic child who is accompanied by an adult in a therapy role. Interaction with *ECHOES* includes learning goals such as colour and pattern matching tasks. The project team's interest in a disruptive method emerged unexpectedly from participatory research. The disruptions—or 'expectation-violations' as observed by Alyssa Alcorn et al. (Alcorn et al. 2013)—refer to moments in the *ECHOES* game-like experience where the system first establishes predictable interactions and then reacts in a way that the participant does not expect.

Figure 2.6 - *ECHOES* evaluation setup (Alcorn et al. 2013, p. 486).

The expectation-violations that occurred in the *ECHOES* project were a result of

a serendipitous system error, with Alcorn et al. (Alcorn et al. 2014, p. 226) identifying that many of these events had the unplanned side effect of the child initiating social communication with the adult therapist who shared the interaction space with them. That these events were unplanned in the original research highlights an interesting opportunity when designing for autistic children, which Alcorn et al. point out as 'a valuable window into the interests and attentional focus of young children with [autism], illuminating the often significant gaps between the adult designer's intentions and the child's experience of the interaction' (Alcorn et al. 2014, p. 228). That is, researchers must to be open to unique or emergent modes of interaction and communication.

This emergence is mirrored in my own experience, which I describe over the remaining chapters of this thesis. I had initially approached this project with the intention of observing modes of sensory communication or expression from neurodiverse children, using the embodied and situated interactive experiences that relate to the work seen in multi-sensory rooms and the *MEDIATE* environment. However, it was through my (at times tacit) use of design principles similar to that of Keay-Bright and the *ReacTickles* iPad application—namely simplicity and ambiguity—that I recognised the importance of giving participants an opportunity to unpack their own experiences.

2.5 Expert interviews

Throughout this thesis I will refer to a series of semi-structured interviews I conducted with expert practitioners, as they are related to my discussion. The first (described in the following section) helps ground the literature I have explored in relation to autism research by identifying the relevance of my approach with an occupational therapist. As is the case with the occupational therapist, each of these experts are drawn from fields related to the subject of this thesis, but approach ideas similar to my own using different methods or philosophical positions. My interviews with them helps to situate my practice amongst a range of fields and assert the validity of my own approach within interaction design.

Interview subjects were approached because of their established academic practice, with the aim of representing a range of fields with some relationship to my own research. Institutions from which these practitioners were drawn included the University of New South Wales (Schools of Art & Design; Arts and Media; and Psychiatry) and the University of Sydney (Faculty of Architecture, Design and Planning). The following list outlines the scope of practices, separated into their self-identified primary disciplines:

- Interaction design and media arts

- Body-focused HCI

- Interaction design and HCI
- Interaction design and HCI and media studies
- HCI and industrial design
- Occupational therapy

The semi-structured interviews carried out with practitioners allowed for an open approach to discussing perspectives and the potential for interviewees to take the direction of discussion towards areas that I may not have originally considered. Sharing my practice and rationale for methods used is one way in which I address the validity and contribution of my research. The topics/questions asked of each practitioner were:

Question 1: What role do participants play in your research?

Question 2: How and where do you include participants in your methods or processes?

Question 3: Do you measure success or completion of a project?

After the resulting interview transcripts were collated, I carried out a thematic analysis across each of the discussions to identify contrasts and similarities between my practice and that of the experts. This analysed data can be found in the appendix to this thesis, along with the full interview transcripts. While the analysis of discussions that took place in this study did not result in data that

can be considered generalisable, the presentation of this knowledge should provide a context or narrative that suggests that the methods I describe throughout this thesis could be applied by other designers working with neurodiverse groups of children (Lincoln & Guba 1986, p. 77).

These interviews also included a visual mapping component, which was carried out after the semi-structured interview questions. After presenting my practice through the exhibition/open studio space (Figure 2.7), the practitioner's attention was directed to a visualisation of the sequence in which I moved through each stage of my process. This mapping was visualised by black tape across the floor (Figure 2.8), connecting different sections of the exhibition/open studio space. Participants were then asked to use chalk to map their own practice, identifying any processes that were similar to my own and any points that contrasted in method or intent.

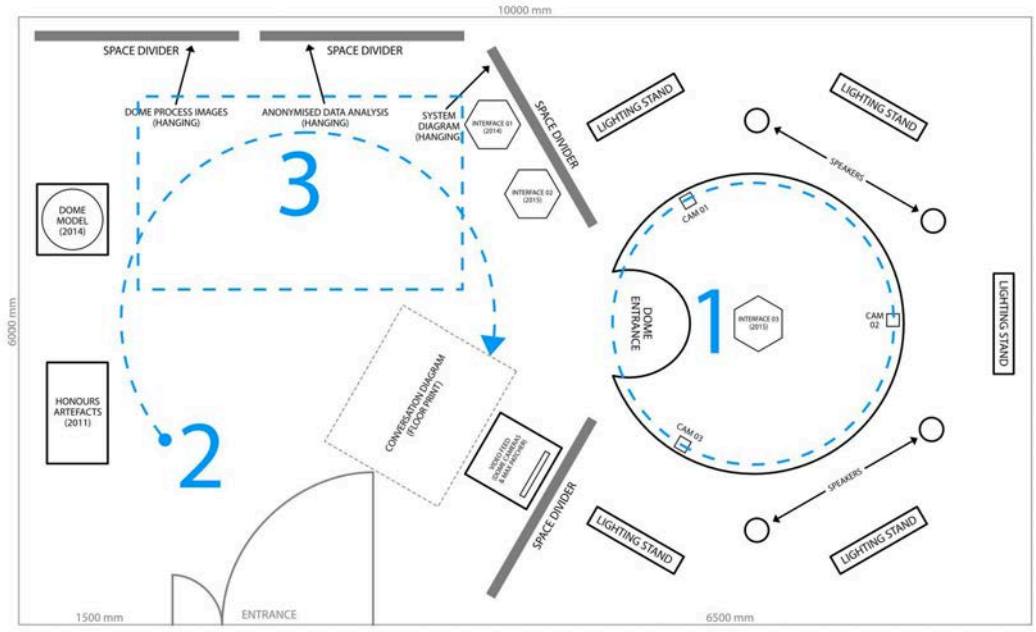


Figure 2.7 - Stages of practitioner interviews.

Figure 2.8 - Connecting stages of my process by mapping across the floor (black tape).

In the same way that embodied experiences are an opportunity for participants to express themselves without the use of verbal or written language in the *RDE* open studio, this changing of feedback modality from verbal (logic) to visual (creative) resulted in different and emergent responses. I will reference the resulting visualisations, along with relevant discussion from five practitioners throughout this thesis, as they are relevant to my discussion. This will locate my practice amongst a range of fields and practice, all in relation to interaction design, participatory engagement and/or neurodiversity research.

2.6 Interview: Occupational therapist

The first expert practitioner interview I am introducing in this thesis is with an occupational therapist who specialises in autism research. While this

practitioner was the ‘furthest’ from my own field, this discussion grounds my reference to technological precedents in this chapter, and much of our discussion centres around the relevance of these kinds of artefacts to the autistic and therapeutic community. While I do not make any claims to be contributing in this space, it is important that I recognise and take into account the impact of autism research on my approach to this project. This informed many of the early design decisions I made in relation to materiality and system feedback in the RDE open studio.

Throughout the expert practitioner interviews I attempted to avoid preconceived notions of what to expect from each discussion, however I discovered bias in my assumption based on research field. In particular, my expectation for the occupational therapist to be the only interviewee who employed a positivist approach to research (where the researcher was seen as separate to the participant as an object of study) quickly proved not to be the complete picture. In our discussion, the occupational therapist described an approach which suggested a certain amount of comfort with ‘messiness’ in research; that they were experimental and open to anecdotal feedback on the use of technological and sensory interventions:

> I worked in a respite facility, in [Western Australia], for kids with disabilities, all sorts of disabilities, and we had this one room set up and it was just a sensory room. We'd spend an hour in there with the kids after lunch and it would be really dark and some bits over there would have cool lighting like this... There used to be this mat on the ground, which was like a vibrating mat, and kids would just lie on it and vibrate. Over there there's a

> wall that they can press and different things light up. And I know there's some research about that and the influences that that can have on some children. (Occupational Therapist, Transcript 04p_14, Line 245)

> …you know, the fact that all the people in the front line and the people with autism themselves talk about the usefulness of this sort of thing [sensory environments]. (Occupational Therapist, Transcript 04p_14, Line 255)

Here, the practitioner was referencing the perceived usefulness of a responsive sensory intervention such as the *RDE* by 'front line' workers in autism. This reflected my own experience when investigating the field; while much of the research in scientific journals and the like were not convinced by the use of multi-sensory environments (MSEs), there was still a great deal of interest from occupational therapists, educators and other health practitioners for technological interventions in this space. MSEs are seen in contemporary autism services, including therapeutic and educational settings, and interest in related projects such the *MEDIATE* environment continues.

With increasing recognition of the person at the centre of a diagnosis (for example, the neurodiversity movement), peer-led and human-centred approaches are gaining traction in autism research. This was reflected in the occupational therapist's own description of her work. Describing a practice that involves connecting with participants in a 'real world' context, the occupational therapist characterised her approach toward social and participatory engagement. Indeed, the outcomes from this practice were clearly driven by the

desire to advocate for and on behalf of participants:

> …pretty much the whole aim of the study is to kind of develop an understanding, or a profile, of physical and mental health, productivity, well being. We have a big sensory processing measure in there, once we get all the data in we've got a control comparison group of neurotypical adults. Once we get it… we analyse it, write it all up, see where the differences are, see where the similarities are, see where the gaps are in services, see what the differences are in mental and physical health, and what that then means for services and policies, and funding bodies. And then from there we kind of do a little bit of advocacy and work with government bodies to try and get that message across about what's happening and why it's important and why there needs to be funding in certain areas to try different things. (Occupational Therapist, Transcript 04p_14, Line 181)

When discussing her own work, it was clear that the 'role' of participants in research for the occupational therapist was not an issue of an objective/subjective relationship—or to put it another way, not a binary case of the participant being treated as an object of study or a participatory collaborator as my own practice drives toward. Rather, the relationship between participant and researcher was dynamic, as was the case with most of the practitioners I interviewed, regardless of discipline. It also supported the emergent potential seen in the technological precedents I describe in this chapter, and flagged possible interest in my practice for engaging in cross-collaborative partnerships.

2.7 Summary

I have shown examples in this chapter of embodied and situated experiences being vital in human-centred approaches to interaction design and autism research. The impact of embodied interaction when working with neurodiverse groups can also be seen in practice of the occupational therapist I interviewed for expert feedback. Throughout the remaining chapters of this thesis, I put many of these principles into action when designing and carrying out the *RDE* open studio.

My approach is informed by not only the design precedents I describe in this chapter, but also for the positioning of this research in recognising the unique knowledge and perspectives of marginalised or under-represented populations. While many of these projects and practices originate from other fields (for example, HCI and psychology) they, similar to my approach, draw from a richly interdisciplinary background in a way that recognises the many ways of being in the world that is significant to neurodiversity. Using this platform, I will introduce the relevance of conversation to my interaction design practice in the following chapter, and describe the usefulness of conversation as a framework for eliciting reflective activities between children, their parents, and responsive design artefacts.

3 Making: RDE Design

As I described in Chapter 1, the impetus for my PhD research emerged from a year-long project in 2011 with an autistic girl, facilitated by an occupational therapist and her mother in their home. This project yielded an iterative series of personal interactive objects designed specifically for this one participant. However it was a serendipitous moment of social interaction with her mother—elicited by the artefact—that proved to be the most interesting outcome of this study. Reflecting on this, I was inspired to look at interaction design as a tool for encouraging engagement between multiple people, and exploring how I might be able to recognise this engagement as an observer of the experience. This is one of the reasons that the *Responsive Dome Environment* (RDE) is a space, rather than an intimate object: it aims to bring the child and parent together, to elicit

social interaction and conversational feedback.

In this chapter I introduce the making aspects of my practice, by way of describing several of the influences on the design of the *RDE*, material experimentation and development. This exploratory work (pre-open studio) is driven in large part by my tacit knowledge of sensory interaction and materiality, which was developed through my background in events, performance and media arts. During this time I also engaged with advocates and contemporary literature around neurodiversity (this discussion can be found in the interview transcripts that accompany this thesis). The influence of this knowledge shaped many of the practical considerations that I bring to the design of the *RDE*.

3.1 Foundations

I conceived the *RDE* as a space in which a child and their parent or carer could engage with one another in a social interaction that was facilitated by sensory experience. This was conceptualised after the experience of my Honours work (2011, described in section 1.2) in which I recognised the potential for agency in a responsive artefact, eliciting joint attention between child and parent. The *RDE* was an opportunity to explore this in a broader (engaging more participants with a greater range of sensory interests) and more embodied way.

One of the aims of the *RDE* was to engage a child in conversation by reflecting

their physical presence through embodied and social interactions. As I note in Chapter 2, the relevance of embodiment to my research can be appreciated through Paul Dourish's (Dourish 2001, p. 126) proposal that embodied interactions lead to the "sharing of meaning through engaged interaction with artifacts." This was particularly important in the *RDE* open studio, where it was expected that interaction with the artefact would lead to social conversation between child and parent. Importantly, embodied interaction provided each child with the opportunity to initiate conversations of their own making, not only with the *RDE* but socially with their parent who shares the space with them, and consequently with myself during a post-interaction process of reflecting on experience.

As a space that affords self-directed interaction (participants are not guided or instructed, but are free to explore the space in any way they choose), the *RDE* is an example of my practice-based efforts to respond to alternative modes of communication and an appreciation for neurodiversity. The term 'neurodiversity' has been brought into mainstream discussion recently by Steve Silberman's book *NeuroTribes* (Silberman 2015) and disseminated by autism activists such as Amanda Baggs, whose video *In My Language* (Baggs 2007, discussed earlier in this thesis) is notable for being an example of sensorially communicating with a physical environment. Although the 'language' Baggs presents in her video is not intended as a learnable semiotic system (like written or spoken languages), she puts forward a compelling case that embodied sensory conversation is a form of expression that neurotypical people are equally capable

of (although less practiced in). Similar to Baggs' proposition, the *RDE* provides a situated context or environment for sensory conversations to take place and to facilitate shared experiences conducive to social communication and feedback.

3.1.1 Cybernetics

> Cybernetics offers values and skills critical to the practice of design in a world of unpredictable, unknowable complexity. While its first-order systemics gives foundation to understanding emergence and unintended consequences, second-order cybernetics offers an ethical, clear-eyed argument for transparent, value-driven design processes. (Pangaro 2017, p. 16)

To ground my own use of the term 'conversation', I introduce cybernetics and its impact on my creative practice in this section. I was drawn to cybernetics through my research of the work of Gordon Pask and his adaptive learning machines, in particular the performative lighting system titled *Musicolour* (1953-1957). The influence of this system on the *RDE* will be explored in my approach to material experimentation in this chapter, as well as the evolution of the system's response to participatory engagement in Chapter 4. As I investigated this interdisciplinary field of goal-oriented systems, I recognised the interconnectedness between cybernetics and my own research practice, and the usefulness of locating the design artefacts, participants and myself as actors in a changing system. In this section, I point to the ideas from cybernetics that informed my making in the *RDE* open studio, and to the work of Pask in particular, from whom 'conversation theory' inspires the framing of my practice

as ‘conversational’.

Norbert Wiener derived the term ‘cybernetics’ from the Greek word for ‘steersman’ (*kubernétés*) in the mid-1940s (Wiener 1954, p. 15). This holds well against a regularly used metaphor for a cybernetic system: a boat making its way through a strong current. The goal-oriented system is, like a boat’s journey, continually responding to the external influence of a current pushing it off course. The steersman experiences the feedback of the current and adjusts accordingly. This description introduces three structural elements of cybernetic systems that I will be discussing here: goals, external disturbance, and feedback loops (Figure 3.1).

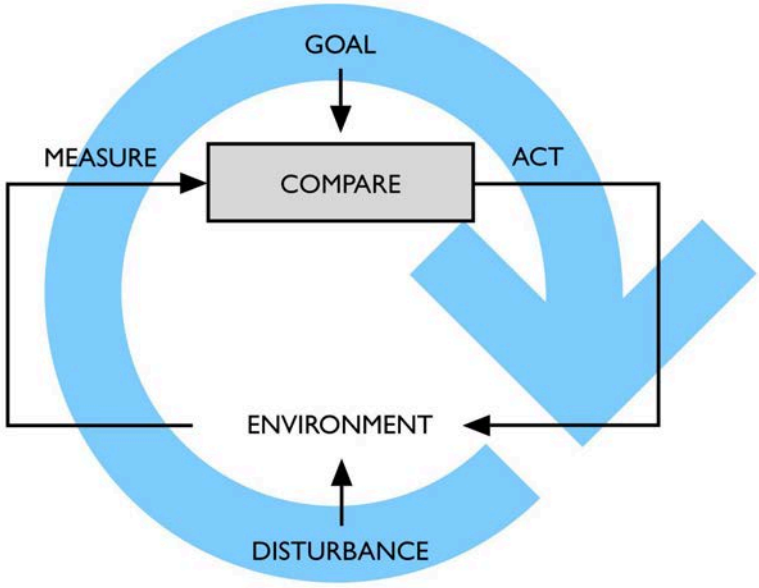


Figure 3.1 - A single-loop (first order) self-regulating system (Dubberly et al. 2009, p. 72).

Wiener and others from the early days of cybernetics speak to the ‘first-order’ approach that aligned with the control-focused disciplines of engineering and

computer science throughout the 1940s and '50s. This first wave of cybernetics considered goal-oriented systems as separate from the researcher/observer. The 'second-order' cyberneticians, however, saw themselves as intrinsically part of the systems they observed and studied, taking a relativist approach to the field and introducing autonomy, self-organisation, and cognition in systems (Heylighen & Joslyn 2001, p. 3). This added a reflective process to a cybernetics system, showing the potential for interest in "processes where an effect feeds back into its very cause" (Heylighen & Joslyn 2001, p. 9). It is this capacity to reflect on past experience that gives a system conversational potential that I am able to leverage in my practice (Figure 3.2).

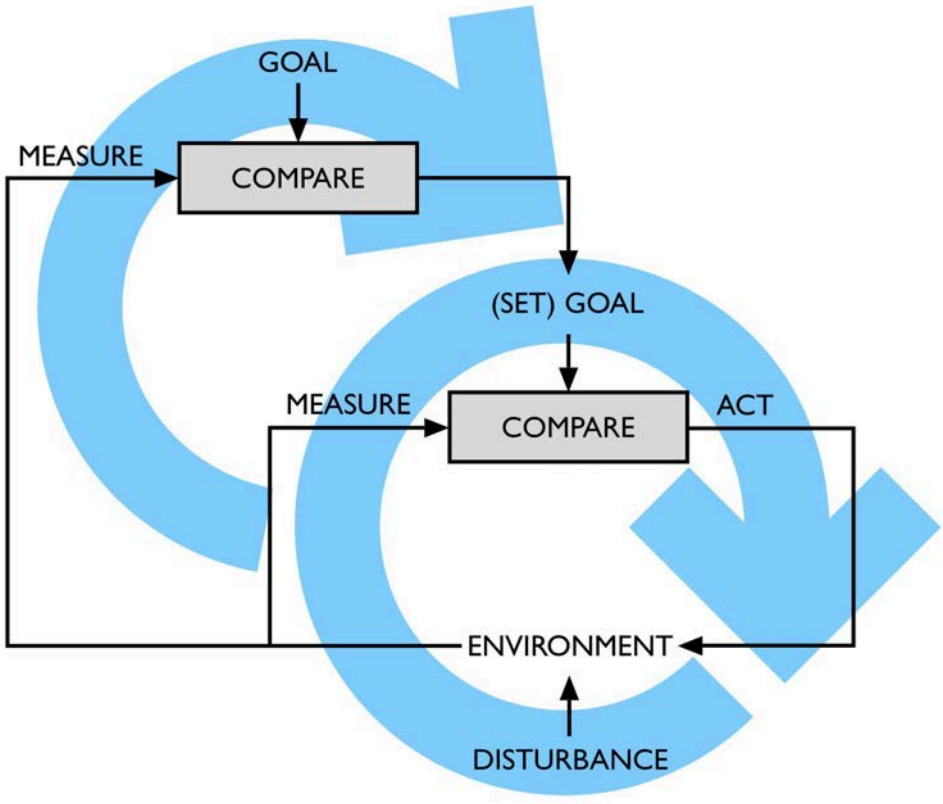


Figure 3.2 - A (second-order) cybernetic learning system (Dubberly et al. 2009, p. 72).

This ability for reflection and learning in a cybernetic system is an important distinction for designing interactions where the intent is to elicit ongoing or evolving conversation, rather than a call-and-response style of interaction. The latter is described by Usman Haque as 'reaction', where the response of a system is fixed, as opposed to 'interaction', where the system is dynamic in its responsiveness (Dubberly et al. 2009, p. 70). Referencing the contribution to cybernetics of Gordon Pask, I will describe how interactions are an act of learning in systems in which action, feedback, and adjustment are parts of a conversation that participants and myself are able to reflect upon.

3.1.1.1 Artistic precedents in cybernetic creativity

Despite being born from technical and scientific fields, cybernetics has a long history of engaging with creative practice, beginning with counterculture movements of the 1960s (Pickering 2010d). A watershed moment in this history was the *Cybernetic Serendipity* exhibition of 1968 curated by Jasia Reichardt, which included work from cyberneticians and artists alike, such as Pask and Nam June Paik. Exploring the intersection of ideas between emergent behaviour, learning, and adaption, these works allowed audiences to engage with the ideas of cybernetics through an aesthetic gateway: the creative artefact.

Here I look briefly at some of the works that were a part of the *Cybernetic Serendipity* exhibition, and then more closely at Pask's performative intervention, *Musicolour* (1953-1957) for its relevance to my *RDE*. This discussion will further

highlight the relevance of cybernetics and conversation to my design practice, not only in the behaviour and materiality of the RDE, but also in the approach to engaging with participants and conversation with each of these systems.

3.1.1.2 Cybernetic Serendipity

Cybernetics reached "its most public highpoint" (Werner et al. 2017, p. 103) with *Cybernetic Serendipity* (1968) an exhibition bringing together a range of "creative forms engendered by technology" (Reichardt 1968, p. 5), at the Institute of Contemporary Arts in London. The timing of this exhibition is telling; early cybernetics piqued the interest of a range of practices and domains, including the counterculture movement, during the 1960s and '70s (Pickering 2010b). This led to a broadening of public interest in how these goal-seeking machines might be related to, or have an affect on, human experience and consciousness through creative, aesthetic artefacts. Reichardt, the curator of *Cybernetic Serendipity*, described the aim of the exhibition as an attempt to:

> … present an area of activity which manifests artists' involvement with science, and the scientists' involvement with the arts; also, to show the links between the random systems employed by artists, composers and poets, and those involved with the making and the use of cybernetic devices.
> (Reichardt 1968, p. 5)

Works presented in the exhibition ranged from computer-generated graphics, films, text, and sound, to robotic devices and environments. A playful, near-utopian attitude to the relationship of computers to co-creativity is evident in

the *Cybernetic Serendipity* exhibition catalogue and other texts resulting from the showcase, including Reichardt's compilation, *Cybernetics, Art and Ideas* (1971). Cybernetician Stafford Beer is exemplary of this creative playfulness, bringing a love of poetry, painting and tantric yoga to cybernetics (Pickering 2010d, p. 216). This is apparent in his description of his *Stochastic Analogue Machine* in the exhibition catalogue through prose:

> What lies between rigidity and chaos—
> Which both have their art and their science?
>
> It is change within order
> which perhaps defines design
>
> Variations on a theme, for art—
> and for science the stochastic process.
>
> A stochastic process generates a pattern
> which is almost rigid in the long run
> through a long series of apparently random events.
> It is defined by mathematical statistics.
>
> Will the next toss yield heads or tails?
> Nobody knows.
> But in a long enough series of tosses
> half will be heads, half tails. (Reichardt 1968, p. 11)

Balancing a desire to understand the system alongside an openness to emergence and unexpectedness was a common trait amongst cyberneticians of this era. Along with Beer, Gordon Pask displayed his desire to explore adaptation and processes of learning through the development of his cybernetic

machines shown at the exhibition. For Pask, he explored these ideas through performative and aesthetic means, which is unsurprising considering his relationship to drama and performance (Pangaro 1993). At *Cybernetic Serendipity*, Pask installed one of his most complex works, *Colloquy of Mobiles* (1968), an installation using the analogy of male/female social communication (in what now seems highly patriarchal and binary in its tone) as a milieu for suspended structures attempting to converse with one another (Figure 3.3) (Pickering 2002, p. 428).

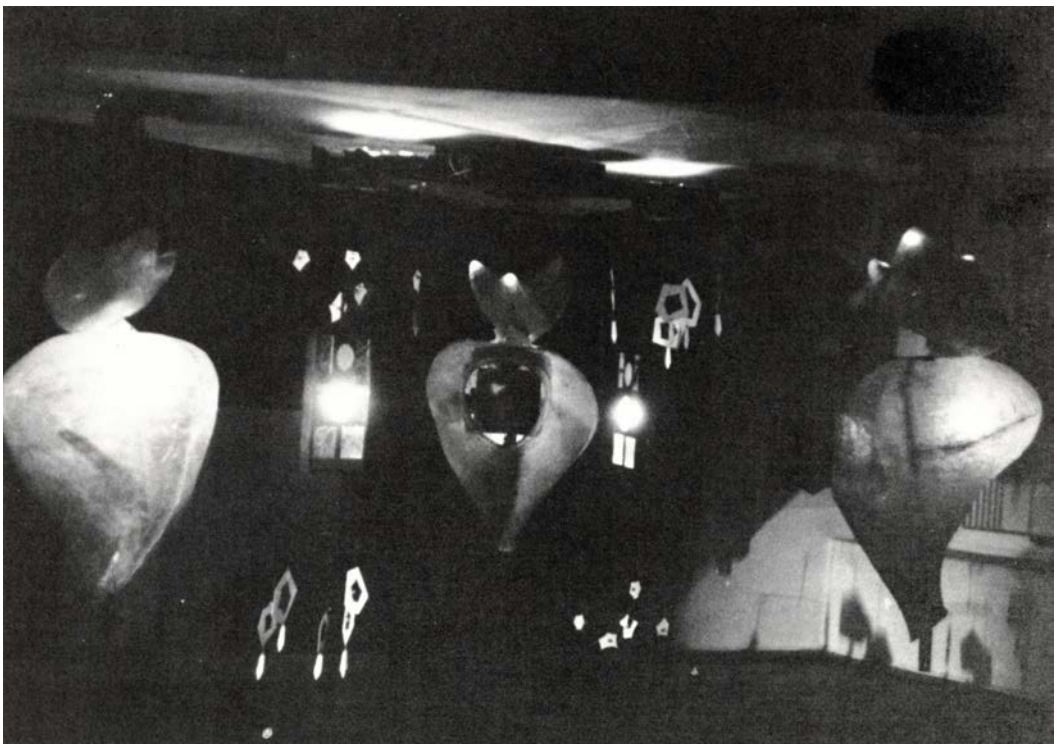


Figure 3.3 - Pask's *Colloquy of Mobiles* displayed at *Cybernetic Serendipity* (1968) (Reichardt 1968, p. 99).

This installation consisted of three balloon-like 'females', that responded to beams of light projected by two mirrored 'males'. These objects would respond to one another, first in an effort to seek novelty, then in defining and achieving new goals (Pask 1968, p. 76). This took Pask's ideas beyond the laboriously

structured and pre-defined goal-seeking approach of the early cyberneticians and toward a model of adaptation based on the emergent behaviour of systems (Pickering 2010a, p. 322). In this context, Pask describes the cybernetic interest in 'control' as:

> broadly equivalent to 'problem solving' but it may also be read as 'coming to terms with' or 'explaining' or 'relating to an existing body of experience' (Pask 1968, p. 76).

As the title suggests, chance and emergence were a central focus for the *Cybernetic Serendipity* exhibition. This parallels with the approach I take in the iterative development of the *RDE*, where my design process is able to be (re)directed by the engagement and feedback of participants. In Pask's *Colloquy of Mobiles*, intervention occurred in the movement of audience members through the space, disrupting the cybernetic agents; in my own project, intervention occurred through participants being disrupted by the unexpected response of the *RDE*. I will return to these ideas in discussing the *RDE* and disruption when reflecting on the experience of participating children and their parents.

3.1.1.3 Musicolour

Andrew Pickering, contrasts positivist perspectives toward artefact production against the approach of second-order cybernetics as "a continuing interaction with materials, human and nonhuman, to explore what might be achieved" (Pickering 2010c, p. 32). The relevance therefore of the cybernetic approach to my own constructive practice can be seen in my exploration of ideas through

materiality, giving the artefact agency in this iterative design process. An openness to emergence and material agency can also been seen in many of the works exhibited in *Cybernetic Serendipity*. However, Pask's *Musicolour* environment—a precursor to *Colloquy of Mobiles*—predated these explorations (Pickering 2010a, p. 321) and serves as a singular example of conversation between human and programmatic systems facilitated by materiality and emergent intervention.

Figure 3.4 - The *Musicolour* machine installed at Churchill's Club (Pask 1968, p. 86).

Pask's *Musicolour* system used the real-time auditory input of musicians to reflect their performance in a visual display, fed back as lighting projected upon

screens of fabric that shared the stage with the human performers (Figure 3.4). Inspired by synaesthesia (Pask 1968, p. 77), the visual feedback of the *Musicolour* machine mimicked formal elements of the musical performance (frequency, rhythm, volume). However, the role of the system in this conversation was not to mirror the input indefinitely. The novelty of *Musicolour* was its ability to grow 'bored' by unchanging interaction (Pask 1968, p. 80). If performers were to repeat a similar musical phrase for an extended period, the *Musicolour* system would appear to reject the monotony of the interaction. Once in 'bored' state, the lighting display of *Musicolour* would no longer map as a reflection of the performance, thereby challenging the musicians to change their own behaviour in an effort to re-engage the perceived interest of the system.

The adaptive behaviour of *Musicolour* was central to the ongoing conversation between the system and performers. Pask describes this conversation as a "close co-operative rapport… between the [person] and the machine" (Pask 1968, p. 83). Pickering (Pickering 2010a, p. 321) describes *Musicolour* as both an "exceedingly complex system (as experienced in practice)" and as a "simple and comprehensible (as described by its wiring diagram)" system. This fits with many second-order cybernetic approaches to design, in that the complexity of an interaction is not a direct result of the artefact's technical prowess, but in its embracing the richness of subjective human experience.

It was important in the embodied experience of *Musicolour* that "the performer conceives the machine as an extension of [their self], rather than as a detached

or disassociated entity" (Pask 1968, p. 86). The kind of 'ontological theatre' that Pickering refers to when discussing Pask is also a recurring theme in my own research. It is through physical and sensory interaction with a responsive system that participants become aware of themselves as playing an active role in the construction of conversation. While my *RDE* is not adaptive in the way Pask's *Musicolour* is (and much of Pask's other cybernetic work), my motivation for disrupting interactions has a similar rationale: to elicit conversation between participants, the system and myself. Whether this feedback is linguistic or physically/sensorially performed is not consequential to its description as a conversation; rather it is the ability of the experience to afford personal expression and reflective feedback with other systems situated by participation with the *RDE*.

3.1.2 Conversation theory

I describe 'conversation' regularly throughout this thesis for its role in supporting participatory interaction and my approach to interaction design (making) and research (methods). This term and many of the conceptual underpinnings I take from the Conversation Theory of Gordon Pask. The work of Pask is most often framed through his relationship to cybernetics, computer science and engineering, however, Pask also had a strong interest in performance and installation art (Pangaro 1993), as I have shown through my examination of his *Musicolour* system. Pask's former student and now contemporary cybernetics champion, Paul Pangaro, described some of the

analogous elements between cybernetic conversation and performance thusly:

> In the Drama it is "the situated action" which causes the actor's behaviors, whether physical or mental, to be exposed to the audience (as well as, perhaps, but not always, to others in the play, including the actor in question). In a scientific realm (the realm in which Pask very much wishes to be a player), to make useful measures would imply the use of an interface, preferably a dispassionate apparatus, to capture the relevant data. (Pangaro 1993, p. 137)

Here I will expand on the creative and relational aspects of Pask's conversation theory as it relates to my practice. However, as Pangaro notes in the quote above, I do recognise that Pask's notion of conversation has had far reaching implications for adaptive and learning systems which go beyond the concerns of my practice.

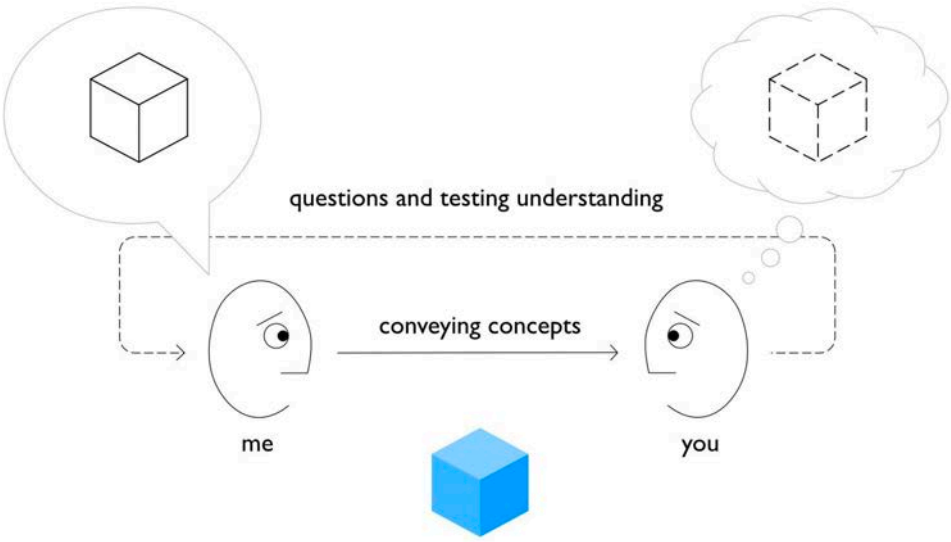


Figure 3.5 - Conversation as a means to convey concepts and to confirm agreement (Dubberly & Pangaro 2009, p. 25).

Pask's Conversation Theory modelled the ways in which cybernetic systems

interact with one another to develop knowledge or reach agreement. In the basic structure of this model, a 'teacher' system and a 'learner' system is described (Scott 2009, p. 152), through which agreement on a concept can be reached through the transfer of information and feedback (Figure 3.5). Within Conversation Theory, a concept is said to be "a procedure that brings about, maintains or recognises a relation" (Scott 2009, p. 154), that is, agreement occurs when understanding of concept(s) takes place between these systems.

Being based in second order cybernetics, conveying concepts requires reflection from the agents that take part in the conversation. However, this is not always a cognitive or even conscious process. As I will describe in the next section, the conversational aspect of my practice is performative, in that the systems I describe have an agency; the potential for emergence and surprise. I draw this idea into my practice in three ways: as a means to look at opportunities for reflection by participants on their own actions during an interactive experience; as a human-centred approach to co-creation with participants; and as a framework for identifying first-hand experiences.

3.2 Design framework

> If there is a sun around which all else revolves, it is performance, not knowledge—knowledge is a planet or maybe a comet that sometimes participates in the dynamics of practice and sometimes does not, and the discovery, for me, was that practice has its own structure that one can

> explore and talk about—as a dance of agency. (Pickering 2010, p. 381)

In his book *The Cybernetic Brain: Sketches of Another Future*, Andrew Pickering speaks of cybernetics as being 'ontological theatre'; that there is a performative agency inherent in the field which foregrounds practice. Pickering goes on to point out that these 'dances of agency' (Pickering 2010, p. 381) show a cybernetic system's ability to surprise through emergent or unexpected behaviour and that the performance is not at service of knowledge, but knowledge may become a part of the dance.

In the remainder of the chapter, I look at how I drew upon the performativity of materials and cybernetic systems by highlighting ideas of conversation in my early experimentation to develop the *RDE* as an agential artefact. In part, this draws from the literature I have described in the thesis thus far. It is also a reflection of my background experience and practice, which I now bring to bear on designing responsive artefacts for neurodiverse children. Here, I will show how my practice aligns with constructive research and design probes. I also describe the relevance of my practice to working with a neurodiverse group of children and look at why a creative practice has much to contribute to the field of neurodiversity research.

3.2.1 Conversation through design

Daniel Fallman uses 'conversation' to broadly describe engagement with the design process:

> Design is a kind of dialogue; a reflective conversation. But if design then is reconsidered in terms of Schön's problem setting and problem solving, it is important that they are not interpreted as two different or succeeding activities. They are rather intertwined in the activity of design, an inseparable pair only unfolded through the design dialogue. Design in this sense becomes more of a search for a symmetrical, coherent, and well-balanced whole—a complete gestalt—than a process of first setting up and then solving problems. (Fallman 2003, p. 230)

Like Fallman, I have found that in my own practice, reflecting on experimentation with materials and processes helps to (re)frame problems and identify possible futures. The artefacts hold agency; potential for opening channels of communication between myself and the participants encountering the objects, as I will describe in the *RDE* open studio. These conversations are methods of engaging participants, identifying their unique knowledge and affording opportunity for them to be co-creators in this project.

In my practice-based approach, research *through* design frames the artefact as 'exemplars' of ideas, providing a means of communicating concepts or intent to another community (Zimmerman et al. 2007, p. 1). I propose that conversation *through* design is the 'on the ground' aspect of my practice; it is a conduit for engaging participants through which they can express their own knowledge and experience. As described by Usman Haque, bringing together participants and designers through conversational (Paskian) strategies 'is about designing tools that people themselves may use to construct—in the widest sense of the word—their environments and as a result build their own sense of agency' (Haque

2007, p. 61). The role of the *RDE* is to create the situation for this participatory conversation to take place and is the location for the performative aspect of my practice.

3.2.2 Constructive design research

Key to my use of the *RDE* as a conversational tool is its framing in constructive design research. Here I draw reference points for describing my practice as 'constructive' from design-related approaches including Richard Frayling's description of 'research *through* design' and the learning theory of Seymour Papert (constructionism), which situates the artefact and human engagement with it as the location of creating new knowledge. Koskinen et al. have used the term 'constructive design research' to locate this practice-based approach to knowledge through pragmatist 'sense-making' (Koskinen, et al. 2011b, p. 17), where the importance of creating design artefacts is highlighted as problem-setting, "discover[ing] things that would otherwise go unnoticed" (Koskinen et al. 2011b, p. 2). In the *RDE* open studio, I show that it is not only the design researcher who can reframe their thinking through a constructive approach; participants can also be encouraged to self-reflect through a conversational dialogue with the artefact.

Frayling's research *through* design (RTD) claims the importance of design-led approaches to under-constrained or wicked problems outside the field of design. Zimmerman et al. go on to add that Frayling's ideas are particularly useful in

fields not easily engaged by positivist scientific or engineering models (Zimmerman et al. 2007). However, Frayling's RTD method has very few conceptual underpinnings. This has left the RTD approach vulnerable to critique for its lack of guidance or transferability for design researchers (Koskinen et al. 2011a, p. 5). Taking the artefact-for-knowledge-generation spirit of RTD, but recognising an existing history of purposeful making and iteration within interaction design and cybernetics, I align my practice-based approach to constructive design research.

Moreover, key to my designerly approach is sensitivity and criticality of preconceptions about neurodiverse people. Important to my practice is allowing participants to reflect on their own assumptions through interactive experiences with responsive design artefacts. This affords the opportunity to have reflective and critical dialogue between participant and researcher. A constructive approach to co-creation and knowledge generation through the design object is one way of achieving this reflective criticality. Following Papert's learning theory, my constructive approach takes the position that understanding is best achieved "through active creation of something tangible/sharable outside of your head" (Stager 2014). Papert places great emphasis on situated media or artefacts and acknowledges "the significance of making things in learning" and that "learners engage in a conversation with artifacts" (Ackermann 2001, p. 1). In the chapters that follow, I will look at how my approach to making informed my desire to open conversation with participants, and investigate how their interaction with the design artefact shaped our reflective dialogues.

My constructive approach implicitly acknowledges that each individual—regardless of diagnostic label—can contribute valuable knowledge. This is an idea that cognitive scientist and autism researcher Jon Brock believes positivist science (generalisable 'laws' as opposed to personal interpretations) struggles with: "heterogeneity is widely acknowledged by researchers" yet "essentialist thinking is a barrier to scientific progress" (Brock 2014). The experiences of each participant in the *RDE* open studio described in this thesis are unique.

As a neurotypical researcher, I aim to have empathy toward the perspectives of each participant and the distinctive knowledge generated through their experience. By drawing on their knowledge to inform the design process, my practice evolves out of "special experiences and viewpoints that can support the technology design process that other partners may not be capable of contributing" (Druin 2002, p. 12).

3.2.3 Design probes

The concept of design probes can be traced back to William Gaver et al.'s ethnographic data collection method, 'cultural probes' (Gaver et al. 1999). Since then, use of the term 'probe' has been appropriated widely as a method for design research. A survey conducted by Boehner et al. (Boehner et al. 2007, pp. 1078-79) identifies the broad appeal of probes by collecting its different uses, including as: material 'packets' or tasks; tools for data collection; participatory engagement; and as 'provocative, ambiguous, and experimental' sensibilities.

Following this broad use across design research, I describe the iterations of the *RDE* as having a probe-like intent: I am presenting the artefact to participants in order to understand more about their perspectives; not necessarily the artefact itself. Framing the constructive artefact in this way also helps to constrain and define the importance of functionality in the *RDE*. Here I turn to one well-known interpretation of 'probe' terminology—Hutchinson et al.'s 'technology probes' (Hutchinson et al. 2003).

Unlike Gaver et al.'s cultural probes (a method that drives toward ethnographic feedback rather than the development of a design artefact), technology probes are described in recognition of the importance in developing knowledge through interaction with a prototypical object. This constructive approach aims to understand "the needs and desires of users in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring users and researchers to think about new technologies" (Hutchinson et al. 2003, p. 17). Notably, Hutchinson et al. point out that technology probes—like the *RDE*—are not designed as prototypes in a product-development sense (Hutchinson et al. 2003, p. 19); instead, they highlight functional and material design assumptions of the researcher. Through a constructive design research lens, they are a site for reflection and knowledge acquisition.

Technology probes provide a useful method for generating reflective feedback, with several distinguishing features that mirror the approach I bring to the design of the *RDE* and subsequent open studio (Hutchinson et al. 2003, p. 19):

- *Functionality*: should be as simple and straightforward as possible
- *Flexibility*: allow for open-ended use and interpretation
- *Usability*: employed to provoke response, rather than assume style of use
- *Logging*: helps to create a point of discussion between users and designers
- *Design phase*: used early in the process, to allow assumptions to be challenged before committing to a final design

The RDE open studio that I describe later in this thesis puts these features into practice. It provides a space (figuratively and literally) to explore how neurodiverse children engage with sensory feedback afforded to them, and how this might lead to social interactions as a result of their situated experience. It is my goal that participants are given an opportunity to express themselves through their experience with the design artefact. As such, my probe-like approach to participatory engagement is an inquiry not only about artefact use, but like Pask's conversation theory, it is an opportunity to elicit interactions that lead to identifying and reflecting on points of agreement or understanding between systems.

In the next section I will turn to the material experimentation that began my process of putting this framework into practice. While much of this early work was tacit—drawing on my training and background as a designer working with interactive technologies—it shows my efforts to explore the 'problem space' of

engaging neurodiverse populations. Here, I aim to construct an experience that supports the ontological theatre that Pickering describes through a practice that uses constructive and conversational artefacts to keep my iterative design practice open to emergent feedback as a result of participatory engagement.

3.3 Development

The making which I examine here is informed by the foundations and design framework described above, but also reflective of my background and existing interaction design practice, which initially led me to the project. This process was carried out without the input of the neurodiverse children and their parents whom became the focus during the *RDE* open studio. This aligns with the philosophy of technology probes, which necessitate a degree of 'completeness' in the prototype for reasons specific to the study population—in this case for issues of participant safety, but also to allow the participant to express themselves in a self-directed manner through the multiple sensory interaction modalities afforded to them by the *RDE* system. Here I will look at the material structure, the lighting system, and the software development of the *RDE*. This technical work occurred in parallel with research into participant recruitment and logistics, but for topical coherence they are discussed separately in this thesis.

3.3.1 Conceptual models

One of the motivations for material experimentation and design decisions prior to participatory engagement was to present participants with a clear conceptual model for encountering the *RDE*. A conceptual model is a personal, high-level understanding of how a system functions. Representation and concepts for knowing how a system responds make up a person's conceptual model and helps them to understand any activities or tasks available to them (Johnson & Henderson 2002). Don Norman describes this as the 'user's model' versus the 'design model' (Norman 1988b, p. 16).

In the *RDE*, I leveraged the commonly-held understanding of how children's toys function (such as wooden blocks and peg-and-hole puzzles) to create a conceptual model for triggering light and sound feedback. This can be seen in my design decisions I outline throughout this chapter in relation to materials, interface, mappings and feedback. In my experience, this is one of the most challenging parts of the interaction design process (yet often, most illuminating). It is important to reflect on how the participant's conceptual model of interaction differs from that of my own intent.

The participant's conceptual model of a system is often based on a *perceived* mapping, that is, they expect the system to behave in a way that is based on their own perception of interaction, which may or may not actually be the way the system has been developed by the designer (Murray-Browne 2012, p. 160). As

pointed out by Tim Murray-Browne, if the purpose of the interaction is to generate personal experiences, it is in fact "these perceived attributes of a system that are of importance rather than what is 'actually' going on" (Murray-Browne 2012, p. 159). When David Rokeby reflected on his own early experiences of *Very Nervous System*, he found that he was providing too much freedom for the user. This resulted in their perception of their actions as not being linked to the output of the system at all (Rokeby 1998, p. 9). In the same way that Rokeby recognised the value in constraining interaction, I chose to limit the dimensions of feedback available to participants in the *RDE* to more explicitly show them their agency for control of the system. This explicitness was more suited to a young group of participants, but also afforded clarity in identifying experiences for conversational reflection.

3.3.2 Material exploration

In my first conceptualisation of the *RDE*, I proposed for it to be mobile and scalable for access by a range of primary school-aged children in standard school rooms. The outer material of the dome would provide a surface to project renderings of realistic images when installed and able to be packed away neatly, leading to exploration of structures much like dome camping tents. In my early discussions with educators and therapists in autism schools, this approach to the structure of the *RDE* received positive feedback and I settled upon it quite early in the design process. However, the sensory feedback and tangible interface of the *RDE* went through many more iterations of development.

The rationale for my first approach to visualisation looked to a history of immersive experiences, in particular the travelling panoramas of the nineteenth century (Grau 2003), which aimed to immerse viewers in a semi-realistic environment. This kind of immersion places the viewer in a 'flow state', triggered by reducing critical distance between the person and sensory experience. In the travelling panoramas of this time, immersion was achieved through "*Gesamtkunstwerk*, or synthesis of the arts, which results from the complex interplay of these components [sensorial dimensions]" (Grau 2003, p. 126). As Oliver Grau notes in his description of travelling panoramas, visual perception plays a central role in human experience, and as such, received the most attention in these works. Similarly, I began development of the sensory aspects of the *RDE* by experimenting with the use of the structural and surface materials as a 'canvas' on which visual feedback was to be projected.

I chose ethylene vinyl acetate (EVA) as the surface of the *RDE* for practical and aesthetic considerations (a 1:5 scale prototype using this material can be seen in Figure 3.6). This plastic sheet-like material diffuses light, softening the visual experience when inside the *RDE*. Both quality of light and the scale of the structure were important considerations in creating a space that would be comfortable for children, in particular those with autism who might become overwhelmed by unfamiliar environments and activities (Sinha et al. 2014). I took this into consideration at this early stage of development when I expected the *RDE* to be used within school classrooms and as such would need to be able to be moved quickly and easily; the scale of the *RDE* was designed to be

manageable for transport and setup, as well as accessible for neurodiverse children, some of whom could feel overwhelmed by a large space or claustrophobic in a small one.

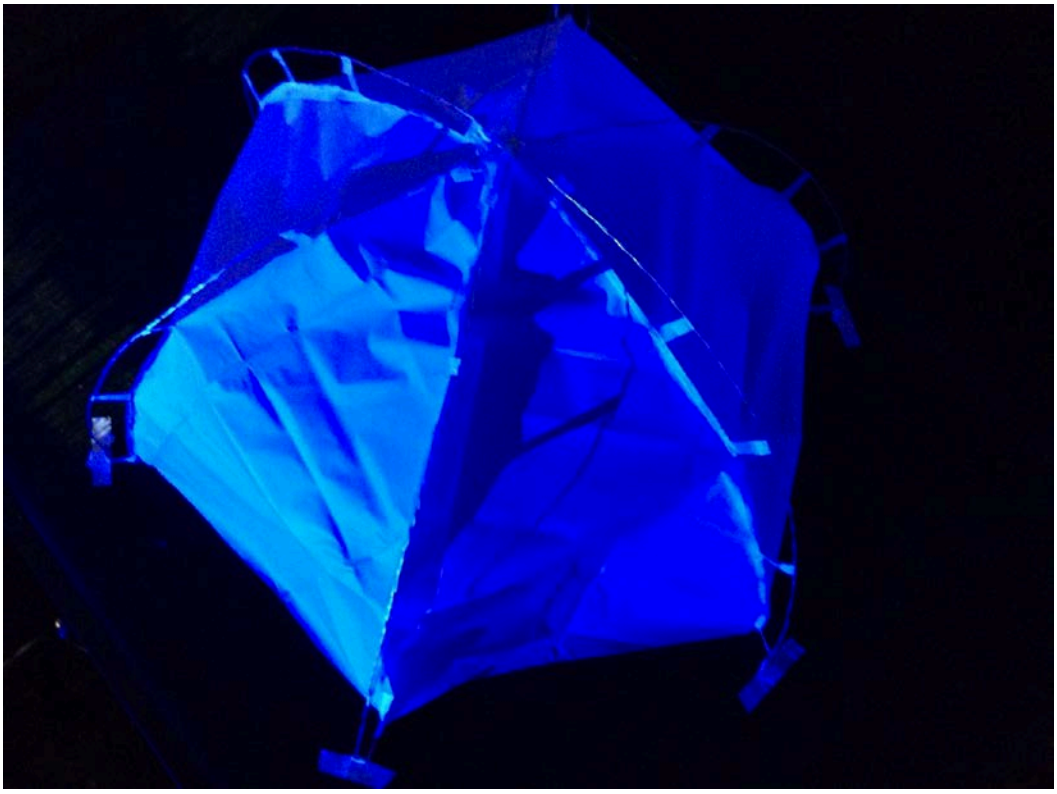


Figure 3.6 - Projecting onto a 1:5 scale dome to test shadow casting.

With consideration of the participants likely to experience the *RDE*, the tent-like structure was built to surround participant(s) from all sides, increasing the immersive potential of the space. For some autistic children for example, containment is important for a sense of security (Edelson et al. 1999). Thus, the *RDE* was created as a space that should feel manageable for the child in relation to their size and physical capabilities and allow them to move freely about the interior of the dome if they wished.

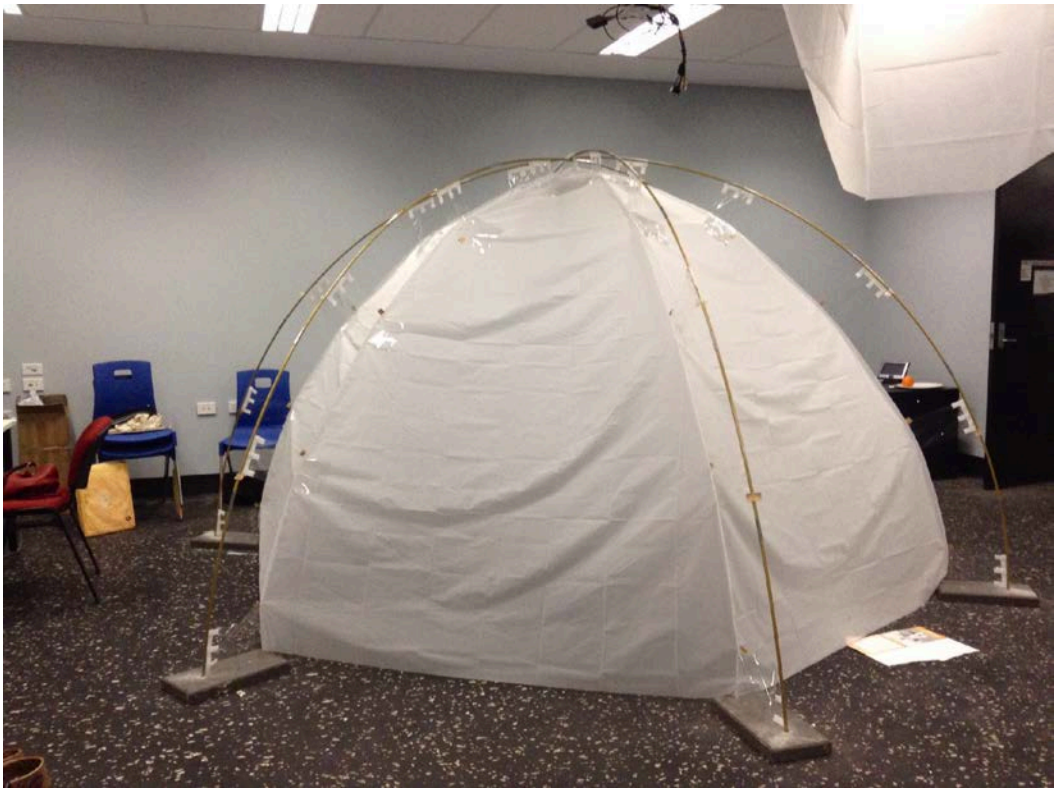


Figure 3.7 - Completed dome structure, before insert of doorway.

The completed dome structure (Figure 3.7) has a floor diameter of 3 metres and at its highest point is 1.8 metres. While there would be adults accompanying children in the *RDE*, my focus was on the anthropometrics for children. I settled upon this size so that the dome scale would be comfortable relation to children aged 2–6 (the conventional age group for early intervention) as well as fitting within the ceiling height of a standard room while allowing space for the lighting system which accompanied the physical structure.

3.3.3 Lighting and sound

Throughout the material development process that I describe above, I tested substrates for suitability by projecting video and still images onto the surfaces. However, during my observation of gallery visitors with the *Binaural dome*

(described in Chapter 1), I recognised the success for abstract or non-literal feedback in allowing participants to experience interaction in a range of (sometimes unexpected) ways.

Moving away from representational or figurative visualisations (still images and video), I explored an abstract approach to visual feedback and turned my attention to using a programmable lighting system capable of a wide range of coloured feedback. The lighting system, much like theatre or stage lighting, could be manipulated to project different hues and brightness from each lighting 'head'.[9] The lighting technologies were chosen for their ability to fulfil several technical requirements. Firstly, LED lighting is low voltage and low heat to meet child safety standards. The lights also needed to be DMX addressable for computer-based control.[10] Finally, the lights also had to meet a small form factor for mobility and set-up in rooms with limited space.

[9] 'Head' is standard lighting industry shorthand for a discrete lighting unit (e.g. 1 spotlight or 1 strobe).
[10] DMX is a standard lighting protocol. Used throughout most controllable lighting systems (e.g. stage or theatre lighting), the protocol allows the user to control a range of features of each light 'head' (e.g. colour, brightness, strobing). The controllable features are dependent on the specifications of the light being used.

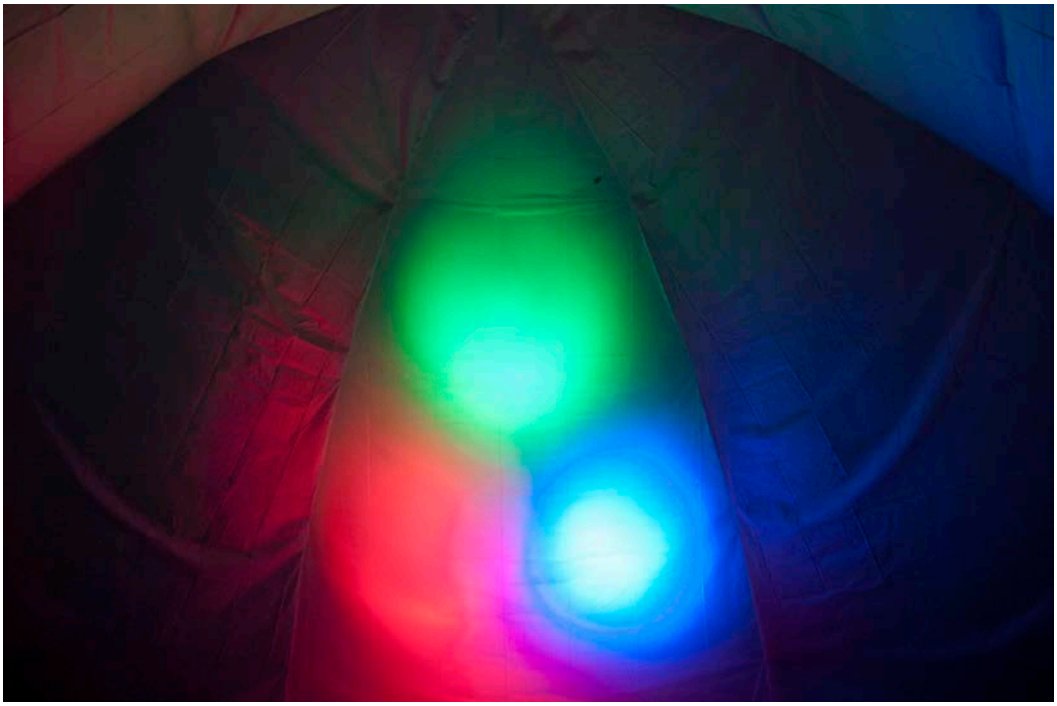


Figure 3.8 - Testing light colours for 'hotspots'.

Due to spatial constraints (given the proposed setup of the *RDE* within standard classrooms), I needed the lights to remain close to the material surface of the dome. This resulted in a 'hotspot' where the centre of the projected light would be far brighter that its surround (Figure 3.8). To combat this problem, I added prismatic diffusing acrylic to each light to soften the hotspot effect. This was at the expense of colour saturation and brightness. Ultimately, I accepted the trade-off for a more immersive and even lighting effect across the surface of the *RDE* (Figure 3.9). To effectively cover the entire *RDE* surface with light, the dome was surrounded by a total of 15 lighting heads placed on tripod stands in groups of three. This allowed each panel of the dome to be lit evenly, with the exception of the doorway, which remained open and unlit throughout the case study.

Figure 3.9 - Inside RDE during lighting test (video screen capture).

3.3.4 Interface development

The role of the RDE is to situate interactive possibilities, including conversations that afford social response (between child and parent) and subsequent reflection (between participants and myself). To continue the theatrical analogy that I called upon earlier in this thesis, I locate the participants as improvisational performers responding to the space as they see fit and the interface (which has a hardware and software dimension) as the 'seed' (the catalyst) for the performance to play out. This metaphor is not by chance; it connects the conversational interaction of the RDE to Gordon Pask's interest in performativity, as well the significance Edith Ackermann placed on play in learning and child development.

As I described in the previous section, early experiments for the design of the RDE had a representational focus. This was mirrored by my initial programming

tests, where I explored ways of displaying images in three-dimensional space, including projection mapping and a matrix array of lights. This was accompanied by tangible interface prototypes using a live camera video feed to interact with the RDE system (Figure 3.10). Aiming to create an immersive experience, I developed this system to take a live video feed of the participant and place them 'within' the image by simplifying the image from the camera feed into the surrounding RDE lighting system. However, while self-testing this system, it was clear that the resolution of lighting 'pixels' was too low to map the relationship between interaction and response of the RDE.

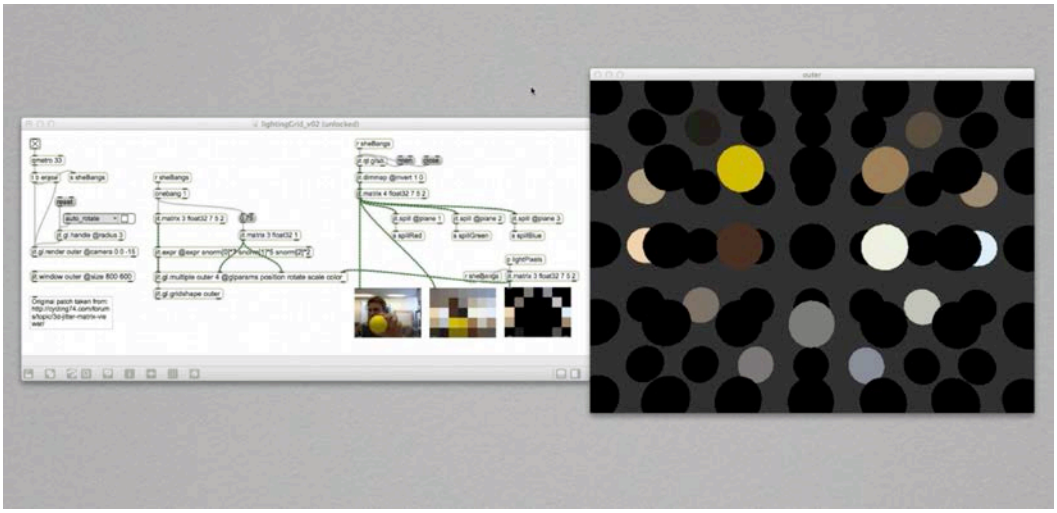


Figure 3.10 - Representing 15 light heads in 3D grid space using Max 6.

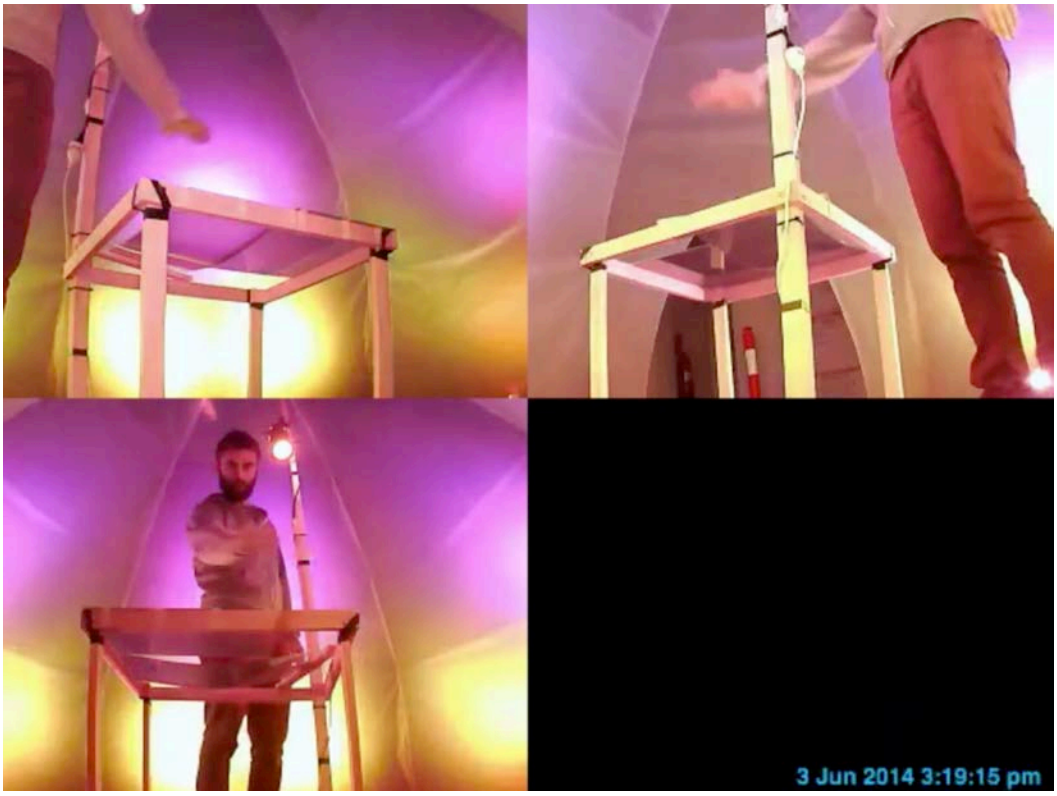


Figure 3.11 - Testing a prototype camera-based interface to control lighting (screen capture).

Recognising this problem clarified for me the role of interaction in the *RDE*. Rather than creating a space that aimed to create a representational experience of immersion (like the nineteenth century travelling panoramas), the *RDE* was designed with an understanding that embodied sensory interaction can itself lead to experiential immersion. In the same way that Baggs (Baggs 2007) spoke of her embodied communication with all aspects of her sensory environment, I designed the *RDE* to facilitate conversation in *any* communicative modality that a participant might choose to engage, rather than encouraging the participant to communicate in a neurotypical language of speech or text.

I note here that my move away from representation in the visual response of the *RDE* was also designed to connect the participant's interaction and response of

the *RDE* system as clearly as possible. In the same way that the *MEDIATE* project (described in Chapter 2) had the goal of providing the participating child with a sense of their own agency in the space, the *RDE* was designed to explicitly map interaction to response, giving the participant an acute awareness of their control of the environment and entering them into a conversational relationship with the system, which would be the foundation for reflection with myself after the interactive experience.

Alongside experimentations with the visual feedback of the *RDE*, I explored several options for a tangible interface based on the colour-centric visual feedback of the lighting system. Due to the age range of children I was targeting (2-6 year olds), my inquiry focused on physical objects that did not require highly-developed fine motor skills, such as wooden children's toys. In addition, to allow the contingency of non-verbal neurodiverse children, any interface design needed to clearly communicate affordance of use without requiring language or other explicit instruction (Norman 1988a, p. 82). By using typically understood modes of embodied and manual interaction such as toy-like objects, my assumption was that children would be familiar with how to interact with the interface and it would not be necessary to instruct participants on their use.

In early experimentation developing an interface, I used play-doh-like materials to construct a low-voltage electrical circuit. The potential for a highly child-led interaction with this interface was its primary appeal. This approach used the malleable material to connect between circuit points and through

communication with an embedded microcontroller, could send event messages to the system to trigger lights and other feedback (Figure 3.12).

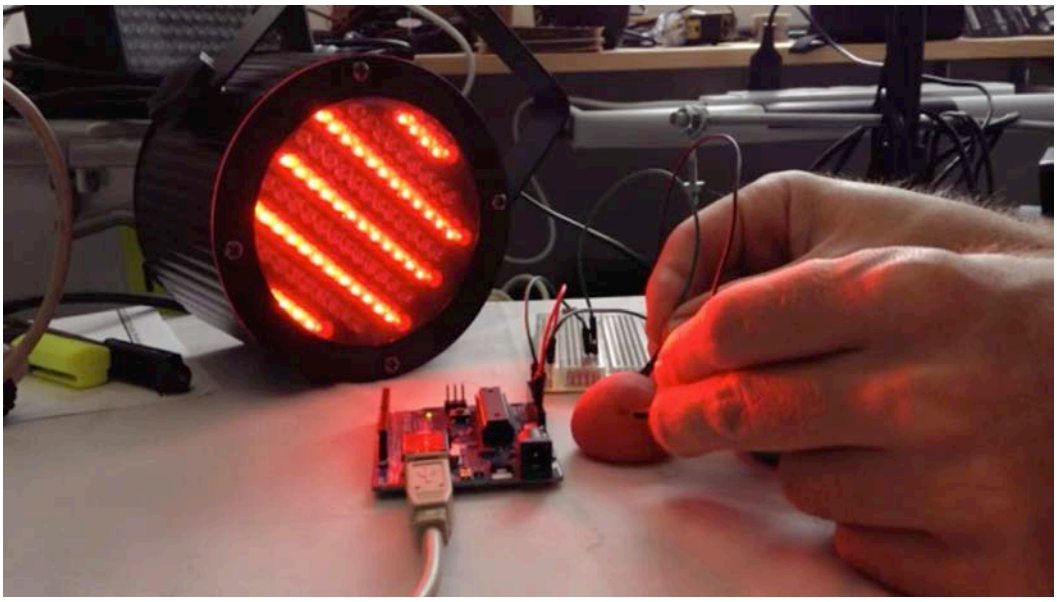


Figure 3.12 - Testing play-doh conductivity to trigger lighting.

While the play-doh interface suggested potential to be an enjoyable interaction in terms of tactile sensory experience, the use of a circuit completion method[11] of interaction required a high-level awareness of how the interface worked, including static start/finish locations as well as needing to keep the material in a single continuous piece. It also could not be assumed that the children would keep each colour (assigned to electrical conductance) as a single material, particularly with such a young group of participants. This discrepancy between the conceptual models of the participant and myself led me to chose a fixed object as a means of interaction—in the first instance, the toy block.

[11] Where the flow of electricity is allowed by connecting all wires or components, that is, there are no physical gaps in the electronic circuit.

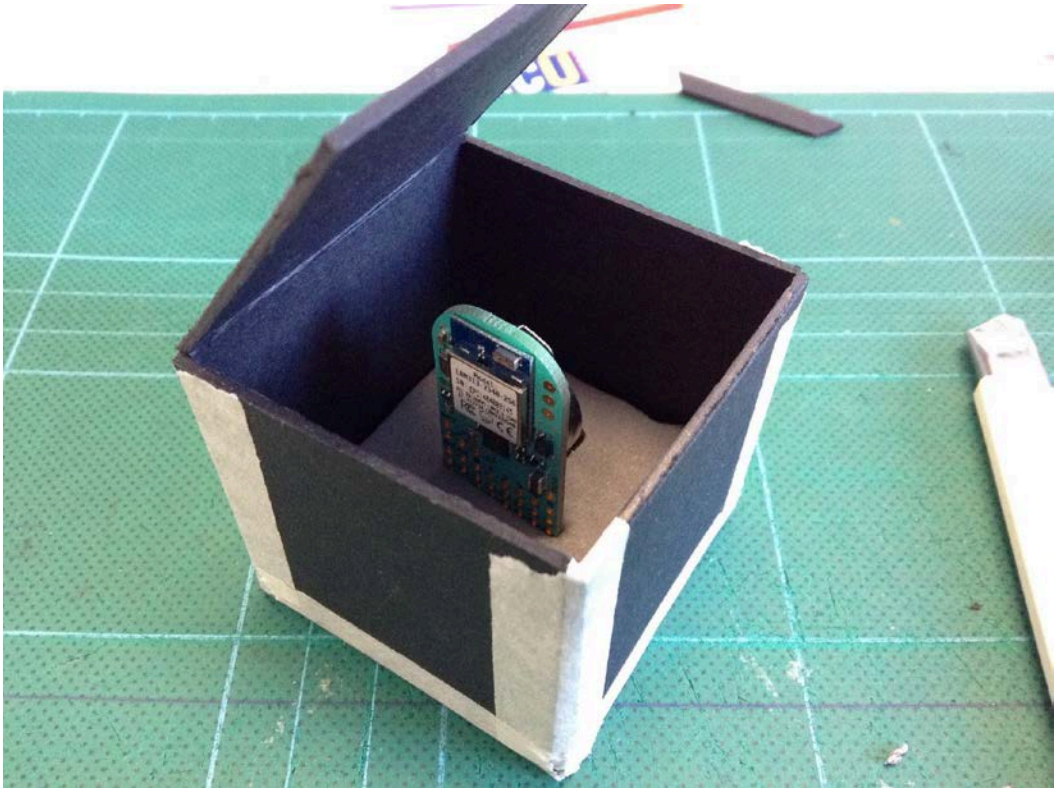


Figure 3.13 - Testing a LightBlue Bean to track box movement.

In the prototype above (Figure 3.13), I constructed a box to house a microcontroller which can measure the orientation of the cube and pass this information wirelessly to a computer via Bluetooth communication. Although this prototype was insightful in exploration of anthropometric scale in interface objects (reflecting on the scale of a child and their motor skills), the design was unable to capture information about its position in space, or relation to other objects. For this reason, I abandoned the on-board microcontroller in favour of a camera-tracking system, that would be able to capture orientation and location.

As a final step in the prototyping stage, I drew upon the reacTIVision framework (Anon n.d.), a camera-tracking system which uses unique markers to track the

position of objects (Figure 3.14). This version of the toy block interface was successful in controlling the audiovisual feedback system and addressing the issues of affordance and physical practicality I outlined above. This design ultimately became the first iteration of tangible interface in the *RDE* open studio.

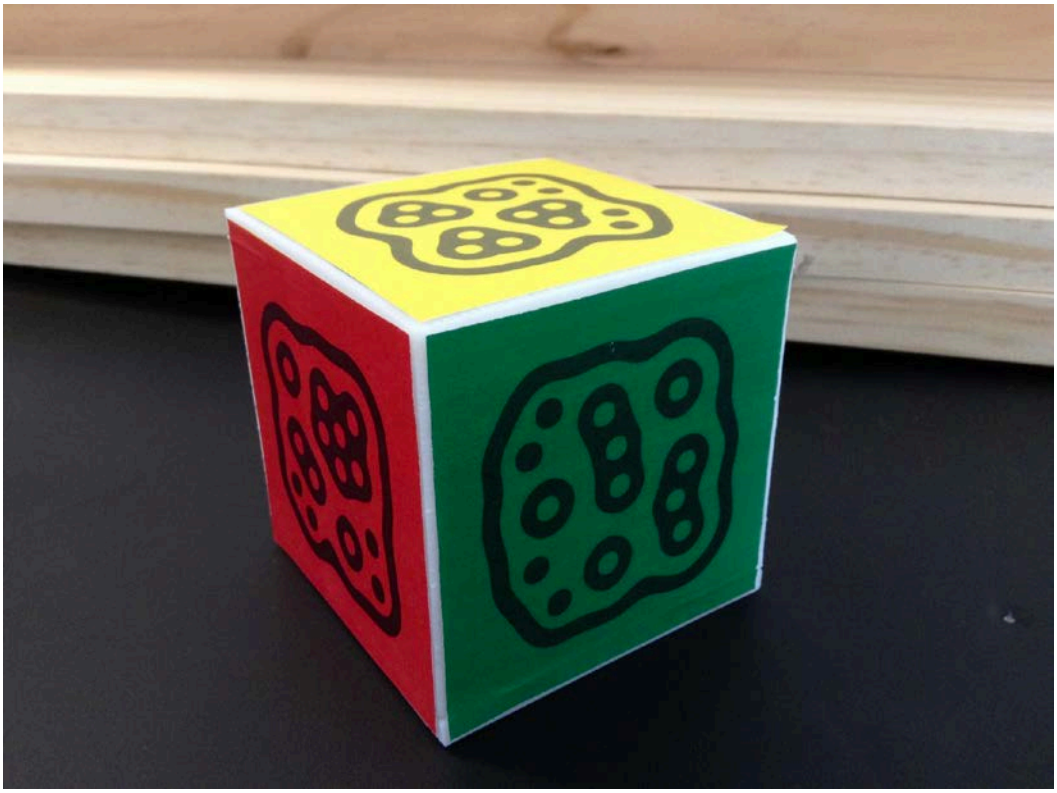


Figure 3.14 - A fiducial box, which would be used for the first participatory study interface.

I designed this block to be used with a table surface in the centre of the *RDE* floor, which remained consistent throughout the project (Figure 3.15). This was a wooden hexagonal table-like structure (to mirror the six dome panels of the *RDE*), providing the parent and child with an object that encouraged physical orientation to one another; when engaging with the interface, parent and child would sit facing one another. This created opportunities for social conversation

and co-operative interaction.

Figure 3.15 - Hexagonal table surface for RDE interface (all iterations).

The spatial mapping between table surface and RDE audiovisual feedback remained the same in each design iteration (a total of 3 designs), and was the key component in allowing participants to reflect on their interaction with the RDE. The surface of the hexagonal interface table was mapped to reflect the relationship between interface and the RDE (right of Figure 3.16). The top-down plan of the RDE (left of Figure 3.16) shows the location of each of the lighting heads, with an inner/upper ring of 5 lights and an outer/lower ring of 10. The relationship between the lighting heads around the RDE and interaction locations on the table surface was designed to give the participants a sense of their agency within the space through their embodied and situated interaction with the RDE.

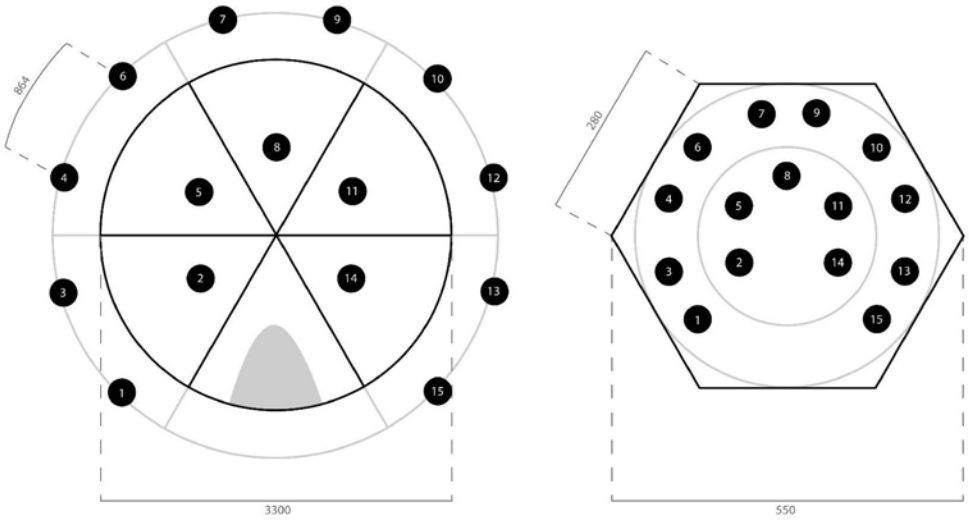


Figure 3.16 - Light position on RDE (left) mapped to block or peg position on table-based interface (right).

In the first iterations of the RDE system, the conversational potential of the environment was designed to be non-challenging. That is, the audiovisual feedback of the RDE would reflect the engagement of participants by locating lighting and sound response to each of the participant's interactions with the interface. This speaks to relevance of technology probes in this framework, where simplicity and open-endedness are key in allowing emergent interactions to take place. As I will describe in Chapter 4, this 'simplicity' in the design of the RDE allowed me to identify conversational drivers in these interactions—namely the disruption of the activity—and draw upon this to inform the subsequent iterations of the RDE system.

3.4 Specifications

The following is a description of the final specifications of each component of the RDE. This section will describe the physical structure, tangible interface, and software system. My approach to designing the RDE was a combination of tacit knowledge (from my experience and background as an interaction designer), practical considerations (often precipitated by limited resources or leveraging expertise with a particular technology) and conversations with a range of stakeholders (site visits to autism services, discussions with educators and therapists). While the physical structure of the RDE remained unchanged throughout the three iterations of the RDE open studio, design changes were made to both the interface and software system based on participant feedback (discussed in the remainder of this chapter).

Many of the system design considerations I brought into the RDE were informed by the models of conversation that I describe earlier in this chapter. I looked for ways to engage the participant in acts of conversation with the system by sensorial means. This drew upon my practice of using light and sound to communicate interactive experiences and allowed me to avoid the need for using explicit signifiers such as language to direct the actions of participants. Structurally, the system of feedback and data flow remained similar throughout the design iterations: a sensor would detect interaction with the table surface, which was mapped by a software system that controlled the lighting and sound feedback around the surface of the RDE. I visually connect the technical

hardware elements used in the RDE below by way of data flow diagram (Figure 3.17).

Figure 3.17 - Flow of input/output in the *Responsive Dome Environment* (Iteration 1).

Over each iteration of the RDE open studio, I made technical changes to help the user's conceptual model of interaction become more explicit. This was my intention from the beginning of the design process, but as I will describe in the following sections, my own conceptual model of the system was very different to that of the children that encountered the RDE (much like Rokeby's early experience with *Very Nervous System*). The first iteration of tangible interface was based on a 'wooden block' design (explored further in section 4.8 of this thesis, which used tracking markers for input); followed by a 'peg-and-hole puzzle'

model of interface in the second iteration (described in more detail in section 4.9, which involved limiting the interaction dimension of object placement); and finally using a button-based interface in the third iteration (removing the ability to move or position objects entirely).

Input

- Iteration 1: This interface was based on a 'toy blocks' metaphor, where participants would place/move blocks to control lighting feedback based on position and colour. The control mechanism was achieved by using reacTIVision fiducials on each side of the blocks, tracked by a USB camera placed within the interface.

- Iteration 2: In response to the 'loose' mapping relationship of the blocks in Iteration 1, this redesign referenced the 'peg-and-hole' puzzle toy that is familiar to most children. The primary colours chosen for each peg were recognised by a Pixy CMUcam (hue tracking camera) within the interface table.

- Iteration 3: The final design of the tangible interface used coloured buttons placed on a 3D printed scale model of the *RDE*. This made the colour and positional relationship between interface and the lighting system highly explicit. Buttons were connected to an Arduino board to receive this control information.

Interpretation

- Throughout the design of the *RDE*, custom software was developed using Max 6 on a MacBook Pro.

Output

- Visual: 15 coloured (RGB LED) lighting heads were located around the perimeter of the *RDE*. These were placed on tripods of 3 lights per stand. Control for the lighting system was achieved by sending DMX messages from Max to an ENTTEC DMXUSBPRO box, connected to each of the lights.

- Audio: Positional sound was created by launching audio samples in Max, and 'panning' these through a multi-channel audio interface to 4 speakers, located around the *RDE*.

By design, the majority of the technical hardware I have listed above is hidden from the participant. For the participant, the focal point is their interaction with a tangible interface being reflected back as audiovisual responses on the surface of the *RDE*. To keep most of this technology hidden, I placed the camera or Arduino board (depending on interface iteration) within the interface table in the centre of the *RDE* space. The lighting and audio system was also situated outside the *RDE* space and therefore out of view of the participant(s). This reduced unwanted distraction for the children and helped them focus their

attention on the feedback of the system and the parent who was sharing the space with them.

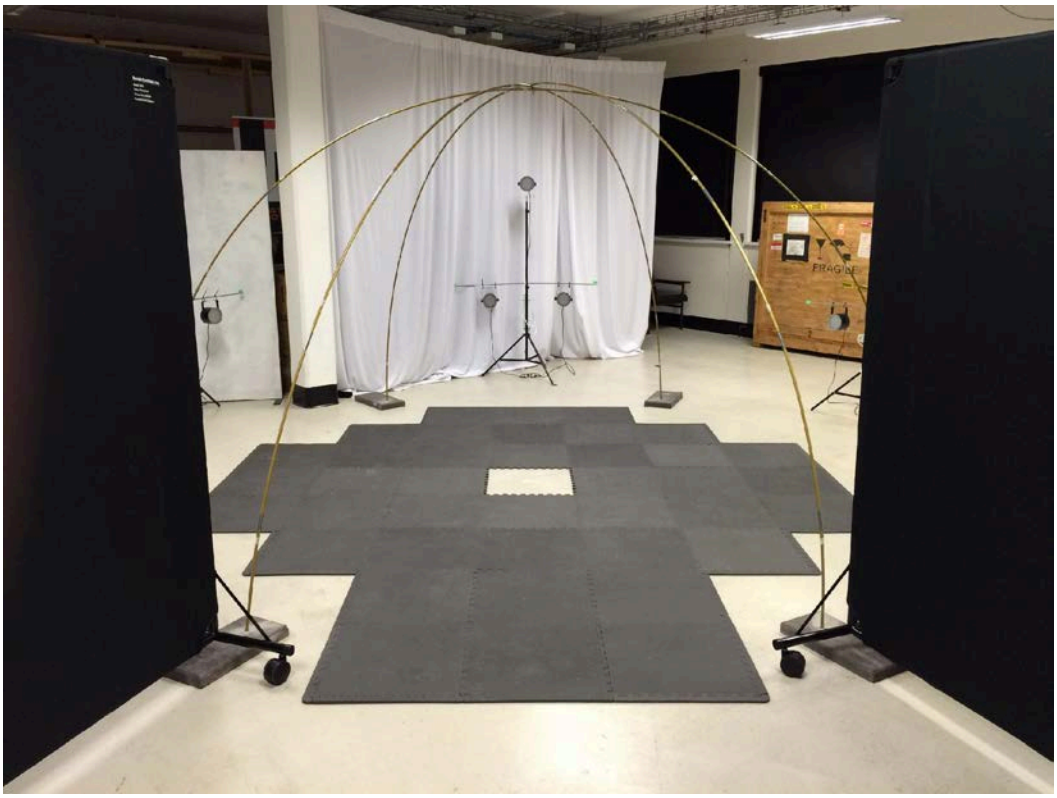


Figure 3.18 - Frame and flooring of RDE.

Working in the experiment space in the Creative Robotics Lab at UNSW Art & Design, I needed to find ways to create a space that felt relatively comfortable and welcoming, and avoided the stark coldness of concrete floors and walls. However, being a shared resource, I still needed to keep the RDE mobile and able to be packed down and stored when studies were not being conducted. I introduced soft flooring in the internal space of the RDE in the form of dark grey foam tiles which made the area more comfortable for sitting (Figure 3.18). I also used several black 'wall separators' to direct the attention of children toward the entry of the RDE as they walk through the door of the room, and

hide technical equipment such as cables and lighting stands as much as practicable.

Around the circumference of the dome, three networked cameras were placed to observe participants during the open studio from several angles (Figure 3.19) and record video for post-interaction discussion with each parent and child pairing. Surrounding the entire structure were four audio speakers, treated as four separate audio channels for quadraphonic panning of sound and mapping of audio feedback to positional interaction across the interface. In all iterations, the audio was composed of two main elements: the atmospheric soundtrack, which consisted of recordings from an Australian bush setting, such as birds and running creek water, and discrete xylophone notes that were positionally mapped in a 1:1 relationship with triggers specific to each interface iteration (wooden blocks, peg-and-hole puzzle, and coloured buttons).

Figure 3.19 - RDE frame and flooring with IP cameras surrounding.

Figure 3.20 - Lighting stands, as viewed from outside the RDE (not visible to participants).

Finally, five lighting stands surround the RDE, each placed behind one of five segments of the dome (the exception being the doorway panel – Figure 3.20).

These stands were positioned approximately 1 metre from the surface material to soften the effect of the light and create a gentle, immersive experience. Like the audio speakers, each light can be controlled individually to elicit a clear mapping of the relationship between the position of interaction on the tangible interface (internal space) and the sensory feedback of the *RDE* system (external space). This mapping was designed to help the participant locate themselves within the space, giving them an awareness of their agency and ability to control the system, as well as entering them into a conversation with the *RDE*.

3.5 Interview: Body-focused HCI practitioner

In this chapter, I have described some of my early design ideation, which comes about through reflection on making and materials. I now look to my discussion with a HCI practitioner who has a background in bodily performance such as dance and theatre. Despite our practices being notably different, through our discussions we found parallels when opening up the definition of a 'design artefact' and exploring the importance of framing a context for eliciting participant or audience feedback. I reflect on that discussion here to consider the role of the *RDE* against other contexts.

Here I introduce the visual mapping of practice that I first described in relation to the *An Exhibition of Process* show (section 1.4). In the image below (Figure 3.21), my own practice is described by the blue line, which begins with background

work (honours artefacts) and then connects to material exploration (dome process images), technical experimentation (dome model), design iterations (interface 01 and 02) and finally reflective feedback (interview analysis).

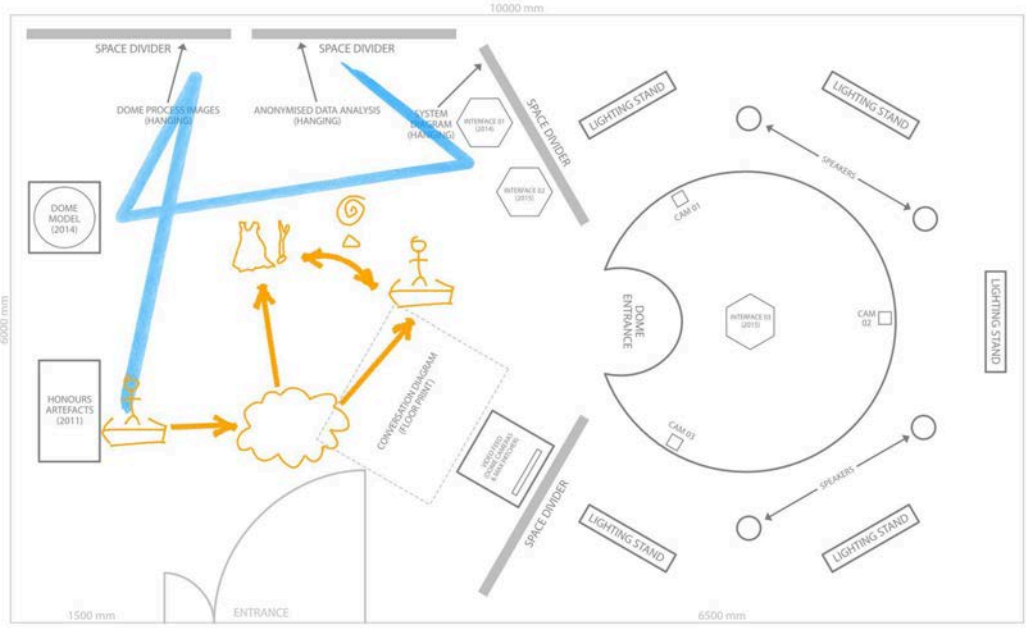


Figure 3.21 - Mapping the stages of practice of Body-focused HCI Practitioner (04p_05).

In contrast, the body-focused HCI practitioner (visualised in orange) does not follow the linear design process of my practice. Instead, their approach iterated through material exploration and performance, but did not explicitly capture audience feedback. This process moved between tacit ideation (thought bubble icon) and artefact creation (dress and prop icons), as well as ideation and performance (figure on stage icon). Both of our approaches are reliant on a viewer to exist (they are created to engage with people in some way), however, the body-focused HCI practitioner did not record the response of the viewer in a systematic way, instead reflecting personally on the experience of performing. Although my own first-person reflections can be seen throughout this thesis,

my attempt to draw from the voices of participants in an active way does contrast with my practice markedly, which is reflected in the visual mappings above.

Where our praxis align is in early ideation being driven by reflection on what can be described as material experimentation. Likewise, the role of the artefact (an object, prop, or performance) is to begin framing the engagement or conversation between researcher and participant—it is not the outcome of an inquiry, but provides a situational opportunity to reflect upon and place in a broader context (beyond the artefact). For both of us, feedback from those engaging with the work (be it participants or an audience) are key in giving us a sense of whether we're 'on the right track' with our design response:

> …if there are people around, an audience, I will respond to them, or allow their presence to you know, influence what I'm doing. So, in a way, if people are staying around and filming, you can sense that they're actually engaged, then that's also something. It tells me something hopefully is going right. (Body-focused HCI Practitioner, Transcript 04p_05, Line 229)

The real-time approach of the body-focused HCI practitioner contrasts with my asynchronous reflection on participatory feedback for the purpose of design iteration. The latter gives me an opportunity to employ methods that identify the role of the participant, bringing structure and form to their first-hand perspectives and using that knowledge to inform design iterations. As I reference when describing the approaches of other experts in this thesis, the practitioners who used this kind of reflection each spoke of striving towards

some clarity in the role of the participant, often in ways where the participant had an opportunity to experience this reflective process themselves. This was less important for the body-focused HCI practitioner, who described feedback as influencing their work in a highly tacit or generative way:

> There's definitely always some kind of criteria, um, I think for any performance or like development of something artistic where you feel like you've created something interesting or worthwhile or feel like I've challenged myself beyond what I would normally do… Like, I wasn't just me, my everyday me, so yeah, if I was able to actually feel like I slipped into something else um, that had some kind of creative, generative thing going on. Then, yeah, I felt that was sort of like how I was measuring that… That has some kind of creative foment in that, and hopefully can affect other people as well. (Body-focused HCI Practitioner, Transcript 04p_05, Line 225-227)

3.6 Summary

In this chapter, I have explored how my material practice was the seed for the participatory engagement that I will describe in Chapter 4. Like the body-focused and HCI practitioner, material experimentation is the 'probe' that I send out for feedback from participants. The design decisions I make at this stage of my practice are based on my tacit knowledge (drawing from my background and experience) as well as the foundational theory I have referenced in this chapter and Chapter 2. Like the body-focused HCI practitioner, my use of the design artefact as a starting point for design iteration through

participatory feedback is not about defining the ‘success’ of a project through measurable outcomes. Rather, this is the first step in an exploration of human response to performativity. For the body-focused HCI practitioner, this centred around their own performance; for my work, I look to the performance of the participant.

4 Action: RDE Open Studio

As I described in Chapter 1, the *Responsive Dome Environment* (RDE) open studio was an iterative design process informed by participatory engagement. It was an opportunity for me to capture feedback from people that interacted with the RDE both formally (in a systematic study-like structure with a group of children and their parents) and informally (when colleagues and peers were in the space with me) by being open to emergent feedback both in the design of the RDE (non-directive interaction) and laying out much of my process work and materials. A total of 3 iterations of the RDE open studio were carried out between November 2014 and July 2015, with the final iteration being open to the public as an exhibition, An Exhibition of Process. In this chapter, I focus primarily on the interaction and feedback of a neurodiverse group of 6 children and their

parents.

Figure 4.1 - Complete *Responsive Dome Environment* with iteration 1 interface.

In the RDE open studio, I look at how my practice builds upon the material experimentation I described in the previous chapter as constructive design research. That is, participatory interaction with the RDE is both the catalyst and location of new knowledge generation. By situating activity within the RDE, I was able to explore neurodiverse experience by reflecting on emergent and individual interactions with the artefact. While I did bring my design knowledge and practice to bear on exploring these ideas, structuring the participatory part of this project as an open studio was in an attempt to remain open to the contribution and influence of the people encountering the design artefact.

In this chapter I will reflect on my work with participants and the ways in

which I was guided by our conversational experiences together. While I looked at the exploration of materials in designing a constructive object in the previous chapter, here I put my framework into action. I will describe how the early iterations of the *RDE* gave me the opportunity to identify experiential feedback, informed by emergent behaviour and interviews with participants. Through the iterations of the *RDE* open studio, the artefact became increasingly conversational, most notably through the emergence of 'disruption' as a tool for bringing activities into conscious behaviour and feedback. I look at how my learnings in this process helped me to frame my practice as conversional and identify this framework for future research.

4.1 Experiment space

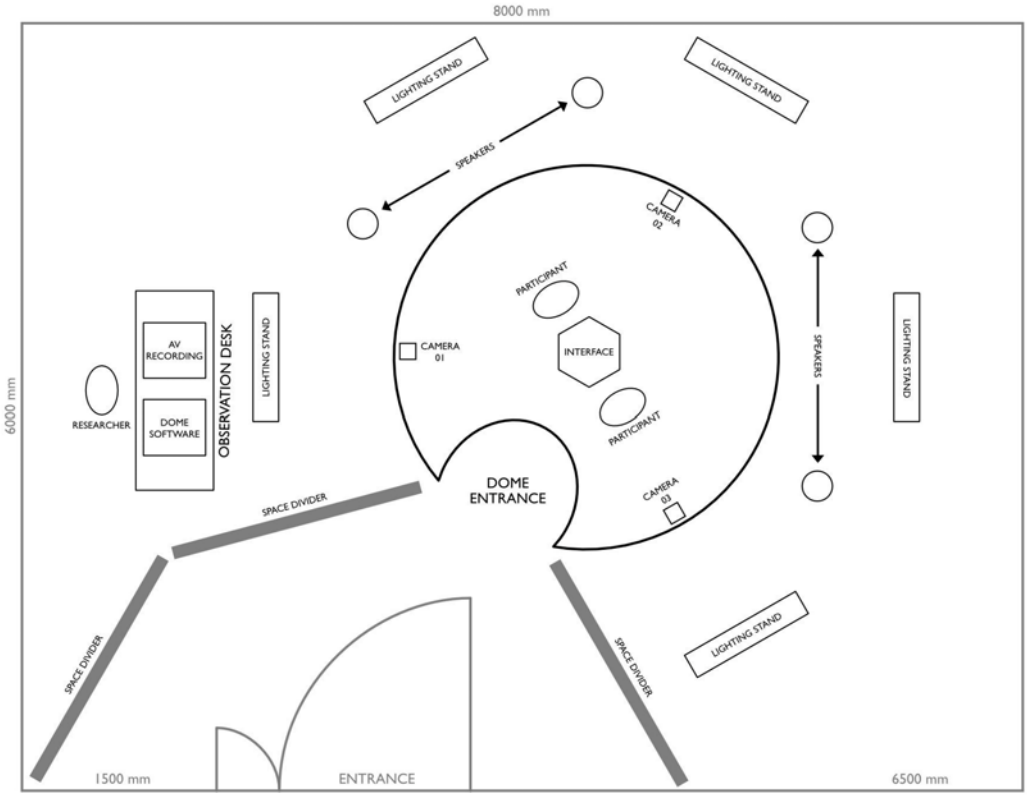


Figure 4.2 - Floor plan of *RDE* experiment space.

To orient the reader to the open studio space, the image above shows a top-down plan of the Creative Robotics Lab (CRL) experiment area (Figure 4.2). Each participatory study, as well as the expert interviews were carried out in the CRL space measuring approximately eight metres by six metres. The *RDE* was oriented so that the child would immediately be facing the entrance of the dome structure when they entered the CRL. The space was also set up to create a sense of comfort and safety in the children, who were not initially familiar with the environment. For autistic children in particular, new experiences can be sensorially overwhelming, so I arranged space dividers and other objects to mitigate this. During the participatory studies, I was seated outside the *RDE* at an

'observation desk', where I was able to view a live video feed of the interaction without being physically present. This allowed me to remain aware of any issues or difficulties that arose in real time as well as being able to intervene in the feedback of the system. The latter allowed me to intervene by disrupting interaction experiences in the third iteration of the open studio.

4.2 Study population

Recruitment for the *RDE* open studio took place through a university faculty callout at UNSW Art & Design, after receiving UNSW Human Research Ethics approval (HC14219). A total of six children—two autistic (one female, one male) and four neurotypically developing (one female, three male)—participated across the three iterations of the *RDE* case study. The age range for all children was 2–6 years over the duration of the study (2–5 years in the first iteration, and 3–6 years by the final iteration). From this group, the two autistic children did not participate in the first iteration and one neurotypical child was unable to participate in the final iteration.

Both autistic children in the group were diagnosed as high-functioning[12] and as such, it was expected that they were developmentally capable of managing their experience in the *RDE*. Importantly, the parent of each child (which happened

[12] I recognise that 'high-functioning' is a term that is not preferred by autism advocates for its implicit suggestion that ability is important and therefore sits counter to the neurodiversity movement. I use it here as an inelegant layperson reference to diagnosis that is widely used to describe a child whom is capable (or close to capable) of attending mainstream schooling.

to be the mother in each case) remained present at all times to ensure familiarity while in the RDE as well as being able to identify any distress or discomfort.

Both the parent and child in each pairing were invited to participate in the RDE open studio a total of three times (with the exception of the autistic child-parent pairings, who attended the latter two iterations only). Each parent agreed to their child's participation by signing a consent form and communication occurred via email only, to ensure that participants did not feel coerced at any time to take part in the study. As per ethical procedures for this research, all identifying information for participants has been removed. In place of names, I have used a numbering system to indicate study iteration and population group. This system is coded in the format 'XXy_ZZ' (e.g. 01n_03), which is broken down as follows:

- XX — iteration of case study (1-3 includes participatory studies, 4 represents expert practitioners only)
- y — signifier of population (neurotypical; autistic; therapist; or practitioner)
- ZZ — number of participant within group, arbitrarily ordered

4.3 Role of the participant

This research—and certainly the *RDE* open studio—has participatory feedback at its heart. I worked with the neurodiverse group of children to not only understand more about the artefacts and experiences I designed, but also to understand more about the problem space by speaking to people with first-hand knowledge. In my use of the *RDE* as a constructive and conversational artefact that elicited and facilitated emergent feedback, I was aiming to bring the 'voices' of participants into the design process by looking at experiences that are important to the neurodiverse population I was working with. This supports my framing of the *RDE* artefact as a constructive object that locates the participant's agency and identifies potential for new knowledge through reflection on conversational interactions.

In the engagements I describe in this chapter, I invite children and their parents to interact with the *RDE*, which generates feedback as a reflection of participatory agency to inform increasingly refined design iterations in response to their conversational experiences. This process follows what Kurt Lewin described as "a spiral of steps each of which is composed of a circle of planning, action, and fact-finding about the result of the action" in his effort to effect social change through field research (Lewin 1946, p. 38). In identifying the values and knowledge of the participant (which may differ from my own) both in the observation of their interactions and their reflective feedback with me afterward, my role was that of a "facilitator of intervention" (Hayes 2014, p. 50).

In response to these interventions, I look to identify feedback—that of the responsive system and the participant themselves—as an indication of agential intent and in turn, a driver of my iterative design process. Notably, the participatory element of my practice is highlighted here in acknowledgement of the political positioning of autistic self-advocates and recognises one of the best known credos from this group: "Nothing about us without us" (Charlton 1998).

Co-creation between researchers and participants has a strong history of application to interaction design. Computer scientist Allison Druin (Druin 1999) urges that when designing new technologies for children, they should be consulted as part of that process. Druin posits four roles that children can play in the design process, which describes their relationship with adult researchers and the technology being designed: user, tester, informant, and design partner (Druin 2002, p. 2). According to Druin, the decision to frame participants within one of these roles is dependent on the researcher's goals, resources and methodological approach. Working from these descriptions, the role of the child as participant in the *RDE* case study is that of a 'tester'. Druin describes this role through the purpose of study and stage of material development:

> Children are a part of developing new technologies that can lead to future product directions and/or new educational theories… with this role, adults have already accomplished the initial brainstorming and design phase. Children do not begin their role as a tester until initial prototypes have been created. (Druin 2002, p. 7)

For the *RDE* open studio, the importance of children engaging with the material

artefact was to reflect on their individual response to the constructive artefact, observed by myself during the study and post-study interview feedback. This informed further design decisions and reframed the design problem, rather than applying feedback to technical or formal artefact development outcomes. Druin maps the role of child as 'tester' in research with similar goals, by describing relationship to adults, relationship to technology, and goals for inquiry (Figure 4.3).

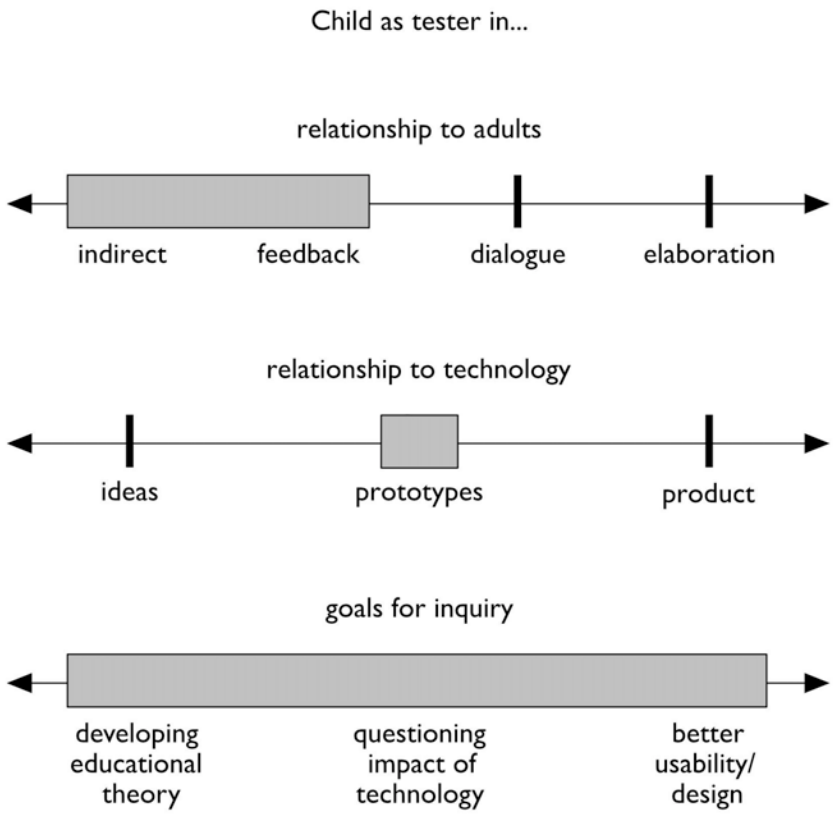


Figure 4.3 - Child as tester from (Druin 2002, p. 7).

Druin's mapping describes a premise that the function of a design prototype is to be a passive (or single-direction responsive) artefact. This does not match the development of knowledge as understood through a constructive design

approach. In the *RDE* open studio, I recognise the agency of the artefact in its ability to elicit and reflect the intent of participant. Here, I have looked at how Druin's model might evolve in response to the ideas I put forward in this thesis. My approach extends Druin's mappings in the tester role, particularly across the dimensions of relationship to adults and relationship to technology (Figure 4.4). The active, conversational nature of the artefact allows for this without an explicit need for the use of language. This enables participants to explore and express themselves in a non-directed and emergent experience.

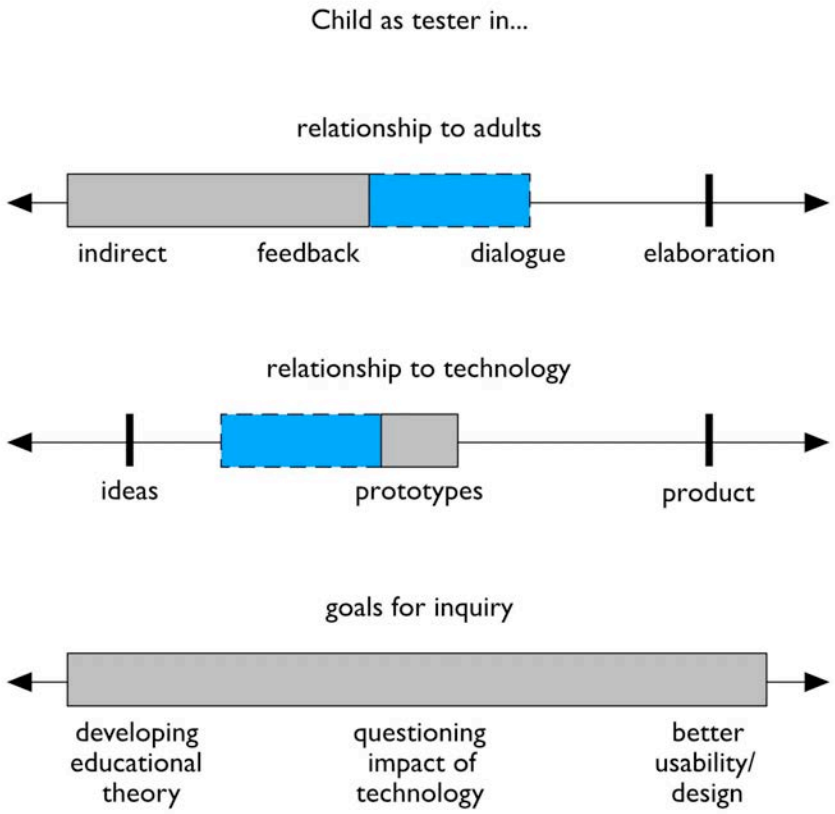


Figure 4.4 - Extension of Druin's tester role through active artefacts.

In the approach I put forward in the *RDE* open studio, the role of the child (or any participant, as my practice is not restricted to a single study population),

and the importance of the design artefact to elicit moments of conversation is not limited to situated or direct interactions. As I will explore in the following sections, the *RDE* is used in this project as a point of departure; interactions with the artefact lead into opportunities for reflection on experiences, both within the study and extended contextualising sociocultural histories.

4.4 Iteration 1: Initial probe

Objective: Initiate early design feedback with a neurotypically developing study group.

The first iteration of the *RDE* open studio was completed with four neurotypically developing children and their mothers, on a child-parent paired basis (one child and their mother participating at a time). My decision to explore the first design iteration with neurotypical children only (no autistic children) was a pragmatic one: it was an opportunity for me to begin feedback on my initial design while autistic participants were being sought (access to autistic participants through services and clinics is necessarily a slow-moving process). It was also an ethical decision; one of the purposes of the first iteration was to identify unanticipated sensory issues that might distress autistic participants, particularly in relation to the feedback of the lighting and audio system.

The structure of *RDE* and its surrounds (material surface, lighting and audio

system, and the arrangement of experimental space) remained consistent across each of the three open studio iterations. This allowed me to focus on the response of participants to two key areas of interaction design: the tangible interface (including physical design and interaction metaphor used) and the software responsible for controlling audiovisual feedback of the *RDE*. In the first iteration, colourful cubes were used as a means of tracking hue and position information on the interface surface via a USB camera placed inside the table (Figure 4.5).

For this design, I drew from a play activity that most children would be familiar with: colourful toy building blocks. I anticipated that this would afford a conceptual model of use to the participants that would not require instruction or direction. The scale of the blocks was informed by objects that are physically manageable by young children, who have small hands and potentially a limited range of fine motor skills depending on the age of the participant. Based on the position and orientation of each block on the interface surface, light and sound feedback of the *RDE* was mapped to a corresponding position on the table in front of the participant. For instance, if the yellow side of a block was placed on the right corner of the table, a yellow light would illuminate the right corner of the *RDE*. This movement was also accompanied by a musical note played from the same position. This tracking and mapped feedback occurred via the camera feed to reacTIVision software[13], sending positional data to a custom Max patch

[13] A computer vision framework for tracking positional markers known as 'fiducials'. See http://reactivision.sourceforge.net

that controlled the lighting and audio output of the *RDE*.

Figure 4.5 - First interface iteration, using the reacTIVision object tracking framework.

Through the use of bold colours, clear geometric shapes, and a conceptual model that was relevant to the study population, my intention in this first iteration was to give children an awareness of their agency. In other words, I hoped that they would come to understand their ability to control the audiovisual feedback of the *RDE* through their use of the interface while providing them with a reasonable degree of freedom in their interaction. This latter point feeds into the 'probing' aspect of my work: it is an opportunity to have a conversation about design aspects through their use and explore my assumptions before iterative redesign.

As I will describe in the next section, the abstraction of the tangible interface (toy blocks) from the feedback of the system (*RDE* surface) provided too much

ambiguity for the children interacting with the space. Children were comfortable with the object as a toy block, but were not always able to make the connection of using a block as an abstracted control object. The ambiguity in interaction was a result of the level of latitude afforded by the surface of the table. In effect, it did not provide clear signifiers toward the mapped relationship between table and dome structure. While there was a relationship in the number of sides on the hexagonal table and the segments of the RDE structure, few participants seemed to recognise this.

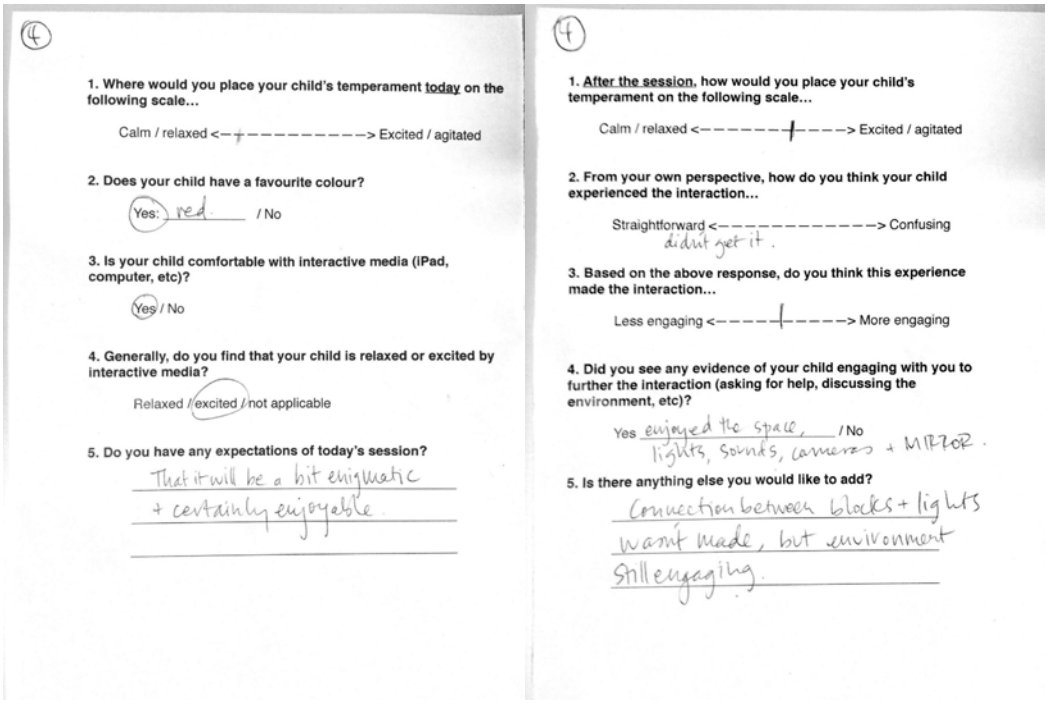
Figure 4.6 - Video still from study 01n_02.

The feedback from this design suggested that my decision to provide children with an un-signified and open relationship to the RDE feedback systems ultimately confused participants. Compounding the issue, a brief lag in the

camera tracking software made the interaction/response relationship even less explicit. Based on my observations during this case study, I decided to move away from such ambiguous control for subsequent iterations. Despite the issues identified with the interface and RDE software in this iteration, participants described a positive response to the tactility of the interface and subdued tone of audiovisual feedback in the RDE. The method of capturing that feedback is described in the following section.

4.4.1 Survey and observations

My first approach to capturing participant feedback was in using pre- and post-study questionnaires, aiming to capture a clear and quantifiable picture of experience in the RDE. My assumption was that this statistical approach would give me a clear picture of what was working in my design and what needed further development. Contrary to my expectations, I found that the questionnaire format did not allow parents the ability to communicate the richness and complexity of experience that they wanted to express. While completing the survey, I was often asked to clarify the language of a written question or give them the option to expand on a response where the questionnaire only provided limited opportunity for feedback. These discussions were ultimately more enlightening than the questionnaire feedback. In the second and third iterations, I did not use questionnaires. Instead, I used semi-structured interviews to encourage the style of open discussion and narrative I found most valuable with parents in the first iteration.



4

1. Where would you place your child's temperament today on the following scale...

Calm / relaxed <–+–––––––––> Excited / agitated

2. Does your child have a favourite colour?

Yes: red / No

3. Is your child comfortable with interactive media (iPad, computer, etc)?

Yes / No

4. Generally, do you find that your child is relaxed or excited by interactive media?

Relaxed / excited / not applicable

5. Do you have any expectations of today's session?

That it will be a bit enigmatic + certainly enjoyable.

4

1. After the session, how would you place your child's temperament on the following scale...

Calm / relaxed <–––––––+–––> Excited / agitated

2. From your own perspective, how do you think your child experienced the interaction...

Straightforward <–––––––––––> Confusing
didn't get it.

3. Based on the above response, do you think this experience made the interaction...

Less engaging <–––––+–––––> More engaging

4. Did you see any evidence of your child engaging with you to further the interaction (asking for help, discussing the environment, etc)?

Yes enjoyed the space, lights, sounds, cameras + MIRROR / No

5. Is there anything else you would like to add?

Connection between blocks + lights wasn't made, but environment still engaging.

Figure 4.7 - Pre- and post-observation questionnaire from study 01n_04 (left and right respectively).

Despite the limitations of the questionnaire format, all four of the parents indicated that their child enjoyed the experience of being in the RDE. This was articulated in different ways. Several parents inferred that I had the intention or 'goal' for the RDE to be a calming space and on this assumption indicated on the questionnaire that their child's interaction with the environment did have that effect. While I did consider how the scale and materiality of the RDE might be comfortable for a child, I did not describe this intent to participants during the recruitment process or the RDE open studio. The expectation that there was a 'correct' answer was evident in the questions that parents asked me while completing the questionnaire. In all cases I gave participants non-directive responses to keep the questionnaire feedback as unfiltered as possible.

ID	Group	Age	Time in RDE	Pre-study state	Post-study state
01n_01	Neurotypical	2.5 yrs	18m 52s	"calm"	"calm relaxed and excited"
01n_02	Neurotypical	5 yrs	14m 3s	11 (Excited / agitated)	3 (Calm / relaxed)
01n_03	Neurotypical	2 yrs	10m 9s	3 (Calm / relaxed)	2 (Calm / relaxed)
01n_04	Neurotypical	5 yrs	20m 47s	2 (Calm / relaxed)	7 (Excited / agitated)

Table 4.1 - Questionnaire feedback results from study 01n on child's temperament state, pre- and post-study.

ID	Group	Age	Time in RDE	Interaction understanding	Interaction engagement (from understanding)
01n_01	Neurotypical	2.5 yrs	18m 52s	"exploration mode was trying to see how it worked"	"more engaging"
01n_02	Neurotypical	5 yrs	14m 3s	1 (Straightforward)	10 (More engaging)
01n_03	Neurotypical	2 yrs	10m 9s	1 (Straightforward)	3 (Less engaging)
01n_04	Neurotypical	5 yrs	20m 47s	"didn't get it"	5 (midway)

Table 4.2 - Questionnaire feedback results from study 01n on child's interaction understanding and engagement, post-study.

The perception from parents that I had a hypothesised position to test in the research was seen most clearly in the questionnaire item 'Interaction understanding' for respondents '01n_02' and '01n_03' (Table 4.2), who both described their child's understanding of the interaction control as being highly 'Straightforward'. In my own observation of these participant interactions and discussions with parent post-study, it was clear that these children were not making a connection between their interaction with the block interface and the mapped audiovisual response of the RDE. Rather, the parents were assuming that this was the ideal response for the success of my research. This was well meaning, but ultimately not useful feedback.

My own observations and unplanned discussions with participants were more useful in terms of design feedback than the questionnaires. In Study 01n_01, I

observed the child exploring the space very freely, behaviour that appeared to be triggered by the ambiguity of interaction through the table interface. This boy pulled the surface of the interface from the table and crawled under the side of the dome structure in fascination, as an attempt to explore the workings of the RDE (Figure 4.8)—a behaviour not unusual for an excited 2.5 year-old child in a space that dynamically changes through light and sound.

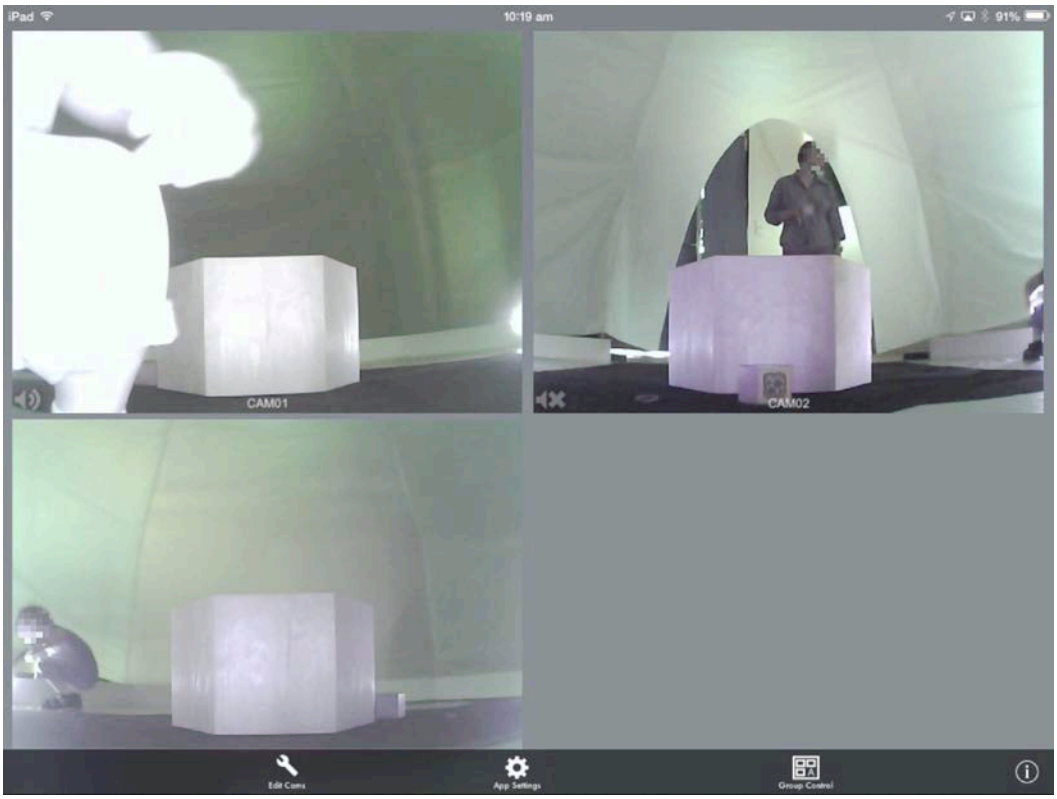


Figure 4.8 - Boy climbing under side of RDE in study 01n_01_a.

This child also attempted to use the reacTIVision tracking patterns on the surfaces of the blocks as push-buttons. Through discussion with the parent, I learned that this child's experience with interactive technology is push-based (e.g., a remote control or touch screen device) which helped contextualise his interactions with the RDE for me as a designer. This feedback suggested that

although the toy block-like design of the interface made the objects easily relatable for the child in terms of a conceptual model of interaction, they could not apply this understanding to this context. By contrast, knowledge of blocks as an interface control could be applied in the RDE. The method of receiving this feedback also evidenced my need to open channels of conversation between myself and participants in future iterations.

In contrast to the boy described above, the eldest child participating in the studies (5 years, Study 01n_02) engaged with her parent in co-operative interaction more often. Once again, this was not unforeseen considering the different stages of development of each child. Also evident in in the behaviour of this participant was that the older child took the lead on the interaction more often. The parent used the interface in a turn-taking response to the action of the child, whereas the parent of the younger child more often attempted to (re)direct attention to the activity.

It is in keeping with the typical developmental differences in these children (2.5 years and 5 years) that the older child would display more of a problem-solving approach to the interaction, including instances of turn-taking, social and co-operative interaction. These differing responses make it impossible to draw any generalisable conclusion from the observational video (as does the small population size). However, more important to my constructive and probe-like approach was to look at these interactions to identify strengths and weaknesses in the design of this iteration of interface audiovisual feedback system. Through

this process, I identified an unclear mapping relationship between the interface and *RDE* feedback, as a result of too few constraints in the control object. By not constraining the participant (particularly younger children) in the space, the level of ambiguity in the interface generated too much noise for conversation and agreement to take place (both during and after the study).

4.5 Iteration 2: Establishing control

Objective: Introduce *RDE* to autistic children and address control ambiguity from iteration 1.

In the second iteration of the *RDE* open studio, I aimed to address the issues around interface mapping that I identified in the first iteration by using a 'peg-and-hole puzzle' as the conceptual model for control (Figure 4.9). Similar to the toy block interface, the design of this interface focused heavily on primary colours, symmetry, and geometric patterns to reduce ambiguity in the relationship between interaction and *RDE* feedback. In addition to these design considerations, the peg-and-hole structure made the interaction more constrained, explicitly signified by holes on the table surface. Through this interface iteration, I aimed to increase the potential for children to understand their agency by clarifying the spatial mapping relationship between interface surface and *RDE* feedback.

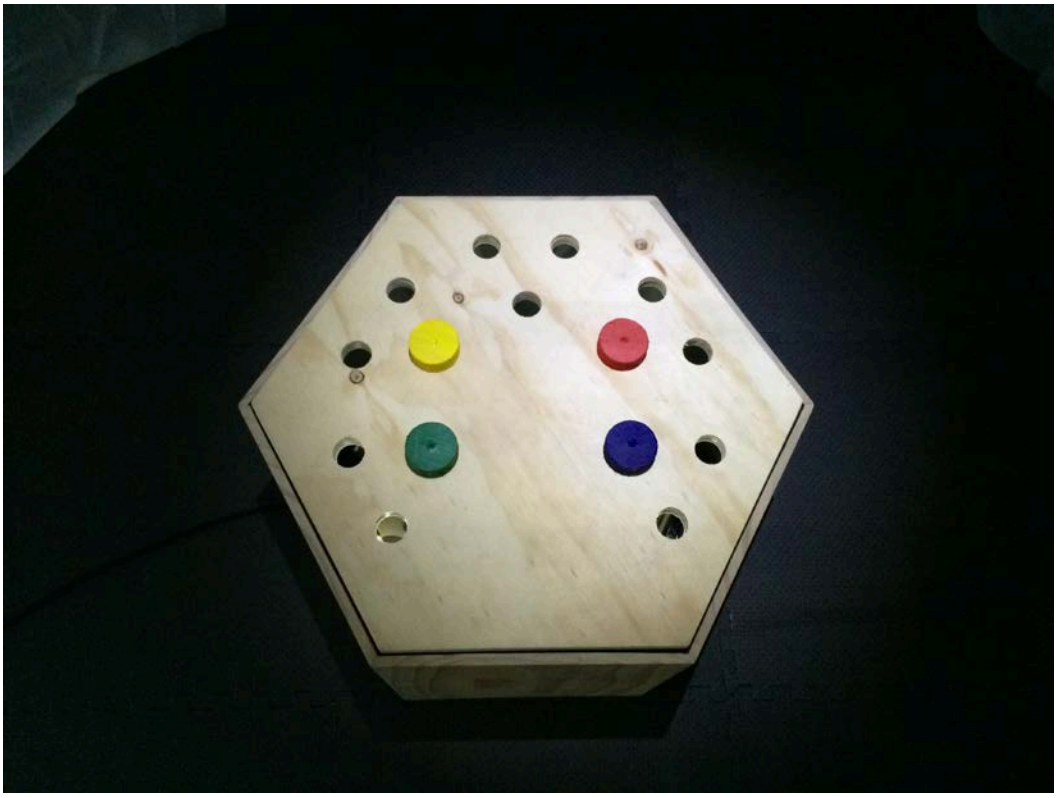


Figure 4.9 - Iteration 2 of the RDE tangible interface.

From the second iteration of the RDE open studio, two autistic children and their parents were introduced to the study population. Due to limitation in access to autistic participants that I faced in this research, these children were diagnosed as 'high-functioning'[14] and attended mainstream schooling. The diagnosis given to these children determined that they would receive little-to-no access to services funded by the Australian Government outside a typical public school system (such as, autism-specific schooling, speech therapy, or occupational therapy sessions).[15]

[14] I recognise that this terminology is not favoured by autism advocates. I choose to use it here only for its reference to the way that Government funding is allocated.

[15] One of the difficulties faced by this research project was that it was not considered to be an 'evidence-based' approach. As Australian Government funding for autism services is afforded only to evidence-based work, autism institutions and practitioners were unable to provide access to their clients for this study. The two autistic participants discussed in this study fall outside the diagnosis range that can access funding, and the parents were therefore very open to the experience of participating in a study that aimed to provide them with a positive and enjoyable experience (no claim for therapeutic benefit was ever made to participants). These mother-child dyads were referred to the study by a psychologist via online social media groups.

This iteration of the tangible interface used a Pixy CMUcam (Lang n.d.) housed inside the table to recognise the colour and position of pegs inserted into the interface surface. Passing this information to the lighting system, the interface was designed to support a similar activity as the earlier toy-block design: displaying a corresponding colour in its mapped position on the dome surface (Figure 4.10). By adding positional constraint to the interface, I hoped that the interaction would be more explicit, encouraging participants to move efficiently from the initial steps of understanding their agency to engaging in conversational interactions with the RDE.

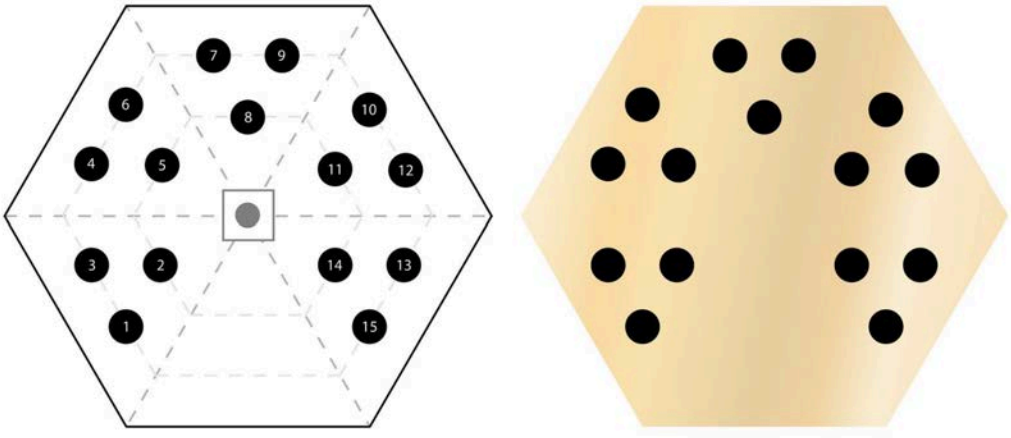


Figure 4.10 - Internal camera tracking positions (left) and hole positions on table surface (right).

Beyond the change in control object (from toy block to peg-and-hole), the table surface and RDE structure was unchanged from iteration 1. This ensured continuity and familiarity for those children returning to the space, and reduced the variables between iterations.[16] The scaffolding nature of this iterative process

[16] As an additional attempt to reduce variability, the total number of colours to select from was reduced from six in Iteration 1 (each side of the cubes), to three colours in Iteration 2 (although Figure 4.9 shows four different coloured pegs, the dark blue was removed during testing because of contrast issues with the Pixy CMUcam).

is a foundational aspect of my practice, which I will unpack in the next chapter.

This was also the first iteration that I invited therapists to give me informal feedback on the design of the space from their expert perspective (all interviews can be found in the appendix to this thesis). I have described these as 'stakeholder interviews' to avoid confusion with the semi-structured interviews I carried out with expert research practitioners elsewhere in this thesis, which are used to locate my practice in the field of interaction design.

Unlike the semi-structured interviews with research practitioners (carried out after the final *RDE* design had been completed), these discussions with stakeholders from autism-associated areas of health, education and advocacy, were more open in scope, to capture more emergent ideas which might be useful during the design process. The first of these discussions (with a psychologist) supported some of the observations I took from the first design iteration concerning the material aspect of the *RDE* (from interview 02t_01):

> ...when you were originally saying lights and I was thinking 'gosh, like I wonder about the intensity of them', but they've got a really muted sense because of the tent which is beautiful I think for a lot of the kids with some of the sensory issues as well. It's actually really mesmerising to watch, particularly these three. (pointing at the tent) I like it. (4:48-5:05)

> …it's got a feeling of privacy, but the lights are a little bit dimmed behind, which is good. But no, I was just thinking that the music is, is quite pleasant, because like, you do lose that sense of, 'you're inside a university campus' kind of thing. (13:28-14:01)

Capturing an additional perspective from a domain expert gave me further confidence in the direction of the iterative design of the *RDE*. While these therapists were interviewed 'out of step' with the *RDE* open studio (not at the same time as participatory engagement of children and their parents), I did treat their feedback as that of any project stakeholder. As an expert from other fields working with autistic people, their contextualised experiences were useful in reflecting on my own perspectives and design trajectory.

4.5.1 Video-cued recall method

In response to the difficulties I faced using pre- and post-study surveys in the first iteration, I turned to a simplified version of the video-cued recall (VCR) method (Costello et al. 2005, p. 51) to identify moments of interest during interaction with the *RDE*. This method was useful in encouraging participants to reflect on their experience by speaking to specific moments from their experience with the *RDE* while watching video playback. As identified by Costello et al., VCR is a useful tool in capturing first-person feedback where other methods may be too intrusive (for example, bio-measurement sensors or the 'think-aloud' protocol[17]), while still capturing salient moments that might otherwise be forgotten.

When using the VCR method, I found that it served to not only remind participants of particular events during the interaction, but it helped them feel

[17] Bio-measurements generally require the use of sensors attached to the body, which can be alienating for autistic children and the think-aloud protocol has the difficulty of taking participants 'out of the moment' while they are engaged in an interactive experience.

more comfortable in opening up about their experience and acted as a starting point from which to contextualise their responses in life beyond that of the RDE interaction. As I will describe, this process would often motivate the parent to identify why the child responded in a particular way, based on a sociocultural understanding that was not available to me through observation alone. More importantly, this gave the child an opportunity to clarify or even disagree with what was being said.

This method continues framing of the participatory case study as a design probe, with interviews being a reflection upon experience with the artefact. Kjeldskov et al. point out the usefulness of interviews that are precipitated by a probe as way to begin conversations between researchers and participants, particularly in relation to interaction with technology, "to prompt memory, seek explanation, and encourage reflection" (Kjeldskov et al. 2004, p. 108).

4.5.2 Interviews and observations

Throughout iteration 2 of the RDE open studio, I observed that the peg-and-hole interaction metaphor resulted in an increase in children focusing on the activity of engaging the audiovisual feedback of the RDE system. The added 'goal' aspect of the task (through a clear relationship between the control object of the peg and the destination of the hole) led to a more explicit signifier for the children to interact with the interface. However, the ability for participants to control up to fifteen individual lighting heads (three per segment on the RDE surface) was

still too complex in the mapped relationship between surface and feedback for the participating age group (2-5 years), regardless of whether they were autistic or neurotypically developing. Anecdotal feedback from colleagues during installation of the *RDE* suggested that unlike my study population, adults were capable of understanding the relationship between the interface and the feedback of the system.

The complexity of mapping between interface and system often resulted in distraction for the children; their attention would drift to other elements of the *RDE* (materials, structure, and so on), resulting in shorter study durations through boredom or lack of interest as participants were free to end the study at any time. My observations from this iteration along with the first iteration were consistent in that the difficulty for children interacting with the system rested with the complexity of mapping between the interface and audiovisual feedback of the *RDE*. While designing an interface that was positionally static (iteration 2) as opposed to freely moveable objects (iteration 1) did make the relationship between interface and feedback more explicit, there was not enough of a connection for a meaningful interaction to take place. In conversational terms, there was no opportunity for (dis)agreement to occur between participant and the system, nor a clear activity to reflect on between myself and the child during post-study interviews.

I identified additional issues with this interface during interviews with experts conducted in the *RDE* space. One of the four interviews undertaken alongside

iteration 2 was with a PhD candidate from UNSW Art & Design who identifies as an Autistic multi-artist (capitalisation used by the interviewee). During this interview, the small LED lights used inside the interface for camera tracking purposes were identified by the interviewee as being distracting for someone with a visual sensory sensitivity (from interview 02t_05 1:30-2:00):

> respondent: And the light is gonna be… there? (gesturing to the interface table)
>
> interviewer: Coming from underneath? Yeah, I think one of things I need to do is try and block that out a little bit, cause it is distracting.
>
> respondent: Well, yes. From here, the type of light is quite penetrating.
>
> interviewer: Because it's so bright?
>
> respondent: Yeah. And focused.

This was a first-hand experiential response to the perceived sensory quality of the light and highlighted the importance of conducting interviews while engaged with the design artefact. Unlike the lights used to illuminate the surface of the *RDE*, which were diffused by the translucent material of the dome, the lights inside the interface would shine directly into the eyes of participants as they placed pegs into holes on the interface surface (Figure 4.9). The quality of this light was also discussed during post-interaction interviews with children and parents participating in the *RDE* open studio. During discussion with a five-year-old autistic girl and her mother (interview 2a_01 4:24-4:56), the parent commented that the light within the interface table was a 'bit jarring', whereas

the light on the surface of the *RDE* was 'really soft'.

This kind of design-related sensory issue was primarily identified during post-interaction interviews. In describing first-person experiences during these interviews, participants were able to engage with and challenge my design assumptions as well as the observations I made during interaction in the space. Being open to this conversational approach to engaging with participatory voices is a key part of my research practice. Interestingly, this approach was not only useful in challenging my own assumptions: there were instances of participating children using this opportunity to challenge the assumptions of their parents during post-interview interviews when expressing their own first-hand account of events.

One of the autistic participants, a six-year-old boy, became engaged in pattern-making behaviours while in the *RDE*. He appeared to be intent on arranging the pegs in holes according to colour. A stereotypical behaviour for an autistic person who has a high ability for pattern-recognition or pattern-making interests, this was dismissed by myself and the parent as being a solitary mode of interaction and his focus on this activity indicated a lack of awareness or interest toward the sensory feedback of the *RDE*. The following insights were gained from interview 02a_02 at 0:59-2:11 (names of participants have been removed):

> interviewer: So, when you first went in, _____ seemed to immediately understand the block and hole system.

parent: Yep.

interviewer: So that as a mode of play is something he's familiar with?

parent: Yes, I don't think that's something we've done a lot at home. But yeah, _____ seemed to know exactly what to do with the blocks and seemed to want a bit of completion there and eventually he started looking for the missing blocks.

interviewer: Yeah, I noticed that he was mostly interested in filling all the holes and not necessarily the relationship between what was happening there and the lights.

parent: No. Yeah, he didn't seem to notice that as much. Whereas I was wondering whether putting things in the blocks was triggering the lights. I think _____ was mostly focused on what was happening at the table — initially anyway.

child: I thought let's move the yellow ones, green ones, red ones all around.

parent: Yeah, you enjoyed moving them around; stacking them on top of each other.

child: Yeah.

On continuing this discussion, the topic turned to tactile sensitivity and the child's feedback regarding the material texture of wooden pegs. Unexpectedly, the child returned to the previous line of questioning, expressing that his interest in colours was neither aimless nor simply pattern-focused. Instead, he verbally communicated his awareness of control that only one other

(neurotypical) child mentioned during post-study interviews (from interview 02a_02 at 6:48-7:19):

interviewer: So you don't like the rough sides so much?

child: Yeah. (incomprehensible)

parent: You like the smooth side better?

child: Yeah.

parent: Yep.

child: Also I found out that these blocks were actually making those lights.

interviewer: Oh, you noticed that they were making the lights!

child: Yeah.

interviewer: Great. Do you have a favourite colour out of the blocks?

child: (holding yellow block)

interviewer: Yellow?

child: Yeah, that's why I picked this one.

The child's parent and I were surprised by his revelation, having made the earlier assumption that his behaviour displayed a lack of awareness of the controllability of the RDE. From the conversational interaction the child had with the system, he was able to articulate his conceptual understanding of the

experience. The adapted use of video-cued recall as a method of participatory feedback was successful as an initiator of conversation, and elicitor of contextual information. Being flexible about this structure allowed participants to return to ideas or redirect the discussion when appropriate. While not all post-study interviews were redirected by the child (this was dependent on the age and relationship between child and their parent, who often spoke for the child), this particular instance is a powerful example of facilitating the voice of the child as a unique centre of knowledge. When empowered to become a part of the conversation, the child's contribution led to unexpected insights and challenged the assumptions of the parents and myself.

4.5.3 Emergence of conversational disruption

Feedback from participants was useful in identifying design issues in the *RDE* (for example, the difficulty in participants understanding the mapping between tangible interface and *RDE* feedback in Iteration 1), but also in capturing first-hand experience that contextualised use. Children often explored the *RDE* in unanticipated ways. By allowing them to express their understanding and interests of interaction through conversation, I was able to reflect on technical and aesthetic issues with the *RDE* that were not identified during design, construction, or testing. In the second iteration of the interface, for example, lighting feedback from the system was being externally generated, disrupting the mapped relationship between participatory interaction and the audiovisual system. When a participant used a wooden peg to trigger a particular light under

certain ambient light conditions (such as uncontrolled daylight entering the experiment space in which the RDE was installed), the triggered lights would illuminate the empty peg holes, causing a 'false-positive' where the camera tracking system would interpret the light as coloured pegs, rather than empty holes (Figure 4.11).

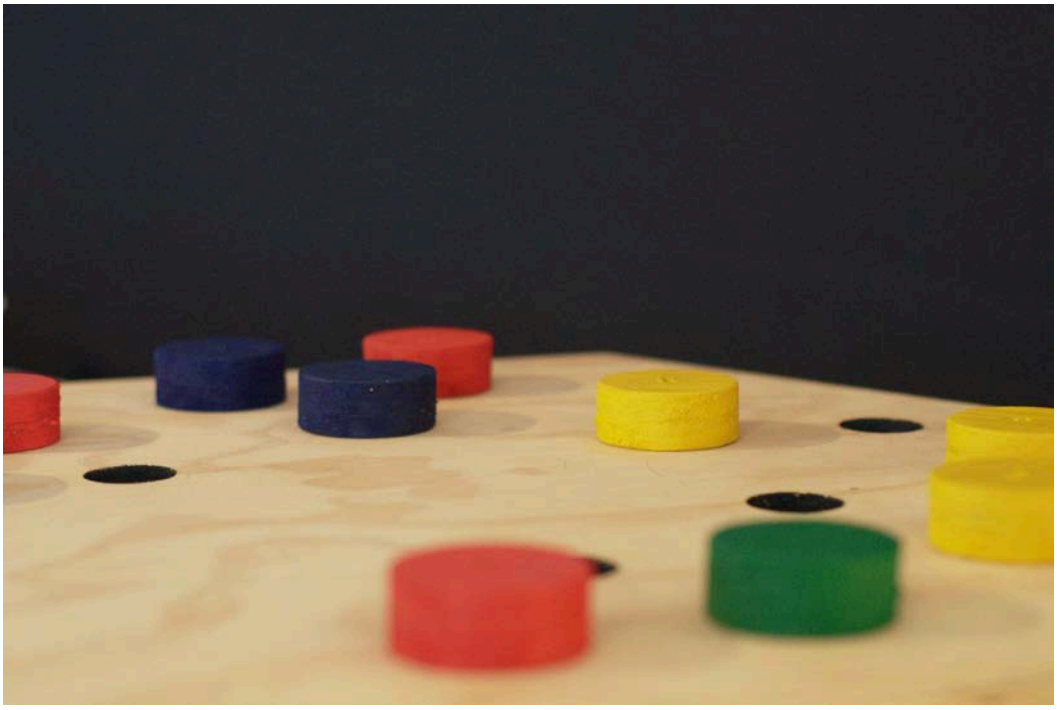


Figure 4.11 - Exposed holes in the second iteration allowed light from the RDE in, feeding the system false triggers.

While this confused and at times frustrated participants, I observed that it was in this state that social interactions could emerge between the child and parent. It seemed that if the system stopped behaving in a way that the child expected—disrupting their conversation with the system—they were motivated to engage with their parent for feedback or assistance. Observing that this unplanned behaviour of the system often led to social interactions initiated by the child, I posited that deliberately disrupting the feedback of the RDE might

provide an opportunity to further explore this conversational opportunity.

My new approach to system control and response led to what is termed a 'breakdown' in HCI literature (Winograd & Flores 1986; Bødker 1996), a phenomena I alluded to in Chapter 3. A breakdown refers to a moment where participants shift their focus or attention between actions. In the second iteration of the *RDE* open studio, the participant often fluctuated from, to use Susanne Bødker's terminology, the unconscious 'operation' of putting coloured pegs in holes (once they were comfortable with the activity), to the conscious or outward 'action' of engaging with their parent for assistance or direction (when their comfort was disrupted). Choosing to externally force this shift of attention also has parallels with the deliberate act of 'sabotage' found in some occupational therapy approaches to learning (Mize 2008) also described in Chapter 3. However, I avoid this terminology for its political and power implications. Instead, as already discussed in previous chapters, I describe the intervening act as 'disruption' and approach it as one of the defining features of my practice, which I expand upon in the next chapter.

Disruption of clearly mapped feedback to instigate a re-assessment of interaction provided an opportunity for conversation during interaction (between parent and child) and in post-study interviews (between participants and myself). In thinking through this approach as an intentional act, I look to Bødker's checklist for using focus shifts and breakdowns as a site for reflection and for areas of observation (Bødker 1996, pp. 168-169). These areas are outlined

in the table below (Table 4.3) alongside my use of the list to describe the most common observations I made in iteration 2 of the RDE case study, especially while reflecting on behavioural video and interview feedback.

Bødker's checklist	RDE open studio
For each focus:	
What is the purpose of the activity/action?	Play; unspecified exploration; control/puzzle solving; sensory experience.
Which object[ive] is focused on and where is it located?	Puzzle solving (interface); co-operative play (parent); sensory response (RDE).
What is the instrument and where is it located?	Interface (mediating artefact).
During co-operation between participants:	
Are purposes, object[ive]s and instruments in accordance or conflicting?	Accordance (working together); directive (assisting).
For focus shifts:	
From what focus/object[ive] to what?	Control/puzzle solving and play (interface/parent/RDE); sensory experience (interface/RDE).
Is it a breakdown or deliberate shift?	Breakdown resulting from disruption or exploration; deliberate shift resulting from co-operative play.
What causes the shift?	Disruption; co-operative play; puzzle solving.

Table 4.3 - A summary of Bødker's "Checklist for HCI Analysis through Focus Shifts and

Breakdowns" (left) and relevant observations from Iteration 2 in the *RDE* open studio (right).

The shift of attentional focus for participants in iteration 2 between the interface, RDE, and parent as a result of disrupted interaction provided an opportunity for me to identify points of conversational agreement or disagreement between participant and the artefact. This was a useful step in understanding the perspectives of children in particular and informed the final iteration of design of table interface, which was ultimately a highly explicit representation of the RDE itself, to provide unambiguous control of the audiovisual system. This final iteration aimed to leverage the potential of disruption identified in Iteration 2 to elicit conversational engagement.

4.6 Iteration 3: Clarifying conversation

Objective: Provide unambiguous control for participants and introduce planned disruption to the system.

Using the participatory feedback from the two previous iterations, the first goal of the final interface design was to provide participants with a clearer understanding of their ability to control the audio and lighting feedback of the RDE. My approach to this problem was to create a scale model of the environment as the tangible interface, with a directly mapped relationship to positional locations and colours on the surface of the dome indicated by arcade-style buttons (Figure 4.12).

Stepping away from the movable object-tracking approach used in iteration 1 and 2, the third iteration involved a 3D printed scale model adorned with bright large red, yellow, and green buttons across each of the five controllable segments of the dome. This was in keeping with the toy-like conceptual models of past iterations, with arcade-style buttons that echo video games or simple interactive toys. In addition to the clarity of the button as a signifier, the visual feedback system was simplified. As a result, entire segments of the RDE surface lit up as a whole when any of the buttons were pressed.

Figure 4.12 - Third interface iteration.

The relationship of the tangible interface to the dome was clear for participants in its design and orientation (Figure 4.12). Segments of the scale model are separated to mirror the segments of the RDE surface, including the arch of the door, which faces the participant as they walk into the space. The coloured buttons placed on each segment also directly signified their role in affecting

feedback. It quickly became clear during this iteration that the directness of this design gave the participants a more explicit sense of control and agency. All participants recognised (identified through observation and video-cued recall interviews) that when pressing any single button, the *RDE* would reflect their interaction by lighting the corresponding segment in the same colour. In addition to visual feedback, discrete auditory response was provided in the form of a musical scale: for each button, a musical note would trigger and play from the corresponding location mapped around the *RDE*.[18] This component of feedback was used to increase the sensory potential of the experience while locating the site of response: if a lighting interaction was taking place behind the participant, the auditory response would serve to draw their attention in the corresponding direction.

[18] For example, pressing a button at the front-left of the interface would trigger a note from the front-left speaker placed around the RDE. Each button would play a successive note in a C Major scale, incrementally around the model, with the high note being at the centre-back of the model and mirroring across the other side, i.e., C1, D1, E1, F1, G1, A1, B1, C2, B1, A1, G1, F1, E1, D1, C1.

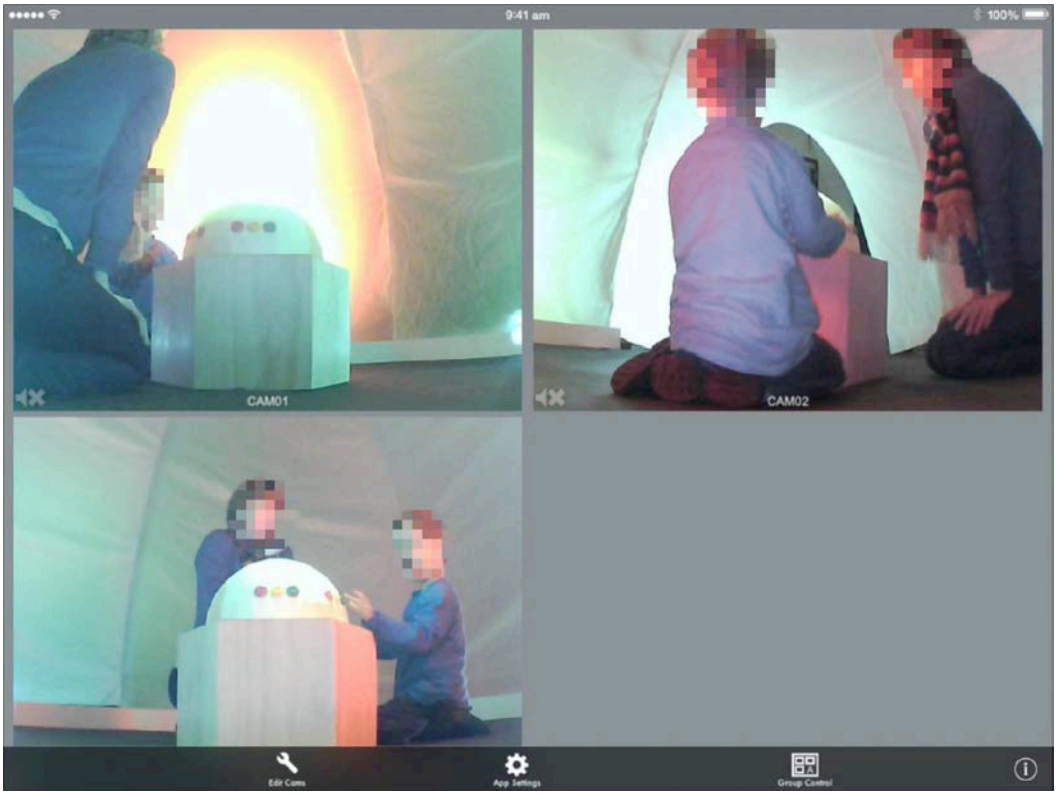


Figure 4.13 - Video still from study 03n_04.

The use of auditory feedback in this way was important in establishing the perception of agency for each child. While the understanding of control by children did appear to be related to the explicit and simplified mapping relationship to colour, the positional relationship to interaction was necessarily more complex. When a child first presses any button on the surface of the interface, the entire RDE would be lit in the corresponding colour (without a positionally mapped relationship). If the child repeatedly pressed buttons within the same segment of the interface, the lighting feedback would progressively become more closely mapped to the position of interaction, eventually only lighting the dome segment that corresponded to the position of buttons being pressed.

However, if the child continued to interact only with that group of buttons (in a single segment), the software system would disrupt this closely mapped relationship. This resulted in the colour and position of the lighting feedback responding in a seemingly random manner across all segments of the *RDE*. This randomised feedback would continue until the participant pressed a button in a different segment of the interface. For the purpose of observing responses to disruption, I was also able to intervene by setting the disrupted mode of the system externally should the participant not trigger this through their own interactions. Throughout many of the interactions in which participants experienced this disruption, I observed a marked change in their behaviour, often engaging with their parent to co-operatively understand why the system no longer responded as expected.

It is in this disrupted state that the design of the *RDE* has similarities to the intent of Gordon Pask's *Musicolour* (explored in detail in Chapter 3). When input does not change over an extended period, the *RDE* system stops responding in an expected way, causing the participant to reassess their actions and are required to change their actions to reengage the system. Both the 'boredom' and subsequent adaptation of Pask's *Musicolour* and the disruption of mapping in the *RDE* encourages a shift of focus from the artefact to reflect on personal experience and intent. In the *RDE*, this could lead to social conversation of engaging with the parent for feedback or assistance. Where Pask's system disrupted feedback to elicit a performative change by musicians, the *RDE* system disrupted feedback to elicit a social change by children, encouraging them to

engage a third party (their parent) in a conversation.

While the feedback from participants suggested that the simplified mapping relationship between the interface and the *RDE* in Iteration 3 helped in this regard, it would also appear that the embodied design of the control surface played a part in communicating understanding through interactions and between parent and child. For example, the scale of the model dome afforded children the ability to wrap their arms around the interface to press buttons in different positions at the same time. They were able to interact in multiple ways and express their intent in embodied interactions, some of which engaged the physical relationship to their parent.

The anthropometric proportions of the study population were taken into account throughout the design process. Being able to use the interface in a range of non-standard ways exemplifies the child being able to physically and sensorially explore their ability for control, often while the system was either remotely or programmatically disrupted. Several of the children displayed this behaviour as an attempt to re-engage the system in conversational agreement (when the *RDE* was no longer responding as previously agreed or expected), while others requested that their parent join them in pressing combinations of buttons across the surface of the interface (Figure 4.13). I interpreted both of these behaviours as an attempt to understand or extricate the conceptual model required to recapture control of the system, whether real or perceived, by the participant.

4.6.1 Observation and discussion

The most pronounced example of disruption resulting in changed behaviour was that of an autistic boy who displayed repetitive mannerisms often associated with autism. In this study (03a_02), the boy immediately engaged with the interface in sequential interactions. He pressed each button in order, following the series around the model dome. He repeated this in a circular fashion for more than one minute. In the post-study interview, the parent reflected on the boy's interest in sound; he was playing the interface like a musical instrument. In an effort to observe his response to disrupted feedback, I then externally intervened, by triggering the un-mapped mode of the system. At this point, the boy sat down to reassess his ability to control the system, moving back and forth across the buttons and requesting assistance from his mother. He did not return to the repetitive behaviour seen at the beginning of his interaction, even when I re-engaged mapped feedback of the *RDE* system.

Reflecting on this observation in conversational terms, I return to Dubberly and Pangaro (introduced in Chapter 3), who have devised an ordered series of tasks that describe a conversation in the Paskian sense (Dubberly & Pangaro 2009, pp. 23-24). These tasks are useful in looking at how a conversing system is established and identifying where a disruption in that process might take place. The table below uses the early moments of the above example (pre-disruption) to show the stages of conversational interaction against the Dubberly and Pangaro tasks. These steps are not necessarily consecutive, but they do build

upon each other successively. For example, when interacting with the *RDE*, task 2, 'commit to engage' (audiovisual response from *RDE*) may not result in the participant proceeding immediately to task 3, 'construct meaning' (mapped connection identified by participant); if no response from the system takes place, the interaction may return to task 1, 'open a channel' (button press from participant).

To expand on this staged approach to conversation and reflect the key intervention from the *RDE* open studio, I have added a 'disruption' task to Dubberly and Pangaro's list (Table 4.4). Using these tasks to describe the experience of the autistic boy in the *RDE*, the disruption appeared to 'reset' the child to an interesting stage of conversational development: task 3, 'constructing meaning'. Initially unable to move forward from this stage, he appealed for assistance from his mother, initiating social interaction and widening the scope of conversation.

Task	**Example**
1. Open a channel	Button press from participant.
2. Commit to engage	Audiovisual response from *RDE*.
3. Construct meaning	Mapped connection identified by participant (e.g. colour or sound relationship).
4. Evolve	Learning to control in the *RDE* is established by participant.
5. Converge on agreement	Participant interacts based on learnings (i.e. masters control).

Disruption	*System is disrupted by researcher.*
3. Construct meaning	Mapped connection is removed from system.
4. Evolve	Participant engages with parent for assistance (desire to reengage system).
5. Converge on agreement	Co-operative interaction and exploration.
6. Act or Transact	Control is shared between child and parent.

Table 4.4 - Use of Dubberly and Pangaro's 'Process of Conversation' tasks in analysing study 03a_02.

In this example, the disruption—triggered by myself from an external position—transposes the task sequence to require the child to reassess their understanding of control. Rather than repeating the same steps, this disruption impels the child to move from the subconscious operations to conscious actions. This not only made their experience more explicit to me through observable actions but also to the parent who is sharing the experience with the child. Framing activities in this way provides a structure to reflect on experiences in the *RDE* through conscious or observable behaviours. This framework also proved valuable given the limited linguistic expression of participants and offered events for reflection in post-study interviews.

4.7 Disrupting conversation

In this chapter, I have pieced together a case for using cybernetic systems and

the language of conversation from Pask to describe activities between participants, interactive artefacts and design researchers. The models of goal-oriented systems and descriptive tasks developed by Dubberly and Pangaro are useful in this instance. Analysing disruption of an interactive experience has been recognised in conversation theory, HCI, and psychology to varying degrees, however, there isn't currently a clear appreciation for disruption as a deliberate act to elicit feedback as a design tool for reflecting on emergent experiences with human participants.

In Pask's Conversation Theory, 'agreement' is key as the building block of exchange and understanding between systems. 'Disagreement' is equally important, as it establishes the alternative positions that systems may take in the transfer of concepts (Boyd 2001, p. 563). However, this is not analogous to 'disruption' as some understanding between systems must take place for the comparison of concepts and disagreement to take place. Conversational events are useful in examining intent because they motivate a participant to reflect on their own experience.

I use 'disruption' purposefully in the context of my research. Specifically, I use the term to describe temporarily withholding control from the participant after (and only after) an awareness of agency has been established. In the *RDE* study, this withholding may be driven either by a dynamic system change (similar to the behaviour seen in Pask's *Musicolour*), or remotely activated by myself while observing the participant interacting with the *RDE* (much like the well-known

'Wizard of Oz' technique, where a researcher 'simulates the system's intelligence' by manually triggering system feedback for a participant (Maulsby et al. 1993, p. 278)). Rather than ceasing interaction, disruption is employed in my practice as a means of shifting attention, encouraging the participant to explicitly reassess the way that they may interact with space and the other people within it.

4.8 Interview: Interaction design and media artist

Of all the expert interviews I conducted during this project, my practice aligned most closely with that of the interaction design and media artist. Similarities in our praxis could be seen in our use of technology, as well as desire for working with participants to drive the design process. In Figure 4.14 (below), the visual comparison of my process (blue) and that of the interaction design and media arts practitioner (orange) can be seen to overlap at multiple points. There are three areas where the practitioner perceived their own process to be aligned with mine: the stages of (a) material development and explorations; (b) critical and technical design tests; and (c) iterative design. This visual representation of methods facilitated reflection from both the practitioner and myself in discussing what was perceived to be important in our approaches. As a low-tech interaction, this method is a further example of contextualising experience through embodied conversation—a recurring approach throughout my research.

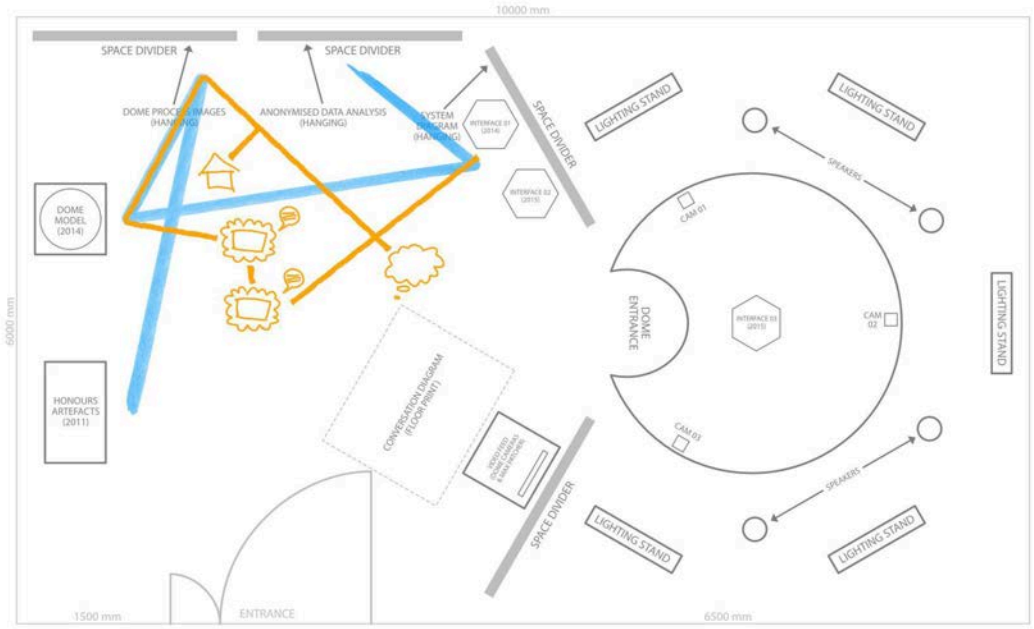


Figure 4.14 - Mapping the stages of practice of Interaction Design and Media Arts Practitioner (04p_03).

In contrast with my practice, the interaction design and media arts practitioner did not initiate their design process through embodied exploration; rather, for them it began with "Something somewhere between an intuitive yearning or a desire for a way that things could be connected" (transcript 04p_03, line 99). This is indicated in Figure 4.14 by the thought bubble, which connects to the institution (experimental space, indicated by the house icon). This practice then passes through material and prototyping stages, before going through iterative designs in a gallery context that facilitates audience feedback (picture and speech bubble icons). Unlike my 'open studio' approach to engaging participants in the design process, this practice aligns with traditional art values, such as the exhibition of a completed artefact. The value of this engagement with the institution was seen by the practitioner as the role of the artefact: to be seen and experienced by an audience.

While the outcome of the design artefact was for it to be exhibited, participation remained central to the purpose behind the interaction design and media artist's practice:

> …that's kind of why I make the work really. It's just that it can facilitate these new ways of connecting. So really, it's a social process, and I use the audience participation and interviews as a way to amplify that thing that's already happening in the interaction itself. (Interaction Design and Media Arts Practitioner, Transcript 04p_03, Line 79)

> The discussions aren't the end point. They're just a pretty equal part of it. So the talking about it, the thinking about it, but also just the physical experience of the work, they're on equal footing. You can't have one without the other. But the direct experience they have of the artwork, of the lights, the sounds, themselves in that, that relationship, that's pretty fundamental. Otherwise it's just intellectualising. (Interaction Design and Media Arts Practitioner, Transcript 04p_03, Line 81)

Similarly to my own motivation for working with participants, this practitioner believes that without the perspectives of others, the research does not exist. Key to this is the framing of participants or an audience as collaborators that bring new and unique knowledge to a project:

> …in some ways they're collaborators. So, the work really only has meaning through the participation of people in the community in it. So it's a way that the work becomes real, through people's interactions and experiences of it, of the work. I guess I think of my work as a way of enabling new interpretations of ourselves. (Interaction Design and Media Arts Practitioner, Transcript 04p_03, Line 75)

The role of the designer in this instance is to begin a conversation through materiality. One of the tools that an interaction design specifically can bring to bear is the 'feedback loop' as an inclusive method for engaging the participant to express their own situated experience. This emerges through a process of reflection, supported by an experience with the artefact as an exhibitive or performative object, but expanded through post-experience opportunities for further conversation:

> …they're involved in some kind of process of reflection and experimentation, and usually they are… I think the point is really to provide an environment where people can really reflect, you know. And the interview and the discussion is just an opportunity to extend that and, and nurture that process of inquiry and reflection. (Interaction Design and Media Arts Practitioner, Transcript 04p_03, Line 85)

4.9 Summary

My desire to engage participants as co-creative partners in the design process reflects the politics that I bring to working with a neurodiverse population. Equally, it recognises my role as being within the conversational (cybernetic) model of intervention and feedback. I do this by acting as a facilitator through the constructive design artefacts I present to participants, aiming to engage them in conversational interactions with the object and myself in reflective discussions. I am only one voice within this project, responding to the feedback and experiences reflected by others.

Given my focus on design iteration in response to feedback, the roles of 'researcher' and 'participant' are more nuanced than that of a typical participatory partnership. I do not rigidly structure or assume the roles of a cooperative partnership, but let participants lead that process through the probe-like approach I take to material design—the artefact is necessarily open to emergent and surprising feedback. In the *RDE* open studio, I have explored approaches to finding this balance, which is particularly important in relation to embracing neurodiverse perspectives.

During the three iterations of the *RDE* open studio, I established different methods for eliciting conversational engagement between participating children and their parents, the *RDE* artefact, and myself. Early material explorations and testing led to the structural elements of the *RDE*, which served as a situating design probe to elicit and capture first-person feedback of experience from children, their parents, and other experts. In affording feedback through multiple pathways, I engaged first-person experiences to inform the co-creation of each iteration of the *RDE* interface and feedback system. These experiences refined the participant's ability to understand their control of the system and ultimately elicit moments of reflection and social interaction triggered by disruption to the output of the *RDE* audiovisual system.

From the *RDE* open studio, I have identified several aspects of my constructive design research approach that contributed to the success of this project in eliciting feedback without relying on verbal or written expression. Through

analysis of the three iterations of the *RDE*, I have shown that my approach has unique potential when working with a population with specific communication interests and traits, such as autistic children. In the chapter that follows, I will unpack the key ideas in my practice that contribute to this potential in drawing out participatory feedback to propel an iterative design practice.

5 Findings: Conversational Practice

As Edith Ackermann (Ackermann 2007, p. 2) points out, a designer makes their own assumptions, ideas or perspectives known by making them tangible. In my practice, this can be seen in the way that I use conversation to inform my material design process and in the elicited participatory feedback by reflecting upon experience. In this chapter I present my 'conversational practice', in which I facilitate participatory reflection on their first-hand experiences with interactive design artefacts. Through reflection on my practice, the previous chapters explore how I was able to elicit conversation and feedback from participants and stakeholders in an iterative design process. This reflection is grounded in the development of my practice throughout the RDE open studio, as documented in Chapters 3 and 4, and supported by the interviews I

conducted with expert practitioners and stakeholders[19] throughout this thesis.

The significance of including neurodiverse knowledge for co-creation when designing interactive artefacts relates directly to Ackermann's point above. When ideas are constructed—made tangible—as a result of the participation of alternative perspectives, a different understanding of human experience can take place. This is relevant for generating more inclusive artefacts in the field of interaction design and beyond. Through interaction with the material experiences I have described in my research, I witnessed new conversations and social relationships taking place. In this chapter, I will describe these conversations with a visual model for designing interactions.

The contribution put forward in this chapter acknowledges the complexity of first-person experience in the messy world as it is, and I focus on the intimate details of interaction and conversation, which I argue are generative in a participatory design practice. The learnings I present here situate my creative practice within the field of interaction design and moreover, identifies the potential in my approach to inform future work in neurodiversity and technology.

[19] As described in the previous chapter, semi-structured interviews with expert practitioners occurred after the RDE open studio with children and their parents was completed. This was so that I could locate my practice in relation to the work of other expert researchers. Discussions with stakeholders were carried out in a more ad-hoc approach, throughout the development of the RDE iterations, which allowed me to gather additional feedback about the design of the artefact itself.

5.1 Interview: Interaction design and HCI practitioner

Here I make a final reference to the expert practitioner interviews conducted during the final *RDE* open studio and exhibition, *An Exhibition of Practice* (2015). This interview centred around relevant interaction design theory and methods for much of the discussion, which was indicative of the practitioner's academic approach to interaction design and HCI. With a background and training in HCI methods, this practitioner often pointed to efforts in the feedback or measurement on the technical aspects of their own work, however, they retained a position that qualitative research is still important in this regard.

> …in many cases, it's more about identifying patterns or strategies or a combination of those… And because most of the research I'm doing is qualitative rather than quantitative, I'm also not usually working with hypothesis and hypothesis driven research. It's more explorative. It's usually not about saying whether you're successful or not… It's more about identifying new knowledge in a particular domain. (Interaction Design and HCI Practitioner, Transcript 04p_06, Line 97)

The relevance of this quote to the way that I worked throughout the *RDE* open studio is useful at this point in my discussion. My practice is highly exploratory and indeed, the significance of the 'features' of my practice that I put forward in this chapter are in relation to research that strives to uncover unique experiences from participants when the problem space might still yet be under- or undefined. Through my discussion with this practitioner, we recognised this common ground around the notion of 'exploration' when it came to drawing

first-hand participant experiences into the development of a project.

The effort to include participants in a conversational process through their interaction with the *RDE* highlighted my desire for cooperation between researcher/designer and participant(s), and was equally evident in this practitioner's approach. Where our practices diverged however, was in the practitioner's use of participatory feedback to justify or confirm their own research/design decisions; ongoing participatory iteration was not a driving force of their work. In the *RDE* open studio, the artefact elicits new knowledge through its ability to facilitate the conversational process with participants, not in verifying design decisions. Despite this divergence in our praxis, participation was viewed as a vital feedback loop and parallels my own framing of participation as central to research:

> …ideally, you want to bring them in as much as possible, right. And of course it's the idea of co-design or collaborative design or participatory design where you bring them in as designers, considering that they're not designers. But that takes just a lot of time and commitment. (Interaction Design and HCI Practitioner, Transcript 04p_06, Line 120)

Reflective processes and the role of feedback data was discussed during the interview. There were many approaches in this practice that aligned with my own, including accommodating emergent or unexpected participant responses, using the 'element of surprise' to foster the relationship between participant and artefact (Line 69), and the inclusion of participants as co-creators or co-authors in a project. This showed an overlap with my practice and established modes of

working in interaction design, and importantly, that there space in the field for research exploration and innovation.

5.2 Participating in conversation

> Individuals contribute both what they know in depth and breadth and their style of interaction. Given a specific group of participants, conversations may go nowhere—they have no value; they create no lasting change in the participants. Other conversations create their own energy and go places—they are generative, have momentum, and lead to new and unexpected knowledge. (Dubberly & Pangaro 2009, pp. 26-27)

Central to this thesis is my positioning of the participant experience as a driver of design iteration. I assert in this chapter that conversational exchange between the participant and the artefact or the participant and the researcher is key in engaging the participant in a cooperative design relationship. In the quote above, Dubberly and Pangaro claim that the characteristics of participants (systems) can limit potential in a conversation (Dubberly & Pangaro 2009, p. 26). For example, does a participant have the motivation to develop new knowledge as a result of conversational interactions?

I engage participants through their use of material artefacts, eliciting feedback on engagement with a responsive system, which situates their unique understanding and experience in dynamic conversational interactions. As I discussed when reflecting on the RDE open studio (Chapter 4), this is not always

a straightforward process. Personal sociocultural histories have a large part to play in a participant's response to the multilayered feedback that results from a situated interaction. One of the strengths of my approach was in remaining open to 'failure' or unexpected emergence when interaction was disrupted. Whether this disruption was planned or not was not important—being able to recognise an alternative perspective for the purpose of co-creative potential evidences the empathic approach I took to research methods and design. In response to the unique challenges I faced in this project, I put forward significant features of my practice which can help other designers working in a similar context.

Before describing these features, I return to Dubberly and Pangaro's sequence of tasks here to clearly frame the structure of a conversation, and look at how these were applied strategically during the *RDE* open studio, which in turn shaped my interaction design research practice described in this chapter. My framing of participation through conversation is relevant to my desire to apply different perspectives and knowledge to my design process. By engaging with the participant in a way that attempts to understand their (dis)agreement in conversation, I was able to reflect on my own assumptions around designing for experience while continuing to draw the participant toward cooperation, regardless of their capacity to engage in a language-based discussion. Recalling my earlier description of Dubberly and Pangaro's work, their original list of conversational tasks is as follows:

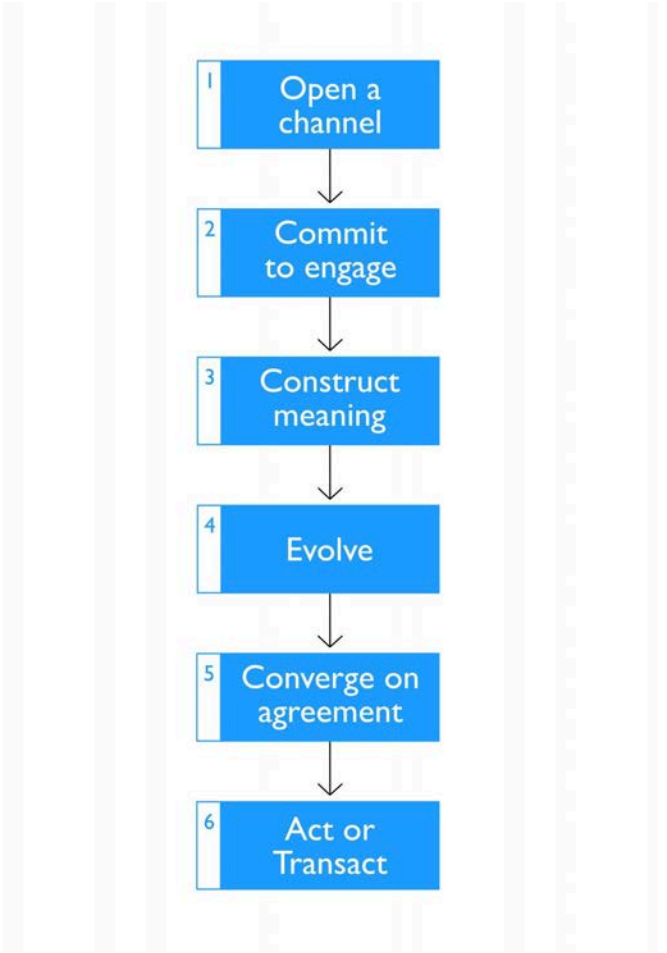


Figure 5.1 - Dubberly and Pangaro's 'Process of Conversation' tasks.

In the final iteration of the *RDE* open studio I reflected on the relationship of Dubberly and Pangaro's list to the conversational behaviours I observed with participants. Drawing out the disruptive element I employed in the *RDE* open studio to these tasks, I now visualise how this intervening act has the potential to 'reset' a participant's progression through the conversation sequence, eliciting a reorientation toward embodied interaction and social engagement.

One example I take from the *RDE* open studio is that of the autistic boy (03a_02) re-assessing his repetitive approach to triggering musical notes after disruption was introduced to the audiovisual feedback system. Importantly, this disruption

to mapped interactions also had the potential to contextualise an event for reflection in the post-study interview. That is, this point of agreement could be explored during the situated interaction (with parents) or discussed after the interaction (with myself).

When faced with a change in the mapped behaviour of the system, participants were motivated to express their change in experience through embodied means, either by interacting differently with the *RDE* or engaging the parent socially. Using Dubberly and Pangaro's tasks as inspiration, my list of conversational activities for participation is visualised in Figure 5.2. To begin with, these steps align with the tasks above (Figure 5.1), however the activities differ depending on whether disruption has/has not taken place. Importantly, the last four stages of the disrupted path (social engagement, cooperative experience, and shared knowledge) are conscious actions, and lay a platform for reflecting on experience.

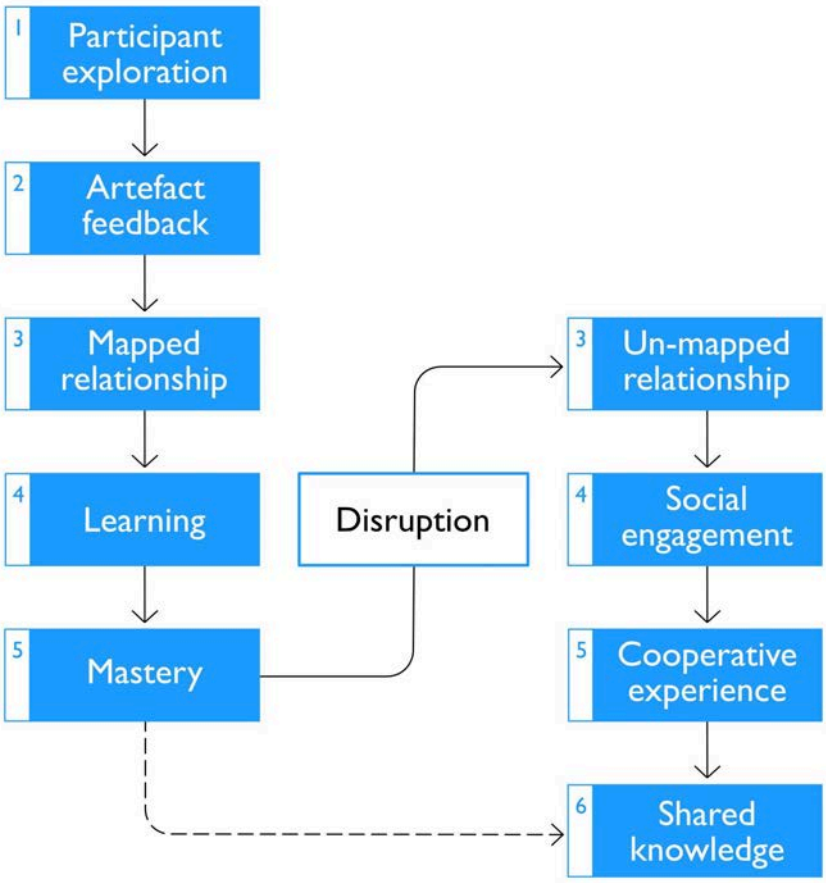


Figure 5.2 - Dubberly and Pangaro's conversational tasks, disrupted.

While it is possible in the above image to arrive at shared knowledge without disruption, my experience throughout the RDE open studio was that this did not occur for the participating children. It was the reorientation of interaction elicited by disruption that shifted attention and focus of a conversation to be a social, cooperative and shared experience. In each of the participatory engagements with the RDE during the final iteration (where deliberate disruption was a design property of the interaction), disruption led to an observable change in the interaction behaviours of each child. Broadly, interactions were shorter, and, in the case of the two autistic children, led to

increased engagement with the parent sharing the space with them. While the younger children from the group (all neurotypical) were less likely to engage in turn-taking interaction with their parent, each still appeared to reassess their engagement in some way. This shows promise that disruption could be used by design researchers to elicit feedback from complex populations, including autistic children.

5.3 Significance and findings

> When researching experience, methods and approaches that open up dialogue between designers, researchers and participants are the most appropriate… it is not easy to understand experience or its meaning except through the kind of dialogue in which the parties engage with each other in constructing a variety of meanings and perspectives that help them to mutually recognize and understand each other, and, indeed, themselves. (Wright & McCarthy 2010, p. 83)

The research I have discussed in this thesis supports Wright and McCarthy's insights into the generative capacity of shared meaning making between participants and designers. Central to this is my conversational approach that has significant potential for social interaction and reflective feedback with neurodiverse children.

Recognising the relevance of my creative practice in exploring ideas of sensory communication and stimulating non-directive channels of design feedback, I set out to capture observational data of neurodiverse experiences. Through my

interactions with children, their parents and interviews with expert practitioners, I was able to reflect on the aspects of my personal design approach to neurodiversity and the research methods that helped me arrive at a deeper understanding of conversation with neurodiverse communities. I formalise my findings in this chapter to help other researchers arrive at a deeper understanding of conversation, with particular interest around groups of people underrepresented in the interaction design process.

Being empathic to alternative values and perspectives is central in my claim to a co-creative foundation to my practice and research. While my own assumptions as a designer is necessarily the starting point for any conversation between participants and myself, it is an openness and willingness to embrace the unexpected through iterative material experimentation that I engage neurodiverse experiences in my design process. Structured reflection on the disruption that generates iteration can be seen in the visual model I have put forward above.

I will revisit what I learned from the *RDE* open studio to expand on and describe these unique aspects of my practice: the link between 'disruption' and embodied interaction; the benefits of 'conversation' in a constructive design research practice; and the capacity for a conversational approach to spur co-creation. Articulating my response to each of these areas, I will summarise two key findings from my approach as significant to interaction design research and discuss how these might be applied to elicit participatory engagement and

feedback from other complex populations:

- The formalisation of 'disruption' as a design method for eliciting and reflecting on first-person experiences. Studying the potential of this fortuitous outcome from the *RDE* open studio, the disruption and the resulting conversational expression supports my participant-led approach to the design of a responsive artefact. By allowing self-direction in an interactive experience, I recognised the usefulness of a disrupted activity in encouraging participants to express their desire in what should or could be happening in terms of design feedback.

- 'Conversation' as a framing of first-person experience and feedback to inform the design process. Key to my use of disruption as a design method was its alignment with the work of Gordon Pask and his conversation theory. Emerging parallels around understanding and agreement as a result of disrupted experience supported my use of conversation theory (and cybernetics) to inform designing interactions. Points of agreement or disagreement serve as important moments for reflection with participants, allowing them to externalise and express their intent, opening channels of feedback for an iterative design process.

As I have described in the literature review in this thesis, the aspects of my practice that I draw out here have parallels with methods and approaches from projects that are related either in scope (*MEDIATE*), intent (*ReacTickles*), or emergent affect (*ECHOES*). The contribution that I offer here is the result of

interrelating the interaction design tools of embodied interaction and disrupted activities, to elicit conversational reflection with underrepresented participants and neurodiverse groups.

I note that the scope of participatory engagement in this research was limited in scale. As such, I acknowledge the limited transferability of my practice to other disciplines. The practice I have described in this thesis demonstrates that my use of a constructive and conversational approach to working with complex populations has potential for eliciting experiential feedback across a range of modalities (including, but not limited to, observation and interviews). This potential provides the foundation for future collaborative research, which could result in a formalised framework applicable to multiple domains.

5.3.1 Disruption as a method of eliciting embodied interaction and feedback

Through disruption of the participatory experience in the second and third iterations of the *RDE* open studio, children were compelled to reassess their now-conscious interactions, and encouraged to reflect on their conversations with and through the artefact. As I have referenced in the work of Susanne Bødker (Bødker 1996), many encounters between humans and artefacts are unconscious operations, which was reflected in the early iterations of the *RDE* open studio: children were not always willing or able to express their intent. To this point, in isolation, embodied interactions on their own are not always useful in generating moments for reflection by the participant either during or

after the experience (Bødker 1996). My thesis supports and expands upon existing research in interaction design by offering an alternative understanding of how participants can bring their values and knowledge to the design process.

I have described examples from the *RDE* case study that show the usefulness of embodied and sensory-based interactions in providing moments for reflection, both during (the autistic boy socially engaging with his mother when the mapping relationship between interface and system was disrupted in Iteration 3) and after exploring the design artefact (the same boy expressing his understanding of awareness in controlling the feedback of the *RDE* system in Iteration 2). As was the case in the first example, there were instances where these moments required external prompting. When interaction intent was not externalised, disrupting the unconscious or internal activity of the participant through a change to the relationship between human and system (for example, changing the mapping of audiovisual feedback in the *RDE*) often led to moments for present or later reflection. The unconscious activity would become a conscious task. Key to ensuring the human-centredness of the approach I take to interaction design is in drawing out actions for reflection. Using disruption as a method of eliciting this feedback allows me an opportunity to better understand the people I am working alongside and helps to bring their values and knowledge into the design process.

5.3.2 Conversation as a driver of constructive design practice

Returning to the formal structures of a conversational encounter (as defined by Pask's conversation theory) was helpful in this project for me to remain open to different perspectives and ways of experiencing the world. In particular, I use the models described in Dubberly and Pangaro's research in this chapter to discuss how my own work maps to their conversational framework and its relevance to a participatory interaction design practice. I do recognise that while I articulate the features and structure of conversation in this thesis, I make no claim that this is the *right* way to have a conversation with an autistic person or any underrepresented group. Rather, my goal is to formalise my intent to allow the participant to define and drive a conversation in the way that they feel most at ease with.

In the following section, I articulate several influences on and features of my practice that support encouraging reflection on human behaviour to inform an iterative design research process: design probes; embodied interaction; and disrupted activities. These features of my practice reflect stages of experience and moreover, are important drivers of a conversational framework. Used together, these features can serve as helpful tools for other designers to engage underrepresented groups. The sensitivities of my interaction design practice to engage a participant and elicit feedback through experiences with the materials and methods found in my approach is particularly significant in remaining open to neurodiverse voices. Finally, in this chapter I will look at how I extend

Dubberly and Pangaro's models of conversation by bringing these features to bear on their research.

5.4 Features of conversational practice

In this section I unpack the key foundations of what I have developed through this project as a conversational practice, laying out its potential for application in design praxis that preference the experiences of neurodiverse and underrepresented communities to drive iterative responses to problem solving. Formalising these features is the result of generating contingent moments of feedback from participants in the *Responsive Dome Environment* open studio to inform and shape my practice. The emergent nature of these moments speaks to the tacit knowledge and sensitivities I bring to material design experimentation and the way that this informs my relationship with neurodiverse human participants. These features are:

- Use of constructive design artefacts as probes to elicit feedback and reflection from participants. Framing the design object in this way places it in a conversational relationship with the participant, where emergent and surprising interactions can result.

- Giving participants the opportunity to express themselves through a range of embodied interactions, to afford feedback in relation to first-person sensory interests. An openness in the conceptual model of an interaction

provides emergent potential and gives the participant agency in directing the design process.

- The disruption of participatory actions to encourage reflective processes and social engagement. This brings attention to the activity at hand for the participant, allowing for personal reflection 'in the moment' and generating contingent experiences for reflection.

Throughout this thesis I have returned to the importance of the participatory experience in contributing to the iterative (re)design of artefacts in my practice. The features I describe in this section are at the service of increasing opportunities for conversational feedback from the neurodiverse children for whom I am designing for; a roadmap for 'opportunity seeking' (Forlizzi 2008, p. 12). Continuing with this motivation, I will identify the critical, inclusive and creative features of my practice as a means of others taking my approach to apply to their own participatory engagements.

5.4.1 Constructive design artefacts as probes

The artefacts developed within my practice serve as a site for knowledge generation and acknowledge that interaction and materiality has agency in changing the behaviour of participants. In this way, the intent of using a responsive artefact to engage participants is similar to that of design probes and in particular the offshoot of technology probes (Hutchinson et al. 2003). Aiming to capture emergent and qualitative feedback from a population through their

use of an artefact, probes inspire, provoke or facilitate unconstrained (or less-constrained) and unexpected ideas. The importance of these 'real-world' experiences and feedback from neurodiverse people places this aspect of my practice in close proximity to Hutchinson et al.'s technology probes.

It is the exploratory spirit of the probe that is most useful in being attuned to emergent and neurodiverse experiences: sending out an artefact into the 'unknown', to return with information that may or may not relate to a design objective or defined problem space. This openness to the unknown is in recognition of handing agency to participants, to initiate and lead a conversation through channels that may be as yet unidentified by myself as the design researcher. Artefacts developed for open-ended and non-directive interactions serve as a site for knowledge generation and acknowledge materiality has agency in examining the experience of participants. Design intervention in relationships between systems (in the cybernetic sense) can provoke the participant to reorient or account for their instinct and assumptions toward ideas embedded in the artefact.

There is also potential within the probe method to bring attention to research assumptions by opening the designer up to the voice of participants. An example of this potential can be seen in my changing understanding of the sensory experience within the *RDE* during an interview with an autistic artist (interview 02t_05). During this interview, the artist recognised the musicality of the audio system in the *RDE*, and commented that "thirty per cent of autistic

subjects… people have perfect pitch" (12:43). This information was emergent and a direct result of engaging the unique knowledge of participants. It wasn't something that I had planned to explore during the interview, but came about through the situated interaction with the artefact.

5.4.2 Embodied interactions for first-person feedback

In the research I have put forward in this thesis, it is through embodied interactions with the *RDE* that participants are able to engage in conversation with the artefact. Moreover, participants are able to engage through a range of sensory modalities, not limited to language or one-dimensional interactions (such as a screen). The opportunity for self-directed expression and reflection on these experiences is key to allowing emergent first-person feedback to drive the iterative design process.

Throughout the *RDE* open studio, it was during reflection upon embodied experiences that participants were able to identify their own learning or knowledge that was expressed to me in post-study interviews. This was not always conscious to the participant at the time of interaction, and so it remained important to facilitate a reflective conversation with children in particular, and as such, methods for reflection on embodied experience (for example, video-cued recall) proved vital in this regard.

Embodied interactions afford rich and personal experiences, which can be reflected upon to inform an iterative design process. However, it is important

that this approach is employed with intent. In the examples I have shown in this thesis, it was key that the design artefact was developed with openness to neurodiverse experience in mind and that opportunities for feedback were afforded to participants (possibly elicited through disruption, as I describe in the following section). These participant-led embodied interactions lead to experiences for observation and reflection. Using these moments to identify points of (dis)agreement in conversation can generate new knowledge that is foundational for iterative development in the artefact-as-probe.

5.4.3 Disruption leading to participatory reflection

Along with the iterative approach I take to using participatory feedback, my approach in the *RDE* open studio is set apart from other probe-like approaches through its use of disruption as a contingent tool for eliciting reflective conversations. That is, the disruptive ability of the *RDE* served to motivate or elicit self-reflection from participants when it wasn't naturally forthcoming. Using these emergent or contingent moments as the source of new knowledge shifted the power balance in the project, establishing a cooperative and participatory role in the iterative design process.

The relationship between disruption and conversation is important. In the *RDE* open studio, disrupting a participatory experience was only useful in informing the design process if there was an opportunity to reflect on the resulting change of activity using conversational methods. In the model of conversation that I

reference from Dubberly and Pangaro (Chapter 3), it is the exchange between systems to identify points of (dis)agreement that is key to conversation. However, there is a lack of exploration by Dubberly and Pangaro around how systems can be impelled to arrive at this exchange.

In the following section I map disruption on to Dubberly and Pangaro's model of conversation, to position it as a useful framework for design reflection. I have shown several times in this thesis how disruption can encourage or elicit participatory feedback, however the extension of the model of conversation can be equally useful in getting designers and researchers to reflect on their own tacit processes. This was my own experience throughout the *RDE* open studio. Conversation—in particular the reflection on points of agreement or understanding—leads to sharing of knowledge from participant to researcher, and remained at the core of my approach to working with neurodiverse experience.

5.5 The visual model

In Chapter 3, I looked at Dubberly and Pangaro's visual model of conversation to convey and confirm agreement between systems (Dubberly & Pangaro 2009, p. 25). This model is a useful starting point in describing some of the key tenets of conversation theory. However, it does not address how an external observer might observe the conversation taking place, nor how the conversation itself

was triggered. Taking Dubberly and Pangaro's model and using the first encounters of children in the *RDE* open studio as an example of an internal conversation between participant and responsive artefact, the model might look like this:

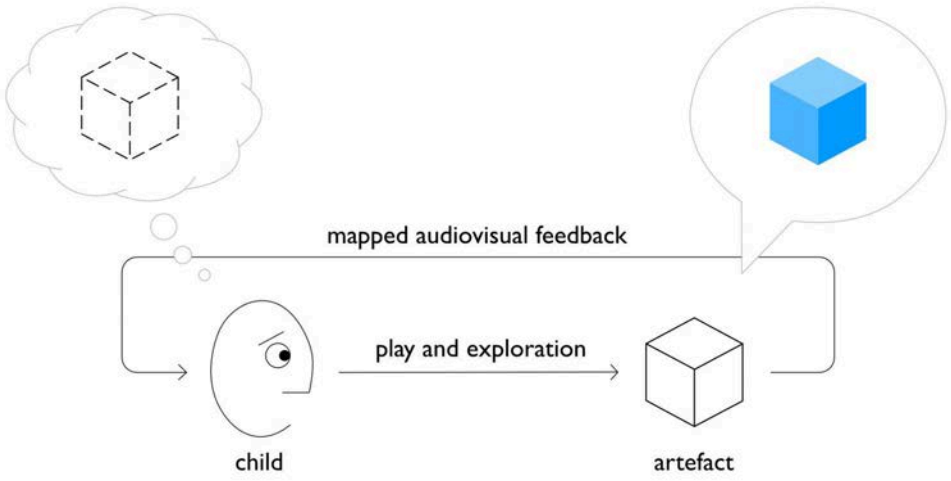


Figure 5.1 - Dubberly and Pangaro's 'conversation to learn' model, in the *RDE* case study context.

In the model above, agreement on a concept (what the child is trying to achieve through their interaction with the responsive artefact) is unclear to an external observer. This model is representative of an encounter with the *RDE* before the introduction of disruption as a method of changing the dynamics of the interaction. While in this state, the mapped feedback of the artefact is explicit and it is difficult to know if the response of the system is what the child desired or intended, or if the output of the system is simply a result of playful exploration in the absence of a particular goal. Bringing a conversational approach to the design of the interface addresses this problem by facilitating more explicit or outward relationships between the participant and their

environment (which could be the artefact or another person, such as the child's parent).

In conducting research with children in the *RDE* open studio, I used a conversational approach in both my material design and feedback methods to elicit and capture first-person experiences wherever possible. It was therefore important to encourage them to express themselves explicitly, whether in post-study interviews or through interaction behaviours with the *RDE*.

There were instances when children did lead this feedback process. As I described in the *RDE* open studio in the previous chapter, the autistic boy (02a_02) who appeared to engage in inwardly focused pattern making activities was able to express an awareness of his ability to control the system in post-study interviews when both his parent and myself were discussing otherwise. These cases were often in reflection of a moment that was pertinent to the child, many of which had been triggered by a disruptive event. In the final iteration of the *RDE*, this trigger was intervening in the 'boredom' of the *RDE* system (to use a Paskian reference) or my own external intervention to disrupt the mapping of audiovisual feedback.

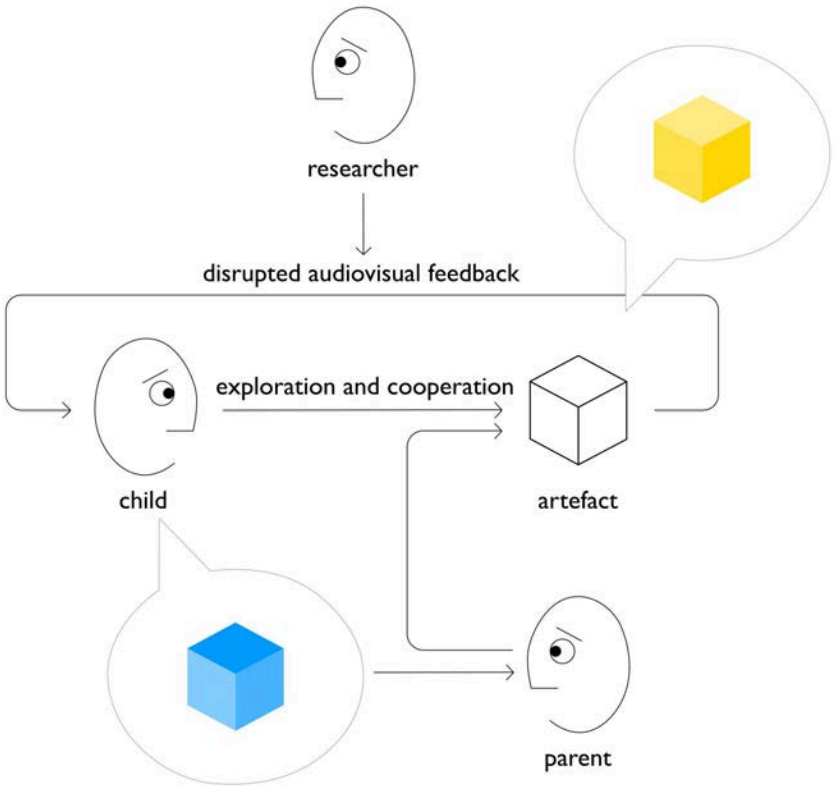


Figure 5.2 - A disrupted conversation between child and artefact.

In the image above, I have visualised the result of adding disrupted feedback to a conversation, along with the relationship of the parent and myself (researcher) in the system. The effect of adding disruption to the Dubberly and Pangaro model (Figure 5.1) was seen clearly during the instance of the autistic boy playing repetitively with the scale dome interface in the third iteration of the *RDE*. When the mapped conversation between the child and the *RDE* was disrupted, he engaged his mother in a cooperative conversation through the interface. Mapping this disruption to Dubberly and Pangaro's model, my role (researcher) in the system is that of an environmental or external influence (Figure 5.1).

These moments of disruption often led to reflection by the child. This could in turn create an opportunity for observable social engagement with their parent (for example, asking for assistance), or serve as an event for later reflection during post-interaction interviews with myself.

In observing these disrupted conversations between child and parent during the *RDE* open studio, I was able to clarify what was most important in my own design practice. I recognised that much of the tacit groundwork my material experimentation laid was allowing self-directed conversation to unfold between participants and the artefact itself. These contingent moments—often elicited through disrupted interactions—allowed the participant to reflect on their experience and in turn, inform the design process.

5.6 Summary

In this chapter I have described my practice-based approach to working with an underrepresented or marginalised community, in reference to my work with a neurodiverse group of children in the *RDE* open studio. My framing of activities and sensitivities toward constructive and collaborative research with participants identifies the usefulness of conversation in eliciting first-person experiences that form the foundation of reflective dialogues between participant and researcher.

Particular in my conversational approach to interaction design is the use of

disruption as a design tool, purposefully introduced as an intervention in unconscious actions in an embodied context. Disrupting interaction activities in this way often led to the participant reassessing their agency and bringing their actions into conscious mind. This lays the platform for reflection that, along with multilayered conversational feedback (embodied, social and iterative) can be incorporated into the design process. Alongside this reflective change in attention, disruption would often lead the child to reorient themselves to the embodied activity at hand, socially engaging with their parent while situated with the artefact. Externalising moments for either at-hand or later reflection, allows personal experiences to inform design iteration, inclusive to multiple voices in the creative process.

As I have examined in this thesis, my approach to this project evolved in response to the participatory involvement of neurodiverse peoples. While I originally set out to design communication-supporting interactions, it was by reflecting on my own material- and practice-based approach to research that I was able to identify the empathic aspects of my project. These empathic aspects support co-creative involvement in an iterative design process. Creativity and material experimentation that can be seen in the design artefacts I have put forward (primarily the *Responsive Dome Environment*) served as the location for conversations between participants and myself. The agency afforded by these artefacts to participants elicits opportunities for feedback—this is strengthened when disrupted interactions occur, which allow a more nuanced discussion or engagement by participants.

While interaction with artefacts is an obvious focal point for neurodiverse experience to take place, it was also through an open approach to feedback mechanisms (for example, the use of Video-Cued Recall as a method for self-directed reflection and discussion) that I was able to support different opportunities for co-creation. The times that my assumptions were challenged—either through unexpected use of the design artefact or emergent ideas in post-study discussion with participants—often provided the most insightful moments into individual experience. Remaining open—and therefore empathic—to different perspectives helped to strengthen the co-creative aspect of my practice. Through iterations of this process, I was able to develop design artefacts that are reflective of neurodiverse interactions. These artefacts are material examples of the conversations that have taken place between myself and participants; evidence of an empathic approach to co-creation with neurodiverse experiences informing an interaction design practice.

6 Future Work: Looking Forward

In this final chapter, I summarise my practice and the outcomes of this research. I also look to future work and the potential to extend my practice into other person-centred constructive approaches to working with underrepresented human populations. Throughout this thesis, I have shone a light on the importance of advocating for the voices of the marginalised and the value in providing channels for first-person feedback and knowledge in interaction design praxis. Prioritising participatory conversations is a useful and important tool within my practice for placing people at the centre of research that aspires to be representative of communities. Conversation then is not just a record of what has passed, but a map for what could be.

At the outset of this thesis, I noted that I believe that a practice-based interaction design approach could contribute importantly to working with neurodiverse children. To explore this inquiry, I have presented both a description of my creative practice and the main artefacts and participatory engagement that put my approach into action. In Chapters 1 and 2, I described the influences that have moulded my practice: an interaction design approach to working with people through constructive design research. This description positioned the making aspect of my practice as a means of locating knowledge production for myself and those interacting with the design artefacts I developed. This was described in a series of material explorations and iterative studies with the making of the *Responsive Dome Environment* (*RDE*) in Chapter 3 and subsequent *RDE* open studio in Chapter 4. In these chapters, I described methods of eliciting and reflecting on the first-person experience of children that encountered the *RDE* for the purpose of informing iterative design changes to both the tangible interface within the *RDE* and the audiovisual response of the *RDE* itself.

The *RDE* open studio located my approach to working with a neurodiverse group of children. My overarching goal was to use their feedback to inform an iterative design process. My use of conversational methods in this regard showed promise in eliciting this feedback. Framing the *RDE* as a constructive design probe for encouraging reflection on experience through interaction with the environment was key in arriving at the outcomes of this thesis. While the approach I describe in this thesis demonstrates the potential of a conversational

and constructive design practice for working with neurodiverse children, it is intrinsically a product of my personal approach. I have identified the novel aspects of this approach that may be of use to other research practitioners, as evidenced by my literature review in autism technology interventions and interviews with expert practitioners in fields related to interaction design. These aspects can be described as:

- Disruption used as a method for eliciting and facilitating embodied interaction and feedback

- Conversational framing as a driver of iterative practice within constructive design research

These are a result of reflection on my practice in action throughout the *RDE* studies. Some of this was serendipitous; for example, the importance of disruption was discovered through the first and second iterations while focusing on other aspects of participatory feedback. Serendipity also underlines other elements of my practice that are important when working with people in a human-centred approach. This includes remaining open to participant and peer-led knowledge as well as first-hand accounts of experience.

As a method of encouraging participants to re-assess their interaction with an artefact, disruption has similarities in scope with concepts from HCI and psychology. However, as a trigger for engaging participants in a conversational model of articulating and sharing knowledge, I have framed it through my

interaction design practice as an important step in focusing on first-person feedback. The conversational approach to exploring experiences with an interactive design artefact is, I believe, a useful way for a designer to capture constructive collaborations—that is, to articulate knowledge created through encounters with a design artefact, based on the sociocultural histories and values of each person involved with a study.

In Chapter 5, I formalised my practice-based approach to working with participants in the *RDE* open studio, where I reflected on the tacit aspects of my practice. My reference to design probes notes the important work done in design in understanding the perspectives of others (technology probes being a key example) while incorporating the unique aspects of my practice to this history: disruption and iterative design methods. Using this departure point, my doctoral project has produced a conversational approach to practice that may be applied by those aspiring to engage with participants in a co-creative partnership, highlighting the unique sensitivities that creative practice can bring to bear on autism research.

6.1 Looking forward

I recognise that I have been influenced by the peculiarities of an academic perspective on research with people. The requirements and structure of a PhD do not reflect the true messiness of life. This is certainly true when it comes to

children and neurodiversity. The *RDE* open studio described in Chapter 4 shows promise for the areas of inquiry that I have discussed, and the resulting aspects of my practice that addresses the messy and wicked problems which emerge in interaction design research are a valuable contribution in response. However, this is far from conclusive in terms of results relating to neurodiversity. A deeper understanding of the usefulness of methods I have proposed requires a larger participatory study, with further peer-led engagement.

My experience throughout the *RDE* open studio has impacted my creative practice by galvanising my respect for neurodiverse perspectives and my belief that it is only through first-person experiences that design can truly contribute in this area. The potential I see in the conversational approach I put forward is not limited to interaction design, or even creative practice. To further refine and reflect on the conversational model I describe in Chapter 5, I would like to look more closely at its potential for transferability across disciplines and application to design research (academia and industry). This requires further resources and collaboration, something I believe my research has shown potential for, particularly as the *RDE* open studio took shape. I hope to explore this further as I turn my attention to expanding the scope of my research to work alongside other experts and, most importantly, neurodiverse people.

6.1.1 Autism MeetUp

As a result of my engagement with other researchers working in neurodiversity,

I have developed a better understanding of communicating the importance of creative practice to fields such as psychology and education. The importance of this as a future-facing outcome of my PhD research is to work more closely in collaboration with other stakeholders—not to 'legitimise' creative approaches to neurodiversity, but to share knowledge and explore ways of developing common language in cross-disciplinary research. As a direct development of the practitioner interviews I conducted in parallel with the *RDE* open studio, I was central in establishing an interdisciplinary research group connecting the faculty of UNSW Art & Design and the Cooperative Research Centre for Living with Autism (referred to as Autism CRC, based at UNSW Medicine).

This nascent collective of postgraduate and postdoctoral researchers is indicative of the growing interest in cross-disciplinary collaboration and has begun to identify areas in autism research that might benefit from different approaches and practices (both creative and scientific). As a group, we decided to organise a public event focusing on community engagement and sharing of our many autism research perspectives. The first event, Autism MeetUp, was held on April 2nd, 2016 (Autism Awareness Day) at UNSW Art & Design campus in Paddington, Sydney (Figure 6.3).

Figure 6.1 - The UNSW Autism Research Group at the Autism MeetUp event, April 2016.

At this event, the public were invited (with a focus on event promotion to autistic people, their families and carers, and those from autism services) to meet UNSW researchers and learn about the variety of interdisciplinary research being carried out in the group. Most importantly, visitors were invited to express their own thoughts on what research directions would make a difference in their own lives. One of the objectives of the event was to make it clear that autistic people and those around them are actively encouraged to be partners in the research process, and that they are not being treated as subjects in a study that objectifies their diagnosis.

It is through my experiences in this project that I have identified these potential futures and communities of practice that—while not an original

objective of this project—have reassured me that we are moving in a positive direction when it comes to autism research. Creative practice still has much to contribute here, and I look forward to continued collaboration with practitioners and advocates from the diverse range of fields that I have only just started to explore.

6.1.2 Lighting module prototypes

The experiences I have taken from the development of the *Responsive Dome Environment* (*RDE*) will also be explored further with the development of a modular prototype of the structure. Based on the feedback from participants in the *RDE* open studio and discussions with experts and advocates from the autism community, I recognise the potential of making technology such as this more accessible. While the *RDE* was successful in the context of my doctoral study, the structure is too bespoke and costly for families or institutions with limited resources.

In future work, I plan to look at responses to this problem, with a current prototype design that is exploring a modular hexagonal system of lighting 'blocks' that are low-cost and scalable (Figure 6.2). Using similar materials and technologies to that of the *RDE*, I aim to examine the use of audiovisual feedback systems across multiple contexts (such as homes, classrooms and clinical settings).

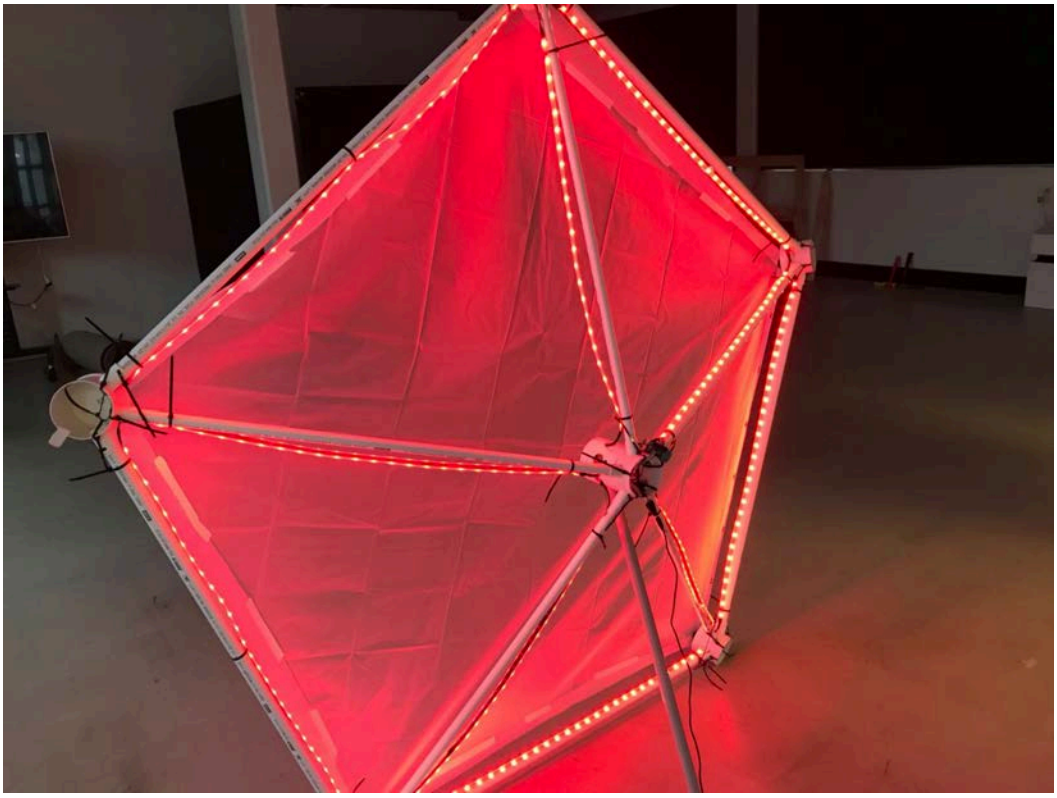


Figure 6.2 - Rear of early lighting module prototype.

This ongoing project also gives me the opportunity to leverage some of the research relationships I developed throughout my doctoral project, by collaborating with psychiatrists and educators from the group involved in the Autism MeetUp. Working alongside other experts will help to extend the reach of my work beyond the field of interaction design.

6.2 Concluding remarks

Throughout my experience of this PhD project, my perspective on the role of a researcher has become much more outward-facing. I have gained so much from working alongside autistic people, their families, carers, and experts that has crystallised what I hope to achieve in my future research. I now see the

trajectory of my work as that of aspiring toward social justice, inclusiveness, and a commitment to advocacy. This highly political aspiration was not one that I began this PhD pursuing, but one that I feel I have been honoured with by the people that I have had conversations with throughout this project. I have been embraced by most of the people that I have come into contact with, despite my naïveté in many areas, and can not think of a better way to return that trust than to continue working alongside autistic communities and try to elevate their voices whenever I can.

I am confident that my practice has become more human-centred as a direct result of this experience and immeasurably more relevant for having opened myself up to the unique knowledge of participants, particularly those to whom I hope this research will be of the most benefit: autistic children and their families. Despite the technical nature of the material aspect of my practice, I see the true contribution of this work is in bringing people together. Finally, I want to return to Gordon Pask's (Pask 1980, p. 999) notion of 'togetherness', which he describes as "human proximity, of meeting and speaking, or dancing together." I have witnessed wonderful moments of togetherness in this research through many varied modalities. These experiences motivate me to continue on this path and remain open to conversation in all its forms.

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