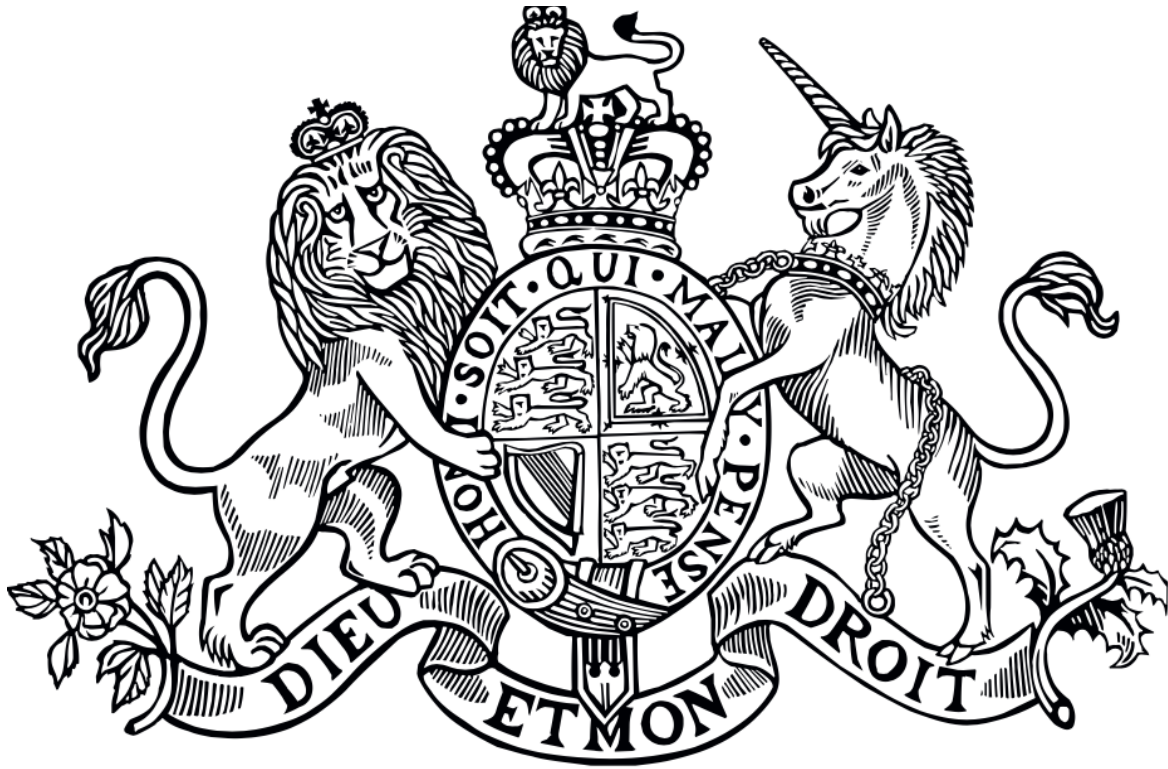




Augmented Design Tools:

Design Ideation, Ambient Technologies, Multimodality,
AI and Exclusionary Potential

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Abstract

This PhD by practice explores the effects and heuristics of experimental computational tools for supporting collaborative design ideation processes. Through the production of experimental prototypes, built upon common computer vision, speech recognition, generative AI, machine learning tools and web technologies, the potential of experimental ambient digital tools to augment design ideation practices is explored. The effects of these tools are then tested with both professional design practitioners and design students in a series of observed studies. This includes the exclusionary potential of design ideation augmented in this way. Meshes of technologies in this context denotes a mix of web search and display applications connected to sensor technology for voice recognition and computer vision for 3D and spatial sensing. These components are then connected to consumer AI frameworks for speech recognition to achieve both speech-to-text and generative text output using platforms such as IBM's Watson and Open AI's GPT-3. These studies examine both the embodied interaction associated with such systems using multimodal analysis, and present reflections by participants of their experiences and expectations of such augmentation. In this context, this research develops an idea of augmented design ideation and, in dialogue with participant reflections, uses this to discuss current technologies as well as trajectories of computationally supported design ideation. During this research, the emerging critical context of augmented design ideation is identified as a significant issue for ideation practitioners and systems designers. This work identifies potential new possibilities for exclusion stemming from both current technology development approaches and their integration with problematic, but common, design frameworks. These are found to be

systemically problematic for augmented design ideation built with current approaches.

Principally, this programme of action research uses a research *through*, and *for* design, approach for generating insights for the design research community and for highly cognate areas of the Human Computer Interaction (HCI) research community. It also describes novel approaches to multimodality in the context of augmented design ideation – specifically the integration of computational elements into multimodal texts – and presents observations in this area. I also present methodological observations on how the approach can be used to exchange insights between design research and HCI and how this builds on work by others, specifically concerning sites of common interest such as interaction design research and practice.

My research examines how experimental computational tools for collaborative design ideation can be used to investigate the understanding and practice of design ideation in our highly networked ubiquitous computing context. A significant contribution of the research is its focus on retaining a concern for the macro conditions of design activity and design cognition that are not a primary concern of related domains, such as HCI. This will be useful to both designers and technologists who are developing tools and processes to support collaborative design ideation work and to researchers interested in the effects of such tools on design cognition. Augmented design ideation is found to have the potential to give rise to practices that amplify the exclusionary effects of the technologies it currently relies upon. In surfacing these issues this research offers the design and technology communities a critical context from which to develop less exclusionary practices, technologies and contexts.

Keywords; Artificial Intelligence, Augmentation, Computational Design, Computer Vision, Design, Design Cognition, Design Ideation, Design Research, Design Technology, Design Thinking, Generative AI, Inclusion, Embodied Interaction, Exclusion, Prototypes, Machine Learning, Multimodality, Surveillance Capitalism, Ubiquitous Computing.

Glossary of Terms (Definitions)

Key terms are drawn from the related fields of design studies and design practice, human computer interaction (HCI), qualitative research methodology and critical technology studies.

AI: AI is the common shorthand for *artificial intelligence*, in this case it refers to a set of technologies based upon common machine learning techniques (Mahesh, 2020). These techniques are then used to produce tools and frameworks, such as GPT-3 (Floridi and Chiriatti, 2020a), from which developers build widespread digital tools and services that leverage voice and image recognition and image and text generation (Krizhevsky, Sutskever and Hinton, 2017). In this thesis AI refers to this whole chain including, machine learning techniques, their algorithms, the resulting tools and frameworks, and their higher-level use in *intelligent* products and services.

Ambient information systems: This describes visual information (text, pictures, formal graphics) encountered in specific spatial contexts such as a room, building or public space (Pousman and Stasko, 2006). Furthermore, in this context, they are considered the products of a ubiquitous computing environment (Dourish and Bell, 2011) in that they do not require direct user requests to be activated and are initially prompted by the *sensing* of the computational systems present in the space.

Attentional Generative Adversarial Networks (AttnGAN): describes a technique of machine learning used to produce images based on text input and natural language processing. (Xu, Zhang, Huang, Zhang, Gan, Huang, and He, 2018). In this research it is of

interest as it provides a means to generate visual resources for design ideation based upon the spoken conversation of participants engaged in design ideation. Generative AI systems such as these are considered important enabling AI technologies for augmented design ideation at the present time.

Augmented Design Ideation (ADI): This describes design ideation (described below) that is augmented by computational means. In this case, it specifically refers to the presence of ambient information systems projecting text and image and graphical prompts onto the paper sketching surface used by the participants when sketching initial ideas on receipt of a design brief.

Co-evolution: This term describes how both design problems and design solutions have been shown to evolve together in collaborative creative ideation contexts (Dorst and Cross, 2001). Furthermore, in a highly relevant manner for this study, how co-evolution has been observed to be “... the ‘engine’ of creativity in collaborative design” (Wiltchnig, Christensen and Ball, 2013, pp.515-542).

Design Cognition: In this thesis, design cognition “refers to the mental processes and representations involved in designing” (Hay, Cash and McKilligan, 2020, p.1). It is useful here as design ideation practices are fundamental to how designers mentally process design tasks and form representations to aid this process (Cross, 2007).

Design Ideation: As a fundamental term to frame this research, and simply put, the term means the early stage of ideas generation in the design process (Jonson, 2004). The term is used as in other key referenced research, for example, ‘By ideation we mean the initial idea generation at the onset of the conception of a design solution’ (Dorta, Pérez and Lesage, 2008, p. 123). Furthermore, in this research, it specifically also includes the practice of sketching (Verstijnen *et al.*, 1998; Jonson, 2005) to support design cognition (Cross, 2007).

Experimental Computational Prototypes: This phrase is taken here to mean a technical assemblage established to augment design ideation with novel applications of web technologies, ambient information systems and AI tools and platforms. In this thesis these are described in detail within a series of case studies.

Heuristics: This term describes the mental shortcuts we develop from our experience in the world to guide future action. Of particular relevance to this study are the heuristics of digital systems developed through the user experience of interaction design prototypes (Chuan, Sivaji and Ahmad, 2015) and the emerging heuristics of user facing AI tools products and services (Lubin, 2022).

Multimodal Interaction: Similar to HCI, multimodal interaction refers to the ‘interaction with the virtual [computational] and physical [augmented] environment through natural modes of communication such as speech, body gestures, handwriting, graphics or gaze’ (Bourguet, 2003, pp.717-720). However, in HCI it is often tightly connected to the input and output of computational systems and the efficiency, or lack thereof, of those systems.

Whereas within this research context, it is also considered part of the semiotic environment (Kress and Leeuwen, 2006) of design ideation and the study of embodied design practice (Malinverni, Mora-Guiard and Pares, 2016).

Multimodality: This term refers to the established inter-disciplinary research approach which ‘looks beyond language to investigate the multitude of ways we communicate: through images, sound and music to gestures, body posture and the use of space’ (Jewitt, 2016. p.[no pagination]). This approach is used here to develop ethnographic methods for the study of Augmented Design Ideation (ADI) and to inform approaches to analysis. It also provides the related term, semiotic resources, which in this approach means, ‘The actions, materials and artefacts we use for communicative purposes - these can be physiological or technological - and the ways in which these resources can be organized’ (Jewitt, C., 2013. pp.250-265).

Pseudodata: In computer programming, this term describes data that is artificially generated in order to test a program i.e., test data. In Case Study 2 (Chapter 7), *pseudodata* is used as an analogy for data derived from the application of a design framework. This borrows from anthropologist Eitian Wilf’s (Wilf, 2016) critical analogy that describes post-it-notes as producing pseudodata in the context of a design ideation activity.

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1. <http://www.cognistreamer.com/about/> (Peter, n.d)
2. <https://innovationcast.com/product/> ('Innovation Management Software • InnovationCast', no date)
3. In 2023, the cost of a 4-day bootcamp was approximately USD\$14,000 see:
<https://www.gsb.stanford.edu/exec-ed/programs/design-thinking-bootcamp>
(Accessed: 15 Nov 2023). .
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5. 'watsonx, IBM's enterprise-ready AI and data platform designed to leverage foundation models and machine learning' available at: <https://www.ibm.com/watson> (Accessed 10th Oct 2023)
6. 'GPT-3–powered search, conversation, text completion, and other advanced AI features through our API.' available at: <https://openai.com/blog/gpt-3-apps> (Accessed 10th Oct 2023)
7. 'Purpose-built infrared camera modules' for hand tracking available at:
<https://www.ultraleap.com/product/> (accessed 10 Oct 2023)
8. 'Kinect is a line of motion sensing input devices produced by Microsoft and first released in 2010.' Available at: <https://en.wikipedia.org/wiki/Kinect> (accessed 10 Oct 2023)

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Authors Declaration

This thesis represents partial submission for the degree of Doctor of Philosophy/ Master of Philosophy at the Royal College of Art. I confirm that the work presented here is my own.

Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

Signature:

A handwritten signature in black ink, featuring a large, stylized 'R' and 'C' followed by a long horizontal stroke.

Date: 5 April 2024

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1.0 Chapter 1

1.0 Introduction: Research programme

This thesis describes a programme of action research (Muratovski, 2021) that explores how experimental computational prototypes can augment design ideation practices (Dorta, Pérez and Lesage, 2008; Luo, Sarica and Wood, 2019) in early-stage concept generation (Jonson, 2005) to aid design cognition (Cross, 2004). The aim of this research is to establish how designers may leverage now common web, voice, ambient projection and machine learning/AI technologies to augment design ideation by providing real-time text and image prompts to collaborative sketching environments. Furthermore, through the development of these prototypes and the study of their use, the effects and implications of these systems on ideation practice, at both the level of the individual and at the platform scale, is explored.

At the level of the individual, this research focuses on multimodal interaction between participants engaging in collaborative design ideation and sketching using the experimental computational prototypes of the augmented design ideation tool. This interaction, between ideas, people and technology highlight the emerging heuristics of these computational practices and provide data to evaluate them. The analysis of this interaction also enables a discussion of the affordances of augmented design ideation tools and the degree to which the effects of such tools is recognised and understood by the research participants.

To consider augmented design ideation at the level of the platform, this research explores

participants' reflections during interviews of their experience of the augmented design tool and how they connect this activity to critical debates concerning assistive technologies and design practice. Participants demonstrate a sophisticated awareness of how they ascribe meaning to design prompts and how they assimilate the dynamics of experimental computational prototypes of an augmented design ideation tool, into their ideation process. They also show an awareness of how they can anthropomorphise such tools – for example assigning human like agency to them – in the context of design ideation and foresee some of the potential problems of using such tools to design for diverse contexts and communities. Their reflections are used, alongside relevant theoretical perspectives, to develop a critical understanding of augmented design ideation at the platform scale, particularly in relation to platforms that are built upon current technologies, ideologies and logics.

In considering design ideation as a situated social practice that encodes and frames specific aspects of applied creativity – such as divergent thinking and creative iteration – it is possible, in this research, to build and evaluate digital tools for augmenting design ideation practices and to consider their effects upon the situated social practice of design.

1.1 Research questions:

The principal research questions of this study are:

1. How can collaborative design ideation be augmented by web technologies, ambient information systems and AI tools and platforms?

2. How can experimental computational prototypes be used by designers and design researchers to explore the critical context of technologically augmented design ideation?
3. What is the exclusionary potential of design ideation tools and practices augmented by consumer AI and web technologies?
4. How can multimodal interaction be used to explore augmented design practices?

These questions are given further description below:

1.1.1 RQ1 - How can collaborative design ideation be augmented by web technologies, ambient information systems and AI tools and platforms? This aspect of the research examines how collaborative design ideation practices can be augmented by experimental computational prototypes comprising web technologies, tools and platforms. This is achieved by setting up co-design contexts to observe computationally augmented collaborative design ideation. These co-design contexts include the presence of ambient information presented to participants via the experimental use of web technologies and AI tools and platforms. The co-design contexts are reviewed using qualitative analysis to describe the *practice* of augmented collaborative design ideation and to expose emergent features of this kind of augmentation.

1.1.2 RQ2 - How can experimental computational prototypes be used by designers and design researchers to explore the critical context of technologically augmented design ideation? This question evaluates the use of experimental computational prototypes in a practice-based design research context (Frayling, 1994; Koskinen *et al.*, 2011a; Gaver, 2012a;

Stappers and Giaccardi, 2017). The question assumes the status of the prototypes as design artefacts that *provoke* thought, practice and reflection, and not as technology solutions themselves (Boer and Donovan, 2012). Through their development and use, they are intended to expose the computational and non-computational trajectories of technologies that can be used to support design ideation from within design practice. This approach enables critical questions regarding how augmented design tools may change design practice to be explored, particularly as designers begin to rely on the assistance of such ambient intelligent systems.

1.1.3 RQ3 - What is the exclusionary potential of design ideation tools and practices augmented by consumer AI and web technologies? This question examines the model of augmented design ideation presented as augmented design ideation tools are often built using technologies that have been shown to be exclusionary (Denton, et al. 2021). Furthermore, common design ideation approaches have faced similar critique (Costanza-Chock; Kolko, 2018), and this question enables a discussion of the exclusionary potential of augmented design ideation tools within the research. It should be noted that in this thesis the exclusionary potential of augmented design ideation tools is not explicitly evaluated, but that an augmented design ideation tool is used as a design probe (Gaver, Dunne and Pacenti, 1999) to examine the exclusionary potential of augmented design ideation tools as used within design ideation practice.

1.1.4 RQ3 - How can multimodal interaction be used to explore augmented design practices? This question examines the efficacy of using methods of multimodal analysis (Jewitt, Bezemer and O'Halloran, 2016) to both describe and understand augmented design

ideation practice. It aims to provide useful approaches for practice-based research that involves using experimental computational prototypes to explore design ideation practice supported by ambient information systems. It also explores how multimodal data produced by the experimental computational prototypes can be integrated into multimodal texts for analysis. Further, it examines the potential of this hybrid approach for multimodal interaction research in the design research field.

1.2 Summary of the Contributions

The significant contributions to knowledge are presented in full as part of the conclusion.

However, the three main areas of contribution are summarised below.

1.2.1 Augmentation of collaborative design ideation with computational systems

This study shows that design ideation can be augmented with experimental computational tools and ambient systems in ways that are readily able to be leveraged by design students and professional designers alike. Research participants consider this augmentation to be an aid to design cognition and has the ability to offer valuable support for divergent thinking in design ideation practices. Furthermore, research participants demonstrate a critical awareness of computational tools for augmenting creative process, and their respective effects on design ideation processes, when co-designing with such tools.

1.2.2 Critical contexts and the potential for exclusion in universalising systems for collaborative design ideation

In the process of considering the critical context of designing computational tools for

augmented design applications, this study identifies such tools as producing powerful trajectories of exclusion. This is due to the potential for exclusionary technology – such as AI tools that lack representative training data – being baked into design frameworks, which have been shown to be highly normative and biased. The emerging material ecology of design activity resulting from the use of such systems may obfuscate, compound and accelerate the exclusionary potential of the design process in ways that are hard to comprehend and mitigate. This study also shows that despite the research interest in fairness and inclusion in both computing and design domains, there is a significant gap in the literature concerning the downstream potential for exclusion in the products of computationally augmented design ideation.

For example, given the experimental computational tools I explore couple search technologies and machine learning technologies – as they are currently constructed – non-white systems users are likely to be faced with both negative forms of representation in image prompts, and systems that literally do not recognise them on equal terms to their white co-designers. This is due, partly for example, to contextual factors such as computer vision systems being developed by white technology researchers (Steed and Caliskan, 2021). In this situation, the potential of such systems to erase or marginalise people of colour and/or actively harm them – through system use – is high. Some of the dynamics of oppression described here are also commonly encountered within design ideation practices, for example, within the manual use of common image search tools by designers. However, the acceleration of such practices by computational processes can often be seen to compound these forms of

oppression, creating inequalities that producers of such tools should be encouraged to address. As outlined within Sasha Costanza-Chock's Design Justice Network Principles (Design Justice Network, n.d), it is clear that, given the issues described above, the degree to which the types of computational tools and platforms I explore in this research are able to contribute to inclusive agendas such as Design Justice is a complex task.

1.2.3 Multimodal practices for the study of design ideation

In developing a research design to explore experimental computational experimental computational tools for augmented design applications, this research proposes a novel application of multimodal methods in an action research context. Primarily, this consists of developing multimodal ethnographic tools which contain computationally generated components and that are integrated and analysed in hybrid multimodal texts. This application of multimodality in design research is uncommon in general and novel in this instance and, as such, demonstrates new approaches to producing multimodal texts for qualitative analysis, specifically in a design context.

1.3 Epistemological and ontological positions

The thesis describes a post-positivist programme of action research in which 'conditional knowledge which can be used to improve conditions' is developed (Tekin and Kotaman, 2013, p.84). As such, the research is concerned with the practical reality of design ideation supported by the ubiquitous computational technologies of the anglophone design industries of Europe, America and beyond, that have come to shape digital experience globally across

cultures.

It is also important to acknowledge that, as is described in the context of education research, action research of the kind described here is understood to include collaboration between researcher and research participants (Yang, 2006). Further, the conclusions drawn capture valid moments of social reality (Crotty, 1998; Ryan, 2006), which are time bound yet contribute to the contingent and ongoing understanding of emerging phenomena.

The research also draws upon interpretivism as it focuses on the meaning of the social interaction of participants engaged in design ideation tasks. As described by Tekin and Kotaman, ‘interpretivist research does not recruit standardized research methodologies; rather, it provides room to deploy less structured techniques such as ethnographical methods’ (Tekin and Kotaman, 2013, p.85). This mix of post-positivist and interpretivist epistemologies is an identified feature of action research (Carr, 2007) and one that holds true for the research presented herein.

1.4 Thesis Structure

Chapter 1: Introduction. This chapter establishes the high-level aims, research questions and contributions of the research. It highlights key literature for the study of augmented design ideation (ADI), defines key terms and, furthermore, establishes the critical social and technical context of design ideation explored in this thesis. The chapter includes a description

of the program of action research undertaken, and it then introduces the epistemological and ontological positions of the research.

Chapter 2: *Design Practice: Development and Iteration of the Augmented Design Ideation*

Tool. This chapter describes and situates the practice-based component of the thesis. It starts with a description of the place of practice within the research and then summarises the design and development of the ADI tool through various stages related to the case studies. It also details the bespoke software developed for the experimental computational prototypes of the augmented design ideation tool and some of the design considerations that were associated with its development.

Chapter 3: *Literature Review, Part 1: Design Ideation and the Web.* The first part of the literature review introduces key references for the study of augmented design ideation. It clarifies what is meant by design ideation broadly and identifies others who have sought to study *augmented design ideation*, including their approaches to the development of technologies for augmenting design ideation. It also explores the role of internet culture in underlying attempts to leverage *crowd knowledge* of internet platforms in design contexts, which was an initial motivation for this research. Going further, this chapter also considers multimodality as a method for exploring augmented design ideation, the increasing place of consumer AI technologies in creative culture, and how design ideation practices are evolving in response to AI.

Chapter 4: *Literature Review, Part 2: Critical Contexts.* The second part of the literature

review addresses the critical context that has developed around related concepts of *design thinking* and the increasingly dominant role of large technology corporations in social reality. This chapter explores the potential for exclusion in these domains and the difficulty that the widely adopted computational augmentation of design ideation systems built from current approaches has in avoiding an exacerbation of identified criticisms of design thinking methods.

Chapter 5: *Methodology*. This chapter introduces the methodological approach of this programme of action research including the use of specific methods and tools. It describes the methods employed, provides a rationale for their selection. It describes approaches to data collection and the development of experimental computational tools including how such tools provide research data in this study. Subsequently, the approach to analysis and multimodality is described and the multimodal transcripts and interviews are discussed.

Chapter 6: *Case Study 1: Augmented Design Ideation and Design Students*. This chapter presents a case study that focuses on design students doing collaborative design ideation with experimental computational prototypes of the augmented design ideation tool that were developed within the first stage of the research. This study also contains some initial work to establish the prototypes and the environment in which the prototypes were set-up for the subsequent studies. The chapter identifies additional prior work (Ali, Morris and Wobbrock, 2019; Wobbrock, Morris and Wilson, 2009), and compares its settings and limitations. The study presents initial findings from, and excerpts of, the ideation event dialogue to illustrate the findings. The case study also presents post-event interviews and associated findings. The

chapter concludes with overall findings and points of comparison for the next two case studies. This study serves as an orientation to the subsequent studies and provides initial insights concerning the structure of design ideation events within the research.

Chapter 7: Case Study 2: Augmented Design Ideation and Design Professionals. This chapter repeats the procedures established in Case Study 1 with new design briefs developed for/with design professionals in order to further test the initial findings and explore comparative differences between the participants who took part in the two case studies. Case Study 2 also highlights additional prior work and borrows from anthropologist Eitian Wilf's (2016) *The Post-it Note Economy: Understanding Post-Fordist Business Innovation through One of Its Key Semiotic Technologies* to explore critical anthropological aspects of computationally augmented design ideation. The study considers how the prototype of the augmented design ideation tool broadly supports design cognition (Cross, 2001). As with Case Study 1, Case Study 2 presents initial findings from, and excerpts of, ideation event dialogues to illustrate these findings. This case study also presents post-event interviews and associated findings.

Chapter 8: Case Study 3: Augmented Design Ideation, AI Tools and Design Professionals. Case Study 3 focuses on the development of the prototype of the augmented design ideation tool including AI text prompts associated with a novel adaptation of NFC enabled methods cards based on Brian Eno's Oblique strategies (Eno, 1975). This approach is informed by IDEO's brainstorming with GPT-3 experiment as described by Ben Syverson in his post, *The Rules of Brainstorming Change When Artificial Intelligence Gets Involved* (Syverson, 2020).

This case study repeats the established procedure associated with the first two case studies but with these additional components. The study presents additional prior work that considers the increasing prevalence of AI tools in computational support for design ideation and studies the effects of these technical additions on the augmented design ideation activities. As with Case Studies 1 and 2, this study presents initial findings from, and excerpts of, ideation event dialogues to illustrate these findings. The case study also presents post-event interviews and associated findings, which show increasing participant awareness of AI technologies and their critical implications for design ideation.

Chapter 9: *Discussion and Observations.* This chapter presents the methodological, critical and practical observations of the research, including professional observations aligned with the design industries featured in the research.

Chapter 10: *Conclusion.* This final chapter presents a conclusion to the thesis, the main contributions of this study and highlights areas for future work.

2.0 Chapter 2: Design Practice: Development and Iteration of an Augmented Design Ideation Tool

2.1 Introduction

This chapter describes the practice-based component of this thesis and its iterative development through a series of case studies. The process of developing an *augmented design tool* is rooted in my experience as a digital designer with professional experience of digital communications design and building interactive experiences with a range of web and other technologies. In developing the tool, significant design effort was spent in considering the heuristics and affordances of the tool in terms of its interaction design, its visual design and its user experience. This was done through a process of iterative testing, development, hacking and making to produce experimental user experience prototypes that were rationalised into the development of the tool and its standard set up and operation. In this part of the thesis, I will describe key aspects of this process, starting with the place of practice in the research, a description of the tool, the key stages in its development, and its application in the case studies.

2.2 The place of practice

The dominant practice domain of this research can broadly be considered as interaction design – in the building and refining of the prototypes – as defined by one of the field’s pioneers, Gillian Crampton Smith. During the birth of the field, Crampton Smith described interaction design as a practice that shapes our everyday life through digital artifacts for

work, for play, and for entertainment (Smith, 2007). To this, I would also add that interaction design is the design of people's interactions with digital systems with a consideration of both user experience and the affective nature of the system being designed.

There are two main aspects to the practical part of my research: my practice as an interaction and communication designer producing prototypical augmented design tools; and my practice as a design researcher exploring the artefacts that result from the application of these tools using visual ethnographic methods, including multimodality (Jewitt, Bezemer and O'Halloran, 2016). I use the findings from these parts of my research to interrogate augmented design tools and their potential effects on wider socio-technical contexts at the intersection of design and society, including their potential to exclude. Within the research I aim to understand how, and if, such tools augment design ideation practices. From this, I explore future directions of investigation for both tool designers and other design researchers. This is in order that they design better tools and processes that truly support divergent ideation practices, and avoid compounding the exclusionary forces present in current relevant technology, thereby enabling more inclusive futures through design.

2.2.1 Contextual Timeline (Technology, Research and Practice).

A number of contextual factors in technology development, design research and advances in artificial intelligence adoption have shaped this research over the extended duration in which it has been carried out. This section identifies these factors and places them on a timeline showing the macro context of the research. Figure 3.1 below summarises developments in

extended (XR) and augmented (AR) reality technologies that have profoundly shaped user experiences and interaction design practices during my research. These are shown next to significant developments in AI technologies that have also taken place within the same period. These technological developments have radically shaped the possibility space for XR/AR user experience paradigms with embedded AI components.

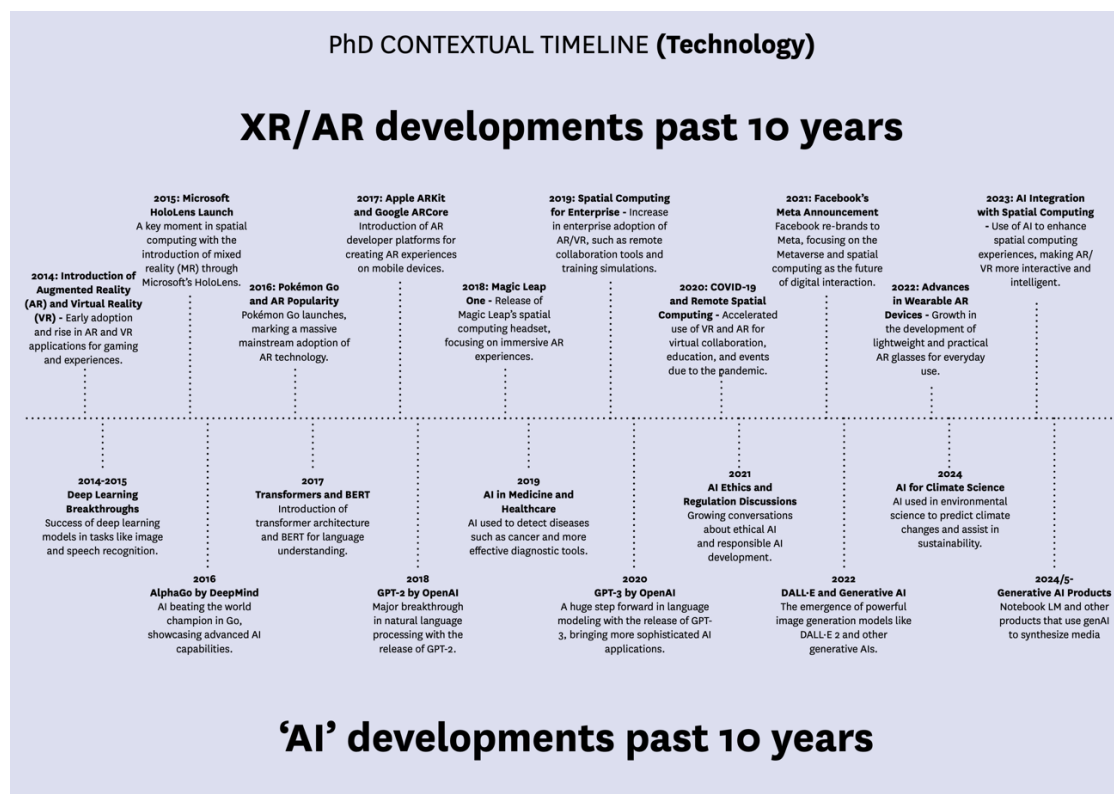


Figure 3.1 – PhD Contextual Timeline (Technology)

The development of these technologies is reflected in the design of my research, from initial prototypes making use of early-stage interaction design technologies and approaches that were superseded by more mature, stable technologies and design practices toward the end of the research period. Furthermore, participants’ understanding of the prototypes I created during my research changed significantly during the research as they also experienced these

technology developments in their personal lives and work cultures. Such changes are evident across my initial research and case studies. Figure 3.2 below plots key developments in design research that occurred within the duration of my research. The timeline places these developments in relation to the practical elements of my research. This includes the creation and deployment of an augmented design ideation prototype tool as a form of design probe ,as well as mapping the ethical dimensions of the emerging model of design ideation proposed by the prototype.



Figure 3.2 – PhD Contextual Timeline (Practice)

Several key themes can be identified in relation to the evolving role of **interactive technology in the design process** over the period of the research. These developments

intersect design thinking, AI, HCI, multimodality, as well as ethical considerations in each of these domains.

1. The Emergence of AI and Design Thinking

Interest in how AI and generative systems can be used to augment divergent thinking processes has grown dramatically during the period of my research, for example from *Runco & Acar (2012)* to *Kim & Maher (2023)* and *Zhu et al. (2022)*. AI-based tools like **GPT-3**, **DALL·E**, and **Wekinator** have introduced new modalities for idea generation—where human-machine collaboration enhances ideation rather than merely automating it. This aligns with Guzdial & Riedl’s (2019) co-creative AI framework, which reimagines the designer working in partnership with intelligent systems.

2. Ideation in Hybrid Environments

A general shift from analogue to hybrid and digital environments is a recurring theme within the timeframe of my research. *Bilda et al. (2003; 2006)* and *Plimmer & Apperley (2002)*, for example, explore how digital sketching tools have altered the nature of ideation, enhancing fluidity while sometimes constraining spontaneity. *Camburn et al. (2017)* and *Dorta et al. (2008)* extend this to prototyping, showing how interactive tools can be used to fill the “ideation gap” between concept and execution.

During this period, interactive platforms—e.g., Miro, OpenIDEO, and innovation platforms like Crowdlcit (Ali et al., 2019)—have also been established, creating networked spaces that

aim to ‘democratise’ idea contribution and support distributed creativity, with mixed results as discussed in later chapters.

3. Multimodality and Embodied Interaction

The role of **multimodal and embodied interfaces** has also become more prominent in design and HCI research and practice. Scholars like *Jewitt*, *Bezemer*, and *Derboven et al.* discuss how combining gesture, voice, visuals, and AR (e.g., *Billinghurst et al.*, 2015) offers designers more expressive and interactive ways to explore concepts.

4. Ethical and Political Dimensions of Interactive Technology

The last decade has seen a critical turn in HCI and design discourse. Authors such as *Crawford (2021)*, *Benjamin (2019)*, and *Costanza-Chock (2020)* foreground the **politics of datasets**, algorithmic bias, and **design justice**. These critiques intersect with technology developments, challenging the assumption that AI is neutral and encouraging designers to adopt more open, abolitionist or decolonial perspectives (*Escobar, 2018; Tlostanova, 2017*).

5. Speculative Design and Open Design Futures

Informed by developments in design such as *Dunne & Raby’s (2014)* speculative design approach, interactive technologies are now conceptualised as not only for problem-solving but for **world-building** (Conference RTD, 2019; Bray et al., 2022). In this context designers now view platforms and AI tools as vehicles for imagining alternative futures, especially through Afrofuturist, feminist, or pluralist frameworks to engage in critical world-building.

Open design (*Boisseau et al., 2018*) and maker cultures have emerged as important paradigms for further decentralising creativity, also in relation to interactive, cloud-based systems and algorithmic design tools (*Fritschle, 2018*).

Conclusion

Interactive technologies have profoundly reconfigured design processes over the past ten years. Alongside these developments, attempts to shift perspectives and practices from Eurocentric models to **pluriversal**, justice-centred approaches, have grown in importance. These developments have modulated and queried the loci of creativity, from the individual to the **human-computer collective**, from static environments to **multimodal ecosystems**.

2.3 The augmented design tool

The augmented design tool developed within the research consists of a web application that delivers real-time projected image prompts to augment design ideation and design sketching during collaborative design ideation events. The tool also records (through cameras and sensors) multimodal features of the collaborative design ideation events, and these are then used to create multimodal transcripts of the events. Specific aspects of the augmented design tool are described within the individual case study sections of the thesis. This part of the thesis describes how the tool is constructed and how it contributes to the research data that is produced within the case studies.

The images below show the tool being used by design practitioners engaging in augmented design ideation during collaborative design ideation events in case studies two and three.



Figure 3.3. Participants use the augmented design tool to facilitate augmented sketching in Case Study 2.



Figure 4. Participants consider the design brief before the collaborative design ideation event in Case Study 3.

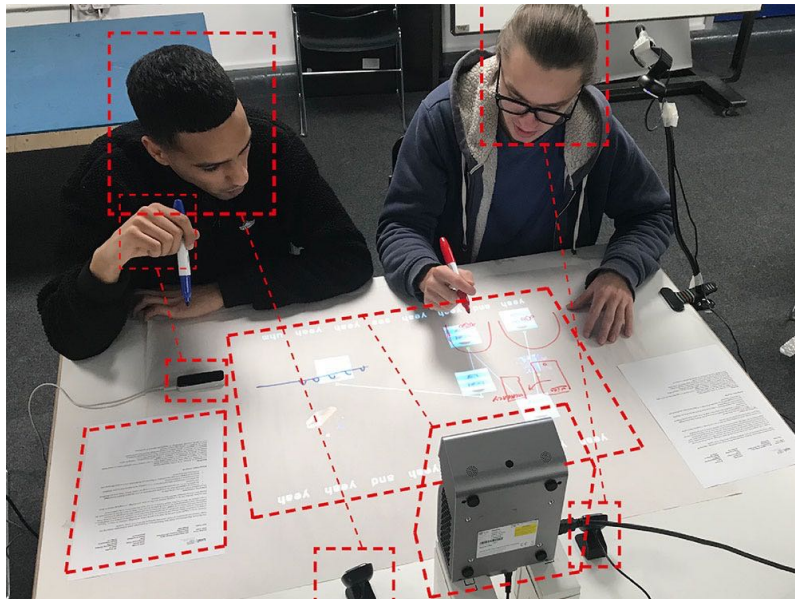


Figure 5. The augmented design tool being used to facilitate augmented sketching with graphic indications of computer vision focus, projection area and gesture capture in a collaborative design ideation event from Case Study 1.



Figure 6. Participants use the augmented design tool to facilitate augmented sketching in Case Study 1 and glance at the live dashboard to see this observation during their co-creation activities.



Figure 7. Participants use the augmented design tool to facilitate augmented sketching in Case Study 2, they cannot see the live dashboard which is presented on the laptop in this set-up.

2.3.1 Wizard of Oz components and the flow of action

The augmented design ideation tool developed within this research generates a mix of visual components that are displayed together to produce a visual prompt. Whilst these visual components superficially present as similar elements of an intelligent system they have different relationships to underlying technologies. They include components that are derived by computational means, including speech-to-text and generative AI components, as well as components that infer system intelligence but rely on design decisions unconnected with intelligent systems, and as such act as Wizard of Oz elements. Fig 8 and 9 below show the main components of the visual prompt element of the (ADI) tool.

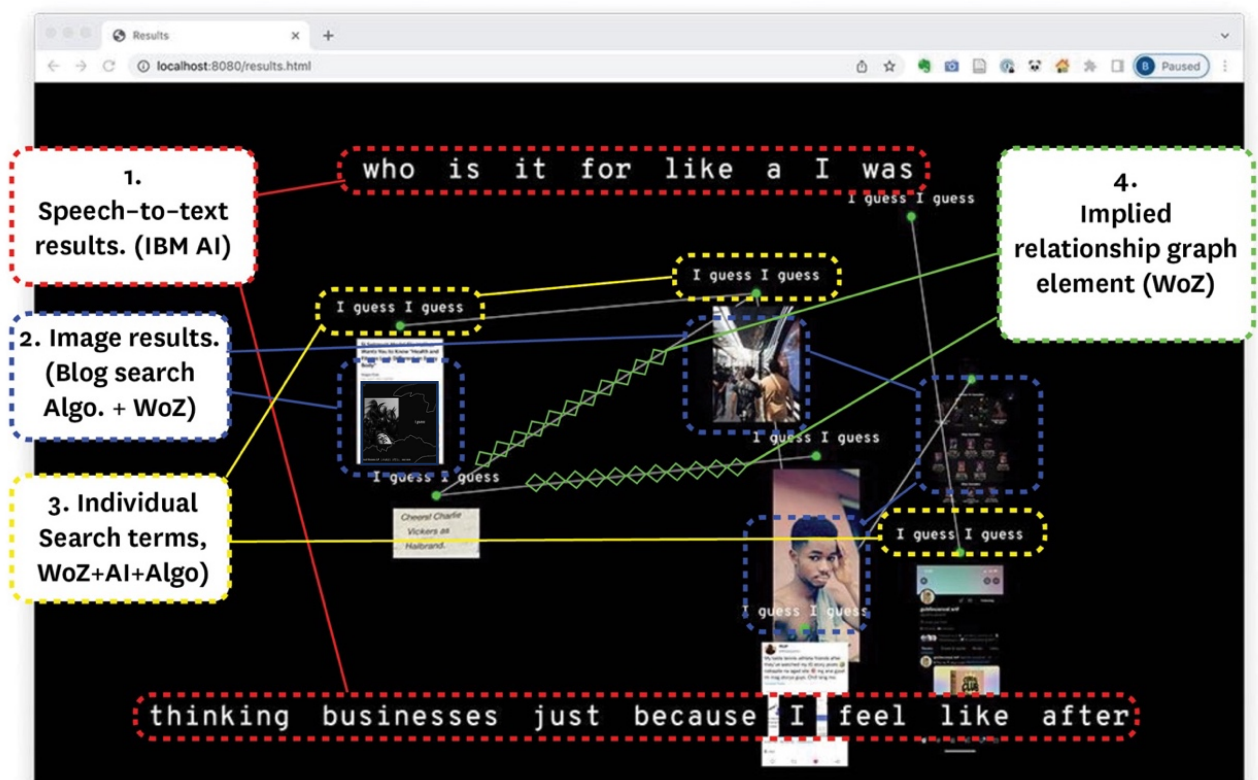


Figure 8.

The diagram is a complex, hand-drawn sketch on a light-colored surface, possibly a table. It features several interconnected elements:

- Central Diagram:** A central area with a green spiral, a yellow circle, and a green circle, connected by lines and arrows. There are also some text labels like "Mileage" and "Year Year".
- Annotations:**
 - A red dashed line with the text "current project involves very little controls" written along it.
 - A yellow dashed line with the text "current project involves very little controls" written along it.
 - A blue dashed line with the text "current project involves very little controls" written along it.
 - A green dashed line with the text "current project involves very little controls" written along it.
 - A red dashed line with the text "current project involves very little controls" written along it.
 - A yellow dashed line with the text "current project involves very little controls" written along it.
 - A blue dashed line with the text "current project involves very little controls" written along it.
 - A green dashed line with the text "current project involves very little controls" written along it.
- Video Player:** A video player overlay at the bottom center of the image, showing a progress bar and a play button.
- Hand and Pen:** A hand holding a black pen with a green eraser, pointing towards the diagram.

Figure 9.
Annotated visual component diagram (Part two)

Component 1. Speech-to-text results. (IBM AI)	This text is delivered by the microphone input, which the (ADI) tool feeds to an online speech-to-text API that returns the text to the prototype. This text is then put into an array and displayed in 10 second chunks as shown. <i>(note: this text is also used as the search query for the images)</i>
Component 2. Image results. Blog search Algo. + WoZ)	This image is delivered by feeding the text generated via component one to a database of associated weblogs and scraping the image from the associated blog post. In this way there is a computational component in this process, but the <i>contextual validity</i> of the image is partly in the domain of a Wizard-of-Oz interface component as it is the result of generic internet search technology.
Component 3. Individual Search terms, WoZ+AI+Algo)	This text is derived from component one above, but its visual association is a Wizard-of-Oz interface component as it placed procedurally by the tool next to the results of generic internet search technology.
Component 4. Implied relationship graph element (WoZ)	These line components link the images in a network graph that implies connection between things. This is a Wizard-of-Oz element that visually associates images arbitrarily. This component aims to promote divergent thinking in the participants by encouraging them to find connections between images and the associated ideas they represent.

Figure 10.
Annotated visual component table

The augmented design ideation prototype combines computational and Wizard-of-Oz components to explore how participants use the tool in augmented design ideation activities as well as specific practices that are associated with design ideation augmented in this way. The (ADI) tool enables a flow of participant action that can be defined here in a Converse, Scan, Connect, Ideate and Hone model as per the table below.

1. Converse	Participants discuss a brief and sketch ideas to mutually explore a design challenge.
2. Scan	The tool displays visual prompts to aid design ideation as described above.
3. Connect	Participants use the visual prompts from the tool to augment ideation sketching and associated conversation and make conceptual connections between visual prompts and their ideation process.
4. Ideate	The tool updates its visual prompts based on the conversation it records. This conversation now contains references to ideas augmented in part by the tools prompts and participants use these updates to move forward in their ideation process as the tool prompts new visual connections.
5. Hone	This cycle repeats with the participants revisiting sketched components, visual and conceptual references from earlier cycles until the ideation session is ended.

Figure 11.
Model of action table

This model, proposed here, conceptualises the augmented design tool as part of a holistic design probe (Gaver, Dunne and Pacenti, 1999) to study augmented design ideation practices within the case studies, rather than as a tool to study the technical efficacy of discrete (technical) approaches.

2.4 The augmented design tool software

This section presents a series of screenshots that document the bespoke software developed as part of the practice element of this thesis and which underpins the augmented design ideation tool. The purpose is to provide a functional overview of the studies and how they were executed alongside a summary of the software products that resulted from the research. The series of screenshots presented below show the workflow for launching the augmented design ideation (ADI) tool and document how the tool's outputs are presented in both live ideation events and in playback mode which replays the ideation event in real time for analysis). Following this, screenshots of code views show key parts of the application to aid comprehension of the basis of the tool and how it functions. These are partial and do not represent a full technical specification.

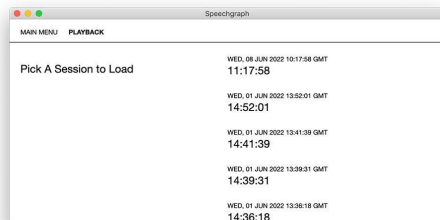


Figure 12.

The dialogue box presented when
playback existing session is selected.

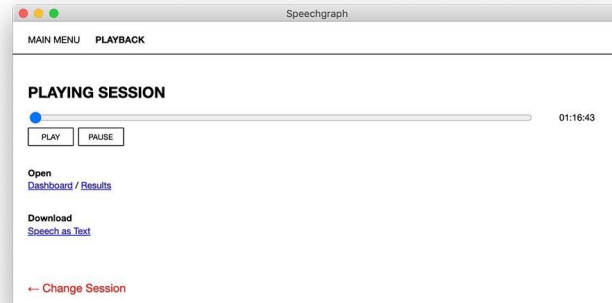


Figure 13.

The dialogue box presented when *a* session is
chosen (Figure 12.) showing options for
scrubbing through the event timeline and
launching the *dashboard* and the image search
results for playback.

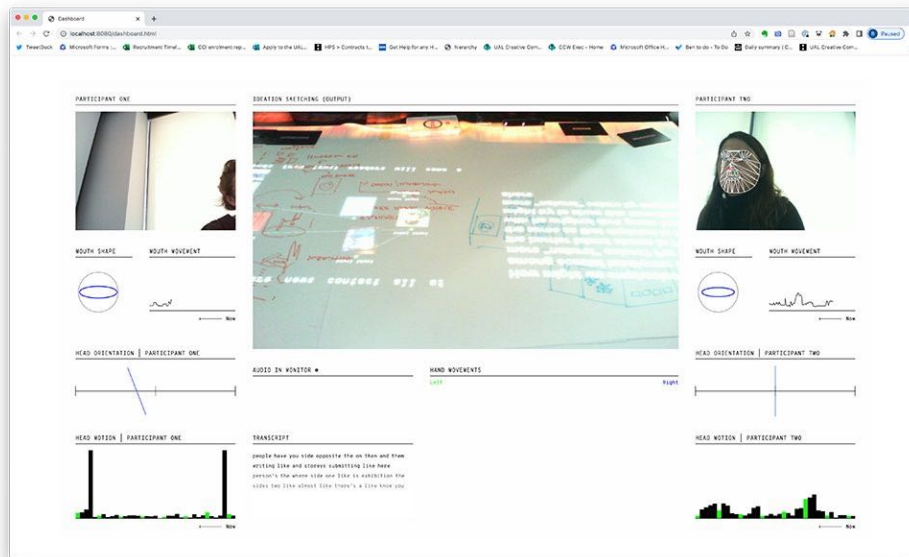


Figure 14. This browser window displays the ADI tool dashboard and shows a live event being captured or an event being played back (Figure 7.).

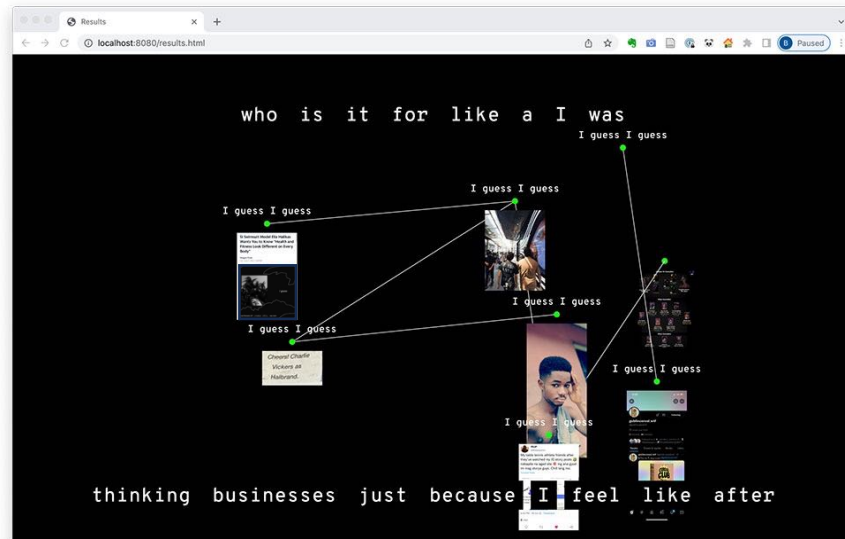


Figure 15. This browser window displays the ADI tool results; in this example a live image graph from a curated image search based on a live ideation conversation from the event has been captured. The image also shows an event being played back, depending on mode selection. This browser window is projected onto the sketching surface during collaborative design ideation events for use as ideational prompts to promote divergent thinking.

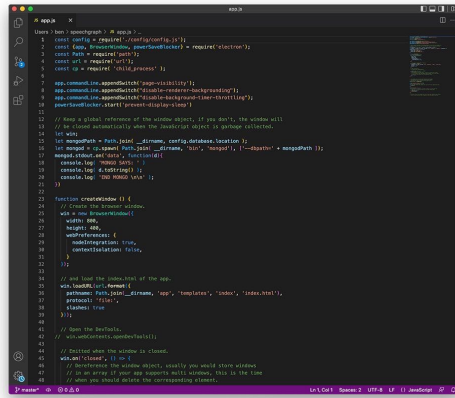


Figure 16. (app.js)
Source code for the main JavaScript application.

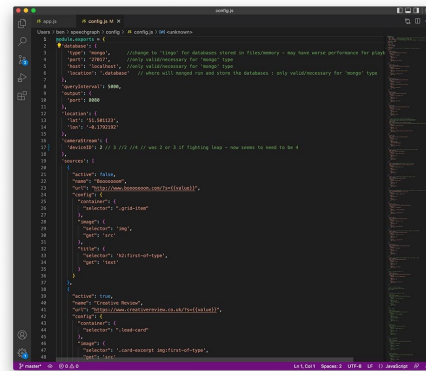


Figure 17. (config.js)
Source code for the configuration file for the application showing sensor and camera configurations and curated web sources for image searches.

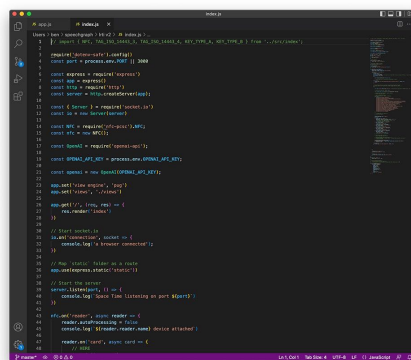


Figure 18. (Dashboard - index.js)
Source code for the *dashboard* page file includes IMB Watson² integration credentials and is also for real-time speech-to-text and face recognition.

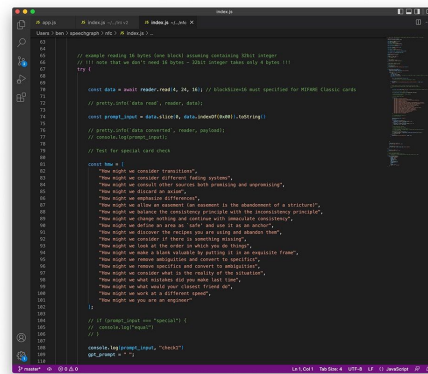


Figure 19. (Results - index.js).
Source code for the final iteration of the *results* page file which includes an integration of GPT-3³ generated prompts developed for Case Study 3.

² 'watsonx, IBM's enterprise-ready AI and data platform designed to leverage foundation models and machine learning' available at: <https://www.ibm.com/watson> (Accessed 10th Oct 2023)

³ 'GPT-3—powered search, conversation, text completion, and other advanced AI features through our API.'

The images above show the software product of the design process that was used to produce an experimental tool for augmented design ideation. Within this tool, there are a complex set of interaction and user experience design decisions across (but not limited to) attributes such as text sizes and image relationships; information design; motion design for results page elements (images and graphs); design decisions regarding pace of change for image results and their effects on design cognition; mitigating sensory overload of users; and tool comprehension based on a variance in any and all of these dynamics. The complexity and interdependence of these decisions are important features within the practice, allowing for the pursuit of design hunches (Leavy, 2010) and the rapid prototyping and testing of experimental computational prototypes.

An outline of the key components of the augmented design ideation tool prototype is presented in the schematic below. The diagram also shows the key relationships between the components.

available at: <https://openai.com/blog/gpt-3-apps> (Accessed 10th Oct 2023)

2.5 Augmented Design Tool Schematic

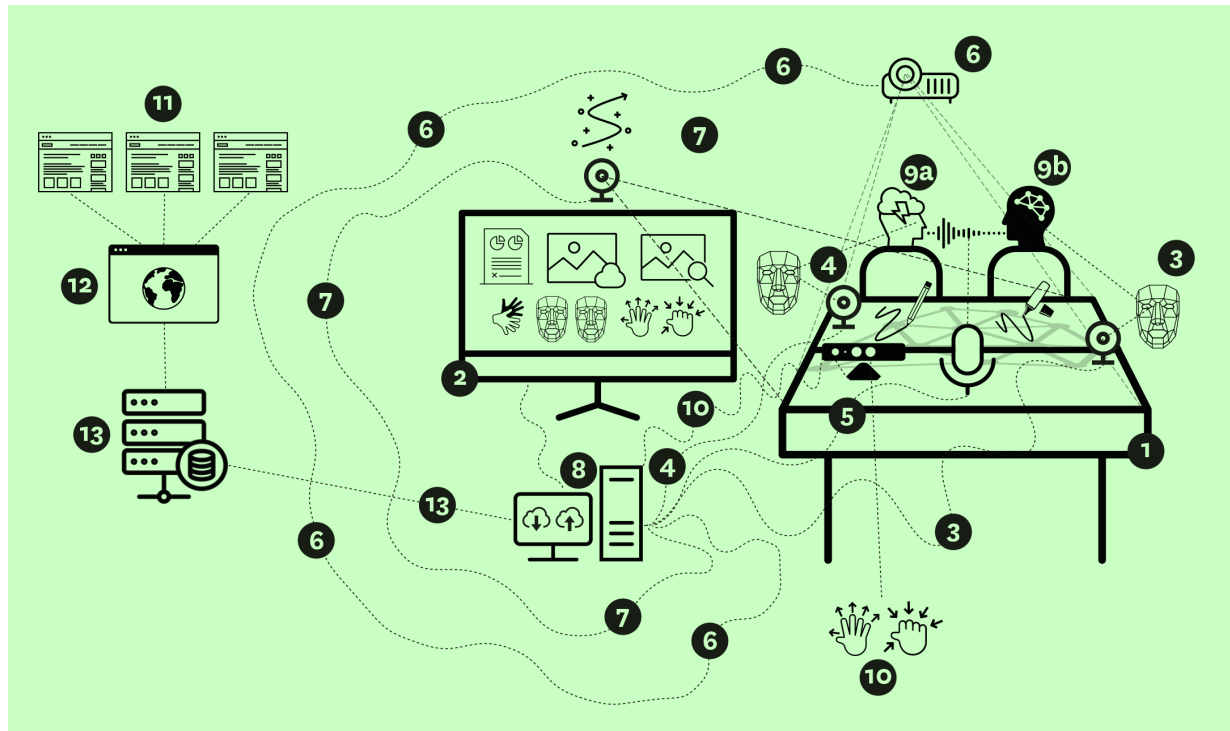


Figure 20. ADI Tool Schematic

A brief description of each of the main components of the Augmented Design Ideation tool is provided below:

1. Ideation notation surface (table/desk). A table for participants to use to sketch notes during design ideation. During the ideation event, live feedback (images, text and visualisation of voice transcription) is projected onto the surface of the table to augment the ideation sketching and conversation processes.

2. Ideation live observation screen (HD/TV). This HD/TV provides a visualisation of the multimodal data that is gathered while the tool is being used along with the results that are projected onto to the table. The visualisation enables the participants to observe the data they are providing to

the system and can also be used by participants as part of their ideation process.

3. HD Cameras gathering multimodal data. These cameras are focused on individual participants and gather face tracking and video data that is used to correlate multimodal data with events during design ideation.

4. HD Cameras gathering multimodal data. (As 3. above.)

5. Microphone for voice recognition and multimodal transcripts. This captures the conversation of the participants and parses it using IBM's Watson Developer Cloud. This, in turn, is used as search query data to provide live feedback to the notation surface.

6. LED Projector. Projection of live feedback (images text and visualisation of voice transcription) to augment sketching during design ideation.

7. HD Camera. Captures live sketching for conversation records and analysis.

8. Mac/PC. This operates as input / output I/O for the system, takes in video and sensor data and runs ideation tools in a web browser and provides the live feedback for projection.

9a, 9b. Participants in the ideation event.

10. 3D Cameras. Capture gesture data. Also, LEAP motion⁴ or Microsoft Kinect⁵ cameras.

11. Data sources. These may include images, text, quotes and diagrams from web pages and social media.

12. Semantic web-pages. These are mined for relevant content by my bespoke curation tools.

13. Curated data sets and curated search tools. In this case these are a selection of design blogs and an approach to searching them based on dialogue.

⁴ 'Purpose-built infrared camera modules' for hand tracking available at: <https://www.ultraleap.com/product/> (accessed 10 Oct 2023)

⁵ 'Kinect is a line of motion sensing input devices produced by Microsoft and first released in 2010.' Available at: <https://en.wikipedia.org/wiki/Kinect> (accessed 10 Oct 2023)

2.5 Prototype: initial development

The initial development of the augmented design ideation tool consisted of prototyping a series of web scraping tools, information design approaches and frameworks, as well as user testing with motion capture using 3D cameras and the integration of text-to-speech tools. The following images document some of the initial prototyping approaches that were conducted during the early development of the augmented design ideation tool, prior to Case Study 1.



Figure 21.

Initial experiments showing live information graphs of sensor data using the D3 web framework (Figure 22 below).

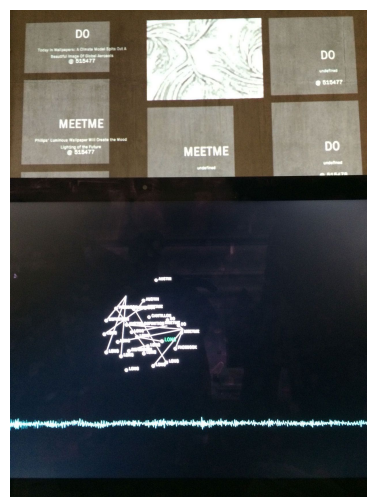


Figure 22.

Initial experiments showing initial experiments for live word clouds bases on IBM speech-to-text AI tool (Figure 23 below) and the first iteration of the custom web scraping tool for the projected image results from the tool.

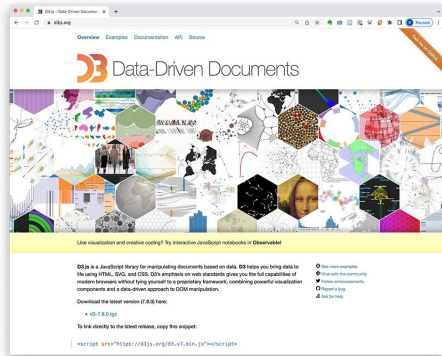


Figure 23
D3 web framework
(Bostock, 2023)

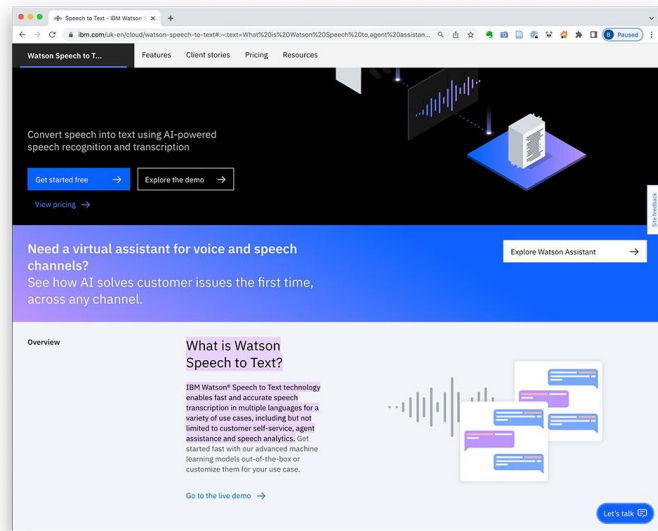


Figure 24
IBM Watson speech-to-text AI tool
(IBM Watson Speech to Text, 2023)



Figure 25
Initial experiments showing live information
graphs of sensor data using the D3 web
framework (Figure 22 Above)



Figure 26
Initial experiments showing the test of image
projection in an ideation setting



Figure 27 Early setup of the ADI tool testing initial prototypes to test spatial interaction.

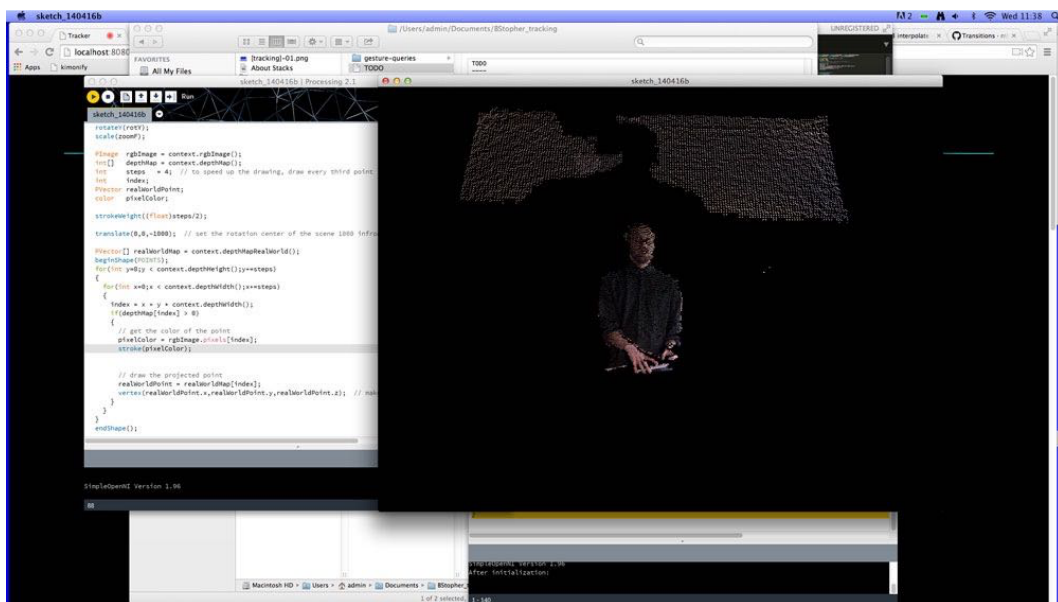


Figure 28 Screenshots of the early prototype set-up that used a Microsoft Kinect camera and the Processing framework developed by Daniel Shiffman (Figure 29, below)



Figure 29 Photograph of an early augmented sketching test showing projected image prompts and a LEAP motion sensor being used to capture hand movements (Figure 30 below).

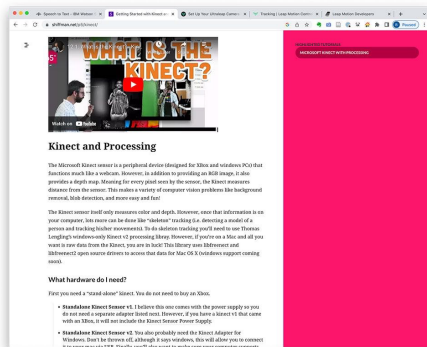


Figure 30

Processing framework developed
by Daniel Shiffman

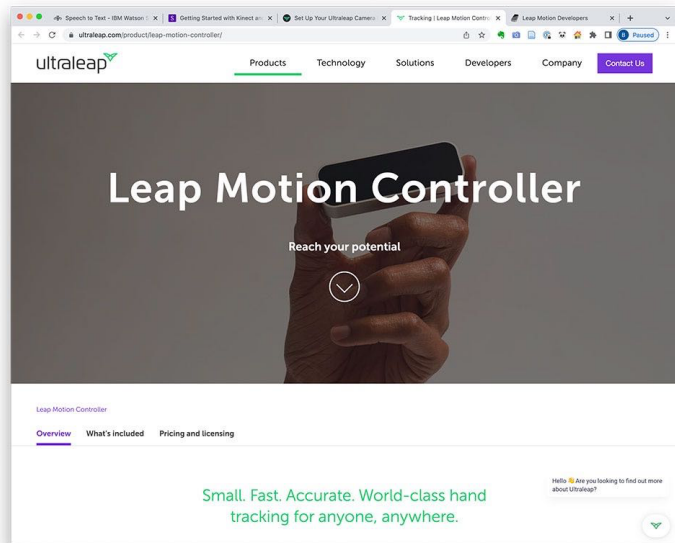


Figure 31

LEAP motion sensor tools website

The development of the ADI tool involved aspects of visual and information design, web development and interaction design, and the use of various computational tools and frameworks. Of note is the assemblage of computational tools and frameworks that was established to capture multimodal data which, at the time of this prototyping, were becoming commonplace, being packaged for designers and developers to use in experimental ways.

2.6 Prototype development: Case Studies 1 and 2

As the initial design work progressed, certain features, approaches and technologies were integrated into the prototypical augmented design ideation tool. A key aspect of this process involved understanding the data that was produced by the ADI tool. Case Study 1 included a pilot study in which the ADI tool's features were defined and iteratively developed. The images below document some of the user testing and ideation events that were conducted during Case Studies 1 and 2.

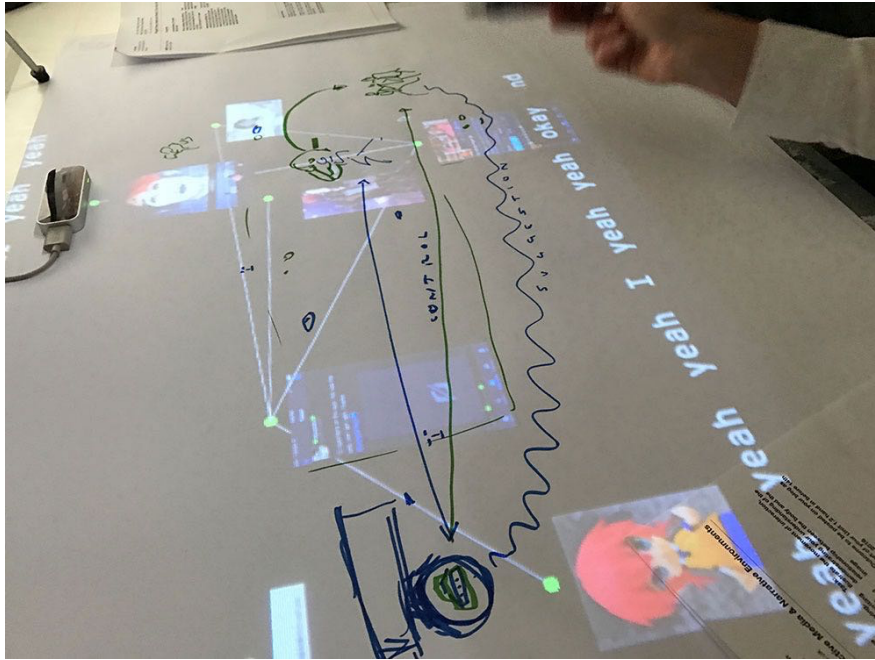


Figure 32 Photograph of an augmented sketching test carried out during the pilot study showing projected image prompts and a LEAP motion sensor being used to capture hand movements (Figure 33 below).

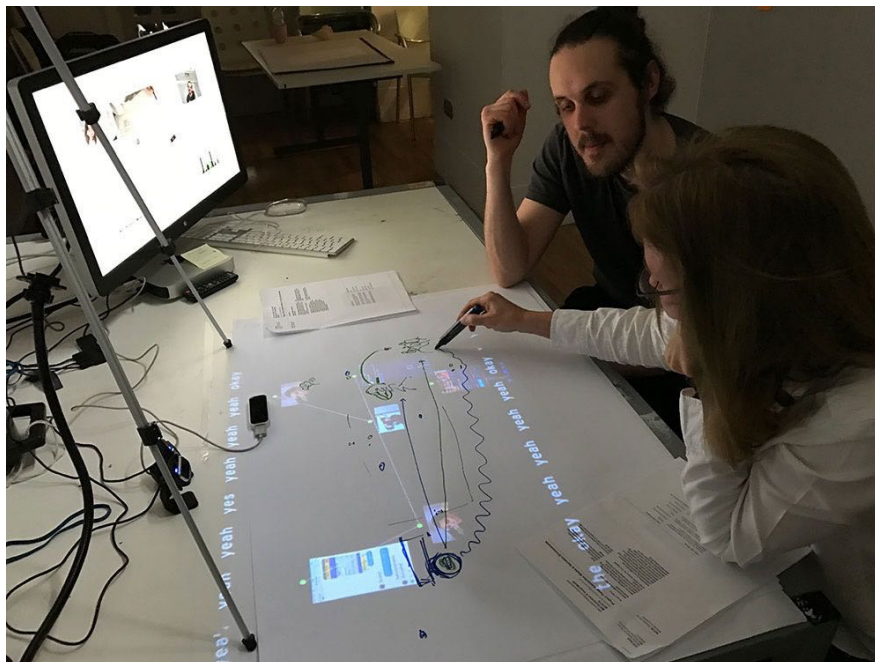


Figure 33 Participants use image prompts in ideation sketching activity.



Figure 34

Initial experimental projection set up
in pilot study.

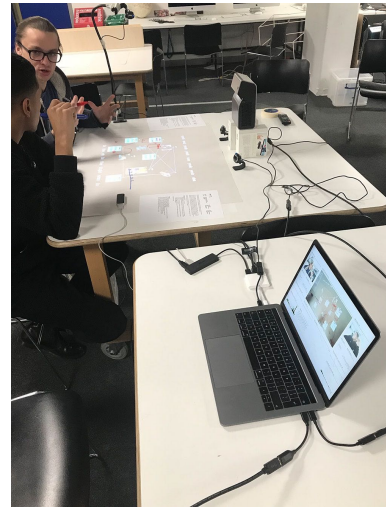


Figure 35

Final projection and tool setup from later
in Case Study 1 using a short throw
desk projector.



Figure 36

Ideation event in progress from Case Study 1
with the ADI tool dashboard displayed in the
laptop screen.

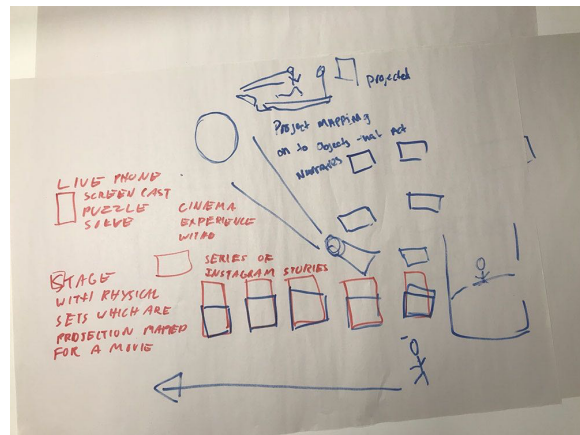


Figure 37

Augmented ideation sketch from the event
pictured in (Figure 36).

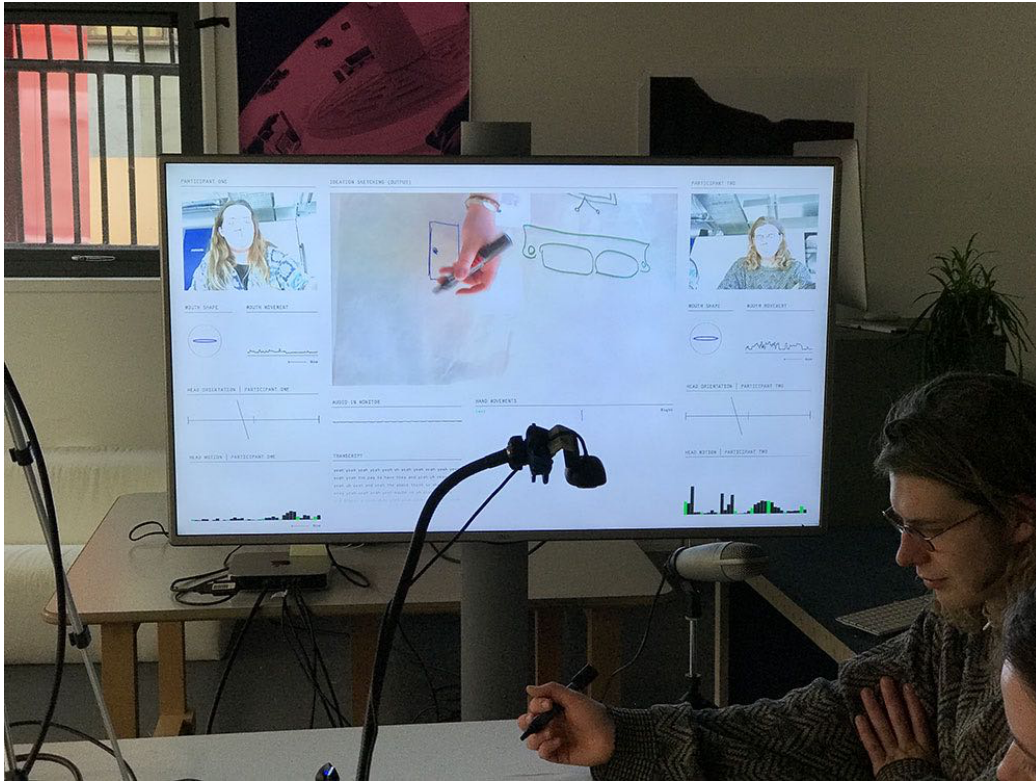


Figure 38 Photograph of an ideation event held during Case Study 1 in which the tool dashboard was made visible to participants.

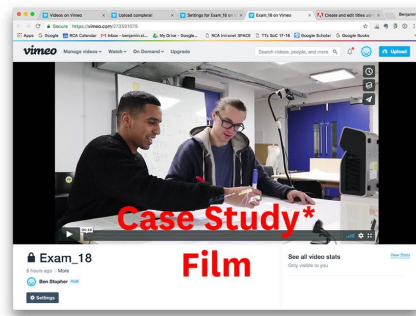


Figure 39

Example video archive of Case Study 1 event.

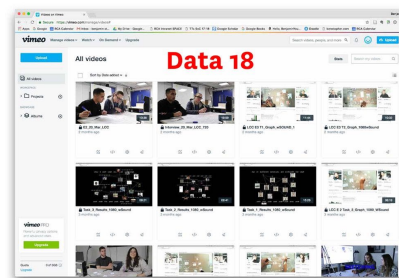


Figure 40.

Example archive of video data from Case Study 1 including *results* and *dashboard* video data. See Figures 41, 42 below.

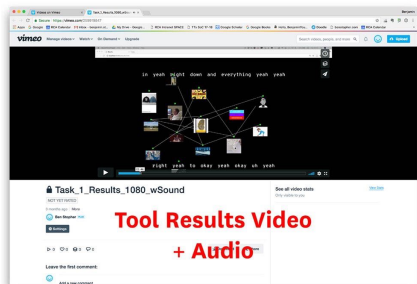


Figure 41

Example video archive of *tool results* data.

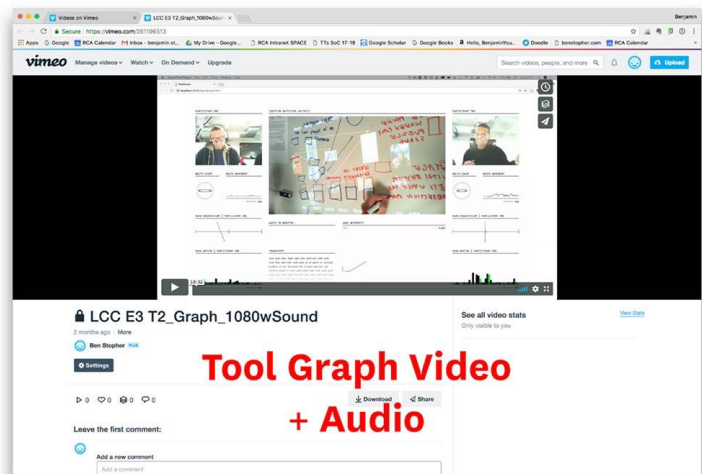


Figure 42

Example video archive of *tool dashboard* data.



Figure 43 Documentation of an ideation event held with design studio Superflux as part of Case Study 2 showing a developed version of the design ideation tool.

The augmented design ideation tool that was developed during the pilot study was used in both Case Studies 1 and 2. Notable design milestones within the pilot study included: spatial UX enabling augmented sketching with desk projection; gesture capture and audio capture in a relatively portable and adaptable setup; finalising the interface design of the tool including dashboard and results components to enable their use in live ideation events; and the final visual motion design decisions to facilitate live presentation of image prompts.

This iterative design process also enabled experimentation with the raw data produced by the tool and the place of this data in the research. This process is described within the methodology chapter. Methodological findings regarding the production of multimodal texts and experimental ethnographic methods are detailed in the chapter 9.

2.7 Prototype development: Case Study 3, generative AI

The augmented design ideation tool was further developed for Case Study 3, based on the findings of Case Studies 1 and 2, to include AI generated text prompts using OpenAI's GPT-3 (OpenAI API, 2021) AI framework and Near Field Communication (NFC) enabled (Ok et al., 2010) oblique strategy cards (Eno, 1975; Ok et al., 2010) that delivered the GPT-3 generated text (Floridi and Chiriatti, 2020b) into the augmented sketching environment. These cards can be seen in Figure 44 (label A) below and the resulting text prompt can be seen in Figure X (label B). This part of the research also involved design work on both the new heuristics of AI text prompts and changes to the user experience paradigm of the tool.

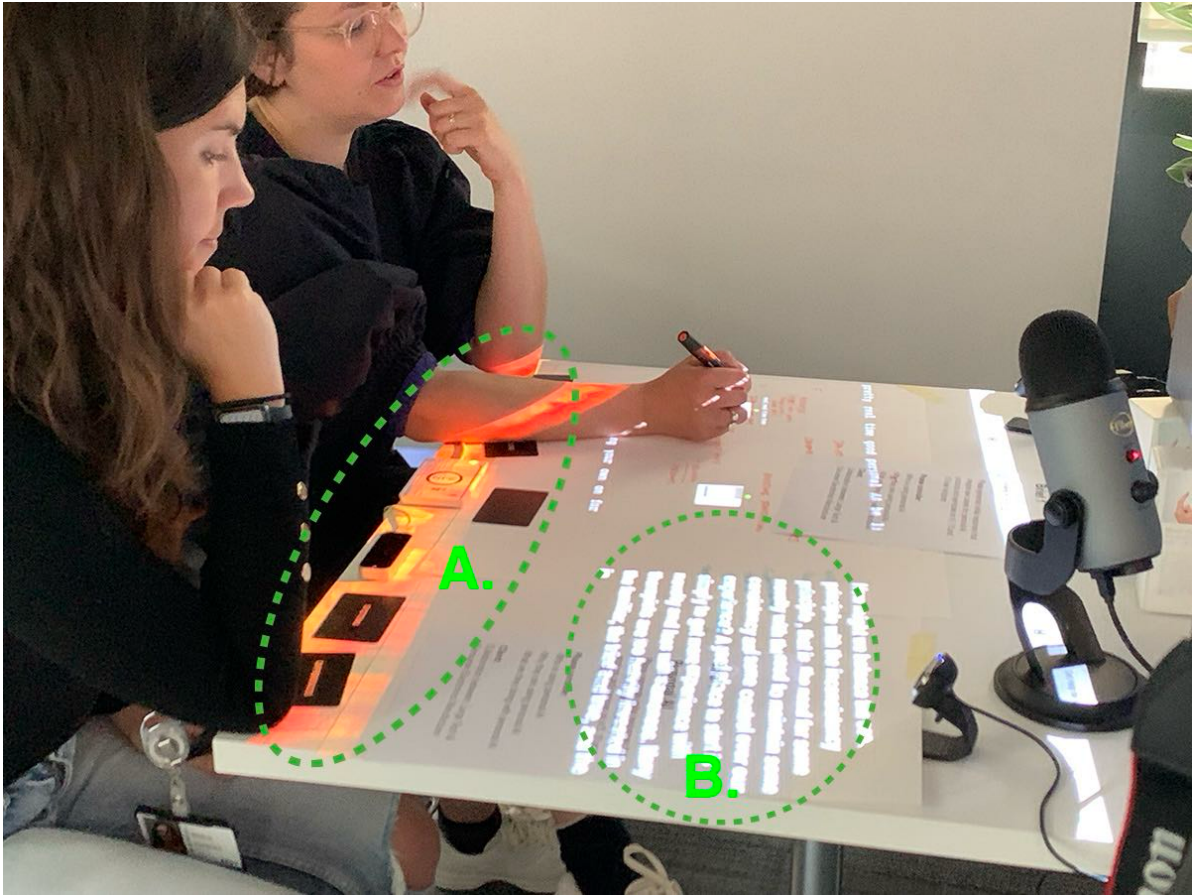


Figure 44 Case Study 3 ideation event showing new NFC AI prompt cards.

Eno and Schmidt's oblique strategy cards (Eno, 1975) were adapted into *how might we* text prompts for use within the ideation event, drawing from IDEO's brainstorming with GPT-3 experiment *The Rules of Brainstorming Change When Artificial Intelligence Gets Involved* (Syverson, 2020). The five-word prompts were labelled on the cards as: Transitions; Systems; Sources; Differences; and Random as explained further in case study three.

Card prompts

1. How might we consider **transitions**
2. How might we consider different fading **systems**
3. How might we consult other **sources** both promising and unpromising
4. How might we emphasize **differences**
5. **Random** (from list below)

How might we list for ‘Random’

1. How might we allow an easement (an easement is the abandonment of a stricture)
2. How might we balance the consistency principle with the inconsistency principle
3. How might we change nothing and continue with immaculate consistency
4. How might we define an area as ‘safe’ and use it as an anchor
5. How might we discard an axiom
6. How might we discover the recipes you are using and abandon the...
7. How might we consider if there is something missing
8. How might we look at the order in which you do things
9. How might we make a blank valuable by putting it in an exquisite frame
10. How might we remove ambiguities and convert to specifics
11. How might we remove specifics and convert to ambiguity
12. How might we consider what is the reality of the situation
13. How might we avoid mistakes did you make last time
14. How might we consider would your closest friend do
15. How might we work at a different speed

16. How might we consider you are an engineer

These prompts were selected and adapted from Eno's collection of over 100 cards (Eno, 1975), based on their relevance to design ideation tasks generally. Eno's cards were originally developed for music ideation during record production, and were later adapted for widespread use in creative ideation practices (Marshall and Loydell, 2016). Some cards were more adaptable than others.

The choice of the *how might we* prefix was also due to the dynamic of working with GPT-3 text generation prompt conventions (Gewirtz, 2023). The generative text prompts were integrated into the study as a basis for exploring how generative elements of rapidly emerging computational systems, including GPT-3, can be used to support design ideation processes.

The participants were instructed, when they felt the need for an extra text prompt, to choose one of the five cards and tap it on the reader to receive a new prompt, as can be seen in Figure 44 (B) above. Figure 45, below, is an example of some of the additional prompts delivered by the augmented design ideation tool.

How might we define an area as 'safe' and use it as an anchor for the interpretation of other data? Are there indications that even the best of us would not be able to interpret data safely? Are there indications that the well-learnt skills in interpreting data may prove to be inadequate or ineffective to interpret data from non-standard sources? The answers to these questions would

Figure 45 GPT-3 generated text prompt.

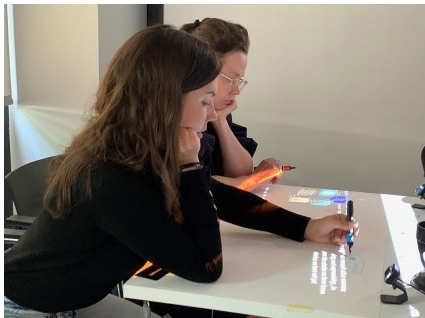


Figure 46

Example video archive of *tool results* data.

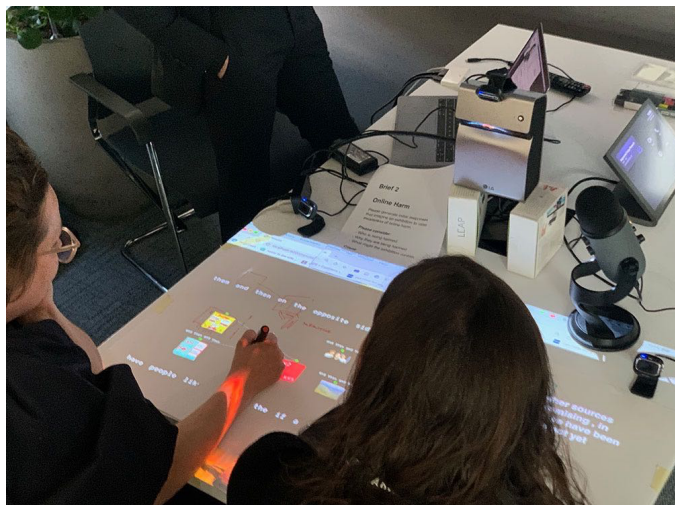


Figure 47

Example video archive of *tool dashboard* data.

As can be seen in this section, the ADI tool was further developed to include an implementation of AI-enabled methods cards that build on common heuristics associated with

card-based prompts in design ideation. This development required significant design work in extending the user experience and interaction design paradigm to include the prompt cards; the temporal design of the call and response interface used for the text prompts; visual design to integrate the text prompts with the image prompts in a way usable by the participants; and further refinement of the overall systems to allow for compatible ideation events to take place in Case Study 3.

The development and testing of the AI enabled aspects of the ideation tool is presented in the Case Study 3 chapter, which also includes a reflection on key findings and the contribution of the tool to exploring the research questions.

2.8 Design Observations and Process Knowledge

During the iterative design process of developing the ADI tool many small design decisions were made. While the design process was carried out in relation to established literature, these decisions also responded to the experience of what does and does not *work* when designing for multimodal interaction with intelligent systems.

2.8.1 Design for cognitive load in ambient systems: The process of designing the prototype included several design revisions associated with managing the cognitive load (Brunken, Plass and Leutner, 2003) of the participants. Design choices were typically made as a result of iterative testing, during which, for example in the pilot study, network diagrams were simplified, iterative cycles between visual refreshes were lengthened, subtle easing motion was introduced to counteract the staccato shock of elements changing in an abrupt manner,

type size was increased to improve legibility and text string length was limited to enable quick visual scanning.

2.8.2 Design for multimodal research: The process of designing the ADI tool also included significant work to design for the multimodal research context. This centred on two distinct areas. The first area focused on capturing multimodal data using arrangements of cameras and sensors while accommodating participants' situated ideation practices. Design approaches in this area included controlling ambient lighting, developing a visual scheme of high contrast elements to enable the use of tabletop projection, and managing ambient sound levels. The second area focused on designing the output of the tool and its relationship to the multimodal transcripts. Design approaches in this area centred on defining an appropriate unit of time (in this case 30 seconds) within which multimodal interactions should be analysed as well as how the elements of multimodal interaction should be presented visually for analysis.

2.8.3 Design for anthropomorphism in intelligent systems: A more unexpected area of design work emerged as a result of observing participants' capacities to anthropomorphise the *intelligence* of the ADI Tool. This is discussed further in the case studies. However, design work in this area centred on highlighting, sources of inference and information. The main approach I experimented with was to *flatten* all visual feedback generated by the tool, with the result being that participants judged all components as being equally *intelligent*. As discussed within this thesis, elements of the tool are not equally *intelligent* and this has implications for the design of trusted systems in the design ideation context.

2.9 Summary and Conclusions

The practice component of this thesis includes a significant programme of design and iteration to research, develop and test experimental computational tools for augmented design ideation. This practice incorporates design experimentation with technology including web tools and frameworks, computer vision and sensing, ambient informatics and spatial interaction, and generative AI. The integration of the design, development and testing of the tool within the programme of action research addressing augmented design ideation is described in the methods chapter.

The practical design, development and testing of the Augmented Design Ideation tool and its application for design ideation and sketching can be differentiated from existing research in the following ways: the ADI tool presents a novel approach to image prompts drawn from an implementation of speech-to-text applications to convert conversation elements into curated web image search; a novel approach to ambient projection of ideation information to assist sketching to support design cognition; and a novel approach to generative AI-based methods cards using NFC enabled cards and GPT-3. This design approach is not present in existing literature concerning computational support for design ideation. It is, instead, a direct result of iterative design development enabled by digital design competencies that have recently become commonplace in design professions.

3.0 Chapter 3: Literature Review, Part 1: Design, Ideation and the Web

3.1 Introduction

This chapter introduces key aspects of design that this research focuses upon and defines the types of associated ideation practices that fall within the scope of the thesis. A key goal, within conceptual design practices and design ideation literature, is often to achieve divergent thinking (DvT). DvT describes thinking that aims for original solutions or, at least, not commonly used solutions. Divergent thinking's relationship with general creativity has been much studied (Baer, 2014) and despite the complexity of this task, DvT and creativity are widely considered related concepts. The degree to which DvT supports the kinds of innovation and creativity encountered within design ideation is also supported by others (Liu, Chakrabarti and Bligh, 2003), although such research indicates that DvT tests often function as proxy measures of creativity in a broad sense (Runco and Acar, 2012). This chapter also explores how prevailing *web culture* and wide-scale digitisation have shaped both design and ideation practices in recent decades and how design research can contribute to an understanding of this process. The chapter also introduces research relating to computational support for creative ideation processes in domains including HCI and discusses how the approach that has been developed within the study presents an original position in relation to these developments. Furthermore, the chapter establishes *augmented design* as a term to cover the augmented design ideation activities that are established within the research and concludes by identifying multimodality as a valuable tool for the study of *augmented design*.

My research is set within a context in which designers have – over the previous 20 years – adopted collaborative digital and web technologies to support their creative practices in significant ways. This context provides the foundational thesis for this study, namely that the heuristics and social reality of digital collaborative and web technologies have changed the nature and scope of design practice. Furthermore, designers have become skilled at building and using assistive tools based on web and consumer technologies. This ability is the result of the design field expanding into areas associated with interaction; the user experience and digital design; and, more broadly, the digitisation of knowledge, work and society (Peruffo, Rodríguez Contreras and Schmidlechner, 2017). This initial context also suggests that there would be significant development of digital assistive technologies for designers and knowledge workers in the short and medium terms (Norman, 2017). As such, the study aims to show how insights from practice-based research undertaken in the design field can offer perspectives important to the development of computational tools for design ideation, which can then be added to the insights generated in related research domains, such as human computer interaction (HCI).

There were two major developments of note in the wider context of the research during the years in which this study was conducted. The first of these developments is associated with the computational technologies that underpin digital assistive tools created for designers. These technologies developed at a rapid pace, introducing novel elements to design practice during the early stages of the research (voice and gesture interfaces) which later became more commonplace (Maeda, 2019). These technologies were accompanied by widespread

development of functional machine learning technologies to produce consumer AI products and services. As a result, considerable discourse has emerged relevant to this study such as, ‘AI biases, ethical design, consumer privacy, cybersecurity, individual autonomy and wellbeing, and unemployment’ (Du and Xie, 2021, p.961; Pasquinelli and Joler, 2021). The second of these developments is the expanding critical context of design practice. Within the period of this research there have been significant developments in the discourse of design research (Fry, 2017; Costanza-Chock, 2020; Mareis, 2020) that reflect the exclusionary and extractive potential of design practice, design thinking and its associated tools and frameworks (Tlostanova, 2017). The consequences of these developments for research that seeks to explore digital assistive technologies for designers is also addressed within the literature review.

In order to explore opportunities for understanding and reimagining assistive technologies for designers, I am specifically interested in augmenting, what has been called, *design ideation*, the ‘matter of generating, developing and communicating ideas’ (Jonson, 2005, p. 613) in our era of ambient *intelligent* devices (Aztiria, Augusto and Orlandini, 2017). Design ideation and creative idea generation practices, more broadly, have increasingly been assisted by collaborative digital and web technologies in the form of web-based mood-board software (Wenzel, 2021), online design communities (Fuge and Agogino, 2014) and, more recently, software with embedded generative AI functionality (*The Best Generative Design Software of 2022*, 2022; Urban Davis *et al.*, 2021). However, research in this context often focuses on what can be technically achieved within a specific use case and not on the broader design environment within which the technology has been applied (Llach, 2019). To address this

gap, the research questions are constructed to explore which characteristics of platforms built on these converging technologies might support creativity and conceptualisation in design ideation and how might these change how we practice and think about the activity of design as a networked and socio-technical practice. *Design* in this context is taken to mean the ritualised practice of generating ideas for products, services and communications (Cross, 2007) although, the types of design ideation practices that are addressed within this thesis can also be applied within broader practices of design outside these immediate areas.

Furthermore, and through critical discussion, this research also considers what these approaches might mean for current concerns for exclusion and equity in design ideation given their reliance on the technologies and practices of large Anglo-centric corporations (Noble, 2018a).

My research questions are constructed to investigate, what I term, ‘augmented design ideation’ in order to understand the potential and effects of the technological convergence described above. This understanding will be useful to those developing these technologies, to those using these technologies, as well as to those studying or speculating about their broader impact in design and society (Müller *et al.*, 2017).

3.2 Design ideation and digital tools

The term design ideation has grown in use in parallel to the growth of the globalised design industries and is now a relatively common term in design literature. Google’s Ngram tool can be used to analyse how the phrase starts to gain traction in the early 1980’s, seeing an early peak around 1990 before a significant uptake from the mid 90’s to the present day (Google

Ngram Viewer 'Design ideation', no date). A highly relevant Design Issues paper regarding the development of a Hybrid Ideation Space (HIS) describes, 'By ideation we mean the initial idea generation at the onset of the conception of a design solution' (Dorta, Pérez and Lesage, 2008, p. 123). However, the most analogous description of design ideation for this research is offered in Ben Jonson's Design Issues paper, *Design ideation: the conceptual sketch in the digital age* (Jonson, 2005, p.613). Jonson substantially builds upon the work of Fowles (1979) by describing a more contemporary context where information technologies present new situations of design ideation. In this context, design ideation is considered a nexus of design processes that coalesce around the generating, developing and communicating of ideas. In practice, design ideation has been thought to involve assistive technologies prior to the arrival of personal computing as well as afterwards, considering assistive technologies on a spectrum from pencils to iPads. Recently, this has developed further to include more computational components as specific technologies, such as generative AI and voice recognition, have become embedded in design processes and in the daily lives of designers. Jonson (2004) identifies *freehand sketching* as being a key component of design ideation in this context following the trajectory of the work of others (Schon, 1984; Cross and Cross, 1995; Goel, 1995; Suwa and Tversky, 1997; Plimmer and Apperley, 2002; Bilda and Demirkan, 2003; Gero, 2014). Jonson also notes how the effects of computer-aided design on design ideation remained understudied during the early 2000s (Jonson, 2004). This underscores the context of my research which addresses how emerging technologies have evolved to augment design ideation since this time. Johnson also identifies the practice of sketching – augmented or not – as a foundational externalising practice of design ideation. Johnson explains the need for externalising practices such as sketching as foundational to

design ideation as ideas that remain in one's head cannot be shared and developed.

3.3 Sketching, ideation and computers

Existing studies on the efficacy of sketching with computational systems have tended to focus on specific tools that are used to generate formal design patterns (Stones and Cassidy, 2007), patterns being adaptable modular solutions that can be remixed for common design tasks in well-defined problem spaces such as furniture arrangement in a room. The Hybrid Ideation Space (HIS) developed by Tomas Dorta (Dorta, Pérez and Lesage, 2008), for example, attempts to create an environment more conducive to ideation by supporting continuous forms of reflection within computer-aided design (CAD) processes:

Ideation is still done with traditional analog manual tools because current computer interfaces are inconsistent with the needs of designers. The Hybrid Ideation Space (HIS) was developed to respond to this lack by augmenting analog tools with digital capabilities respecting the designer's needs for uninterrupted reflective conversation with the representation that should, in turn, enrich ideation. (Dorta, Pérez and Lesage, 2008, p. 121).

The model of CAD explored by Dorta is based around industrial design approaches and focused on the development of spatial representational tools that facilitate ideation in this context. Dorta's HIS struggles to move beyond the formal concerns of shape, texture and size to the conceptualisation and problem forming stages that are part of design ideation processes across design disciplines. Dorta's industrial design approach to ideation can be seen in the images below. They provide a useful comparison for the spatial properties of my research,

which supports a broader notion of design cognition beyond the formal properties of a well-defined object or situation.

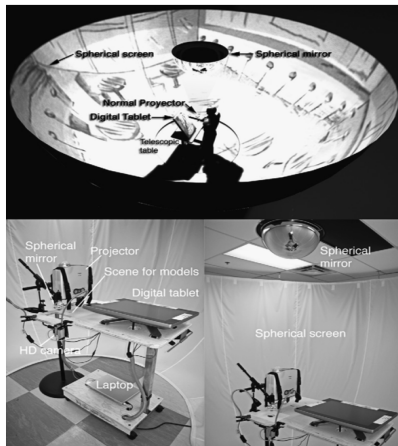
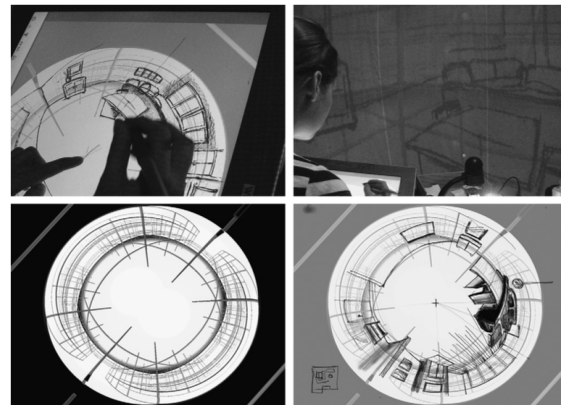


Figure 1 (left) - The Hybrid ideation space | Figure 2 (right) - Immersive sketching in action – spherical graphical template – spherical sketch (Dorta, Pérez and Lesage, 2008, pp. 126–7).

Dorta's study does however identify computer-supported design ideation as an undeveloped research area, stating, 'In design, the ideation gap is the void of relevant digital support when it comes to generating new ideas' (Dorta, Pérez and Lesage, 2008, p. 121). This highlights the lack of research concerning computationally supported ideation, and the lack of amenable technologies for doing so, at the time the HIS was developed.

Since Johnson and Dorta, the study of design ideation and associated technological approaches has also kept pace with technological development more widely, as can be seen in several studies published within the Design Science Journal. (Gonçalves, Cardoso and Badke-Schaub (2016, p.2) investigate, '...designers' approaches to the selection of

external stimuli for inspirational purposes’ , which is relevant in that the tools developed here present computational approaches to this problem and their effectiveness will be correlated to the approaches they explored. Papalambros (2015) describes Design Science as a discipline that ‘ studies the creation of artefacts and their embedding in our physical, psychological, economic, social and virtual environments’ . Hay *et al.*, (2017) conducted a *Systematic Review of Protocol Studies on Conceptual Design Cognition: Design As Search And Exploration*, which contains important insights about the role of information search in the design process relevant to the augmented design ideation context. Camburn *et al.*, (2017a, p.1) explore prototyping in a way that emphasises the importance of place and how prototyping is ‘ interwoven with nearly all product, service, and systems development efforts’ . Although none of these studies directly explore augmented design as described in this research, they nevertheless provide important insights into specific elements of augmented design environments.

3.4 Design ideation and creativity

Researchers have long been interested in how computers support creativity. Candy (1997), working in the late nineties, explored how creativity research informs the development of tools for ‘ knowledge, visualisation and collaboration (Candy, 1997, p.3). Candy also identified concept generation in design as a specific instance of knowledge work that ‘ cannot be easily handled in current computer systems’ (Candy, 1997, p. 4). This is opposed to knowledge work sufficiently bound in scope to benefit from a computing environment that

served information from static sources that simply swapped the filing cabinet for the hard drive. She states, ‘Where experiments into creative thinking have been carried out, the impact of the materials used have proved to be influential in making differences to the outcome’ (Candy, 1997, p. 5). This finding resonates with my own study in exploring the effects of the new kinds of materials represented by current technologies, tools and platforms. In their work, Gabriel *et al.* (2016) and Frich *et al.* (2019) describe the current state of emerging creativity support systems:

In today’s globalised competitive context, organisations need to maintain their competitiveness by regularly generating new ideas, new products or services, and new processes. Globalisation also requires remote collaboration and extensive use of digital devices, as creativity is becoming a collective process. (Gabriel *et al.*, 2016)

Their research examines how design activity within globally competitive organisations can be seen as a primary site of a mediated collective process. Their study ‘focuses on digital systems that support creativity during conceptual design and innovation initiatives and, more specifically, innovation approaches that involve teams, such as creative workshops’ (Gabriel *et al.*, 2016, p.1). In their paper, they identify four categories of studies that have been undertaken in the area of creativity support systems, ‘(1) to determine how creativity is associated with personal characteristics (personality traits, cognitive ability); (2) to examine the cognitive and social processes that are involved in creativity; (3) to foster ideational creativity by means of computer tools; and (4) to identify the environmental factors that nurture or inhibit creativity’ (Gabriel *et al.*, 2016, p.2). As argued by Bonnardel and Zenasni

(2010) and Sugimoto, Hosoi and Hashizume (2004), the study of digital systems to support augmented design ideation and creativity is incomplete. My research addresses this gap explicitly. Gabriel *et al.* (2016, p.5) also consider differences between the related concepts of ‘innovation vs. design vs. creativity’ in their research. In my own study, I broadly accept their premise that, ‘the most common definition of creativity is the ability to achieve a new and adapted production of concepts’ (Gabriel *et al.*, 2016, p. 5) and that ‘creativity is a balance between concept novelty and usefulness’.

There are other distinct facets of design ideation and its relationship to creativity that are important for this research, including divergent thinking and the social context of design ideation activity. These interrelated ideas and practices are important as they provide a scaffolding for the production of material artefacts and prototypes, and a framework to evaluate ideation tools and processes as a social activity.

Divergent Thinking (DvT) is significantly related to efforts to promote ideational creativity in the well-established field of creativity studies (Runco, 2010). This research builds upon this work, extending it to the specific context of design ideation and, therefore, uses DvT as an indicator of the efficacy of the augmented design tools that have been developed within the study. Creative iteration, meaning the ability to produce many *design ideas* in a *design process*, has also been identified as a *divergent process*, part of DvT in the design context (Chan and Schunn, 2015). This study builds upon the work of these authors and accepts that augmented design tools should promote DvT and, in particular, provide scaffolding for rapid

creative iteration involving ‘far combinations’ of source concepts in a manner shown by Chan and Schunn (2015, p.104) to ‘highlight the importance of iteration for generating creative concepts’. Far combinations describe ideas that connect seemingly unconnected things in novel ways, with the analogy of distance being a proxy for perceived relatedness. As such, my own research proposes that the scope of any design ideation activity is partly related to the amount of divergent thinking it involves and that computational tools can aid DvT by co-relating semiotic resources of design ideation in real time. My research explores how computational support can provide greater opportunity for creative iteration with combinations of concepts and ideas being promoted by the additional stimulus of the types of augmented design tools that have been developed in my study.

3.5 Cognate tools and recent further examples

Further prior work relevant to this research identifies creativity support systems (CSS) (Palleis et al., 2013; Gabriel *et al.*, 2016), and specifically CSS which engage with concepts including creative ideation and divergent thinking. The 2013 University of Munich Department of Computer Science Media Informatics Group’s *Beyond the Desktop* (Palleis et al., 2013) report finds a significant amount of cognate work using experiential interface prototypes to support creativity in a variety of contexts. More recently, Gabriel *et al.*, (2016) undertook a further relevant systematic study of experimental creativity support systems. Relevant examples identified in these studies include *ilounge* which ‘focuses on the concept of representations produced in the context of collaborative design’ (Artman *et al.*, 2005) and *Momentum*, ‘a tool that elicits topic-oriented responses prior to a group brainstorm’, which

‘found qualitative differences in task focus, quality and rate of ideation, and efficiency of storytelling between users and non-users of the tool’ (Bao *et al.*, 2010). Furthermore, this study also identified the development of web platforms to support creativity, innovation and ideas development. Two prominent examples, Cognistreamer⁶ and InnovationCast⁷, indicate the potential of web services in this context, demonstrating how web platforms are seen by researchers in cognate projects as having value in creativity support systems in specific ways, such as providing repositories of visual reference useful in ideation to support design cognition.

Gabriel *et al.* (2016, p. 26) also show that efforts to develop collaborative CSS tools typically bifurcate into two dominant types: (1) web-based tools that support collective collaboration but are accessed by typical – although occasionally novel – web-based interfaces and (2) tools that support individual collaboration at the level of people interacting physically. Examples of the former include the Idea Expander project (Wang, Cosley and Fussell, 2010, p.1), which retrieves pictures based on text chat and aims to produce ‘a tool to support group brainstorming by intelligently selecting pictorial stimuli based on the group’s conversation’; and the Idea Storming Cube (Huang *et al.*, 2007, p.1), which gamifies design ideation and ‘works like an online poker game requiring 2 to 6 participants’. Examples of the latter include the MemTable from the Fluid Interfaces Group at MIT which is ‘an interactive tabletop system that supports co-located meeting capture and asynchronous search and review of past meetings’ (Hunter *et al.*, 2011).

⁶ <http://www.cognistreamer.com/about/> (Peter, n.d)

⁷ <https://innovationcast.com/product/> (‘Innovation Management Software • InnovationCast’, no date)

More recent studies that document research in neighbouring areas of HCI can be seen in Frich *et al.*'s work (2019), which offers an account of the field from within HCI. This research identified 286 creativity support tools (CST) and a subset of 43 papers which presented a prototype tool between 2015-2018.

One further notable example of a highly cognate research project that was completed contemporaneously to this study is *ImageSense: An Intelligent Collaborative Ideation Tool to Support Diverse Human-Computer Partnership* (KochJanin *et al.*, 2020). This project presents 'ImageSense, a digital mood board tool that supports both divergent and convergent thinking for visual ideation'. The tool developed in the ImageSense study, however, follows other CSS tools in that its interaction is computer-based, with interactions via a typical screen, mouse and keyboard setup and, as such, does not extend to the ambient augmented context explored in this research.

The *ImageSense* study and the other studies cited above demonstrate that the potential of design ideation to become supported with collaborative software that integrates semantic web technologies and contemporary approaches to AI products and services is an active area of research (Kim, Maher, 2023). They also show that the majority of approaches in the literature do not aim to investigate the augmented context described in this research, relying instead on the typical heuristics and affordances of the personal computer. From a design perspective, this research extends this work in ways that consider the naturalistic practice of design ideation and the potential disappearance of the input-output mechanisms of the personal

computer in the context of ambient *intelligent* environments.

3.6 Knowledge, design practice and the web

In the context of design ideation, it is important to consider where the impetus for using the web as both a computational and cultural resource is derived from. A simple condition to consider is that mass culture has become increasingly indexed online (Porter, 2013) as we have poured our sentiments, visual culture and photographic records onto blogs and social media (Krumm, Davies and Narayanaswami, 2008; Pearce *et al.*, 2020). In this context, our cultural and scientific institutions have also moved to models of open access science communication using similar practices (Kouper, 2010; Rivero Moreno, L.D. 2019).

Furthermore, the developers and users of blogs and social media technologies have created advanced systems of metadata (tagging, markup, page ranking etc.) (Ferrara *et al.*, 2014) to facilitate search and advertising, and have more recently employed machine learning (Alam, Ofli and Imran, 2018; Suganya and Vijayarani, 2018) to assist this process of metadata development and analysis. Approaches for deriving semantic relationships from user generated context has been explored by many researchers including Hsu *et al.* (2015) in *Mining various semantic relationships from unstructured user-generated web data*.

In this research, the kind of data existing online that may be of use in design ideation contexts includes images presented on curated design blogs and websites. Such images have typically been selected by human experts as they present particular values within the context of design. The development of such resources has been described as curatorial labour by Scolere and

Humphrey (2016), labour which encompasses the associated contextual data surrounding the curated data itself in the form of discursive text and semantic features such as titles and subtitles. Surfacing visual references drawn from contextual web data in design ideation environments using experimental tools is a key approach in this study. This approach seeks to leverage online images in curated contexts as described above. In this study, sources that hold such images are commonly design inspiration blogs and other semantically related web-based images sources outside the design domain such as scientific repositories, maintained by universities or scientific institutions. This practice of gathering visual references is a common manual process within design ideation as described by Margolis and Pauwels (2011).

3.7 Ideation platforms and Open IDEO

Attempts to bring the power of the web to the specific case of design ideation can also be seen in the development of digital platforms created specifically for designers within initiatives such as Open IDEO (IDEO, 2022), a web platform developed by the design and innovation firm IDEO. In the following marketing text, the ideology of the open web and, indeed, a deeper Californian ideology – a boosterish vision of free markets disrupting power in a new economy ushered in by the internet (Barbrook and Cameron, 1996) – can be clearly seen in the cultural positioning of Open IDEO (2022):

OpenIDEO is a place where people design better, together for social good. It's an online platform for creative thinkers: the veteran designer and the new guy who just signed on, the critic and the MBA, the active participant and the curious lurker. Together, this makes up the creative guts of OpenIDEO.

To become a place where good ideas gain momentum, OpenIDEO depends on participation — your inspirations, his comments, her concepts, our design process. It's these efforts, these big and small moments of sharing and collaboration, that make this platform a dynamic resource for tackling significant global challenges.

IDEO, a design and innovation firm, developed OpenIDEO as a way to include a broader range of people in the design process through inspiration, concepting, and evaluation.

Notwithstanding the gendered language and hype that disguises a deeply extractivist proposition, values of connectedness and evolution are seen, in OpenIDEO, to be benefits of a platform approach, with ‘constant reference to the larger culture’ identified as a key motivation for participatory designers (Armstrong and Stojmirovic., 2011, p. 117). With this said, there seems to be little regard for how the affordances of the platform and the narrow description of platform users can be reconciled with inclusive design principles (Clarkson *et al.*, 2013) that seek to involve a multiplicity of voices and bodies (Hendren, 2020).

Open IDEO, in this context, can be seen promoting itself as an example of participatory design that responds to the material exceptions that have developed in this area by conflating its status as an *open* internet platform with inclusive participation in the design process. This conflation is problematic as computational heuristics can be highly exclusionary when applied in a design process that applies universal solutions to complex human needs (Park and Humphry, 2019).

As a result, IDEO has to deal with dynamics that prevent or encourage *user* participation, i.e. motivation, authority, arbitration, copyright, and this highlights the dynamics of participation associated with these kinds of platforms. IDEO has attempted to codify some of these dynamics of collaboration on the OpenIDEO platform using a recognition system called Design Quotient (Hajiamiri and Korkut, 2015), which ‘corresponds to how active you are in the inspiration, concepting, and evaluation phases of a challenge. It also measures your collaboration, increasing every time you comment or build on other people’s inspirations and concepts’ (Hatrack M, n.d). This highlights some of the specific computational heuristics of Open IDEO as a platform that encourages a gaming of design process for social capital. This seems incompatible in a truly inclusive and open design process (Micklethwaite, 2017). For example, this gaming of design process for social capital would also seem to facilitate the privilege of self-selection and narrowing of voices (Cansoy and Schor, 2016; Vorsino, 2021) thereby diminishing important and marginalised perspectives.

As seen in the case of Open IDEO, when platform logics of fast-growing internet and social media companies are applied to design ideation processes, these processes inherit and amplify these exclusionary forces in ways which do not complement inclusive design goals. In this context platforms for design collaboration such as Open IDEO have been seen as part of the large ecology of platform capitalism (Srnicsek, 2017) with its problematic corporate agenda. However, more recently there have been efforts to describe platforms outside this critique (Poderi, 2019) in order to frame a more inclusively oriented platform commons for design activity.

3.8 A case for augmented design

As web-based platforms for collaboration have given rise to new material expectations for the design and design ideation process, this thesis proposes a framework of augmentation to describe computational support for a network mediated design process. As such, the term *augmented design ideation* can be thought of as describing the provision of visual prompts to promote divergent thinking via ambient information systems. Just as augmented reality provides an information layer overlaid onto live visual content, through which digital information is blended with what is being seen in a spatially and contextually integrated way (Billinghurst, Clark and Lee, 2015), augmented design can be conceptualised as a live information layer for the design ideation process. In this context, augmented design tools can be thought of as tools for divergent thinking (Acar and Runco, 2019).

This aspect of the research also echoes the historical context for computational thinking concerning augmentation, examining the birth of these ideas in computer science in Douglas Engelbart's famous paper, *Augmenting Human Intellect: A Conceptual Framework* (Engelbart, 1962). In this paper, Engelbart imagined:

An integrated set of tools and techniques will represent an art of doing augmentation research. [...] there are many applicable or adaptable tools and techniques to be borrowed from other disciplines. Psychology, computer programming and physical technology, display technology, artificial intelligence, industrial engineering (e.g., motion and time study), management science, systems analysis, and information retrieval are some of the more likely sources. (Engelbart, 1962, p.71).

Engelbart's description above maps well to the programme of applied research presented in this study in that it is the effects of the products of the research that matter, in addition to the insights gained during the construction of augmentative systems.

3.9 Design ideation and multimodality

Technology-augmented design ideation is difficult to study as it involves complex human activity that relies on expert tacit knowledge, sophisticated interpersonal and human/machine communication (Cross, 2011), and digital technologies that have particular mediating effects (Kalay, 2006; Gonçalves, Cardoso and Badke-Schaub, 2016). This has specifically been studied in the context of embodied interaction (Dourish, 1997) in relevant ways.

How designers undertake design activity has been the subject of significant study. For example, analysis of design activity (Cross, Christiaans and Dorst, 1997; Jonson, 2005) demonstrates how design researchers have adapted tools involving participant observation from cognitive psychology (Dorst, 1995; Shah *et al.*, 2003; Hartson and Pyla, 2019) to develop insights into the special case of *designing*. Approaches for investigating design activity have also been developed in non-design fields including multimodality.

Multimodality focuses on the different communication modes that people use to create meaning. Norris and Maier (2014, p. 22) describe a mode as a socially and culturally shaped resource for making meaning. Image, writing, layout, speech, moving images are examples of different modes. Kress and Leeuwen (2006, p.344) state that modes can also be semiotic. They describe how 'semiotic modes, similarly, are shaped by both the intrinsic characteristics

and potentialities of the medium and by the requirements, histories and values of societies and their cultures.’ Social semiotic multimodality is distinctly different from multimodality in computer science and offers an important way for my research to interrogate augmented design ideation practices alongside the potential of augmented design ideation tools. This is because I am interested in the communication between designers when collaboratively developing design ideas, and how this can be augmented with automated visual feedback in the form of text, images and informatics. In this setting, my research takes a multimodal approach to data gathering, not seeking to explain the nature of the communication but rather attempting to observe its effects on design ideation.

In considering the importance of computational technologies to multimodality, Van Leeuwen states that, ‘Software designers now create the semiotic resources we use’ (Van Leeuwen, 2014, p. 23), acknowledging some of the ways in which networked software resources and platforms can be seen to be changing design practice.

3.10 Creative AI in the context of design ideation

During the timeframe in which this research was carried out, there has been a considerable development in the field of *creative* AI with researchers explicitly exploring how AI tools can support creative processes (Guzdial and Riedl, 2019). This development follows the earlier development of practitioner tools for co-creation such as Wekinator (Fiebrink, n.d) and Google’s Teachable Machine (Teachable Machine, 2021), which have seen wide-scale adoption. Furthermore, initiatives such as Google Artist and Machine Intelligence (AMI)

group (Artists and Machine Intelligence, n.d) have developed around these approaches and technologies. The AMI group has supported projects that explore co-creation involving machine learning. *Precursors to a Digital Muse* (AMI, 2021), for example, asks ‘Can machine learning inspire a writer’s process?’. These projects have catalysed discussions of relevant topics in design research such as *Rethinking Design Tools in the Age of Machine Learning* (Hebron, 2019). These kinds of studies, tools and projects show an expanding domain for co-creation with machines leveraging common and rapidly developing AI tools and frameworks.

It is apparent that the kinds of systems proposed in this research are also likely to integrate emerging AI technologies with existing design practices and cultures. As such, it is necessary to consider the critical and cultural contexts of computational artificial intelligence, which have themselves become distinct fields of interdisciplinary academic study within and beyond design. For example, sociologist Ruha Benjamin argues in her book, *Race After Technology* (Benjamin, 2019), that the logics of internet technologies replicate social division and become part of the production of race itself, whereby race becomes another technology that sanitises the injustice of our modern experience. Senior Microsoft researcher Kate Crawford explores the political and ecological consequences of consumer AI technologies in her book, *Atlas of AI* (Crawford, 2021). Creative AI, as I have described, is another facet of the AI world that Crawford comments upon. Crawford sees AI as a socio-technical phenomena built upon extractive practices, cheap labour and differential labour standards in a globalised economy. In my opinion, Creative AI, has the potential to be co-opted into augmented design tools, though without careful oversight, it also has the potential to

exacerbate forms of extractivism that continue to be associated with AI technologies, laundering the results through the social practice of creativity, whilst, in fact, limiting our creative endeavours due to the fundamentally closed, mechanistic and partial nature of contemporary AI technologies. For me, this framing is powerful but absolutist in nature and as approaches to build *fair* AI emerge (De Cremer, 2020; Feuerriegel, Dolata and Schwabe, 2020), creative AI has a chance to evolve differently. In Dan McQuillan's book, *Resisting AI: An Anti-Fascist Approach to Artificial Intelligence* (McQuillan, 2018), AI technologies are something to be resisted, both politically and functionally. For McQuillan, AI approaches need reframing towards the common good and away from the relentless optimisation so often seen in contemporary commercial contexts. McQuillan's research highlights the power of computational logics in socio-technical phenomena. Considering how augmented design ideation tools could engage more carefully with AI for the common good offers ways for augmented design ideation tools to be developed in more inclusive directions.

Although my research does not seek to investigate the machine learning technologies that are colloquially referred to as 'AI' directly, the properties of such technologies have profound consequences for the kinds of systems and approaches that are developed within my research. The properties of these systems also have profound effects on augmented design ideation practices that engage specifically with such systems.

3.11 Summary and Conclusions

In this first part of the literature review, I described augmented design ideation in broad terms

and examined existing research that relates to augmented design ideation today. I have identified how design ideation practices, such as sketching, are known to aid design cognition and how others have sought to support this process with computational tools in comparative studies. Furthermore, I have identified how broader concepts of support for creativity relate to design ideation practices generally and how my research develops a unique approach within this field. I have also explored why web tools are thought to be a valuable yet contested form of support for augmented design ideation efforts and the resulting expectations that have grown up in collaborative design practice from the development and use of such tools. Furthermore, this chapter identifies multimodality as a viable ethnographic approach for my research. Lastly, this chapter also introduces aspects of the rapidly developing field of creative AI that are relevant to my research. Creative AI has significant implications for the future context of augmented design ideation research, presenting new critical dimensions associated with the field of AI studies and, in particular, its intersection with developments in design studies that concern fairness and inclusion.

This chapter also identified gaps in the literature to which my own research can make a contribution. These include formal/technical and critical elements, and I will briefly describe these in turn. Regarding the formal/technical gaps in the literature, no comparable studies were found to examine the ambient projection of image prompts into the design environment in the way that is examined in my research, and no other comparable studies exploring the use of speech recognition as search queries as investigated in my research were identified either. As such, this study offers a novel convergence of common technologies to support design ideation practice. The study shares some common features with other studies, but as it

focuses on design ideation, the findings presented in the thesis are original. Considering the critical gaps in the literature, the review above identifies the intersection of computational fairness and design justice approaches to be a significantly understudied area, particularly when considering the *world building* (Coulton, P., Lindley, J.G., Sturdee, M. and Stead, M., 2019) function of corporate design industries to produce socio-technical environments when working at scale. This area has been identified as needing further exploration and the second part of this literature review focuses on this critical context and its associated implications for the research and practice of augmented design ideation.

Considering the work identified above, it is clear that the kind of augmented design ideation presented in this research, builds on work that has speculated about how now common technologies would produce the kind of augmentation demonstrated in this research. It also demonstrates that studies that explore these ideas have often been technology focused while the research presented here aims at a broader applied understanding of the phenomena of augmented design ideation in a contemporary social and technological context.

4.0 Chapter 4: Literature Review, Part 2: Critical Contexts

4.1 Introduction

The critical contexts of design and technology research have developed significantly during the period of my Doctoral study. These contexts are intimately related to the design, testing and development of augmented design tools, including those that are investigated within my research. In this part of the thesis, I consider some of the main critical contexts that are relevant to my study.

4.2 Western centrism in design practice

Awareness of just how problematic dominant western centric corporate design practices have become has had a significant effect on design discourse in recent years. In their book, *Design Justice* (Costanza-Chock, 2020), Sasha Costanza-Chock explores the relationship between design, power and social justice and offers a powerful critique of dominant cultures of universalist design, including those in which design ideation has been largely codified. For Costanza-Chock, and many others, ‘universalist design principles and practices erase certain groups of people—specifically, those who are intersectionally disadvantaged or multiply burdened under the matrix of domination (white supremacist heteropatriarchy, ableism, capitalism, and settler colonialism)’ —and invites readers to ‘build a better world, a world where many worlds fit’ (Costanza-Chock, 2020, [no pagination]).

Costanza-Chock's research proposes that intersectionality should be considered within the development of all computational systems, including systems that are intended to be used to augment design ideation. These systems require attention to better understand their potential to exclude marginalised voices and compound the existing privilege of typical systems developers. This would involve examining how the component technologies in such systems may exclude or empower a diversity of individuals. In these instances, such systems ultimately empower or exclude through their design, development and use while also adding to the values of the design process within which they are ultimately integrated. Furthermore, questions such as who builds these systems and what norms the systems reproduce, would be key to understanding how the development of such systems' might contribute to a design justice agenda. For example, it can be assumed that if these systems reproduce many of the problematic correlations identified in common image search technologies (Otterbacher *et al.*, 2018), then those systems are likely to reinforce gender and body stereotypes and, therefore, have the potential to exclude and discriminate against people in subtle and powerful ways, particularly if they are applied within universalising design processes. Furthermore, if such systems are built on top of flawed and/or biased combinations of computer vision and machine learning technologies, then the potential of such systems to negatively impact people is high. In her book, *Algorithms of Oppression* (Noble, 2018b), Safiya Noble describes how search engines reinforce racism by perpetuating harmful stereotypes on a vast scale; this is highly relevant when considering systems that use internet image search technology. Costanza-Chock (2020, p.6) also describes design justice as a practice of design which centres communities and 'uses design to sustain, heal, and empower'. The author goes on

to say that design justice pays special attention to community and folk knowledge rather than seeking solutions that render value in a capitalist mode. The degree to which the types of augmented design tools that are investigated in this research can serve such an agenda is both a matter of their production and their use. Augmented design tools that respect knowledge or image corpus drawn from local communities have the potential to aid inclusive design processes (Huybrechts, Teli, Zuljevic, and Bettega, 2020). However, augmented design tools that exclusively mine internet sources unrestrained typically fail to respect the design justice principles that Costanza-Chock et al have defined (Costanza-Chock, 2018; Denton, E. *et al.*, 2021).

In *Design Justice*, Costanza-Chock (2020, p.40) also examines the ‘affordances and dissaffordances of socio-technical systems’ which, in the context of design, also concerns the potential role of designers in ‘reproducing the matrix of domination’. This, and similar critiques of design practice, have led to design research efforts exploring more inclusive approaches. One such example is a design toolkit developed by Bray *et al.* (2022) called *Radical Futures: Supporting Community-Led Design Engagements Through an Afrofuturist Speculative Design Toolkit*. These efforts point to the fact that any design process has a set of socio-technical forces acting upon it that greatly affects its ability to be inclusive; this is true of the systems that are the subject of this research. In the context of professional design activity that forms the context of this study, the network of power relationships that has drawn a set of people with distinct economic and educational privilege into a room to use a socio-technical system also potentially places those designers in a position to reproduce the

matrix of domination (Costanza-Chock, 2018). Compound effects, such as the interplay of geographic concentrations of design industries, producing both expert users and expert technology, form a broad problem for inclusivity in research that considers how diversity in experimental socio-technical systems can be promoted and supported.

4.3 Do artifacts and datasets have politics?

The politics of designed objects and material culture have long been considered by academics and practitioners. For example, Langdon Winner's (1980) widely cited paper, *Do artifacts have politics?*, makes a compelling case for the existence of political and racist objects. Winner examines a collection of bridges designed by the infamous New York city planner, Robert Moses, that prevented the predominantly black population of bus travellers from accessing certain beaches as their tall busses could not pass under his intentionally low parkway bridges. Today, the designed objects of the contemporary digital experience (applications, extended reality experiences and UX implementations of all kinds) inherit many of the same ideological agendas of their physical forerunners. Indeed, the reduced cost of deployment and the enhanced scalability of the global systems of the internet mean that the political agency of the objects of digital design has increased exponentially (Dahlgren, 2013; Peacock, 2014). Information systems that exclude specific groups based on race, class and gender can be equally problematic as the designed physical infrastructure described by Winner (1980). However, within the information space, exclusion can be harder to see as it often occurs in layers beyond the quotidian experience (Bratton, 2016), dispersed within network operations and the compound effects of computation. A powerful example of this in the narrower context of augmented design ideation includes the invisibility of labour used to

produce underlying AI technologies. Such a case recently came to light with Open AI's ChatGPT product, which was found to employ 'outsourced Kenyan laborers earning less than \$2 per hour' (Perrigo, 2023). Indeed, this research used the related GPT-3 AI technology in later iterations and this condition of its production (i.e., unfair wages) was not something that was well known when the prototypes for this research were developed. This situation is a typical consequence of the *black box* (Pasquale, 2015) character of the computational technologies that currently underpin much of the data hungry digital infrastructure that augmented design tools, as explored in this research, often rely upon. Recent research, including Ramon Amaro's doctoral thesis, *Machine Learning, Sociogeny, and the Substance of Race* (Amaro, 2019) has focused on examining gaps in the epistemological foundations of data science and machine learning, exploring how race is produced and reinforced in the research, design and application of computational systems. This work further highlights the potential of tools developed to support augmented design ideation, including those investigated within this study, to inherit political ideologies associated with the technologies and digital artefacts they are built with.

The exclusionary potential of emerging AI technologies has also been addressed by researchers exploring some of the foundational technologies that underpin contemporary consumer AI. In a recent and impactful paper, *Do Datasets Have Politics? Disciplinary Values in Computer Vision Dataset Development*, (Scheuerman, Denton and Hanna, 2021), academic and industry (Google) researchers explore a framing for computer vision data that directly invokes Langdon Winner's observations of non-neutral public infrastructure for the

data sets on which machine learning is built. The authors identify that, in the field of computer vision, the idea that data sets have a political dimension is not commonly acknowledged and, therefore, any corresponding values in their creation are systemically ignored. They state that:

Existing retrospective critiques of the values of computer vision datasets have been constrained to specific identity categories, such as race [17] and gender [96] and their potential downstream impacts on model bias. Prior work has not examined the broader politics historically and presently incorporated into computer vision dataset development. Thus, we currently do not understand exactly what values are present, or absent, in computer vision data practices. (Scheuerman, Denton and Hanna, 2021, p. 317:2)

In further work, Denton *et al.* (2021) attempt to produce a genealogy of a particular machine learning data set by producing a critical history of ImageNet, the large visual database designed for use in visual object recognition software research. In this paper, the authors, ‘conceptualise machine learning datasets as a type of informational infrastructure and motivate a genealogy as method in examining the histories and modes of constitution at play in their creation’ (Denton, *et al.*, 2021, p. 1). The authors expose a large and complex domain of socio-technical consequence. In the context of augmented design ideation, the politics of the informational infrastructure on which design activity relies has a material and political impact on the design processes it can support.

4.4 Corporate politics as design thinking

Design as a professional activity has become commodified by large US management consultancies, such as IBM (Brown, 2008; Liedtka, 2014), and it is increasingly being seen as problematic (Hernández-Ramírez, 2018; Kolko, 2018). Much of the critical analysis of design thinking concerns the US home of design thinking, Stanford University's D School, and focuses on issues associated with methodological rigour, scant evidence of effectiveness and general boosterism, especially relating to the proximity of the vast agglomerations of capital of the local technology sector in Silicon Valley. Whilst the merits of these criticisms of D School's approach to design thinking can be debated, it cannot be denied that with very high fees⁸ for a four-day design thinking bootcamp, the level of access to certain sites of design thinking clearly excludes many with no access to deep corporate resources. This situation begs several important questions such as, how inclusive can design thinking be?; does it mask a cultural hegemony that forms a neo-colonial force when applied in very different global contexts?; does it erase the experience of people outside a narrow conception of gender, class, race and ability? These questions challenge how design processes conceptualised in universal form can be anything but harmful to those with the least power (Hamraie, 2016). This lack of inclusivity within the current design thinking canon has latterly been recognised by foundational proponents of design thinking methods, including Don Norman, who now includes inclusive design thinking in his recent programme for design education in the 21st century (Meyer and Norman, 2020).

In his book, *Design for the Pluriverse* (Escobar, 2018b), social researcher, Arturo Escobar,

⁸ In 2018, the cost of a 4-day bootcamp was approximately USD\$12,000 (Vinsel, 2018).

argues that the dominant professional model of design practice comes from a ‘broadly, patriarchal capitalist modernity’ and, logically, will bolster a broadly, patriarchal capitalist modernity, as can be seen in IDEO’s universalist approaches. The issue of how to challenge this situation and allow for a plurality (a pluriverse) of worlds to be sustained by design, rather than one world of universal design (a universe), is explored expertly in Escobar’s book. The challenge presented in Escobar’s vision of a pluriverse for augmented design ideation is that there is a clear tension with the reality of a digital culture that relies on a dominant cadre of technology companies formed in the hyper capitalist context of the US and, increasingly, China. If augmented design ideation does nothing more than inject this culture into design process, it would be safe to assume that the field would be moving away from Escobar’s Pluriverse and will further extend an already powerful hegemonic reality.

4.5 Platform capitalism and surveillance capitalism

Augmented design systems, as investigated in this research, are an extension of web platforms, both technically and ideologically, as they attempt to leverage web dynamics of openness, connection and scale. To say this is to acknowledge that any attempt at building such systems at scale requires some idea that value can be created at the platform level, even if it is likely to be co-opted (Van Dijck and Nieborg, 2009). This is partly because digital platforms exist predominately within capitalist conditions that expect returns on the investment required to build and maintain the technologies. This situation is, however, not without consequence. In his widely cited book, *Platform Capitalism* (Srnicek, 2017), Nick Srnicek describes how digital platforms have emerged under capitalism to be drivers of value

extraction at the expense of labour. He also frames how the success of these platforms has positioned them as a hegemonic force that demands all labour submit to the power relationship inculcated by their operation. He argues that the demands of these platforms are not new in capitalist development and that they continue capitalist imperatives to seek to produce value from labour in ever more innovative and intrusive ways. For Srnicek, the signals of consumers laid bare by digital communications data provide a new opportunity for the allocation and extraction of capital. Furthermore, in capitalist societies, there is a tendency for monopolies across different industries. In the agriculture and food industry, for example, conglomerates squeezed out the small family farmers in the 20th century. Similarly, digital giants were bound to emerge by design, and sites of digital extraction were identified and populated. Where Srnicek sees digital platforms as different, however, is in their ability to traverse geographies at speed, although the potential emergence of a balkanised internet (Polatin-Reuben and Wright, 2014) seems to suggest there may be political limits to individual companies if not, the logics of digital extraction. The extent to which augmented design tools, as imagined in this research, function as sites of extraction under this critique will have much to do with who designs these tools, which technologies are included in the tools, and what values are bought to their operation (Poderi, 2019).

In parallel to Srnicek's *Platform Capitalism*, American scholar Shoshana Zuboff defines broader cultures, in '*Big other: surveillance capitalism and the prospects of an information civilization*' (Zuboff, 2015), as an unprecedented power being seeded to the digital platforms that now dominate economic and social life. Zuboff's book, *Surveillance Capitalism* (Zuboff, 2019), chronicles the agglomeration of economic and democratic power by technology

companies through predicting and then nudging (Halpern, 2016) human behaviours.

In considering augmented design tools under “surveillance capitalism” , Zuboff explores, what she terms “instrumentarian power” which she describes as ‘the instrumentation and instrumentalization of human behaviour, for the purposes of modification and monetisation’ (Zuboff, 2015, p.4). Augmented design systems operating under surveillance capitalism have the potential to rely on this concept of instrumentarian power in complex and subtle ways. If, for example, augmented design tools achieve a large scale – and following the logic of current internet platforms – they could be monetised in similar ways to these web platforms. This may manifest in blunt approaches such as the delivery of advertising alongside visual prompts or promoting relevant services to the design task at hand. It could, however, be more insidious than this. For example, visual prompts themselves could be filtered to promote political views or to demonise particular groups, resulting in a design environment coerced by already powerful actors. As Zuboff describes clearly, this is already the information environment we live in and importing these dynamics into even more parts of life and commerce is not without significant risk.

4.6 Decolonising design and critiques of universal design

Within design studies, there has been a significant development in scholarship in recent years exploring and exposing the colonial roots and operation of western centric design discourse, and, in particular, the canon and practice of universal design. Writing in *Design Struggles*, a

collection of essays by design academics, educators and activists (Mareis, C. and Paim, 2021), Claudia Marieis and Nina Paim note:

Historically, Western design as a professional and academic field has been a narrow and exclusive domain that often imagines itself as universal. Striving to define ideals and norms, the modernist lineage of design has proved largely ignorant of its all-pervasive anthropocentrism and exclusionary assumptions, projecting visions of the worlds largely defined by a small set of mostly white cis-gender designers in the Global North. (Mareis and Paim, 2020, p. 11)

In his contribution, Arturo Escobar goes on to say that he believes ‘we are witnessing a significant reorientation of design theory and practice at present’ (Escobar, 2021, p.26). He goes on:

The emergence of a transnational space, anchored chiefly but not exclusively in the Global South, that problematizes anew design’s embeddedness in global historical relations of power and domination, variously explored in terms of design’s relation to histories of colonialism and imperialism, its functioning within the modern/colonial matrix of power, the geopolitics of knowledge (eurocentrism), racism, and patriarchal capitalist colonial modernity. (Escobar, 2021, p.26).

This recognition of the flaws in Western-centric design discourse and practice has powerful implications for research that explores ambient computational support for design process so steeped in universal assumptions and narrow geographical bounds (Mareis and Paim, 2020, p. 11). Ensuring that augmented design ideation does not further entrench a vision of design that is known to be problematic is urgent because these technologies see rapid adoption as they

are bought to market (Babich, 2023).

Design Struggles, a wide-ranging collection of design thought, contains many critiques of the colonial legacy of Western-centric universal design. In their contribution to the book, Ahmed Ansari and Matthew Kiem – both members of the decolonising design group (Ansari and Kiem, 2021 p.160) – state, ‘design’s elevation as a matter of concern to the academy is reflective of its value to the colonial matrix of power’. The colonial matrix of power was first proposed in a seminal article by Peruvian sociologist, Anibal Quijano (2000) and has subsequently been described by Mignolo, (2007, p.156) as having ‘four interrelated domains: control of economy (land appropriation, exploitation of labor, control of natural resources); control of authority (institution, army); control of gender and sexuality (family, education) and control of subjectivity and knowledge (epistemology, education and formation of subjectivity)’. There has been much interest in examining the legacies and continuing forms of colonisation in many domains and design is no exception. In the application of decolonial thought to the design domain, Ansari is sceptical that western centric design, as it stands, will be able to extract itself from the colonial matrix of power and will, instead, attempt in the first instance to co-opt and neutralise design instead: ‘decolonising design should not be founded upon the assumption that we can decolonise design practice without significantly altering to transforming its prefigurative conditions’ (Ansari and Kiem, 2021 p.163). Design practices that leave power where it currently resides - in Western and Sino design and innovation corporations, universities, research organisations and big technology – continue and deepen neo-colonial tropes, and any efforts to decolonise them are likely to be rhetorical.

In considering the potential of augmented design tools in relationship to the colonial matrix of power and their ability to operate outside the matrix and potentially exist in a decolonial design ecology, there are some key features of such tools to consider:

1. Who creates and controls them at the platform level and to what ends?
2. How accessible are they, given the affordances of culture and ableness they assume?
3. How accessible and useful are they outside the Anglophone Global North?
4. In terms of the semiotic resources given by such systems, who is represented and how, and how do such tools correlate positive and negative cultural associations?

These questions highlight how current augmented design ideation tools that use AI are unlikely to exist outside of the colonial matrix of power and, in fact, offer new vectors for its operation. Under capitalism, widely used augmented design tools rely on the capital resources of large technology corporations and are inevitably limited in the levels of inclusion and diversity they can achieve. As such, augmented design tools at scale are very unlikely to support Escobar's model of a Pluriverse while they impose universalist conditions on design practices that exist outside their frame of reference.

4.7 Summary and Conclusions

The investigation of augmented design that I have carried out in this research faces significant challenges in meeting contemporary concerns for fairness and inclusion. As I have

outlined in this section of my thesis, these concerns stem from the two domains of design (Mareis, 2020) and technology studies (D'Ignazio and Klein, 2020) that are brought together in my research. This section of the literature review acknowledges that computational tools for augmented design will likely inherit the harmful traits of any technology or design framework used to construct them. While this is relatively obvious, augmented design practices that involve *world building* (Boni, 2017; Coulton *et al.*, 2017; Escobar, 2018b; Costanza-Chock, 2020) and producing design solutions for potentially large numbers of people (Oswal, 2019) present considerable risks which are generally poorly understood.

The studies highlighted within this part of the thesis set out a context within which fairness and inclusion for augmented design tools can be considered. However, there is no significant literature that addresses the use of augmented design tools in design ideation specifically. There is a vibrant research domain for fairness and inclusion in digital systems, represented in conferences such as the ACM Conference on Fairness, Accountability, and Transparency (ACM FAccT) (ACM FAccT, 2023), but systems for design ideation have not received significant attention in this context. Furthermore, within design research, critiques of design ideation regarding fairness and inclusion largely stem from broader critiques of design thinking in general (Irani, 2018; Kolko, 2018).

The trajectories of design and technology that my research explores can be considered as constituent parts of a larger set of socio-technical developments shaping society on a large scale. The wider effects of the types of tools that are investigated within my research need to be understood and evaluated for their potential to contribute both positively and negatively to

design and society. The question of how digital tools of all types can be more inclusive and pluralistic, as suggested by Esobar (2021), is one that becomes more important when the outcomes of such interactions become enmeshed in the design ecology of our world through co-design processes that engage with such tools. This also raises the question of who is included and who is excluded in the design, development and use of digital ecosystems. With current digital ecosystems failing many, strategies to build better collaborative digital tools are urgently needed.

5.0 Chapter 5: Methodology

5.1 Introduction

This chapter describes the nature of the intersecting methodological components of this research. At a high level, the research is framed as action research involving practice-based design research and is positioned as a mixed methods qualitative study. It draws on the distinct fields of Design Research, Human Computer Interaction (HCI) Research and Social Research (multimodality). The practice-based research completed within this study involves the production of experimental computational prototypes of the augmented design ideation tool using common web technologies. The prototypes are tested and developed through three case studies which involve participants in co-design settings and semi-structured interviews. The use of the tools within the case studies also provides multimodal data, which is used in conjunction with participant observation, visual ethnographic methods and multimodal analysis to explore the dynamics of the augmented design context. This combination of methods supports an analysis of collaborative design ideation which then enables findings to be made regarding the ability and heuristics of prototypes to support design cognition and participants' understanding of their use.

5.2 Methodology Diagram

The case studies incorporated several methods within a programme of participatory action research that also involved designing and testing technological design tools. These are

summarised in the methodology diagram below.

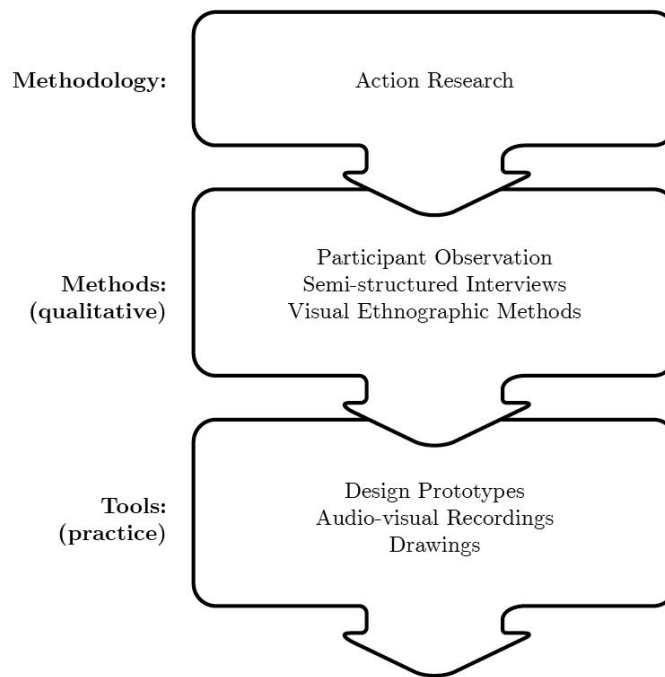


Figure 48 Methodology diagram.

My approach to working with experimental technologies is informed by design research in both interaction design and HCI contexts. Gaver (2012) describes what can be expected in a research through design approach concerning experimental technologies, contextualising the importance of diverse approaches that utilise design examples as a strength of the field.

Stappers and Giaccardi (2017) further contextualise Gaver's work and how the design process contributes to knowledge in a practice-based approach in interaction design and HCI

contexts. These approaches offer practical ways to interrogate complex and interdependent research questions through the production of experimental technologies and the study of their use. The approaches are consistent with established research *through* and *for* design approaches (Frayling, 1994) and are further extended to include new computational materialities – such as the experience and expectations of AI – within design research.

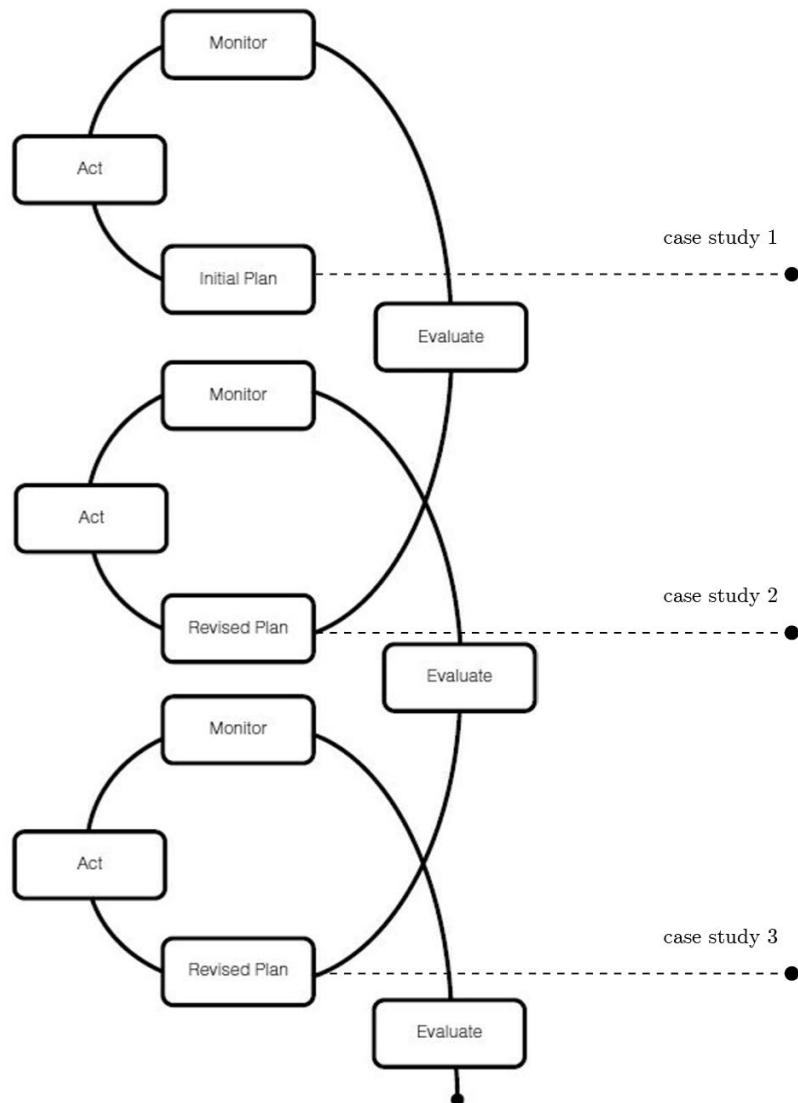
In my research, qualitative methods drawn from the social sciences are adapted for use in studying collaborative ideation contexts. These include participant observation, interviews and ethnographic methods, and specifically multimodality (Jewitt, 2016). These methods allow for the research design to explore meaning making amongst the communities of practitioners (Schon, 1984), for example designers, who are involved in the study. The inclusion of multimodality also supports the exploration of interactional multimodal cues present in collaborative design cognition (Cross, 2004) and the identification of important dynamics within the augmented design ideation experience. These include, for example, identifying moments of concept formation between participants as a result of tool prompts and how participants develop call and response behaviours while working with the augmented design tool.

My research involves a series of case studies that apply these in specific contexts with specific participants and specific iterations of the augmented design tool. The case studies describe ideation events that use the augmented design tool to augment sketching, which has been shown to be both a valid component of design ideation practice, and a practice that participants often reflect upon (Jonson, 2005). These case studies also reflect the practice of

exploring experimental computational tools in an open-ended manner, informed by comparable interaction design approaches such as those described by Wang *et al.* (2015) in their paper *Tangible Interaction Design: Preparing Future Designers for the Needs of Industrial Innovation*. The authors explore tangible design approaches for designers designing for ubiquitous computing contexts. Given this, the case studies generate data that is used as the basis of analysing key concepts in the research questions, such as the heuristics of augmented design ideation, participant awareness of the critical context and potential problems with current augmented design approaches, and the utility of multimodal approaches to explore augmented design ideation.

5.3 Methods Used

The research foregrounds qualitative methods including experimental prototypes, participant observations, semi-structured interviews, and visual ethnographic methods, including multimodality, across three case studies. Each study addressed specific aspects of augmented design ideation and featured participants with different types of design expertise and, relatedly, different settings. The first study included design students in a university environment. This study established the participants' ability to use the prototype and the associated augmented design tool heuristics, in the context of collaborative design ideation with students. The second case study included design professionals in their independent creative studio environment. This explored the use of the prototypes and their heuristics by professional experts in collaborative design ideation. This second study also offered a comparison to the first study regarding differing levels of ideation expertise. The third case study included design professionals in their multinational corporate work environment. This final study featured an update to the prototype to include AI-generated text prompts and provided opportunities for further exploring how the expert designers interacted with the augmented design tool, including AI, as well as the associated evolution of augmented design ideation practices. These methods enabled a programme of action research consistent with the description provided by Muratovski in his recent book, *Research for designers: A guide to methods and practice* (Muratovski, 2021). To illustrate this, the diagram below is an adapted version from that book that overlays the position of my case studies in the action research cycle.



Process of applied research (Action Research)

Figure 49 Action research process diagram

5.4 Methods Selection Rationale

This study brings together established qualitative methods and approaches from design research, HCI research and social research. The research design places practice-based design research as a central activity that has evolved through evaluating insights generated through participant observations and semi-structured interviews, across three case studies (as in the diagrams above).

5.5 Developing a Methodology

Action research methodology integrates qualitative approaches (participant observations, interviews) common in design and HCI research as well as in the sub-field of interaction design (Boer and Donovan, 2012; Gaver, 2012b; Stappers and Giaccardi, 2017). For analysis, this study also used multimodal methods (Jewitt, 2016) to explore meaning making between participants in the study. This is a less common approach within design research as it is more commonly applied within educational and medical settings (MODE, 2013). The integration of these methods enables insights to be included into the development of the practice component as the research progresses, as is common within an action research approach (Muratovski, 2021).

5.6 Data Collection

The following sections explain how data was captured for this study. This starts with a description of the experimental computational prototype of the augmented design ideation tool developed in the practice component, as this is key to understanding how data was captured both through its use and by the tool itself. Following this, I describe the process for

video data collection and the interview data collection and how these were integrated into multimodal texts for analysis.

5.7.1 Data collection and analysis methods

Data was collected in two primary ways, each with their own purpose for this research. I refer to the first method of data collection as *Event Data* comprising video data of the ideation event. It includes a wide-angle shot of the ideation event that shows the whole scene and captures the sketching activity, the interaction of the participants and, importantly, their dialogue. Secondly, there is additional multimodal data that is captured by the augmented ideation tool (face tracking data, voice recognition data, visual data and sketching data), called here *Tool Data*, which is stored by the augmented design tool to enable playback of the events in the dashboard of the tool. To understand how these two types of data are produced, they are introduced below. Then, I summarise how they overlap and work together to support the analysis of the design ideation events.

5.7.2 Video data of the ideation event (Event Data)

This data provides an overview of the ideation event that then forms the basis of the multimodal analysis. The data includes a transcript of the dialogue (produced from the video) and derives key units of analysis – when participants reference the tool or when they use the visual prompts provided by the tool – to generate insights as to the effect of the ideation tool. The use of video in this context can be described as ‘video based field-work’ that seeks to gather ‘naturally occurring data’ (Jewitt, 2012, pp.1-8), as is common in social

interactional studies involving multimodal approaches. In this case, the environment is more constructed than is typical in this kind of study, but ideation tasks can be thought of as naturally occurring on the practice of design. In order to manage what Snell (2011) calls the ‘problem of sensory overload’, the video data acts as a rich source of interactional events that can be explored through identifying meaningful moments and interactions.

5.7.2 Data captured by the augmented ideation tool (Tool Data)

Multimodal data captured by the tool is messy and complex and, in its raw state, it exists in a Mongo database (Meier, A. and Kaufmann, M. 2019) as there are various time-stamped outputs from the tool inputs, i.e., face tracking data, voice recognition data, gesture data, visual data and sketching data. This tool data is multimodal data in the context of HCI; that is, it is produced and used in the computational processes of the tool by turning various aspects of the participants’ interactions and communication into data points. The study does not include the raw tool data because the focus is on the multimodal analysis of the use of the tool and a resulting qualitative analysis of participants’ perceptions of the tool.

5.7.3 Tool Data as event data

The overlap between these data types in my research lies in that fact that the tool – as built – has been designed to replay this messy tool data in real time and (in one case study) is shown to participants in real time (see Figure 50). This means that there is another resource level of data that can be subjected to multimodal analysis and integrated with the video (event) data and used as part of a multimodal transcript and correlated as appropriate. The idea that

multimodal data in the context of HCI can be integrated with multimodal analysis is an important topic for this research.

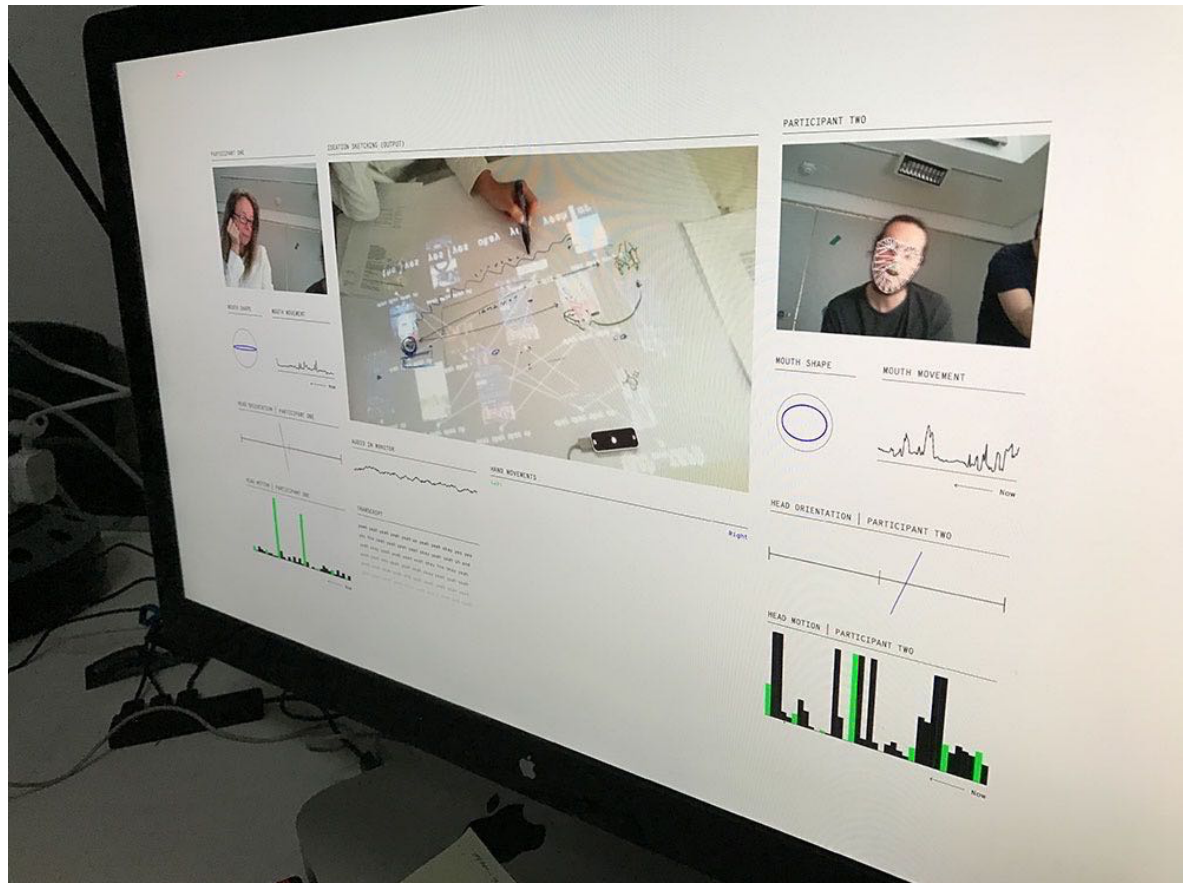


Figure 50. Tool data being displayed in the RCA ideation event in Case Study 1.

Practically, to achieve the analysis of this tool data as event data, I ran screen recordings of the tool data in playback mode and turned them into video data so that they could be analysed in similar ways to the event data videos. Examples of this can be seen in Figure 45 which shows a screenshot of the rendered video of the speech-graph (projected visual feedback) created from the ideation event in Case Study 1, while Figure 44 shows the speech-graph

dashboard from the tool and ideation event. This level of data in the case studies enabled me to explore the effects of Van Leeuwen's 'semiotic resources' (Norris and Maier, 2014, p. 23) in the context of the design ideation that was provided by the tool in the case study.

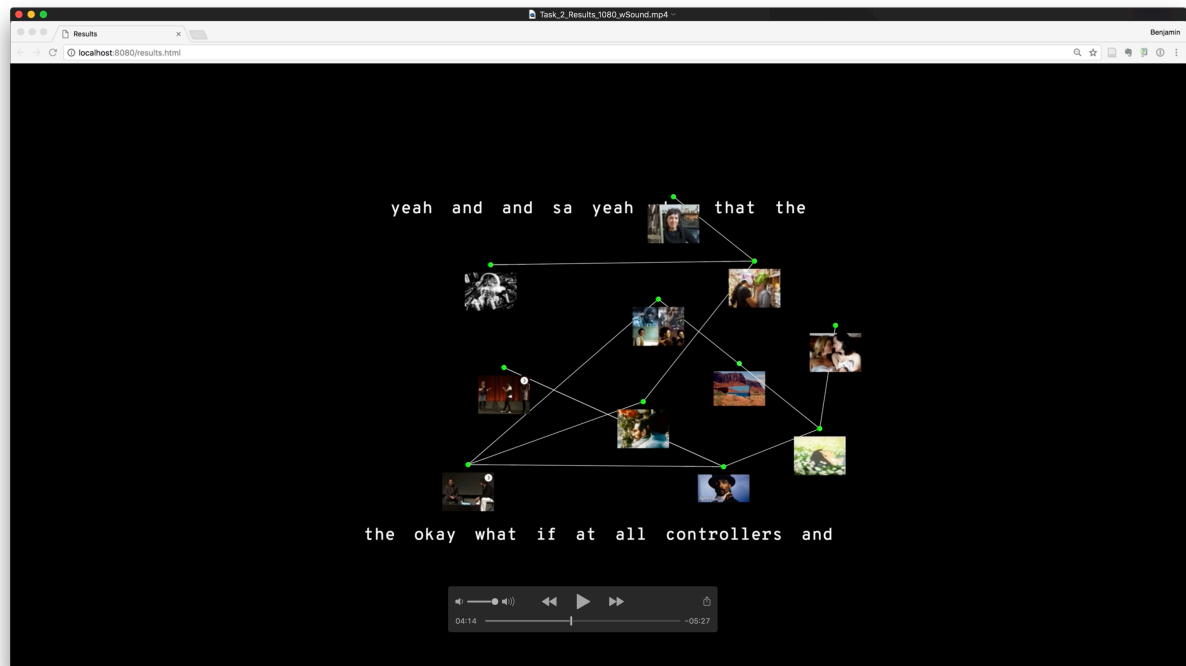


Figure 51 Tool Data (Speech-graph) rendered as a video file for analysis.

5.8 Data Overview.

There is considerable complexity presented by the integration of data from qualitative sources, such as video, interview transcripts and the data from the ideation tool data presented here. In order to understand how the various elements of the data within the case studies came together for analysis, Figure 46 below shows how my research design combined the elements of data from the ideation tasks of each event into data for analysis.

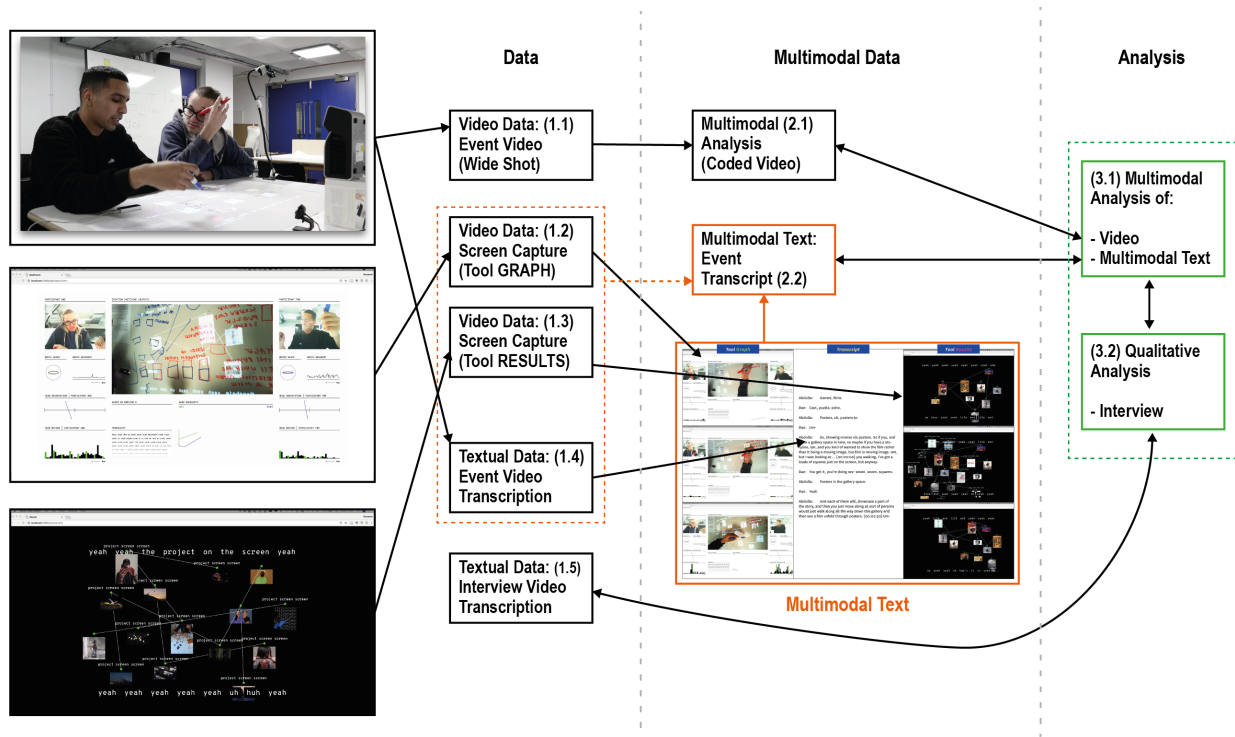


Figure 52 Data Structures Diagram

Figure 46 above shows how the observation of two participants using the augmented design tool produced various kinds of data for analysis within this case study. The individual elements are listed below:

1.1 This is a video of the whole event that, from a wide angle, shows both participants and their sketching.

1.2 This is a video made from a screen recording of the *Tool Graph* which records various data points of both participants and their sketching. It also provides an overview of the sketching surface. The data points that are visually represented are mouth shape, mouth

movement, head orientation, head motion, at waveform representing the audio level and the words that are being picked up by the speech-to-text element of the tool which, in turn, are being used as search queries by the tool.

1.3 This is a video made from a screen recording of the *Tool results* which provides the visual feedback projected onto the sketching surface. These images are delivered by the tool in a node-based diagrammatic format to encourage participants to connect disparate images within their sketching. These images are shown live from the web with the queries being driven by tool-based observations of the participants.

1.4 This is a transcription of the ideation event audio usually taken from the video of the event but, early in the study, was taken from a separate voice recorder.

2.1 The ideation event video is analysed by coding the video, looking across the activities of the participants to find moments of engagement with the tool. This process forms part of the multimodal analysis of the ideation events.

2.2 This is a multimodal transcript of each ideation event that provides a 30-second per page snapshot of the ideation event that includes all dialogue in this 30 seconds and three screen grabs – one every ten seconds – screen shot from both elements 1.1. and 1.2. This transcript constitutes the substantive multimodal text for analysis.

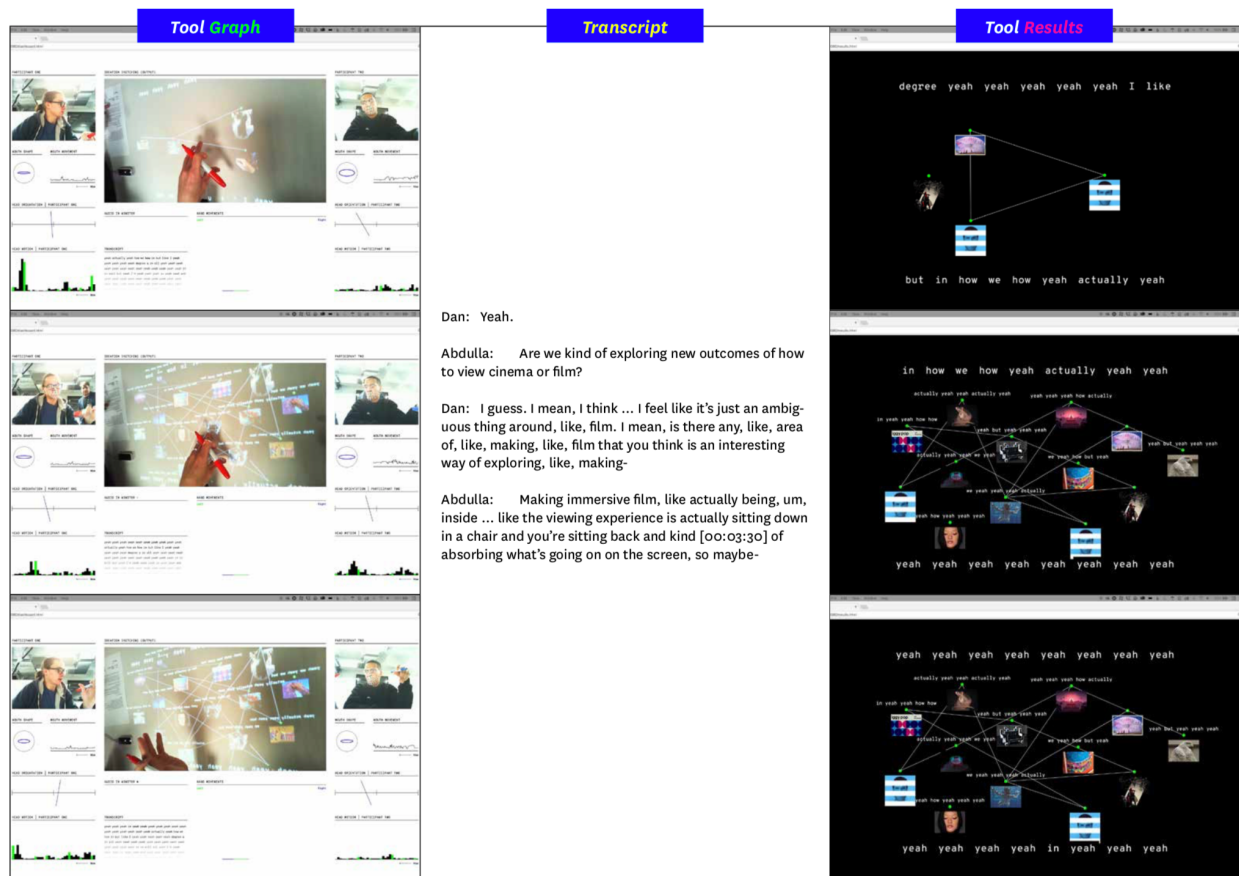


Figure 53 Multimodal Transcript

3.1 This element describes the multimodal analysis of an ideation event that rests upon both the analysis of the ideation video and the multimodal text.

3.2 This element shows that a post-event interview is used explore participant perceptions of the effects of the tool and potentially corroborates findings from the multimodal analysis.

5.9 Data Manifest

In order to present the corpus of qualitative data collected during the research, this section includes a data manifest that describes the amount and types of data produced in each case study.

Data is derived from three case studies: Case Study 1 includes design students, Case Study 2 includes design professionals and Case Study 3 also includes design professionals but features an updated prototype. Each case study features ideation *events* captured by video and the tool as described above. Case Study 1 contains more *events* than Case Studies 2 and 3 as it also includes a pilot study to find a stable set-up of the prototype for use in all the case studies. The corpus of each study is presented below.

Qualitative data is represented in the case studies where I primarily used multimodal methods to analyse participants in augmented co-design events. In this analysis, I produced multimodal texts that integrated – in 30 second periods – images from the tools’ multimodal dashboard (including voice and gesture data), audio transcripts for that 30 second period, and the visual results from the tool that were received by the participants in the event. These texts were then used in the discussion and analysis of the event and of the semi-structured post-event interviews.

Case Study 1

Case Study 1 was designed to iteratively develop the procedure for the later case studies, as the potential complexity of developing, using and recording the application of experimental

digital tools in the context of multimodal research was anticipated to be high. The case study itself was a result of four different *Ideation Events*, referred to as E1-4 in the table below, which refer to one set of participants undertaking *Ideation Tasks* i.e., augmented sketching sessions lasting 10 minutes. As expected, as the case study progressed and prototype development continued throughout the events, both the stability of the tool and the quality of the video and sound recordings increased. This means that there was some small variation in data collection between all ideation events within Case Study 1. The table below specifies the data that was used within Case Study 1. Events 1 (E1) and 2 (E2) in Case Study 1 were constituted as a pilot to test various parts of the process while Events 3 (E3) and 4 (E4) were the first full events in the study representing the format of events for the later studies.

Data manifest table for Case Study 1.

Case Study One Data Manifest							
Ideation Event (location, date, participants)	E1 (RCA)	E2 (LCC)	E3 (LCC)			E4 (LCC)	
Ideation Task (recorded ideation tasks)	T1	T1	T1	T2	T3	T1	T2
Video Data: Wide Shot	x	x	x			x	x
Video Data: Tool GRAPH			x	x	x	x	x
Video Data: Tool RESULTS			x	x	x	x	x
Textual Data: Task Transcription	x	x	x	x	x	x	x
Textual Data: Interview Transcription	x	x	x			x	
Multimodal Text (Tool + Video + Transcripts)			x	x	x	x	x
Coded Video (Qualitative Analysis)		x	x	x	x	x	x

In order to further understand the data that constitutes Case Study 1, the table above shows the following:

- 7 x Ideation tasks equalling 70mins - 7 x 10 minute individual tasks.
- 5 x Ideation task wide shot video equalling 70 minutes.
- 7 x Audio transcriptions of ideation tasks equal to 12,280 words.
- 4 x post-Ideation Event interviews, one per event, equal to 8,600 words.
- 5 x Multimodal texts equal to 104 pages.

Note: In Case Study 1 there, were four events with seven ideation tasks. In Case Studies 2 and 3 there was one event with two ideation tasks.

Case Study 2

Case Study 2 was more design-focused because it did not include the pilot tool development activities of the first case study and it consisted of two ideation events with two experienced designers from the independent design agency Superflux. The case study is described more fully in chapter 7, however the data produced is shown in the table below.

Data manifest table Case Study 2.

Case Study Two (SuperFlux) Data Manifest		
Ideation Event (location, date, participants)	Event One (SuperFlux, Brief 1)	Event One (SuperFlux, Brief 2)
Ideation Task (recorded ideation tasks)	T1	T2
Video Data: Wide Shot	x	x
Video Data: Tool GRAPH	x	x
Video Data: Tool RESULTS	x	x
Textual Data: Task Transcription	x	x
Textual Data: Interview Transcription	x	x
Multimodal Text (Tool + Video + Transcripts)	x	x

In order to understand the data that constitutes Case Study 2, the table above shows the following:

- 2 x Ideation tasks equalling 23minutes (1 x 11 minute, and 1 x 12minute individual tasks).
- 2 x Ideation task wide shot video equalling 23 minutes.
- 2 x Audio transcriptions of ideation tasks equal to 4,356 words.
- 1 x post-Ideation Event interviews, one per event, equal to 5,650 words.
- 2 x Multimodal texts equal to 48 pages.

Case Study 3

Case Study 3 was as design-focused as Case Study 2 and consisted of two ideation events with two experienced designers from the design futures team at the multinational engineering and design firm, Arup. The case study is described more fully in the chapter 8 however, the data produced is shown in the table below.

Data manifest table Case Study 3.

Case Study Three (Arup) Data Manifest		
Ideation Event (location, date, participants)	Event One (Arup, Brief 1)	Event One (Arup, Brief 2)
Ideation Task (recorded ideation tasks)	T1	T2
Video Data: Wide Shot	X	X
Video Data: Tool GRAPH	X	X
Video Data: Tool RESULTS	X	X
Textual Data: Task Transcription	X	X
Textual Data: Interview Transcription	X	X
Multimodal Text (Tool + Video + Transcripts)	X	X

In order to understand the data that constitutes Case Study 3, the table above table shows the following:

- 2 x Ideation tasks equalling 23 minutes (1 x 12 minute, and 1 x 11minute individual tasks).

- 2 x Ideation task wide shot video equalling 23 minutes.
- 2 x Audio transcriptions of ideation tasks equal to 4,596 words.
- 1 x post Ideation Event interviews, one per event, equal to 5,330 words.
- 2 x Multimodal texts equal to 46 pages.

5.9 Reflections on Data

As can be seen from the data manifest tables above, the case studies generated a significant amount of video and textual data for analysis. The multimodal texts that were generated during the case studies integrated this data into a format that allowed key moments to be identified. Key moments are defined as moments where participants made use of the semiotic resources (visual prompts and image relationships) and made verbal or gestural references to them in the process of ideation. Analysis of the multimodal texts enabled moments of video data to be reviewed for further context and these moments are described within the case studies. This approach of producing novel multimodal texts and analysing them in combination with video data allowed design ideation to be explored in a way that was both practical and qualitatively useful from the perspective of the researcher. The approach to producing multimodal texts also allowed for the integration of complex visual resources generated by the tool itself in an accessible manner. This approach enabled these texts to present complex data in a readable format given the context of the studies.

5.10 Analysis

This section describes the analytical methods employed across the three case studies. As described above, the analytic procedures developed in this research have their roots in qualitative data analysis, multimodality and design research.

5.10.1 Multimodal Analysis, Words, Pictures and Gestures

The multimodal approach to analysis I developed during the research was shaped by initiatives in the social sciences, such as the Institute for Education's (IoE) Mode project (Bezemer, 2012) which ran from 2012-2016. This project describes multimodality as 'an inter-disciplinary approach that understands communication and representation to be more than about language. It has been developed over the past decade to systematically address much-debated questions about changes in society, for instance in relation to new media and technologies' (Jewitt, C. 2013a, p.141). This research adopts the key premise of Bezemer's approach in that the multimodal analysis allows for the generation of insights about how people act with novel technologies, such as the augmented design tools in this research.

Multimodal research of this kind has also been used by HCI researchers who look at co-design, design processes and technology. Derboven *et al.* recognise the utility of multimodal methods for studying co-design and that 'The multimodal approach we take allows researchers to treat both verbal (notes, writings) and tangible material outcomes as complementary ways of communicating design ideas' (Derboven, Van Mechelen and

Slegers, 2015, p.2825). This perspective accepts that research participants in a co-design study are producers, in their own right, of semiotic artefacts that can contribute to multimodal texts, as in this study. Derboven *et al.* also frame the act of design ideation as the subject of multimodal study in a manner consistent with the approach described here. These ideas informed the development of this study in that, in the co-design ideation context, semiotic resources emerged during the study from both the human actors (augmented sketches) and the technology prototypes (image prompts), and a wholistic approach to analysis is key to the research design.

5.10.2 Interviews and transcripts

In addition to multimodal approaches, each case study presents a post-ideation event interview with an associated discussion as participant perceptions are thought of as key to exploring the effects and exceptions of augmented design tools. These interviews also allowed the context of the case studies to be acknowledged as they occurred at a time of rapid advancement in common information technology used by designers and their increasing awareness of the implications of consumer AI tools and services. As such, they are well placed to interrogate participants' practice approaches as the research progresses and to provide insight to the meta context of design ideation in the context of ubiquitous computing. This approach to generating insights using interviews is common within design research as well as in HCI as described in *Research Methods in Human-Computer Interaction* (Lazar, Feng and Hochheiser, 2017) and *Design Research Through Practice* (Koskinen et al., 2011).

5.11 Methodology Summary

The research methodology I have developed for my research combines aspects of action research, qualitative methods and practice-based tools.

The practice element of the research is represented by the development and iterative improvement of the augmented design prototypes and the communication artefacts that surround their presentation. These design artefacts have generated insight for the research questions through their production. The prototypes have also given rise to a critical discussion of the macro contexts of such tools, presented later in this thesis, as the context of such tools has shifted radically during the time of this research. This rapid technology development has also been paralleled in the design field by a re-evaluation of the ethical and social implications of design practice for and with such tools, also explored in this thesis.

Considering the qualitative element of the research, I used multimodal methods to analyse participants in augmented co-design events as described in this chapter. Through the production of multimodal texts, this approach enabled the integration of visual data from several sources (video, audio and informatics generated by the augmented design ideation tool) in a manner which rendered them meaningful for analysis. This was used in conjunction with semi-structured interviews, presented in each case study, which enabled the findings to be drawn from the research participants about their experience of using the prototypes, tools and their experiences of augmented design ideation in this study. In the next chapters, the case studies will be presented and their insights and implications will be discussed.

6.0 Chapter 6: Case Study 1: Design Students

6.1 Introduction

This chapter presents the first of three case studies which are based on this research. The case studies were formed from a series of 5 participant study events, during which design students studying at the London College of Communication, University of the Arts London were brought together in pairs to undertake a sketching task in response to a design brief (included in Appendix 1). This form of initial collaborative design ideation task is common in design education (Jones and Haugen Askland, 2012), especially following the introduction of a new brief and it often involves sketching as a method for recording and synthesising concepts to inform group discussions (Sosa, Vasconcelos and Cardoso, 2018). In this study, this design ideation task was augmented by the experimental prototype, described in Chapter Four ‘design development’, to add visual references/prompts to the paper on which the students were sketching. This case study analyses both the experimental computational prototype of the augmented design ideation tool and the ways in which the participants incorporated the visual feedback generated by the prototype into their sketching.

6.2 Research Questions - Case Study 1

This first case study addresses two of my research questions.

Research Question 1: How can collaborative design ideation be augmented by web technologies, ambient information systems and AI tools and platforms? Research

Question 1 is addressed by examining how students used the prototype experimental computational prototypes of the augmented design ideation tool in the context of an initial collaborative design ideation task based on sketching, using a combination of observations and interviews. During the case study, students were asked to reflect upon their experience of using the experimental tool and to consider its effects on their ideation practice and, more broadly, on the design field. The study involved students enrolled on an interaction design undergraduate course as they were used to performing initial ideas sketching tasks within their studies. Participants were also asked to reflect upon undertaking such a task augmented by an experimental computational prototype of the augmented design ideation tool.

Research Question 4: How can multimodal interaction be used to explore augmented design practices? Research Question 4 is addressed by producing and analysing a

multimodal transcript – as introduced in Chapter Five ‘Methodology’ – that incorporates video output generated by the experimental prototype which captures sketching activity, gestural and other forms of feedback as well as visual references provided by the prototype and transcripts of the conversation between the participants. The multimodal transcript incorporates multimodal ‘metadata’ elements generated by the experimental tool with other qualitative multimodal data, such as speech. This approach examined how multimodal data obtained by an experimental computational prototype of the augmented design ideation tool can be incorporated into multimodal analysis as applied to human interactions during collaborative design ideation activities.

6.3 Limitations of this case study

As this case study brings together interviews, multimodal analysis and computational prototypes, it is important to acknowledge the specific limitations associated with these approaches.

6.3.1 Interviewer bias

Interviewer bias, which occurs when an interviewer's expectations for their research interfere with opinions provided by their interviewees, and conformation bias, whereby people interpret information in ways that comport with their experience (Nickerson, 1998), are inherent challenges in the design of this case study. Both are compounded in relation to my role as a figure of authority for the students who participated in the case study and their associated willingness to accept my prompts and explanations as an expert. For example, how productive, in a creative sense, research participants felt (when asked) is likely to have been influenced by their desire to perform in a productive manner for their tutors. Furthermore, my tacit endorsement of augmented design tools (given I am presenting them with one I designed) may validate their willingness to accept its value, purpose and utility. Although these types of bias cannot be eliminated within this setting, open questions were used to mitigate the biases becoming dominant or overpowering within the study. Open questions allow research participants space to qualify their answers and engage in dialogue to explore their perspectives in ways that can elicit perspectives divergent from the orthodoxy of the interviewer. Furthermore, conformation bias in design research has been identified as a significant aspect of the design process itself. For example, Hallihan and Shu (2013) explore how the design process involves conformation bias as ideation takes place between people

with differential perceived design authority. This study is particularly relevant, as what qualified as a good ideation activity in my research may have been shaped by my presence and framing of the investigation, though this is an expected feature of case study based action research projects.

6.3.2 Selection of multimodal features and approaches to multimodal analysis

This study acknowledges multimodality as a research method with limitations that are relevant to this study (Jewitt, 2016). These limitations include the selective nature of the features that are focused upon as the researchers makes a choice about which interactions are considered meaningful and which are not, and over what timescale said interactions are considered to be meaningful. This is also true of the analysis of embodied phenomena on the part of the researcher who proposes what any of these interactions mean to the subject, once they have been identified as being meaningful. My approach to multimodal analysis through developing a multimodal text using 30 second time intervals that brings together dialogue, video and screen captures from the prototype, acknowledges these limitations and the complexity of the phenomena being studied. The case study aimed to strike a balance between considering moments of meaningful interaction to infer the effects of the experimental computational prototype of the augmented design ideation tool on design ideation practice, and the multiple more subtle interactions that cannot be captured reliably by human or computational analysis in this study.

6.3.3 Wizard of OZ and random prompts

The use of the augmented design tool prototype, as described in this study to elicit user response, draws from classic Wizard of OZ experiments. This is because the visual ideation prompts – while generated by the tool – are analogous to a hidden person (a wizard) providing users with visual feedback while posing as a computational system. As in Wizard of OZ experiments, how the visual information was actually given to the users in the study is not of primary importance as long as they believed the visual information was being derived computationally. This is a well-established method (Schlögl, Doherty and Luz, 2015) that is widely used for developing early-stage feedback in the design process of interactive systems. However, it is important to note its associated limitations in this study. Specifically, ascribing effects to specific technical procedures within the prototype was not something attempted in this study so. For example, the computational approach to providing image prompts was not evaluated in the study. In this context, the role of the technical prototype is to elicit user behaviour (Ali, Morris and Wobbrock, 2019) with a system supporting design ideation activity. This approach is broadly consistent with comparable studies, such as User-Defined Gestures for Surface Computing (Wobbrock, Morris and Wilson, 2009), which explores gesture-driven system-supplied elicitation.

6.4 Setting

This case study involved four separate events: an initial pilot event that was held at the Royal College of Art (RCA) and three subsequent research events that were held at London College of Communication, University of the Arts London (LCC). The initial pilot event involved a PhD student and a recent MA graduate of the RCA Information Experience Design

programme. This event served as a precursor to further events in the case studies in order to test the technical set-up of the tool and methods of data capture.

6.4.1 Pilot Study (Event 1): Royal College of Art

As part of the action research process, this event was designed to enable me to test both the tool and the data gathering techniques. It is important to say that this was not a pure ideation event in the context of this case study, as I was active in prompting the participants at various points and more than in subsequent ideation events (in this and further case studies). As such, the data from this event is related, but not directly comparable, to the events discussed later in this case study. However, this study provided the opportunity for me to generate informed observations at an early stage to help to refine the case study work and develop initial findings. Participants worked with the same design briefs to the same process as described below for the main LCC events.

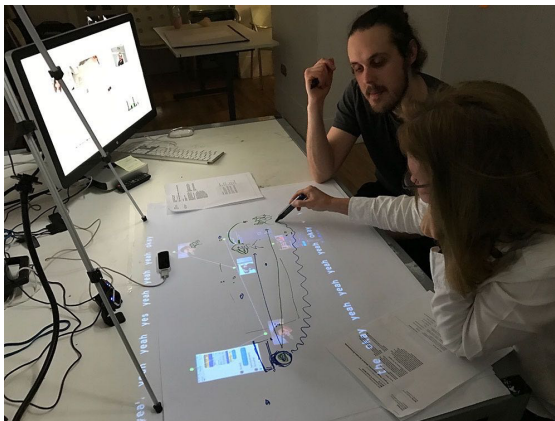


Figure 54. Pilot study: setup at the RCA

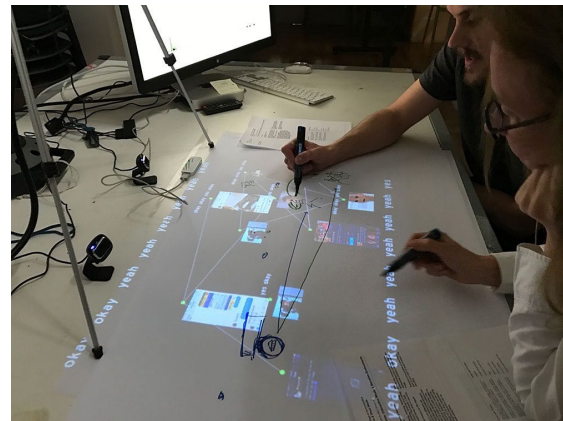


Figure 55. Pilot study: augmented sketching at the RCA

6.4.2 Events 2, 3 and 4: London College of Communication, UAL

The three research events that were held at LCC as part of case study one involved six undergraduate students from the BA (Hons) Interaction Design Arts programme. Part of the rationale for choosing to work with design students as participants is that they are familiar with design ideation and design sketching practice. This is especially true of interaction design students who have expertise in conceptualising and using novel technology prototypes. This also means that, as students of design, they can also be considered experts belonging to distinct ‘communities of practice’ (Wenger, 1999), that extends to design professionals who make up the participants of the later studies. This shaped how they understood and performed design ideation tasks and how they integrated the ideation tool into their sketching activities.

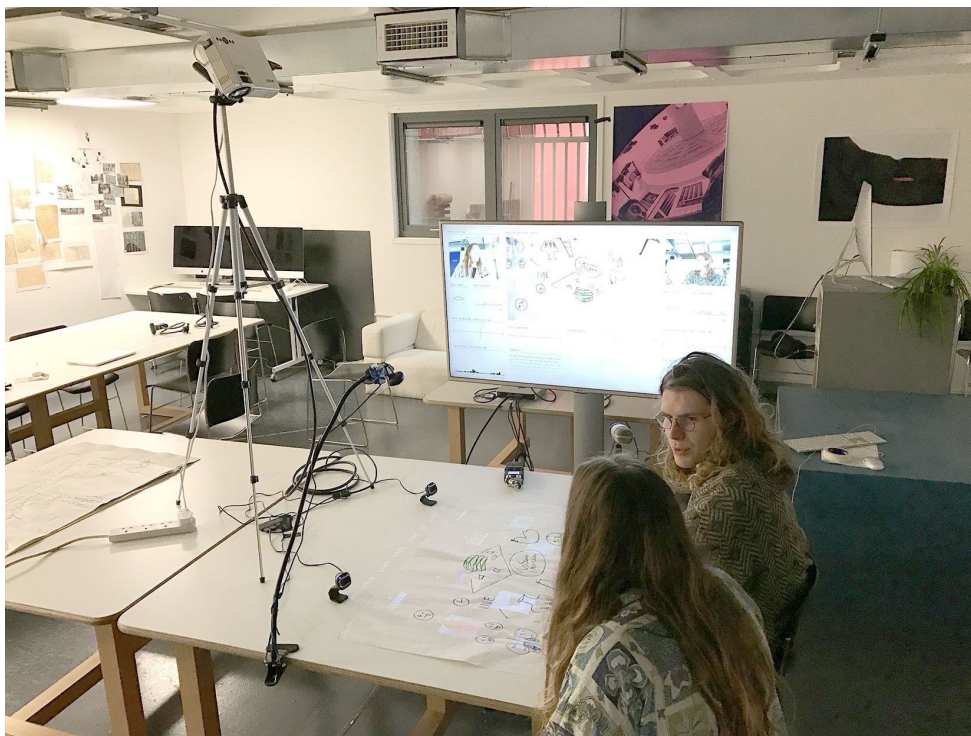


Figure 56. Studio Environment March 2017: BA (Hons) Interaction Design Arts.
London College of Communication, UAL

The sketching activities took place in the students' studio environment at LCC, where they regularly undertake ideation activities, as shown in Figure 56. Figure 56 shows the participants sitting at a table with marker pens and sketching paper. The sketching paper is a primary visual means of participants externalising their ideation discourse and a surface upon which they received visual feedback from the augmented design tool. This visual feedback was projected onto the sketching paper via the LED data projector, as seen in Figure 53. In addition, Figure 53 also shows a large high-definition television which was used to present a visual representation of the data that was captured from the participants, including web camera data (Face OSC data: head movement, head orientation, mouth movement, mouth shape), voice data (a volume graph and a textual representation of the participants' dialogue as captured using a microphone and a cloud based speech recognition platform), and gesture data (from a Leap motion 3D, Camera). A full description of this technical set-up is included in Chapter Four 'Design Practice and Development'.

Visual data representations produced by the experimental ideation tool and provided for each participant can be seen in Figures 57, 58 and 59 below. The purpose of providing these live visualisations within the case study environment was to explore whether participants 'performed' to the data environment. It soon became clear that this element of performativity was not something that was seen in relation to this dashboard being present in the events and this feature was removed from the experimental ideation tool during the latter case studies.



Figure 58. Individual participant metrics captured during Augmented Ideation Event

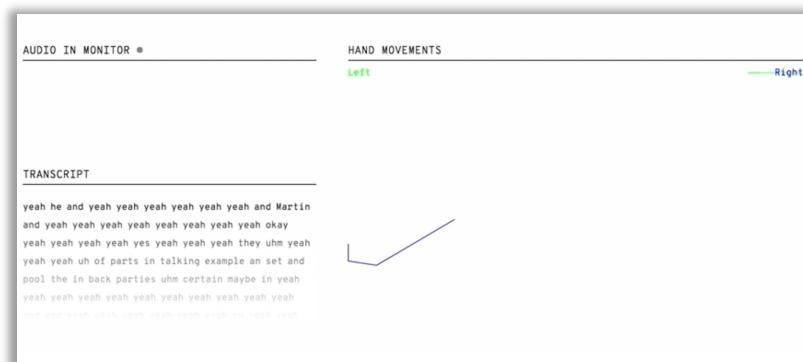


Figure 59. Conversation and gesture metrics captured during Augmented Ideation Event

6.5 Ideation Tasks

The participants were asked to undertake a series of short 10-minute ideation tasks based on supplied undergraduate and postgraduate (UK Level 4-7) (QAA, n.d) design briefs. The briefs, included in Appendix 1, asked participants to conceptualise a “Social Object” addressing an “Internet of Things” context. Participants were familiar with both the content and format of the brief, which allowed them to get involved with the ideation task with minimal instruction. Their knowledge in this case was very much shaped by their educational experiences as they were used to being asked to conceptualise initial ideas quickly (i.e. perform design ideation) when presented with a brief of this kind. This approach ensured that the ideation events focused on the areas identified within the research questions and not on developing other ideas of ideation practice. Furthermore, post-event interviews were used to elicit perspectives on how design ideation using the computational prototype of the augmented design ideation tool differed from usual experiences of this kind of work.

6.6 Sample

Eight students participated in the study, six were full-time undergraduate students, one was a part time research-student and design academic and the other was a recent graduate and design professional. This sample was broadly representative of the design student body within both institutions.

6.7 Findings

Presented below are the observations and findings from Case Study 1 drawn from the

multimodal transcripts and associated dialogue. The subheadings indicate what the observations and findings relate to, for example, the transcripts of an ideation event dialogue or post-event interviews. For reference, excerpts from transcripts can also be found in Appendix 1.

6.7.1 Findings, RCA Ideation Event (Event 1)

As a testing ground for some of the foundational ideas in this research, the transcript of the pilot study (Event 1) provided useful insights and highlighted some practical issues around data capture and analysis as the design of the prototype matured. However, the participants in the pilot were able to integrate the visual feedback from the tool into their ideation practice and found some utility in the prompting action of the tool and its potential to assist ideation processes:

It puts things in a, like encourages you to try and pushes you to make connections. I think. and Yeah, it does that, but it also does that serendipitous magpie artists design process that goes, Oh, there's something interesting there that I'm sure I can make it connect. So, it creates that opportunity for connections. And then it also gives you all this free space in between where you've got all these eyes and you've got no idea what I'm doing. (Student 1, Event 1)

6.8 Post-Event Interview (RCA)

Immediately following ideation event one, the two participants took part in unstructured interviews that explored their experience of using the experimental tool. This also helped me refine structure of the interview within the unstructured interviews that were held during the event with LCC design students.

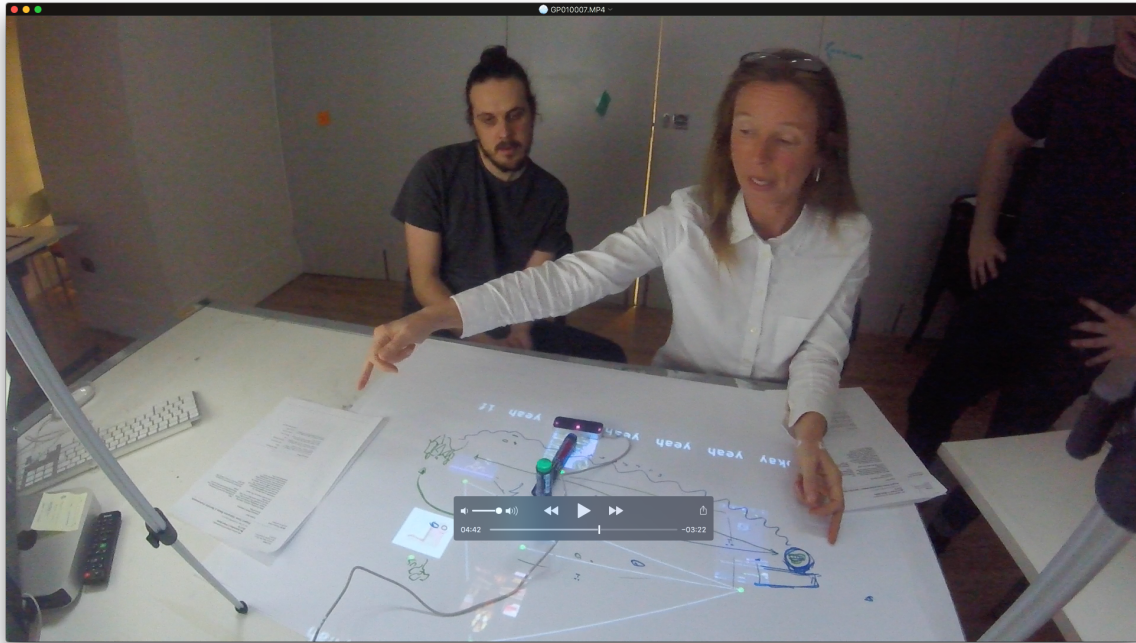


Figure 60. Post-ideation event interview at the RCA

6.8.1 Findings, interview excerpt (1): The participants initially described the experimental tool as being stressful to use, though they also stated that the tool ‘pushes you to make connections’ (Student 2, Event 1). During the interview, Student 1 reported,

Yeah, it does that, but it also does that serendipitous magpie artists design process that goes, Oh, there's something interesting there that I'm sure I can make it connect. So, it creates that opportunity for connections. And then it also gives you all this free space in between where you've got all these eyes and you've got no idea what I'm doing. (Student 1, Event 1)

The ‘serendipitous magpie artists design process’ that student 1 describes is a key feature of ideation practice identified by Goldschmidt and Smolkov (2006) who show that during ideation, varied visual stimuli is important to innovation outcomes. Student 1 also noted that the experimental tool ‘creates that opportunity for connections’ and this shows that she was able to ascribe this property to the tool in her first interaction with it. Secondly, she also describes how the tool ‘gives you all this free space in between where you've got all these eyes and you've got no idea what I'm doing’ . While this comment is somewhat ambiguous, I interpret it to mean that there is space in the ideation process for the designer – as someone using the tool – to work with the feedback and this is considered by the participants to be valuable.

6.8.2 Findings, interview excerpt (4): In some instances, the dynamics presented by the tool are frustrating to the participants, Student 1 says ‘It's fucking annoying when it disappears’ , meaning that the visualisation updates and changes whilst she is sketching specifically with (on top of) images presented by the tool. This kind of insight is important as it shows several things regarding the heuristics of augmented design tools both expected and experienced. Firstly, it shows that there is engagement and perceived value with the visualisations that support sketching and that there is preference to conclude discrete moments of conceptualisation before the tool moves on. Secondly, participants invest in the meaning of the image prompts during ideation and see them as resource to be held whilst conceptualising a particular idea in ideation and are annoyed if they cannot complete this

with the tool.

These are interesting observations as this dynamic of rapid change in the tool is also a primary way the tool may act on design fixation, for example by disrupting patterns of externalisation at arbitrary points and forcing regular re-conceptualisation or radical breaks. Edelman *et al.* (2012) describe radical breaks as moments of ‘... “thinking out of the box”’, and reframing problems to find new and unique solutions. A radical break occurs in the course of a redesign when designers make a major departure from the provided artifact’ (Edelman *et al.*, 2012, p.31). The heuristic described as ‘annoying’ by Student 1 may be a symptom of the tool enforcing radical breaks rather than letting design fixation set in. The staccato nature of the visual prompts provided by the tool were designed with this kind of effect in mind.

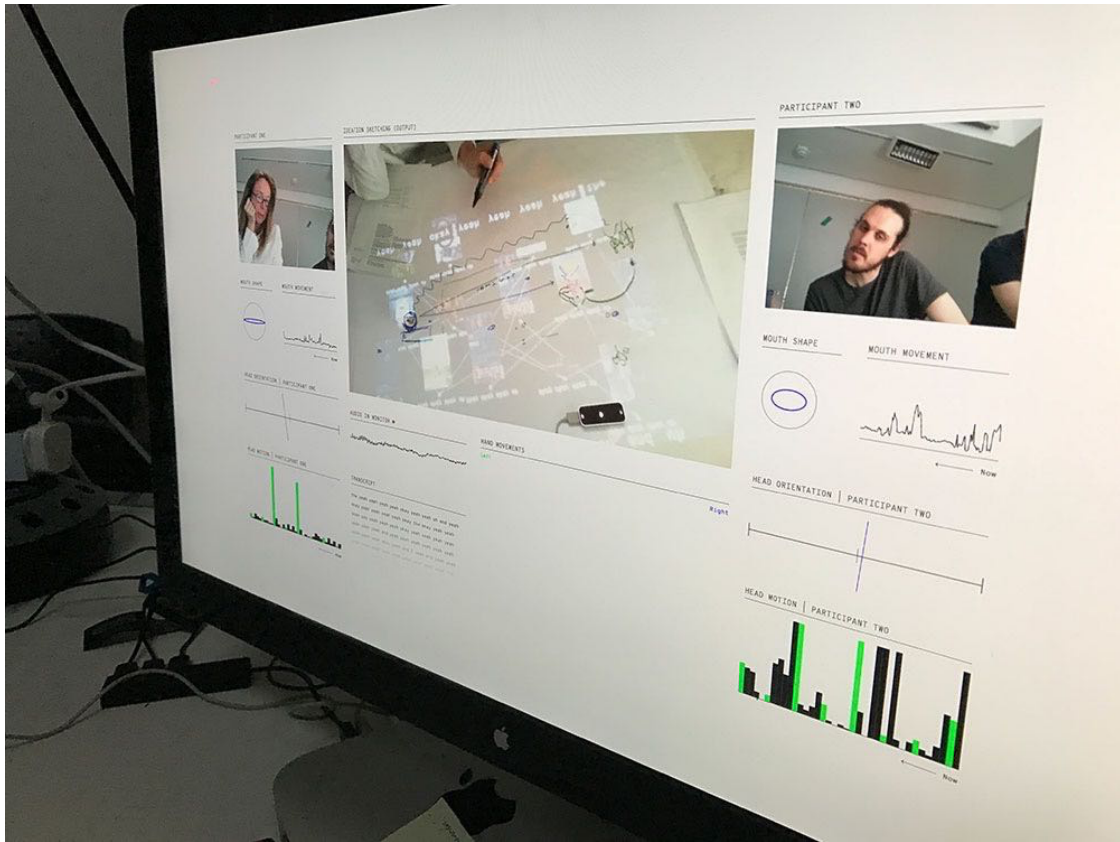


Figure 61. Tool dashboard during event at the RCA

6.9 Ideation Events (London College of Communication, LCC)

This section documents the ideation events that took place with LCC undergraduate students who were invited to undertake an initial design ideation task in response to a design brief, as described above. At first glance, their dialogue seemed partial and this is to be expected as it represents one mode of their complex interaction that encompasses several key elements, including interpersonal negotiation and mediated negotiation of the feedback provided by the tool. Presented below is an analysis of how and when the visual feedback from the tool appears in the students' dialogue and to what extent the visual feedback from the tool can be

seen to prompt conceptual development. This is important to the research questions in that establishing how the visual feedback provided by the tool is handled by the participants is fundamental to understanding how such tools can augment ideation practices that involve sketching.



Figure. 62 Ideation event at LCC

6.9.1 Findings, LCC Event (2) Excerpt (1): The transcription of the audio recording that was made during the first ideation event underscores just how messy and unstructured design ideation tasks can be. This is relevant for the practice-based element of my research, i.e., the development of the ideation tool, which attempts to codify some of this messiness into useful

data points. In the development of the tool, this meant devising computational solutions to capturing discrete manageable elements for the tool, for example by dividing the dialogue into arrays of words in specific time blocks to be used as search queries for returning image results.

The transcripts from excerpt 1 shows that the visual feedback provided by the tool clearly adds to the semiotic resources (Norris and Maier, 2014, p. 23) used in this form of augmented design ideation. Participants made repeated references to the images provided by the tool and evaluated their relevance for the ideation task at hand. Furthermore, their interactions showed that participants that had even an entry level experience of design ideation practices – as undergraduate students do – were able to integrate visual feedback into both their sketching activity and their conceptualisation.

6.10 Findings, LCC Post-Event Interview Excerpt (1): The participants described some initial adjustment to the augmented design tool and the effects that they observed the design tool had on their ideation process. For example, Participant 1 mentioned, ‘I don't know, it felt like there was a lot more stuff on top of what was going on’, thereby expressing that, on reflection, she noticed a tangible extra dimension to the ideation practice when she used the augmented design tool than when she did not use the tool. She identified that the ideation process, ‘felt a lot more weighted’, which also lends validity to the augmented design tool acting at a conceptual level during the ideation event. Participant 2 also commented that ‘compared it to some group work kinda brainstorm, brainstorming session [without using the

augmented design tool] [...] where you just kind of like end up driving around in circles’.

This indicates that Participant 1 may have felt that the tool helped him extend his idea generation process, demonstrating that the tool may have potential to help address the so called “ideation gap” (Dorta, Pérez and Lesage, 2008, p. 121). The *ideation gap* describes the lack of digital support that exists in initiatives that are designed to develop digital tools to support idea generation processes. The participants in this study expressed they felt that the tool promoted focus, creative scope and helped to break unproductive patterns of circular ideation.

6.11 Overall Initial Findings, LCC Post Event Interview

Key findings identified within the transcripts of conversations that took place within this case study include: (1) that participants with a base tertiary level of design education understand what design ideation is and what it is for; (2) that with no prior exposure to an augmented design tool – such as the one described here – the participants were able to integrate the feedback generated by the tool into their ideation process and sketching with minimal instruction; (3) that participants found the tool useful for ideation; and (4) that participants commented on how the tool may retrospectively provide designers with valuable insights into their own ideation processes ,after the fact, in a manner similar to sharing notes and observations in a designer’s sketchbook.

Video Data and Tool Use

The video data and multimodal transcripts generated during the LCC event include moments

in which participants can be clearly seen to be making use of the tools.



Fig. 63. LCC ideation event moment (a.) A participant uses the outline of a newscaster (visual feedback presented by the tool) as a sketching prop.



Fig. 64. LCC ideation event moment (b.1/2) A participant integrates a visual reference generated by the tool into a conversation with another participant.



Figure 65. LCC ideation event moment (b. 2/2)

A participant integrates a visual reference generated by the tool into a conversation with another participant.

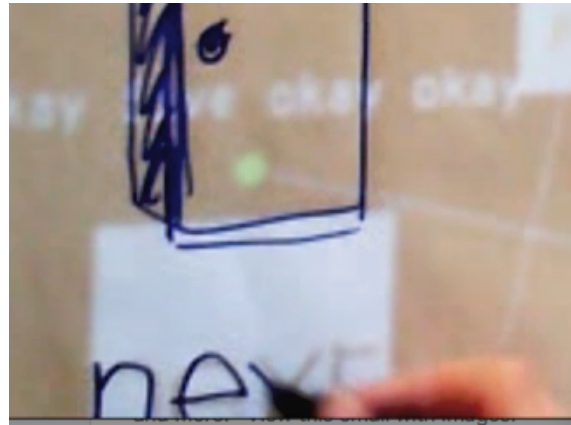


Figure 66. LCC ideation event moment (b. 2/2)

A participant traces over a visual reference generated by the tool during a conversation with another participant.

6.12 Conclusion

In this chapter, I report on the initial testing of the augmented ideation prototype with postgraduate design students at RCA and undergraduate design students at LCC, while establishing a participant study model that is used in all three of my case studies. This study shows that, with the design students in the sample, design ideation and design sketching are amenable to augmentation by computational means. Furthermore, that the students readily integrated visual prompts delivered by the augmented design tool developed in this study into their sketching and ideation practices.

The study documents how participants reflected on their awareness of the effects of the tool on their ideation activity. Participants specifically described how the speed of their ideation practice increased and, in some cases, how they used this as a proxy for being more productive within a given period. Furthermore, the participants also credited the tool with helping them establish new conceptual territories in a manner that indicated that they perceived the tool as making a tangible contribution to their design cognition.

This study also shows that the heuristics of the augmented design tool developed in this study can act in subtle ways. For example, the network diagrams presented by the tool are perceived by the participants to encourage them to make connections between images and concepts. This also highlights the potential value of tools that elicit certain behaviours that support design cognition even when the visual cues – such as interface elements in this case – may be based upon, essentially, computationally derived Wizard of Oz prompts. However, this also highlights an area where some of the critical issues identified with the relative lack of diversity of images and computational classification in such tools must be acknowledged given the willingness of participants to use such prompts in ideation practices. This dynamic of digital tools and their associated abilities is seen by the participants as a rapidly evolving space for design practitioners.

The manner in which the participants responded to the presence of the augmented design tool developed in this study was also tested in this case study and the following key observation was made. It was clear that visual feedback that was generated by the experimental design ideation tool and any of the interface elements that fell outside the “sketching surface” were

not appreciable by the participants during the ideation events. On reflection, this is seen as likely being linked to the high cognitive load of the augmented sketching task, leaving little headroom for other interface elements. However, the post-event interviews show how the participants' abilities to observe themselves producing and processing data using techniques such as computer vision expanded their conception of acting with the tool.

In this study, I also described moments from the video data that showed how participants made use of the visual prompts that were generated by the experimental tool. These included sketching directly over visual elements and drawing connections first suggested by the tool diagrammatically. This enabled an observation to be made – that the augmented design tool starts to initiate and shape iterative conceptualisation. This observation is explored in greater depth in the following two cases studies.

The next chapter introduces the second case study, which builds on the approaches, observations and models of ideation events that were established within Case Study 1. Focussed on working with professional designers as participants, the second study sought to establish how professional designers might use the augmented design tool and if their expectations for the tool differed significantly from the students who participated in Case Study 1.

7.0 Chapter 7: Case Study 2: Design Professionals

7.1 Introduction

Case Study 2 included a series of participant ideation events in which design professionals were invited to work together in pairs to undertake an ideation sketching activity in a similar way to Case Study 1. Case Study 2 builds upon Case Study 1 by further testing the augmented design tool with experienced design professionals. This case study also looks at the critical perception of the augmented design tool among professional designers who have experience of using assistive tools that have been developed for designers.

7.2 Case Study 2 Aims

The aims of Case Study 2 are:

- a. To explore multimodal data – both computational and observed – in the context of design ideation.
- b. To explore the practical constraints of augmented design tools.
- c. To explore the experience of designers (domain experts) using augmented design tools.

The aims listed above explore all three research questions in an integrated manner, thereby enabling further findings regarding how augmented design tools support professional users; their critical understanding of such augmentation; and further use of multimodal approaches

to the study of augmented design practices. Additionally, this study has two further aims:

- d. To explore the differences between the participants' use of the augmented design tool in Case Study 1 and 2.
- e. To explore the professional context of traditional Post-It Note ideation methods in comparison to augmented design ideation using the prototype augmented design tool.

These additional aims are intended to offer further insights into augmented design ideation, using the prototype augmented design tool within a professional setting to elicit expert reflection from design professionals.

7.3 Limitations of this case study

This case study built upon the first case study and, as such, the limitations that were described in Chapter 6 (interview bias, limitations of Wizard of Oz studies) also apply to Case Study 2. This study does not attempt further mitigation of these limitations as they are deemed acceptable, and it is important that the central approaches are respected across the studies to produce a coherent and comparable corpus of research data. Further limitations of this case study are discussed below.

7.3.1 Participant Diversity

In this study, the participants are similar in age, experience and cannot be said to be representative of wider society in terms of socioeconomic group or ethnic background and no claims are made in this regard. This said they can be considered typical of design agency staff

in London in terms of educational and professional background. The participants also have representative professional experience and skills and belong to the broad professional community of practice (Schon, 1984) of professional designers. As such, their experience of the augmented design tool in this study is meaningful, especially because the insights garnered here would be relevant to others who also belong to this group across advanced global economies within professional design sectors. With this said this community of practice is clearly not diverse in a broad sense and still can be said to suffer from associated issues as identified over a decade ago (Eikhof, and Warhurst, 2013) in a UK context. This means that whilst this research serves this community it also identifies the constitution of the professional design community as a barrier to inclusive design ideation practices. It should be further noted that the globalised nature of technology and design education are factors that underpin the relevance of this research to the community of practice to which the participants belong. Again here, global design education has also been examined as to a lack of inclusive pedagogy and its colonial character (Mareis, and Paim, 2021) and this is also identified in this research as a barrier to inclusive design ideation practices.

7.3.2. Workplace Heuristics

This study was completed in a professional co-working space, described in the introduction below. This space was not a neutral venue for the study and may have played a role in promoting creativity and design cognition (Leiva-Lobos, De Michelis and Covarrubias, 1997). Setting up the prototype augmented design tool in this setting introduced the benefit of doing creative work in an ideation environment, this is also discussed further below.

7.4 Previous Work

Prior work regarding the practice in this case study is broadly similar to that described in the literature review. However, two key theoretical papers informed the analysis of the data that was generated during the case study: Eitan Wilf's *The Post-it Note Economy: Understanding Post-Fordist Business Innovation through One of Its Key Semiotic Technologies* (Wilf, 2016) and design theorist, Nigel Cross's *Expertise in Professional Design* from *The Cambridge Handbook of Expertise and Expert Performance* (Cross, 2018).

Several concepts from Wilf's critical evaluation of the types of brainstorming activities that are associated with IDEO and design innovation, widely practiced in professional settings, (Grönman and Lindfors, 2021) are relevant for data analysis for this case study. Within his evaluation, Wilf considers the Post-it Note as 'a key semiotic technology of idea generation' (Wilf, 2016, p.732) much in the same way that my research investigates how augmented design ideation sketching tools have the potential to function as semiotic technologies in design ideation-based idea generation and sketching processes. Wilf's concept of *ritual insights* is particularly relevant to my research.

7.5 Ritual Insights

Wilf identifies how designers ritually employ formal artefacts and standardised objects such as Post It Notes and draw from their formal qualities (size, shape and stickiness) to generate insights during their design ideation activities. He observes how, as they have become reified

in the social practice of design innovation, co-design and within idea generation processes,

Post-it notes' weak adhesive properties afford the real-time diagramming of the reasoning process that presumably led to the insights. This real-time diagramming is a form of ritual semiosis [rituals for meaning making] — that is, a ritual event that dynamically figurates [represents] the concrete effects it is meant to have in the world and that is meant to have such effects precisely by virtue of such figuration (Wilf, 2016).

This critique of such a staple object of design ideation resonates with my research as augmented design tools also produce new and complex ritual insights. For example, the formal properties (shape, size, colour, visual hierarchy etc.) of augmented design ideation tools are important factors within their design and the heuristics they produce. The degree to which ritual insights can be observed within case study 2 is discussed later in this chapter.

7.6 From Design Practice

In contrast to some of Wilf's observations, Cross (2018) focuses on describing expert performance in the context of design ideation. Within his chapter, Expertise in Professional Design, Cross focuses on exploring the degree to which professional designers' expertise supports ideation practice and presents a nuanced overview of the literature of design ideation in a professional context. Cross seeks to understand the value and effects of dominant design methods and tools used by designers (specifically in the post-19th century global capitalist context), addressing how some of the implicit criticisms of design ideation that Wilf

advances can be seen to relate to established practices amongst experienced and expert designers. Cross (2018) identifies that visual representations can be an important feature in design ideation.

7.7 Visual Representations

Cross identifies that visual representations can function as ‘A key tool to assist design cognition’ (Cross, 2018, p.379), thereby serving numerous purposes for expert design practitioners. However, Wilf observes that certain visual representations seem to be so denatured by the reductive formal properties of even the simplest design tools – including Post-it Notes – that they produce pseudo insights. Cross describes sketching as being ‘tied-in very closely with features of design cognition such as the generation and exploration of tentative solution concepts, (Cross, 2018, p.379) noting that ‘designing is difficult to conduct by purely internal mental processes; the designer needs to interact with an external representation’ (Cross, 2018, p.380). Exploring how the behaviour of augmented tools relates to the formal properties of the tool – as described by Wilf – whilst still respecting established approaches to design cognition within an expert design context is of relevance to this study.

7.8 Setting

This case study was developed with design studio Superflux and involved two members of

their current design team as participants. Superflux⁸ is a commercial design organisation based in London, UK: ‘Founded by Anab Jain and Jon Ardern in 2009, Superflux is a boundary-defying, award-winning design and experiential futures company...” “... producing impactful futures work for clients like Google AI, Cabinet Office UK, Anthemis, Suncorp, Sony, Samsung, Gov. of UAE, IKEA, UNDP and DeepMind.’ (Superflux, n.d)

For this study, the participants were provided with two briefs and given 10-15 minutes to complete them. The first brief, titled *Personal AI*, asked the participants to ‘generate initial responses imagining use cases for personal AI products and services on 5, 10 and 15 year time horizons’ for a collaboration between a large technology company and a consumer electronics manufacturer. The second brief, titled *Online Harm*, asked the participants to ‘generate initial responses that imagine an exhibition to raise awareness of online harm’ with the client being a national museum. When presented with the first brief, one of the participants stated ‘That's very nice. We have a bit of experience with this’ (Participant 1, Event 1), indicating that both they understood the brief and that they had relevant experience of working on similar projects for the studio.

Both members of the Superflux design team that participated in the case study (Senior Designer and Filmmaker, and Designer and Researcher) have experience in design ideation practices in early-stage project work at Superflux. They also stated that they had experience

⁸ Available at: <http://superflux.in/index.php/about/> (Accessed: 24 April 2022).

with projects that explored similar territory to the briefs provided to them in this study.

The physical setting for the study was the Superflux studio base, Studio 48 housed in the co-working space Somerset House Studios (SHS) in central London. The meeting room in Figure 67 below shows the specific meeting room in Studio 48 that was used for the study. The Superflux desks can be seen through the glass wall in addition to other SHS resident workspaces.

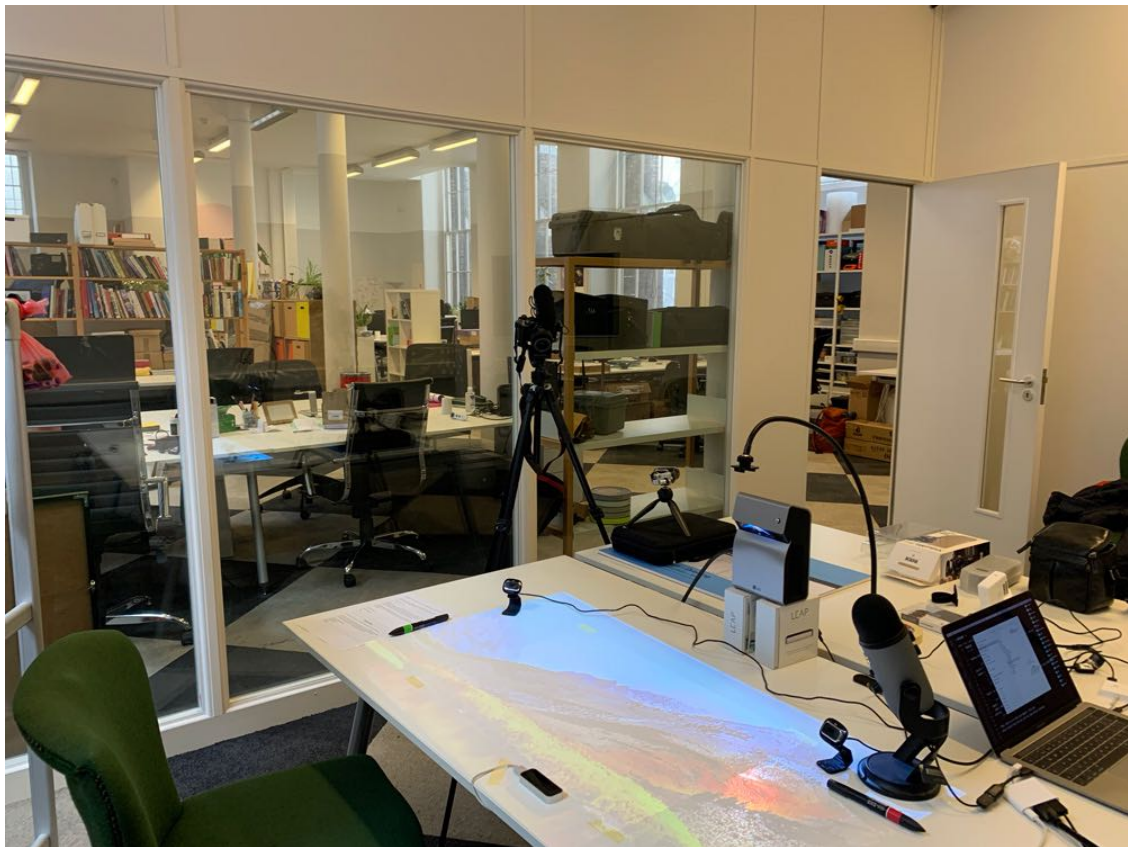


Figure 67. Studio 48 meeting room and study location.

Acknowledging the *communicative practice* (Rickards, Runco and Moger, 2008) of

Superflux's creative professional environment and effects of design expertise in professional contexts (Cross, 2018), I entered this case study with the expectation that these expert participants would engage in ideation in different ways compared to the students who participated in Case Study 1. This difference is important to this study as it is instructive in exploring the efficacy of augmented design ideation tool and for observing differences in performance and practice that might be apparent.

Cross describes the design sketching activity and visual representations around which this study is based:

A key tool to assist design cognition is the use of representations, including the traditional form of the sketch. It seems to support and facilitate the uncertain, ambiguous and exploratory nature of conceptual design activity. Sketching is tied-in very closely with features of design cognition such as the generation and exploration of tentative solution concepts, the identification of what needs to be known about the developing concept, and especially the recognition of emergent features and properties. (Cross, 2018, p.379)

Given their professional design experience, I expected the participants of case study 2 to show greater fluency with sketching, in general, and with augmented sketching, in particular. This difference is due to simple factors such as the amount of time professional designers will have spent developing ideation activities and because their ability to work towards an applied design outcome will be far more developed. The differing goals of design students and professional designers is of interest to this study as it has the potential to show how the augmented design tool provides value in related but different design ideation contexts.

7.9 Event 1 (Personal AI), Introduction

During the event the participants were given a brief to ‘generate initial responses imagining use cases for personal AI products and services on 5, 10 and 15 year time horizons’ for a collaboration between a large technology company and a consumer electronics manufacturer. This event contained relatively few moments where the participants used the tool as it served as an orientation to the experience of design sketching with the visual feedback provided by the augmented design tool. During their orientation to the augmented design tool participants observed the visual feedback from the tools and decided how they would use it. They very quickly built a framework of exceptions for using the prompts generated by the augmented design tool in their ideation process. The following moments stood out as they discussed their experiences in relation to the research.

7.9.1 An IDEA Journey: Alexa, Wine Bottle, Supermarket IoT Experience

When the ideation event was about half-way through, the participants were fed a visual prompt of a wine bottle as they discussed the amazon Alexa voice experience. This did not seem related to the discussion so the participants felt that it was a divergence, as Participant 1 remarked, ‘I mean, it's interesting, right? 'Cause the, a lot of people are using ... Yeah. (laughs) Wine bottles’ . At this moment, this visual prompt became a key semiotic resource within the ideation task and it forced, what Edelman calls, a radical break (Edelman et al.,

2012), thus shifting the dialogue in a new direction. Furthermore, one of the participants sketched around this wine bottle as they talk in an act that appeared to cement this new direction of conversation as important; this can be seen in the image below.

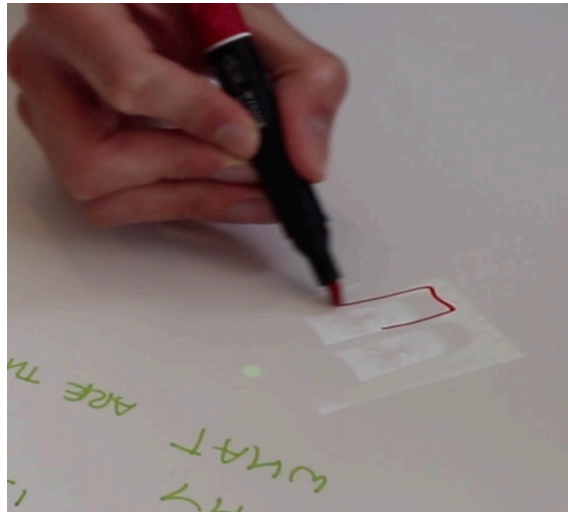


Figure 68 participant draws around a visual prompt.

The participants used the wine bottle prompt and, over the next minute, built a design concept for a connected supermarket shopping experience. This kind of idea journey is a common feature of design ideation practice (Cross, 2018) and, in this context, the visual feedback from the tool was clearly integrated into their process. The ability of professional designers to assimilate dynamic visual feedback in this way is an expected feature of the development of the augmented design tool, and this interaction clearly demonstrates how the tool supports this process. Further images of the interaction are shown below.

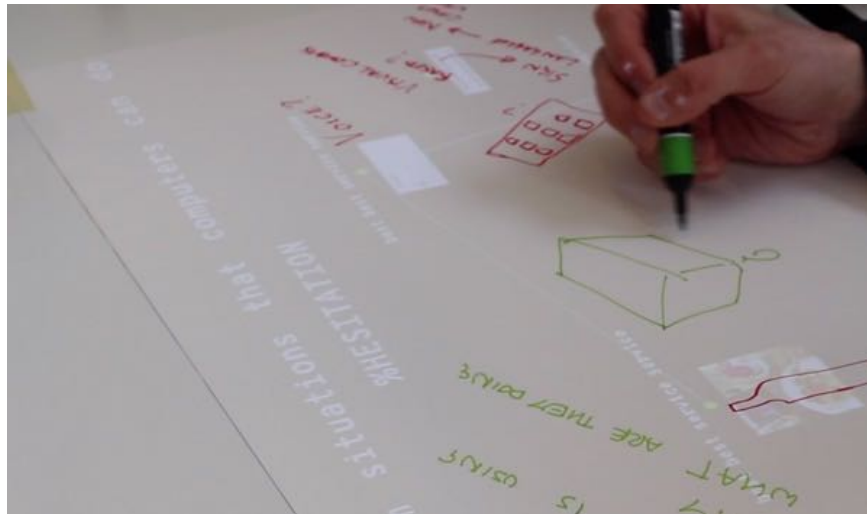


Figure 69 Sketching for a connected shopping experience.

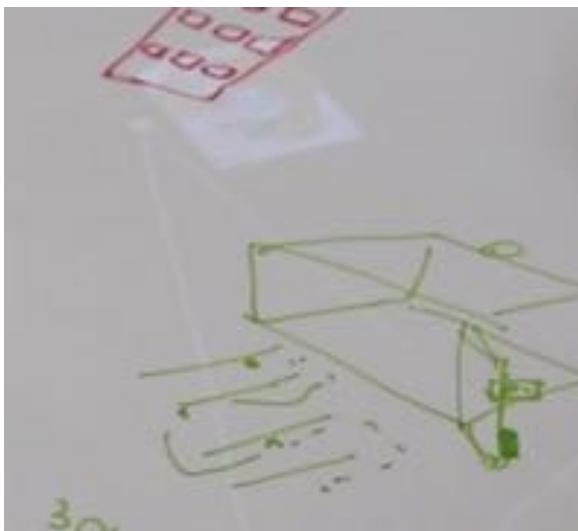


Figure 70 Sketching for a connected shopping experience.



Figure 71 Sketching for a connected shopping experience.

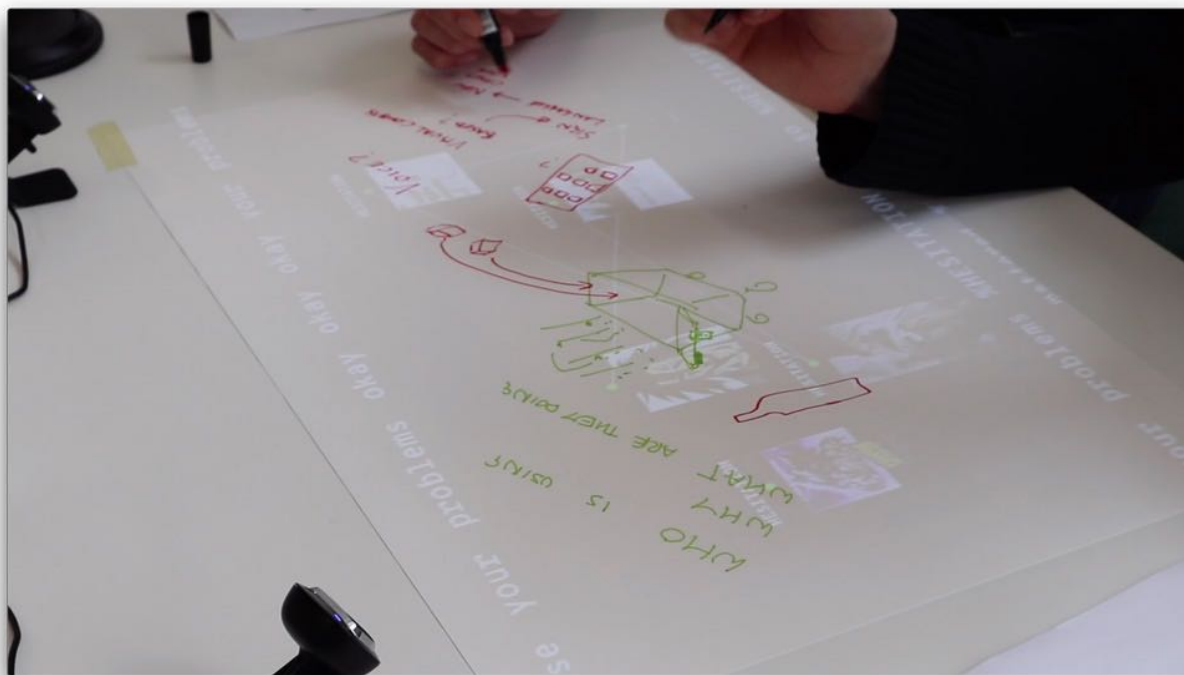


Figure 72 sketching for a connected shopping experience.

7.9.2 Spam content: Pornography, Web expectations and Banality

One unexpected interaction in this event was the appearance of an explicit visual reference (as shown below). While this was not necessarily remarkable, the reactions of the participants were. The image likely came from an online article discussing intimate relationships and technology, as there are no specific explicit image sources in the tool. However, Participant 1 noted the explicit image in passing and remarked, ‘This is strong, that's definitely a strong prompt (laughs)’ and then moved on with no further comment. This is interesting because it reveals something about the heuristics of web-based systems in that we have expectations that search based internet tools will deliver such material as a matter of course (Vieira, 2015).

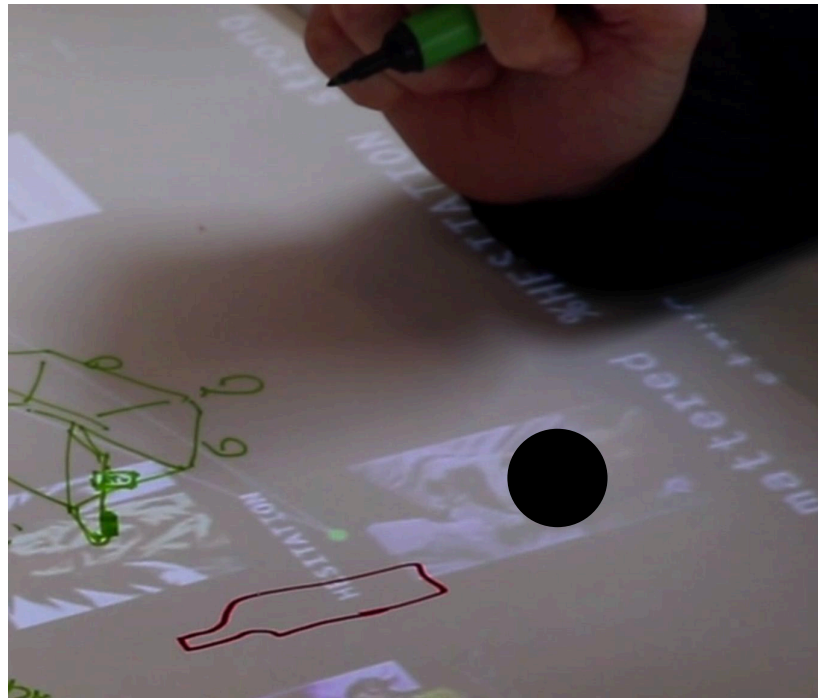


Figure 73 Explicit visual reference show by the augmented design tool.

7.10 First Event Observations

In this first event, the participants became accustomed to the tool and, by the end of the session, they were readily able to integrate prompts generated by the experimental augmented design ideation tool into their ideation practice. They also already had a set of expectations regarding the features of the tool, such as the image prompts and the pacing of the prompts, and, therefore understood the premise of the tool. This was apparent in both the next ideation event and the post-event interview. In comparison to the student participants in the first case study it was notable that, as professional designers, the participants had a clear ability to use the prompts generated by the tool. This was further evidenced during the second event of the study.

7.11 Event 2: Online Harm Brief: Introduction

The case study participants engaged more deeply with the augmented design tool during this event than in event 1 and showed a notable interest in their direct (dialogue discussing augmented design tool prompts) and indirect references (contextual and framing activity including speech, gestures and sketching that used some components of an augmented design tool prompts). The event was introduced with the following ad hoc request, ‘And this time, can I just ask you to really try and use the prompts ... in your conversation?’ (Ben Stopher, Event Facilitator), to encourage engagement with the brief, acknowledging that the participants had developed a familiarity with the augmented design tool during the previous ‘Personal AI’ event. The designers developed a momentum within their idea generation processes more rapidly during this event. This may have been affected by their increasing familiarity with the task, though the speech recognition within the augmented design tool was particularly accurate during this event, which drove rapid visual refresh rates for the augmented design tool and generated seemingly relevant images as visual feedback. The improvement to underlying component technologies – such as the speech recognition platform – that underpin the augmented design tool has a material effect on the studies as text displays and, therefore, search queries have become accurate and the participants were observed to have felt more connected to the feedback from the augmented design tool in this study.

7.11.1 Speech, Text, Image

One example of the improvement of underlying technologies is that during the ideation event, the timeframe between a participant saying something and those words appearing in the visual feedback generated by the augmented design as text, and then being used as search terms for the displayed images was shorter, and the results were more accurate than had been the case in previous events. This can be seen in the image below which accompanies a comment made by Participant 2, ‘Ah, so we can think about maybe different age groups. Obviously, there's the, uh, **you know, children being disproportionately affected**, uh, by predators **of various sorts on social media**’. The words in bold were clearly seen within seconds of being uttered and this was true throughout this event.

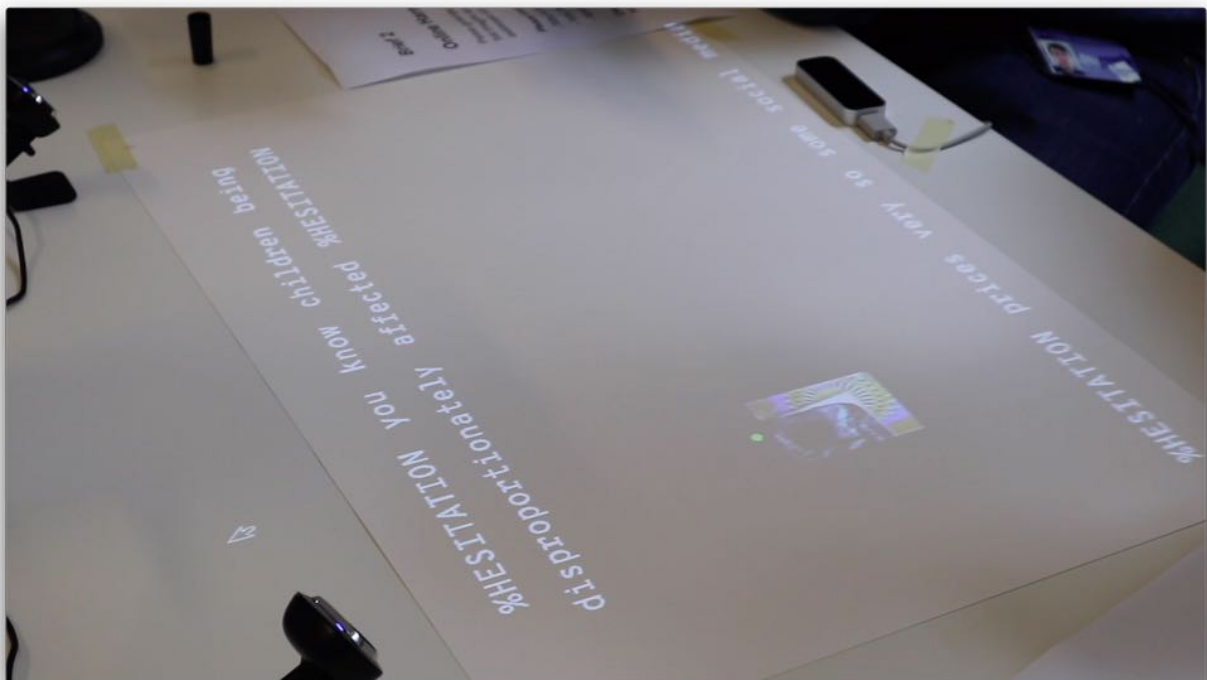


Figure 74 Clear textual representation of a participants verbal statement resulting from speech recognition improvements within the augmented design tool.

7.11.2 Words, Pictures and Ideas

The participants' ideation processes also appeared to embrace the word, picture, idea pipeline that can be commonly found in design ideation activities. This can be seen below in Figure 75 (marked elements A. and B.) which shows an excerpt from the participant's conversation that was converted into text along with a spiral sketch element that was drawn to accompany their verbal discussion. This process is described by Cross when discussing expert performance by professional designers when he describes how the conception of Starck's lemon squeezer came to be imagined by visual analogy, making using sketching as a support process and the importance of *representations* and how sketching in this manner '...seems to support and facilitate the uncertain, ambiguous and exploratory nature of conceptual design activity' (Cross, 2018, p379).

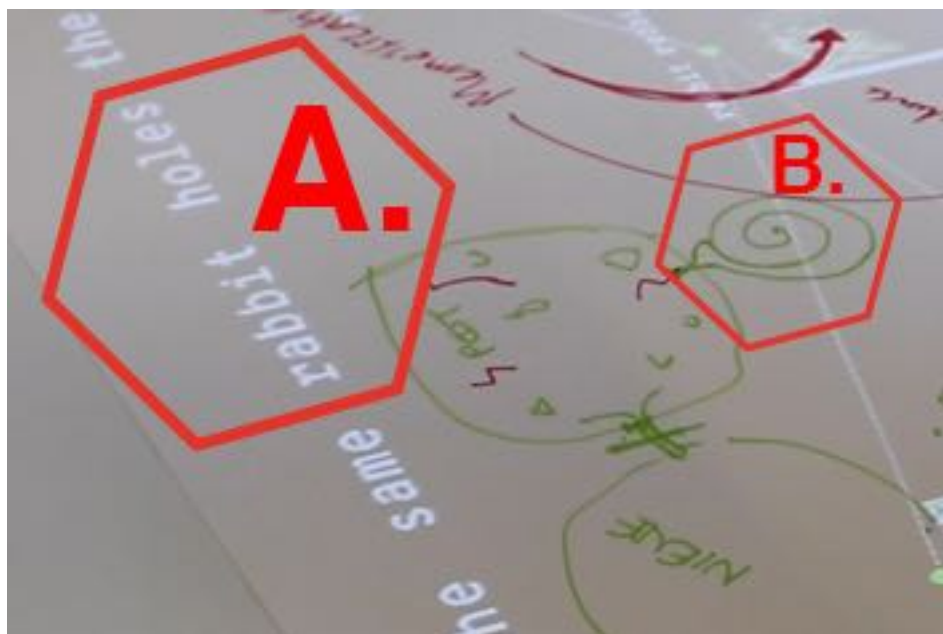


Figure 67 Textual representation (A.) encoded in sketch element (B.)

Verbal discussion associated with Figure X shown below

Participant 2 (07:08): Yeah, how it becomes, like, you can have these, like rabbit-holes that like, feed out.

Participant 1 (07:14): Mm.

Participant 2 (07:15): They, like, feed into these, like, hate points.

7.11.3 System loop <= Ideation loop?

Near the end of the event, I directed the participants that time was nearly up and to put on paper their last ideas before the end of the session. During this part of the event, the participants commented on the appearance of memes and this started both a loop of references and a loop of ideas, showing how ideation and, potentially, systems loops can emerge during augmented design ideation.

Participant 2: Oh, there we go. So many memes.

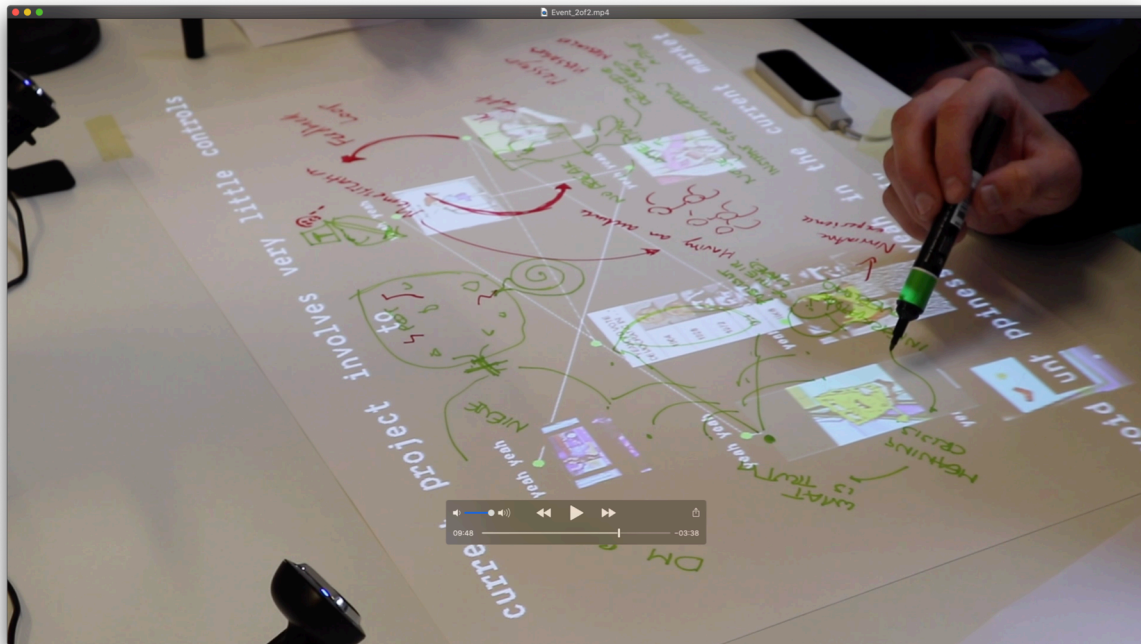


Figure 76 Ideation event video grab related to this (meme) exchange.

Participant 1: ...because that's an institution in itself. Um... (laugh) I love how it just keeps throwing memes at us.

Participant 1: Um, maybe that's it, maybe it's just like, **kind of a portrait gallery of memes**.

And, again it's j- just it's a- again with feedback

Participant 2: memes.

The appearance of memes led, over the course of 2-3 minutes, to an idea of a 'kind of a portrait gallery of memes'. This represents a type of loop where the augmented design tool caused a narrowing of reference – as the visual references returned were similar in subject or source – and the idea and lexicon became embedded in the design cognition of the

participants and was quickly reinforced by the augmented design tool. This kind of effect is similar in result to recommender systems in that they have been shown to narrow choices in certain circumstances (Nguyen *et al.*, 2014).

The pitfalls of this approach can be seen in this context where *memes* dominated a section of the ideation activity. This narrowing, however, did not go unnoticed by the participants, who started a conversation about a ‘Browser's controlling the data that the information that you see’ (Participant 2 Event 2). This resulted in them sketching browser references, perhaps as a means to overcome unhelpful references provided by the tool during the event.

7.12 Post-Event Interview Superflux

The following section presents selected findings from the post-ideation event interview. These can also be found in Appendix 3 along with further findings and notes from the interviews.

7.12.1 Findings, Interview Excerpt (1): During this initial discussion, the participants described their initial adjustment to the presence of the augmented design tool with statements such as ‘it was really kind of rapid’ (Participant 1, Post event interview) and ‘I don't want to say like kind of pressure. But it was- it was like it, just, yeah.’ (Participant 1, Post event interview). They also felt that the augmented design tool prompted their activity and they seemed to quickly adjust to its presence by the end of task 2 as they felt comfortable

using the augmented design tool in the context of the ideation task stating: ‘But for the second one, it came a bit more naturally for me, because I was more used to the format’ (Participant 1, Post event interview). There was also some notable discussions about the relevance of the feedback provided by the tool being better during the second task, for example ‘in the second one, maybe the prompts were, uh, like m- more on topic’ (Participant 2, Post event interview), showing that by the end of the task, the participants had already established a mental model of how the visual feedback from the tool contributed to their ideation process and how helpful it was at addressing different ideation contexts. The ability of the tool to act in this way for the participants suggests that the heuristics on which it relies are readily available to design practitioners. This would suggest the tool itself has some of the features of a boundary object (Fox, 2011; Star, Griesemer, 1989) enabling knowledge sharing and demonstrates how ‘Artifacts sometimes play a role in the active negotiation of shared understanding amongst communities of practice’ (Lee, 2007, p.313). Both participants appeared to use their professional tacit knowledge, drawn from their wider community of practice (Schon, 1984), to conceptualise both the augmented design tool and its role within their design ideation activity.

Furthermore, in comparison to the participants of Case Study 1 (design students), the participants of Case Study 2 (design professionals) established the utility and purpose of the tool more quickly and drew upon their tacit knowledge to qualitatively make judgements about the tool more quickly.

7.12.2 Findings, Interview Excerpt (5):

In broadening the framing of the question and asking the participants to consider the potential of the tools, the participants made specific statements about how they thought augmented design tools, such as this, could contribute to design ideation. This perspective is valuable as these participants have expert experience of professional design ideation practice. Firstly, the participants spoke about the value of “prompts” specifically in the context of overcoming moments of “block”. This idea is a foundational premise of this research, and whilst the participants’ responses do not prove this, they indicate that there is an expectation that an augmented design tool, such as the one developed in this study, could be used in such ways.

The discussion among the expert practitioners also elicited some contextual framing of augmented design tools in relation to other mood boarding products such as Pinterest (Linder, Snodgrass and Kerne, 2014). These platforms have been adopted widely by design practitioners and have been integrated into ideation practices (Wenzel, 2021).

Within their discussion, the participants also leaned on broad cultural imaginaries of web culture under surveillance capitalism (Zuboff, 2015), with a discussion of algorithmic recommendation originating from the entertainment industry, which was believed to be problematic in a design context. The participants also commented on a tension associated with producing novel connections within an entertainment industry recommendation model as this model was thought to be a homogenising force. This was then quickly connected to models of monetisation that platform capitalism often aims at, leading to general anxiety

about the trajectory of such tools. Of note here is the sophistication of the perspective of the participants who seem readily able to integrate the tool into their process and make use of it in a material way (and reflect on its utility), while simultaneously acknowledging the questionable imaginaries that can underpin such tools.

7.13 Conclusion

This case study shows how expert design users were able to readily integrate the augmented design tool into their ideation and sketching practices and how their expectations of such systems place tools of this kind within the scope of usability within specific design environments. Specifically, the study shows that the tool supported the participants' design cognition during sketching activities, as described by Cross (2018, 2001). Furthermore, it demonstrates the potential to assist the participants in the co-evolution of the problem space as described by Maher and Poon (1995). In this context the tool assumes a team member like function in a co-evolution as described in a study of team-based design practice where design problems and solutions evolve together in dialogue between the team (Wiltchnig, Christensen and Ball, 2013).

The case study also shows that the ritualised practice of sketching with design ideation, whilst performative in nature, can be intrinsically tied to insight generation in ways that are consistent with Cross's description of the place of sketching activity in design cognition (Cross, 2018). As Cross states, 'Sketching helps the designer to find unintended consequences' (Cross, 2018, p.380) and the tool in this study was observed to contribute to this practice. The degree to which augmented design tools may produce the problematic types

of pseudodata that Wilf proposes seems minimal as the tool in this study does not present concepts in the immutable ways Wilf criticises. Instead, the study demonstrates that the visual connections that exist during the ideation event are used as scaffolding (Jones et al., 2020) for discussions between case study 2 participants in ways that draw on their domain expertise in design.

The following chapter presents the next case study which builds on the work presented in this study and Case Study 1. It also uses the model of ideation events with professional designers developed here. Further, it presents an evolution of the tool to include GPT-3 generated text prompts and, as such, offers an opportunity for the further exploration of some of the speculation of the participants concerning AI driven tools.

8.0 Chapter 8: Case Study 3: Design Professionals 2, Prototype Development



Figure 77 Ideation event setting at Arup London

8.1 Introduction

This chapter presents Case Study 3, during which design professionals were brought together in pairs to undertake an *initial ideas* sketching activity in a similar manner as Case Studies 1

and 2. There was, however, a significant development of the computational prototype of the augmented design tool for this case study with the addition of Near Field Communication (NFC) enabled cards delivering machine learning generated text prompts into the augmented sketching environment.

8.2 Case Study 3 Aims

The aims of Case Study 3 are:

- a. To explore multimodal data – both computationally recorded and humanly observed – in the context of design ideation.
- b. To explore the practical constraints of augmented design tools.
- c. To explore the experience of designers (domain experts) using augmented design tools.

As in case study 2, the aims relate to all three research questions and to enabling further findings regarding how augmented design tools support professional users; their critical understanding of such augmentation; and further use of multimodal approaches to the study of augmented design practices. Additionally, this study has two additional aims:

- d. To explore the addition of machine learning generated text prompts into the augmented sketching environment
- e. To explore the differences between the participants experience of the previous case studies

These additional aims are intended to offer further insights into augmented design ideation using the prototype augmented design tool within the intended professional setting of such

tools and, as such, to elicit further expert reflection from design professionals.

8.3 Generative Machine Learning in this Study

Case Study 3 uses generative machine learning (ML) in a way that the previous case studies do not. The role of machine learning in case studies 1 and 2 was limited to the speech-to-text component of the prototype. Generative machine learning describes a technique of machine learning used to produce text and images based often upon, as is the case here, text input and natural language processing. (Xu, Zhang, Huang, Zhang, Gan, Huang, and He, 2018).

Functionally here this means the production of AI generated text derived from the speech of research participants. Participants were invited to infer meaning from the additional text prompts that were provided by the GPT-3 driven cards, as described in Chapter Four, Design Development, and to use them in a similar way to the image prompts that are also generated by the augmented design tool. However, the GPT-3 generated text did not exist prior to its generation and does not have any kind of indexical link to the ideation activity. The semiotic resources provided through machine learning are qualitatively different in that they include the effects of the computational process that made them in a way that the other image prompts in the augmented design tool do not. These parts of the tool also relate to established biases and normative structures (Denton et al., 2021), meaning that the augmentation that occurred within the study may have been influenced by an algorithmic imprint (Ehsan et al., 2022), the dynamics of which were not known. It was not feasible to assess this during the case study. Furthermore, the ability of ML generated semiotic resources to take up residence in design cognition and the heuristics of this is not considered in this study.

8.4 Limitations of Case Study 3

This case study builds upon Case Studies 1 and 2, and therefore the limitations acknowledged in those case studies (interview bias, conformation bias, limitations of Wizard of Oz studies, participant diversity, workplace heuristics and limitations on non-protocol studies) also apply. Further limitations apparent in Case Study 3 are discussed below.

8.4.1 Machine Learning Efficacy

This study does not attempt to judge the efficacy of ML tools for design cognition nor the performance of such tools within this context. While recent studies in this area (Zhu and Luo, 2022; Zhu, Zhang and Luo, 2022) explore ways of doing this they focus on indicating the trajectory of generative tools and their implications for research.

8.4.2 Generative semiotics

This study does not attempt to assess the GPT-3 generated text for meaning internal to itself. Recent studies looking at the semiotic potential of generative AI systems in relation to design methods, such as del Campo's *Architecture, Language and AI* (del Campo, 2021), consider this materially. This study, however, explores the utility of the GPT-3 generated text as an aid to design cognition in the context of augmented design ideation. Other studies pursue methods to improve the semiotic potentials of knowledge systems based on open web data and in recognition of the multimodal context that this research explores (Kumar *et al.*, 2020). This case study, however, does not attempt this and the prototype make no claims to do so. It

is, however, notable that projects are emerging around these technologies, showing that generative systems have become part of the terrain of cooperative creative work (Shakeri, Neustaedter and DiPaola, 2021).

8.4.3 Physiognomic Artificial Intelligence

This study occurred during a time when the mining of facial recognition data and other surveillance technology was increasingly seen as being problematic, with some experts declaring that it had started to enable a new and deeply harmful physiognomy (Stark and Hutson, 2022, p922). The degree to which this study enables this kind of environment is worthy of consideration. However, this case study makes no machine-based inferences based on facial or gestural data.

8.5 Previous work

There has been a significant amount of interest in using generative AI tools in design practice with the arrival of frameworks such as GPT-3 (Robertson, 2022). A design experiment led by Ben Syverson, Senior Design Lead, IDEO Chicago, is chronicled in a blog post (Syverson, 2020) concerning the use of GPT-3 in the context of brainstorming. Syverson's post also concerns the integration of GPT-3 with IDEO's *7 Simple Rules of Brainstorming* (IDEO, n.d). Of note here is the striking similarity of those seven rules with some of Brian Eno's oblique strategy cards (Eno, 1975) as described earlier in this thesis. The main point of difference is that in the case of this research, the generated text is not considered a design

idea at all (as in the IDEO example) but, instead, a prompt for the humans involved.

AttnGAN is a text to image technology that ‘can synthesize fine-grained details at different sub-regions of the image by paying attentions to the relevant words in the natural language description.’ (Xu, Zhang, Huang, Zhang, Gan, Huang, and He, 2018). Del Campo’s subsequent study of ‘Attentional Generative Adversarial Networks (AttnGAN) as a design technique in architecture’ (del Campo, 2021, p.211) ‘explores the information space present in programmatic needs, expressed in written form, and transforms them into a visual output’. Del Campo’s study is socially interested in language as a mode of input for generative computational systems, where the formal outcome of the design work is defined, as seen in their study of using (AttnGAN) as a design technique in a competition entry for the 24 Highschool in Shenzhen, China cited above. The role that AttnGAN plays in del Campo’s design process is one that resonates with the conception of augmented design tools used in this research and demonstrates the interest in finding computational means to aid design cognition.

Another notable example can be found in the Zhu and Luo’s study of GPT-3’s use in design methods (Zhu and Luo, 2022), *Generative Pre-Trained Transformers For Biologically Inspired Design*. Their study concerns an approach to concept generation within the field of biomimetic design or as the authors describe ‘bio-inspired design’ (BID). They note that despite limited metrics for evaluation of the quality of the design output, the case for generative tools in design concept generation seems sound, particularly opening up “design-

by-analogy” as an ideation support vector for computational systems. Although this study, again, places generative systems at a different location to my own research, it is a clear example of the potential place of such systems to computationally support concept generation in design practice.

8.6 Setting

Case Study 3 was conducted at Arup offices in London in a small meeting room shared by multiple teams; a more generic space than the space used in Case Study 2. Arup, a design and engineering firm, is one of the largest employers of designers in the world with many teams with specific design expertise. The participants in this study were drawn from Arup’s foresight team: ‘... a multi-disciplinary team of consultants and designers that can help our clients understand change, identify emerging opportunities and future-proof their business’ (Arup, 2022), each with approximately five year of experience within the team. The meeting room in Figure 78 below shows the specific meeting room at Arup used for the study.



Figure 78 Ideation event at Arup London

8.7 Ideation Tasks

The ideation tasks that were developed for Case Study 2 were reused during Case Study 3. The participants were given two briefs and a set time of 10-15 mins for their completion. The first of these, entitled *Personal AI*, asked the participants to ‘generate initial responses that imagined use cases for personal AI products and services and 5, 10 and 15 year time horizons’ with the imagined client being a collaboration between a large technology company and consumer electronics manufacturer. The second brief, entitled *Online Harm*, asked the participants to ‘generate initial responses that imagine and exhibition to raise

awareness of online harm' with the client being a national museum.

8.8 Event 1 Arup Introduction

In a similar way to the first event of the Case Study 2, this event served as an orientation to the experience of design sketching with the visual feedback provided by the tool. The following selected moments are presented as participants speak to the aims of the study and the integration of the GPT-3 generated prompts into the experimental augmented design ideation tool.

8.9.1 Sketching with GPT-3 Generated Prompts

As captured in Figure 79 below, participants were able to continue design sketching, drawing over the paper with overlaid projections where the visual feedback and GPT-3 generated prompts were presented. The event seemed to elicit more text-based sketching notes than were produced during Case Study 2. This may point to the heuristics of text prompts being more likely to elicit text results in this tool setup in contrast to the mainly visual prompts in the earlier studies which elicited more pictorial sketching notes in those studies.

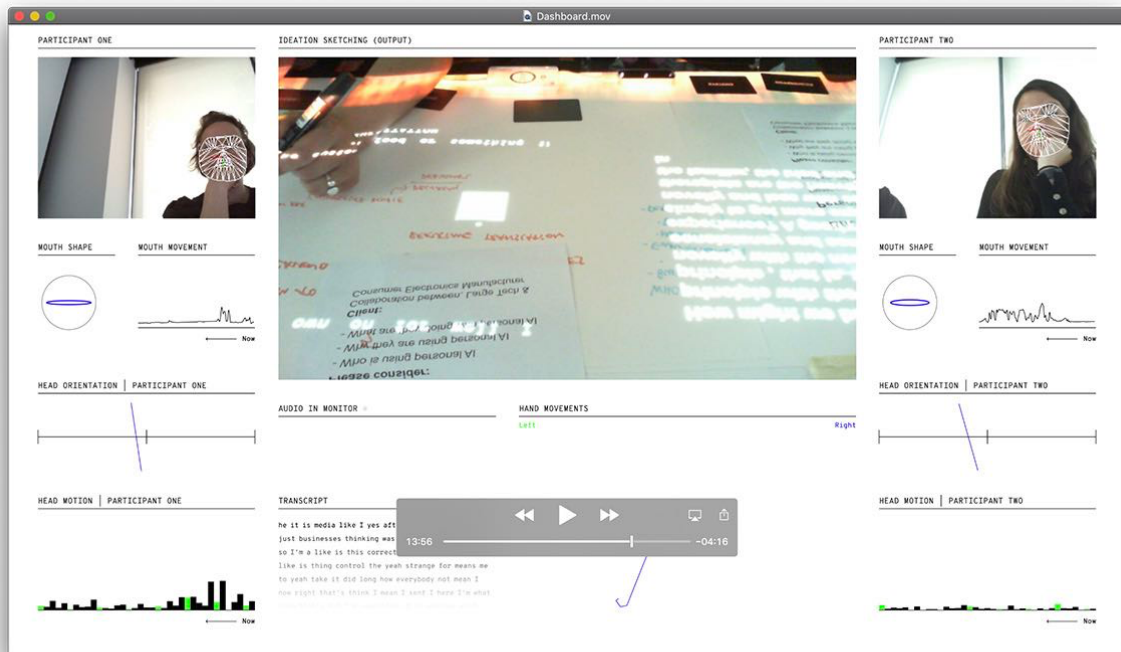


Figure 79 Augmented design tool dashboard screenshot at the ideation event at Arup London

8.9.2 First Use of the Prompt, “differences”

During the first event, the participants were verbally asked to use the prompt cards when the conversation slowed. This intervention was part of the initial need to be explicit with the participants about the role of GPT-3 generated card prompts. In the following, exchange the prompt was pre-emptive as one of the participants also sensed a break in the conversation and considered using one of the cards to support it.

Ben: Why don't you use a prompt card-

Participant 1: Yeah.

Ben: ... to get you be two, three, to get you like-

Participant 2: Yup. I think that's exactly what I was thinking.

Participant 1: Mm-hmm.

Participant 2: Go for it. You do it.

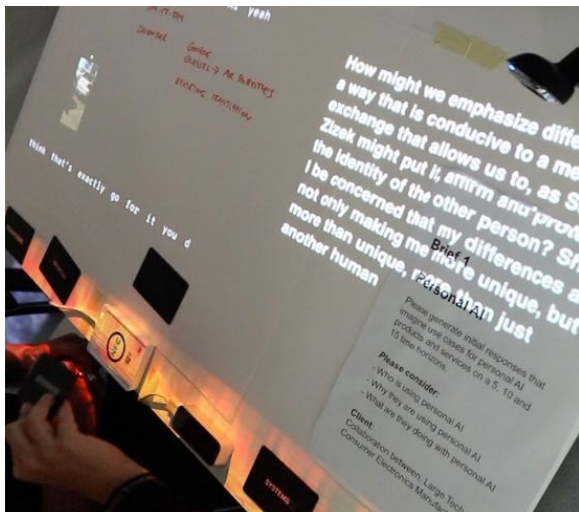


Figure 80 first GPT-3 text prompt appears

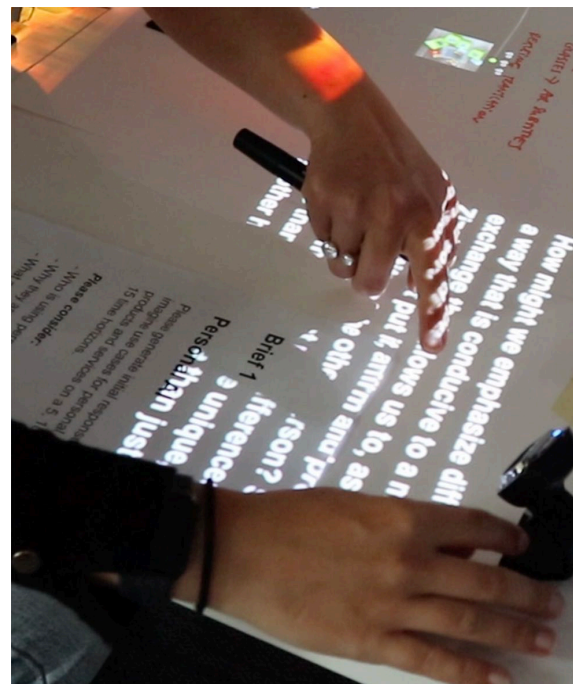


Figure 81 GPT-3 text used by participants

Participant 1: Differences...

Participant 2: One second.

Participant 1: No. Different...

Participant 2: Differences.

Participant 1: Differences?

Participant 2: Awareness conducive to meaning.

Participant 1: Have a meaningful exchange. (laughs)

Participant 2: And you can say that one [inaudible 00:07:30].

Ben: You can try that one if you like.

Participant 1: Yeah. Gonna continue from another person.

Participant 2: I think that's kind of the opposite of what we were saying.

During their discussion, the participants were able to use the prompts in the manner they envisioned and to consider the meaningfulness of the GPT-3 generated feedback in the context of their ideation. In this case – as was often the case – the feedback was felt to be a point of view from the position of the train of thought they were exploring. The perspective was considered and evaluated and discounted, as is often the case when designers explore design concepts. However, it was not considered invalid, strange or disruptive to the activity as a whole.

8.9.3 Further Use of Prompt Cards, “differences”

Following the exchange above, the participants returned to the prompt cards to seek more relevant prompts, seemingly warming to the card component of the tool. They proceeded to generate and discount several prompts as shown below.

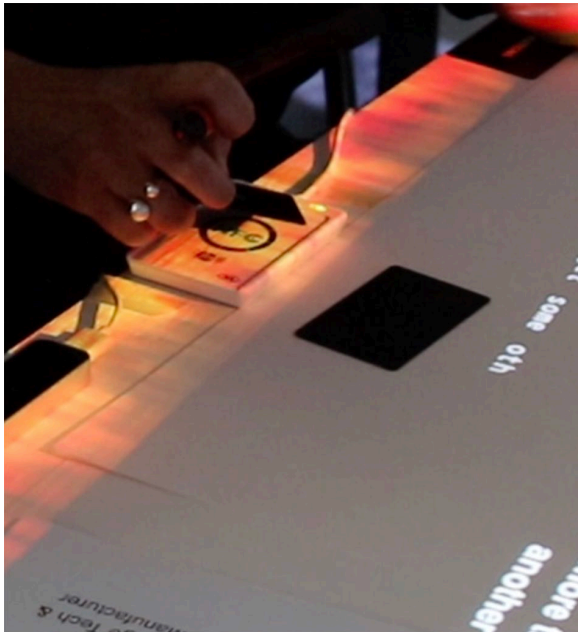


Figure 82 GPT-3 NFC prompt cards being used by participants

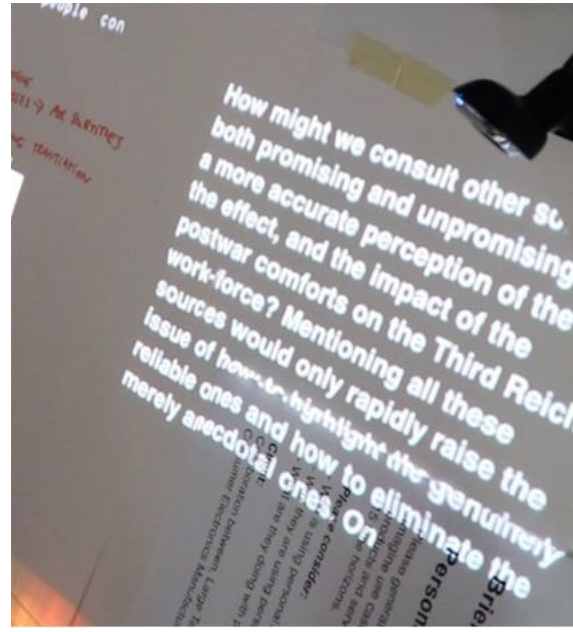


Figure 83 GPT-3 text used by participants

One of the prompts that was generated by the tool contained a reference to the Third Reich (Fig. 83) and this was quickly discounted. Another tap of the method card on the card reader by the participant to generate a new prompt was quickly forthcoming, followed by two taps in quick succession (shown below) that also generated responses that were quickly discounted as being unhelpful and/or not relevant. This episode exposed some of the issues that have recently seen with Microsoft's problematic integration of ChatGPT (a relation of GPT-3), into generative chat products (Huang, 2023).

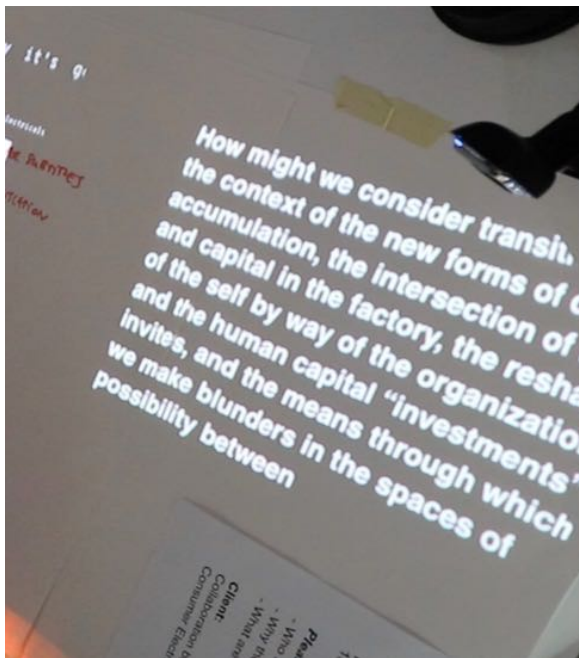


Figure 84 GPT-3 text prompt used by participants

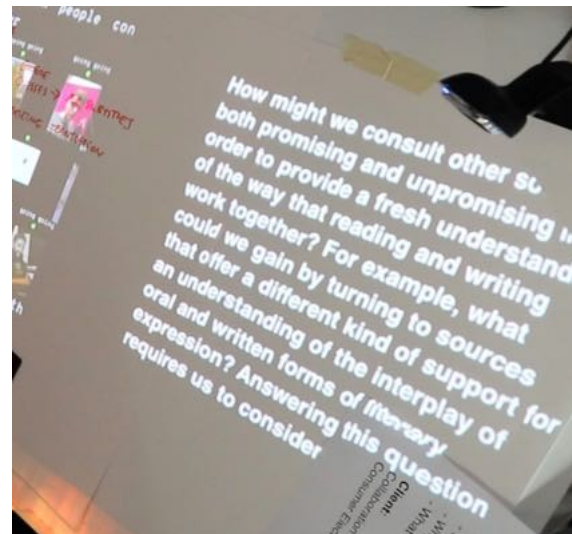


Figure 85 GPT-3 text prompt used by participants

The speed at which participants were able to scan and disregard GPT-3 text prompts during this part of the ideation event, quickly evaluating the prompts and moving on from them, was notable. The next prompts that appeared were qualitatively different as the participants paused with the generation of a particular prompt (Fig 78), catalysing the following exchange:

Participant 2: Yeah, the control thing is like privacy.

Participant 1: Mm.

Participant 2 : For sure. Um... I think personal AIs. I think something to reflect on, it's not like that. What's the... How do you make it personal, I guess?

Participant 1: Mm-hmm.

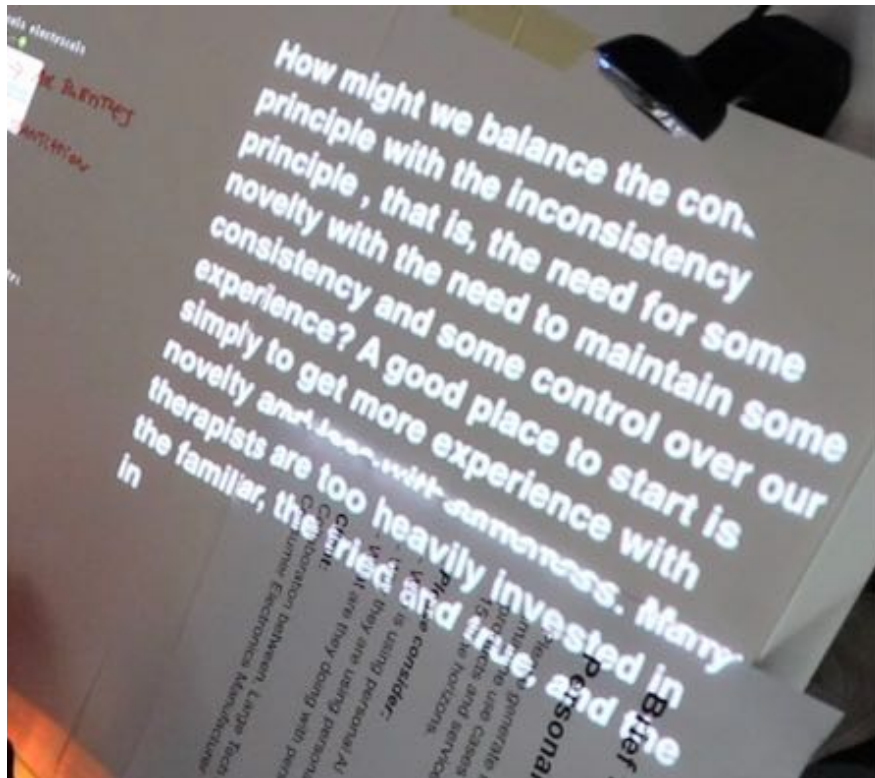


Figure 86 GPT-3 ‘control’ text

prompt used by participants

The theme, “control” , was picked up from the prompt above and then integrated into a discussion that also integrated some of the image prompts as seen in the transcript below.

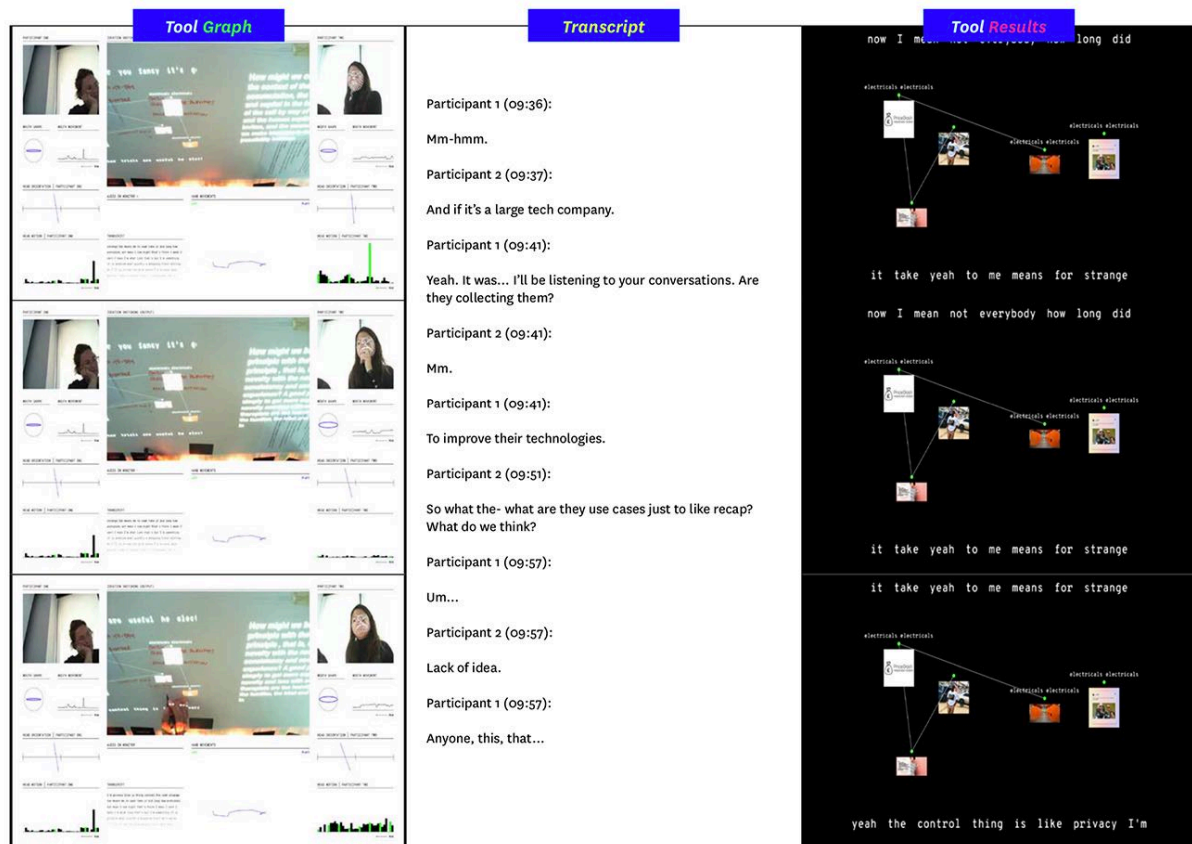


Figure 87 Multimodal transcript at
prompt use.

The idea of control was also added to a sketch generated by the participants (Fig 80) as it became part of their conversation. The verbal conversation prompted by GPT-3 was then picked up by the tool. Some of the participants' responses are displayed in the textual feedback, as seen in this quote and in Figure 81 below, 'Yeah. It was... I'll be **listening to your conversations**. Are they collecting them?' (Participant 1).



Figure 88 Prompt integration into augmented sketching.

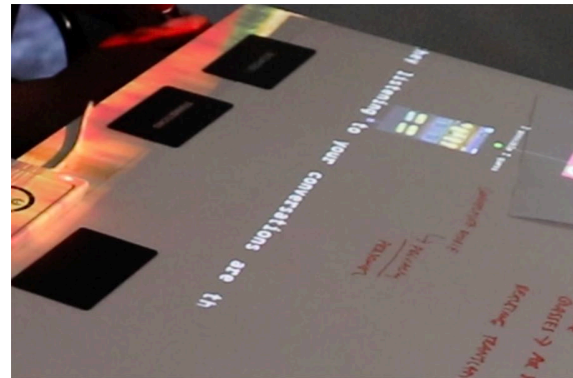


Figure 89 Prompt integration into voice recognition text and augmented design tool search queries.

This process of incorporating the GPT-3 text prompts, via the prompts being verbalised by the participants, created a sort of “ML in the middle” loop where both human sentiments and machine augmented sentiments are represented in the design ideation process.

As is evident in these exchanges, both participants were able to use the GPT-3 generated prompts in a design setting and to integrate the GPT-3 prompts into their general ideation activity. Their ability to do this sped up as they gained confidence using the tool. The event showed that they also were clearly able to read across both the image and text prompts and maintain ideation conversations, indicating that the GPT-3 prompts provided additional semiotic resources to the main event.

8.10 Ideation Event 2, Introduction

As with Case Study 2, the participants showed much more dynamism using the augmented design tool during the second event in Case Study 3 as they became more familiar with the setting and the integration of the visual and textual prompts into their ideation process. The following selected moments stood out as they spoke to the aims of the case study.

8.10.1 Sense and Sketches

This event started with a participant seeking a GPT-3 prompt and reading it aloud. This audible reading of the prompt became habitual in this event and seemed to be an attempt to lift the text prompt to the level of spoken conversation for discussion. This initial prompt that was read is shown below in Figure 90.

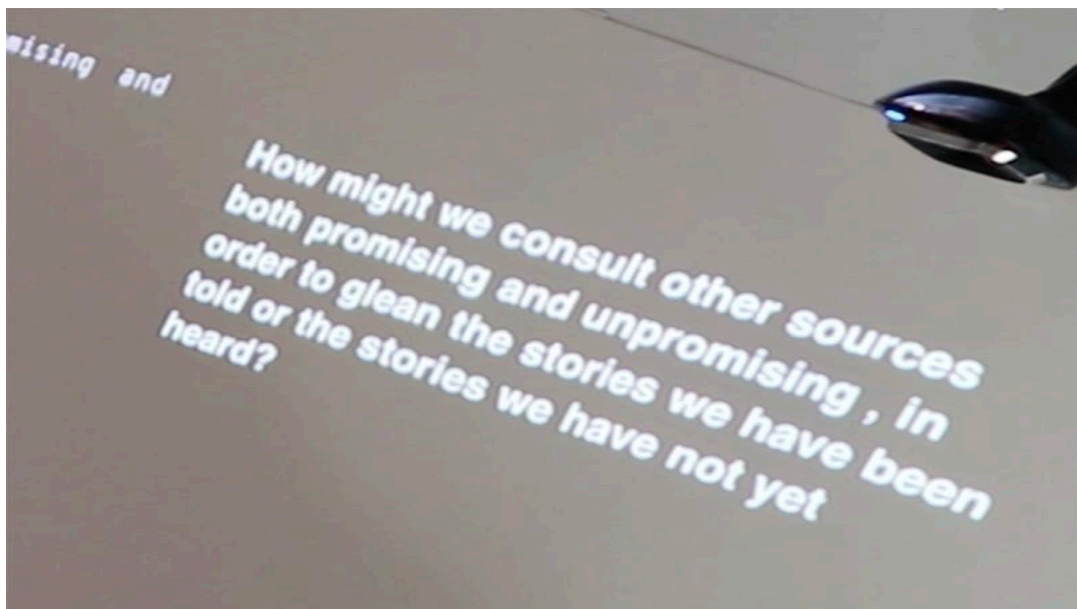


Figure 90 Initial prompt read aloud.

It is evident that the initial prompt was understood by the participants and demonstrated by the following quote, ‘Well, that one makes me think of, like, an exhibition’ (Participant 1, event 2). This shows that both participants acknowledged a conscious effort to interpret the relevance of the prompt and that the prompt acquired an identity as a viable resource for design ideation.

In this study, when a prompt has the effect of sparking a train of thought, these thoughts were transferred to paper as sketches and, in this way, became visually embedded in the ideation process. This can be seen in the sketches below which resulted from a GPT-3 prompt.

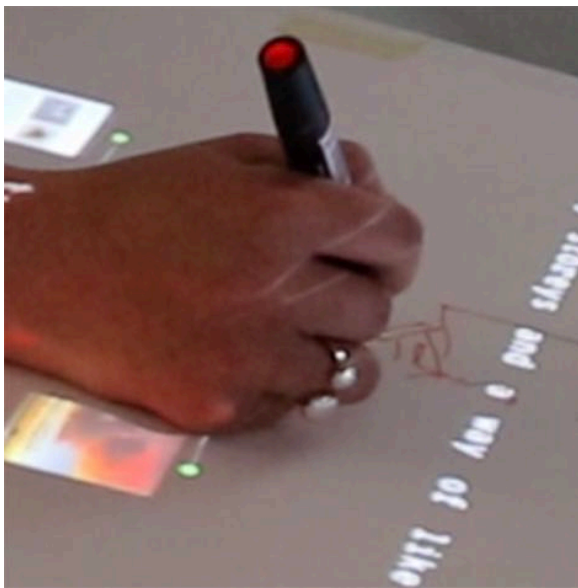


Figure 91 Sketching GPT-3 prompted idea

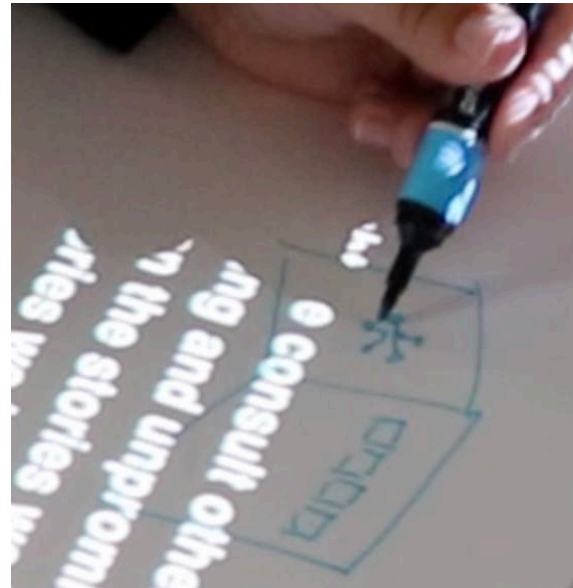


Figure 92 Sketching GPT-3 prompted idea

The activity of making sense of the text prompts and their relevance to the ideation activities is a new feature part in this case study. This new ideation loop of comprehending the text

prompt by verbalising it, then evaluating it in conversation, and then sketching the ideas it generated, is qualitatively different to the sole use of visual prompts in Case Studies 1 and 2, and can be seen below in both the dashboard of the tool and on the multimodal transcripts.

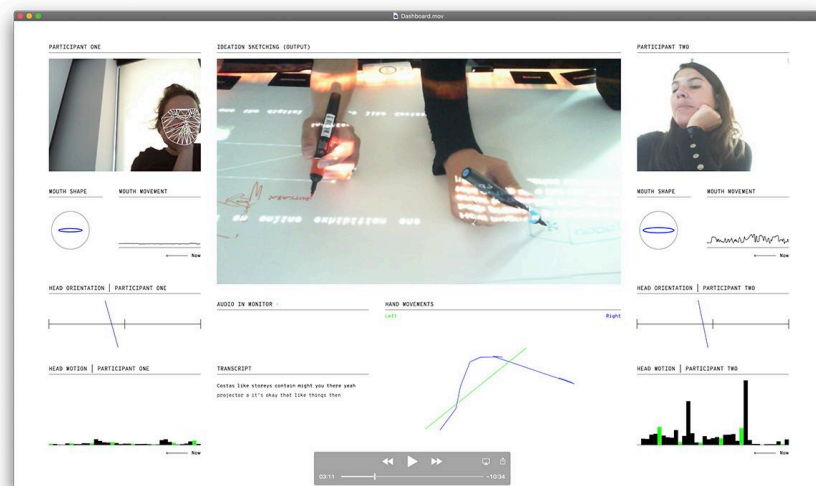


Figure 93 Sketching GPT-3 prompted idea recorded in the dashboard

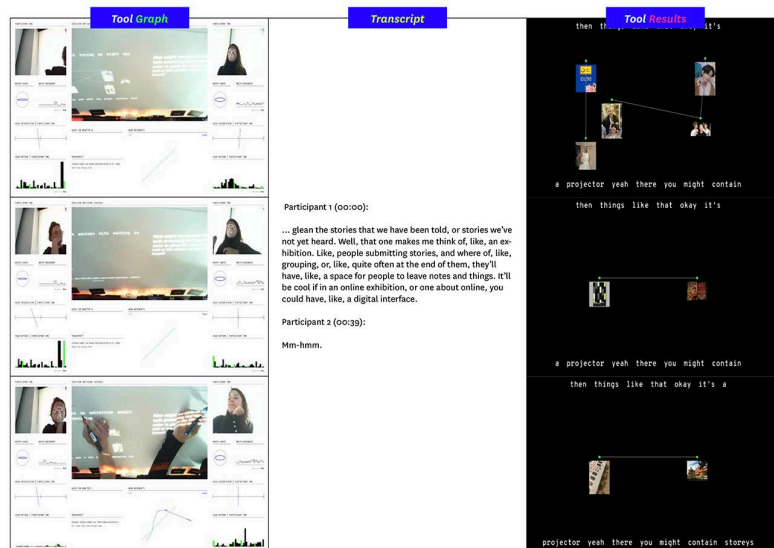


Figure 94 Sketching GPT-3 prompted idea recorded in the multimodal transcript

8.10.2 The Final Prompt

As this ideation event ended, the participants continued this loop of text prompt selection, then dialogue, and then sketching. In indicating one last such loop, the following exchange indicated the loop was now a conscious approach for the participants in this study, ‘Mm. Right, last one. How might we consult other sources [inaudible] more nuanced judgements?’ (Participant 2).

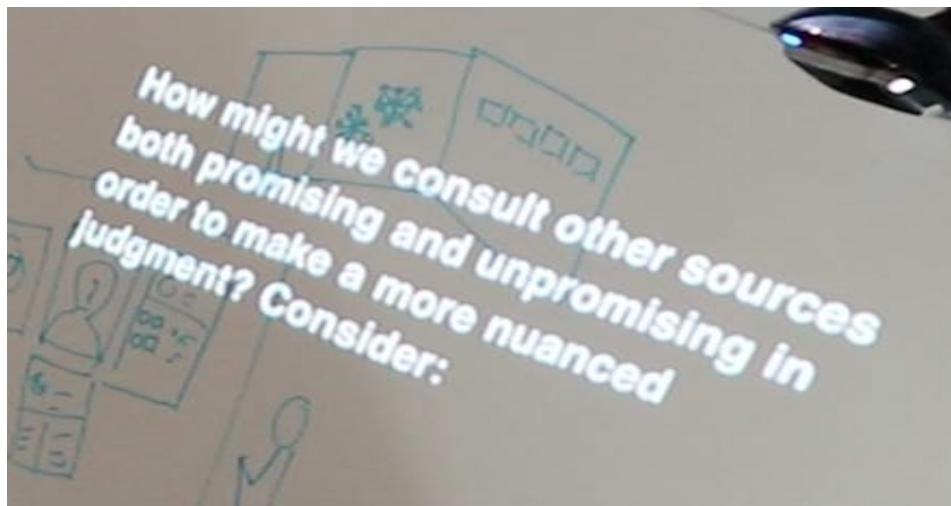


Figure 95 Last GPT-3 prompt in the event

The use of the images provided by the augmented design tool in this part of the event increased as there was a time pressure right before the end of the session, as the participants used the augmented design tool to get their final ideas down on paper. During this process they made multiple references to context with images and their relevance for design concepts and the brief in general.

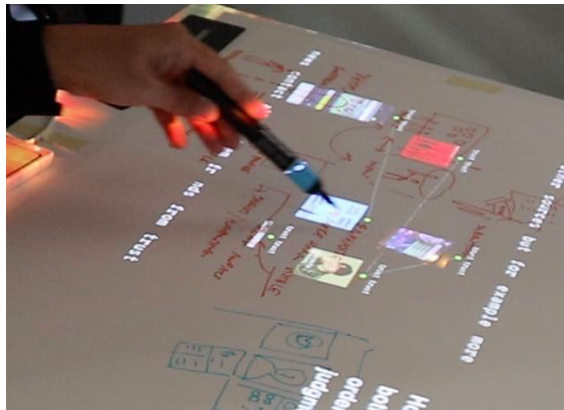


Figure 96 Augmented sketching last in ideation Event 2

The participants integrated icons and chat icons from the images into their ideation and continued using prompt cards as they built a fast-paced dialogue for final ideas for the brief. This resulted in a final exchange reframing some of the feedback from the tool in relation to the integration of design concepts for the brief before the session ended.

8.11 Post-Event Interview - Arup

The following section presents selected findings from the post-ideation event interview, a transcription of which can be found in Appendix 4.

8.11.1 Findings, Arup Interview Excerpt (1)

The participants remarked on their ability to take a somewhat incongruous task and undertake design ideation and sketching readily. They specifically mentioned that as designers, they were familiar with exercise prompts and ideation. They also indicated that although this was a novel process, it was comprehensible and achievable. Furthermore, the addition of the

GPT-3 generated prompt cards did not disrupt ideation in any way for them. This also demonstrates that adding these cards to the augmented design environment did not fundamentally undermine the process in comparison to Case Studies 1 and 2 which did not include the cards.

8.11.2 Findings, Arup Interview Excerpt (2)

During the interview the participants were unequivocal about the tools perceived usefulness stating that *‘it was useful when we were stuck ’* ; *‘So, getting the prompts, and having prompts available, and being able to just discard them if they weren't useful, and get another one quite immediately, it's useful’* (Participant 1, Post event interview) ; and *‘So, I'd say it was definitely more stimulating’* (Participant 2, Post event interview). Their comments indicate how the participants thought the augmented design tool would benefit the productivity of their augmented ideation activities, though any objective measure of this would require further analysis. Furthermore, whether or not augmented ideation has the potential to increase productivity compared to approaches such as competitive prototyping (Camburn et al., 2017b) where design teams compete in parallel to solve a common problem, is beyond the scope of this study.

8.11.2 Findings, Arup Interview Excerpt (4)

While participants articulated many positive views about the augmented design tool, they

also expressed concerns that augment design tools might ‘funnel[s] you into a very specific way of doing things’ (Participant 1, Post event interview), and leave them ‘questioning why this particular set of information is being fed to me’ (Participant 1, Post event interview). These concerns resonate with earlier discussions in this research concerning the degree to which digital technologies perpetuate “filter bubbles” (Pariser, 2012) and have the potential to narrow the scope of thinking during ideation activities. It is possible that this feeling – expressed by the participants – owes something to the broader contexts in popular (Fritschle, n.d.) and material culture (McQuillan, 2022). The participants also expressed concerns about anxiety and authorship with one person saying, ‘So, I felt a bit anxious that I’m being, like, forced into something that I maybe wasn’t sure whether it was my idea or not. So, I felt a bit manipulated in that sense’ (Participant 1, Post event interview) and ‘I felt a bit like I’m being puppeteered to an extent’ (*Participant 1, Post event interview*), indicating that designers may feel that their individual creative work can be undermined by assistive systems. While suggested within this research, such a tension could also be linked with the network assets of collaborative tools that have evolved to incorporate significant elements of, what can be called, crowd elements (Schmidt, 2017). Crowd elements can be considered more occluded when generative and AI-based systems are involved (Castelvecchi, 2016), and this occlusion seemed to be felt, in this instance, as undermining individual agency in design ideation.

8.11.3 Findings, Arup Interview Excerpt (7)

The interview discussions for Case Study 3 differed qualitatively to Case Studies 1 and 2 given the presence of the GPT-3 generated text prompts and their effects on the participants' perceptions of the presence of AI-based processes in the augmented design tool. The potential for such tools to support broader discussions during ideation activities was identified by the participants, who described the potential for such tools as an opportunity, to 'tap into some things that are more, um, that become more about, um, equitable and accessible' (Participant 1, Post event interview), meaning that the ability to design for a broader set of contexts, users and scenarios may be enabled by such tools.

8.11.4 Findings, Arup Interview Excerpt (8)

An additional question concerning perceptions of bias in AI systems was included within the interviews in Case Study 3. During this discussion, participants initially framed bias as potentially residing in image sets accessed by the tool, representation bias, and observed that this was likely common across many types of design image sets gathered for inspiration, particularly those based on stock commercial photography (Frosh, 2020). This was a notable observation but somewhat out of scope for the case study and it is not how the augmented design ideation tool works from a process perspective. However, the questions of the bias contained in the blogs and websites that the tool drew from is a valid concern. Secondly, there was an interesting discussion of augmented design ideation tools offering greater accessibility in terms of decoding technical language for non-specialists and the potential to expand the image reference domain of designers from western contexts. This was seen to be limited, however, by the images sets that the tool draws upon. Finally, the participants

acknowledged that AI-based augmented design ideation tools could be purposefully used in a negative context and raised concerns about how this might be recognised before such systems are deployed at wider scales. This concern also mirrors some of the narratives relating to problems associated with platform technology companies that have been reflected in popular culture (Morozov, 2013; Hawley, 2021).

8.12 Conclusion

Through adding GPT-3 generated text prompts to an augmented ideation environment this case study demonstrates a significant development of the prototype. In extending the prototype, the study further explored the augmentation and critical context of collaborative design ideation using experimental technologies, ambient information systems, AI tools and platforms, and experimental computational prototypes. The following key observations were made in this study.

8.12.1 Integration: Participant Capacity to Integrate Generative Text Prompts and Generative Machine Learning for Design Ideation

This study demonstrates that participants were able to integrate GPT-3 generated text prompts into their ideation activity. This was achieved, in part, by co-opting a recognised design process tool – the prompt card – and expanding its function using web-based machine learning technologies and interactive opportunities using NFC wireless communication. The participants' willingness to use the prompts in the ideation process in conjunction with the visual feedback provided by the tool was clearly visible. This demonstrates that assemblages

of assistive and generative technologies can be added to augmented design ideation contexts and that there is a reasonable expectation that professional users will have the ability to use the semiotic resources they provide. However, this study also shows that participants' abilities to integrate modes of augmentations are dependent on the interaction design that is deployed alongside them as this facilitates how elements are interpreted. During the post-event interview, it was clear that the presence of ML technology within the prototype influenced the participants' reflections on broader cultural concerns associated with using ML tools, particularly bias and representation. Furthermore, questions of authorship were more keenly expressed in this context.

9.0 Chapter 9: Discussion and Observations

9.1 Introduction

This chapter summarises observations in three key areas and develops a discussion of their relevance to research that aims to explore augmented design ideation.

9.2 Methodological Observations

This section summaries methodological observations that were identified during the research. The methods used were selected to enable the exploration of *experimental prototypes* through practice-based design research and to evaluate participants' experience of *augmentation* within design ideation tasks.

9.2.1 Methodological observations related to multimodal research

To explore the construction of meaning within *augmented design ideation* this research uses the concept and practice of multimodality. Multimodality is an approach that has been specifically developed to describe the complex way meaning is created, particularly at the intersection of social experience and technology (Bezemer & Mavers, 2011). Consequently, multimodality is observed to offer a way to analyse the complex social and interactional relationships at play in *augmented design ideation* as presented in the case studies.

Multimodal methods are observed to make useful inventories of the social semiotic resources at play during *augmented design ideation* and, that these can be linked to novel approaches to multimodal transcription. These novel approaches to transcription are observed as being an important site of multimodal research practice development. For example, the experimental computational prototypes of the augmented design tool developed in the practice-based element of this research design, have embedded in them methods for the recording of *ideation discourse* with relational word clouds, video data, sound data, haptic gesture data (and graphs of this data) which are recorded throughout the ideation events. From the perspective of design research, this ideation discourse is observed to have potential beyond the scope of this study in that the ideation discourse data that may have use in generating new taxonomies of design ideation or act as repositories to record the design knowledge generated in these expert gatherings. In this study however the ideation discourse forms part of the multimodal transcripts that enable an integrated approach to multimodal analysis.

The approach to multimodality presented here has generated sufficient insight for this research and it is observed that more scope exists to apply and extend multimodal methods in the study of augmented design ideation using emerging technologies.

9.2.2 Summary of Methodological Observations

My research involves both practice-based and qualitative elements and draws from ideas established within practice-based design research approaches. My design research adopts methods depending on the problem or phenomenon it is attached to (Stolterman, 2008). This is also a reflection that ‘Design problems are fundamentally “indeterminate” (Buchanan, 1992, p16) and, as such, are often addressed through co-opting other bodies of knowledge and, in the case of design research, other methods from outside the field of design research (Gaver, 2012). The methodological approach I have established for my research has both the

commonality and difference of the design research approaches described by Gaver and Stolterman and acknowledges the contribution of *designerly* (Cross, 2007) knowledge to methodological choices.

9.3 Critical Observations

9.3.1 Design Research, Design Thinking and the Possibility of *Pluriversal* Augmented Design Ideation

The study of design ideation resides significantly in the design research community and there has been a renewed interest in equity and representation in this field with initiatives such as the 2019 establishment of a Special Interest Group in Pluriversal Design by the Design Research Society (DRS, 2019), the 2016 establishment and subsequent growth of the Design Justice Network (Design Justice Network, n.d-a), the establishment of groups such as the Decolonising Design group (Decolonising Design Editorial Statement, n.d.) and their influence in the design industries (Khandwala, 2019). Given this shift in perspectives, the extent to which practices of augmented design ideation can be said to rely on colonial practices and/or technologies is observed to be an important area for further work. For example the experimental computational prototype of the augmented design ideation tool developed in this research relies on search and image technologies that have been shown to be colonial in character (Noble, 2018 and Denton, E. et al. 2021). Furthermore, the case studies presented here show that the practice of augmented design ideation potentially accelerates the use of these technologies without specifically addressing these concerns. The further concerns of the proponents of design justice approaches (Costanza-Chock, 2020) who

see systemic issues with design ideation practice per se including, who is designing for who, and the power relationships present in the corporate design context of the US and Europe are observed to be under explored. Participants in the case studies are also observed to be aware of the exclusionary potential of design ideation in an augmented context.

9.4 Observations for the Design Industries

9.4.1 Collaborative Design Tools and AI Design Tools

Collaborative design tools and AI design tools have been developed and deployed rapidly within the design industry (Wenzel, 2021). These technological developments have supported the creation of niche practices including the development of discreet products and practices associated with generated design prompts and associated prompt tools (Fleck, 2021).

Assistive systems have become an increasingly common feature in design practices, including ideation and the increasing ability of novel uses of these tools by designers to build custom ideation workflows. The trajectory of these practices appears to be pulling away from holistic technology enhanced spaces and towards assemblages of web of devices and services. It is widely anticipated that design facilitation roles will emerge within the design industry involving new groups of design professionals able to leverage assistive AI technologies during ideation processes (Robertson, 2022).

9.4.2 Designers' Awareness of AI Systems

The general level of awareness of AI systems and their effects have become a subject of much public discourse, often not celebratory in nature (O'Neil, 2016; Noble, 2018b;

Crawford, 202; McQuillan, 2022). Within the design field much discourse has also been developed to consider the effects of AI systems and contexts on design practice (Fritschle, n.d.; Leach and Yuan, 2018; Jones and Hirsu, 2019; Maeda, 2019). The design professionals who participated in my research demonstrated concerns informed by the broader cultural discussions of AI systems and interweaved these with more nuanced issues identified from within the domain of design practice. Discussions relating to the application of AI within the design field have developed considerably within the time of my research and have set out important questions for the design industries, particularly in relation to how designers anthropomorphise ambient intelligent systems and how this has begun to frame co-design practices. For example, in the case studies the participants readily anthropomorphised the tool and specifically accepted tool feedback as input as if from a third person and ascribed both human and non-human computational perspectives to its prompts. If design teams do not have a good understanding of the nature of these prompts in augmented ideation contexts they may unwittingly undermine the value of their expertise, in part by being too credulous of machine generated context and content. Design organisations will therefore need to better understand the effects of anthropomorphised expectations and critical concerns relating to the adoption of AI within their design workflows.

9.5 Conclusion

In this chapter, I have discussed macro observations drawn from the program of research described. In particular, the methodological observations relating to the programme of action research as a whole. These methodological observations serve as a guide to orient other

design researchers who wish to use multimodal methods in experimental ways to explore the broad context of co-design with computational support in a manner that accounts for both technical and social phenomena of the augmented design context. Specifically, the approach of using visual tool output from the experimental computational prototype of the augmented design ideation tool, to develop *multimodal texts*, demonstrates how a practice-based design approach can contribute to multimodal ethnographic methods in the design research field. This integration allows the design process to shape multimodal ethnographic methods and open possibilities for the observation and analysis of the rapidly evolving practice of design activity assisted by technology where new phenomena emerge often.

The critical observations of my research highlight an urgent need for further work to explore the potential of augmented design tools to accelerate contemporary colonial dynamics of universal design approaches and western centric technology solutions. These critical observations are important to both tool designers and users of such tools. Without careful attention to the heuristics of design related digital tools, design will further compound computational oppression into our design ecology.

This chapter has also presented observations for the design industries and the adoption of assistive AI-based tools into technology supported co-design contexts. I have shown that there is already growing expertise in the design professions to leverage the potential of such tools and a strong concern for the material effects of such assistive technology.

10 Chapter 10: Findings and Conclusion

10.1 Introduction

This chapter presents my findings in relation to each of my research questions and describes the contributions to knowledge made by my research. The findings are drawn from the three case studies and concern the design and development of experimental computational prototypes of the augmented design ideation tool, how multimodality can help explore augmented design practice, and the exclusory potential of such tools.

10.2 Summary Findings and Research Questions

10.2.1 How can collaborative design ideation be augmented by web technologies, ambient information systems and AI tools and platforms?

Collaborative design ideation is shown to be a practice that can be augmented by assemblages of web technologies and ambient informatics, especially when they are developed into augmented design ideation tools. The students and professional designers who participated in the research were able to integrate augmented design ideation tools into their collaborative ideation without significant training or orientation. The three case studies that form the main part of my research show how the heuristics of design ideation sketching practices are able to incorporate visual and textual feedback generated by augmented design tools. Further, the participants who took part in the case studies were able to infer semiotic

relationships between visual and textual elements and to apply these within design concept formation and design cognition. Augmented design tools, such as the experimental computational prototype I have developed during this research, are able to leverage web search technology to provide visual stimuli for ideation tasks that is context specific while also supporting divergent thinking within design ideation. Tools for the acquisition of multimodal data, such as speech recognition, are shown to have evolved to the point where they are sufficiently accurate and accessible to be used in such tools in an ad hoc manner by designers and researchers.

10.2.2 How can experimental computational prototypes be used by designers and design researchers to explore the critical context of technologically augmented design ideation?

Experimental prototypes are found to be useful in demonstrating *near term technical tools*, meaning tools that are considered likely to exist in the next 5 years in some form. The prototypes that have been developed during the research are found to be useful for exploring the multimodal context of design ideation and for experimenting with parsing multimodal data and suggesting to users that certain features of systems are correlated to their modes of communication. Additionally, the prototypes are found to be able to produce elements of multimodal texts in the context of design ideation. The prototypes are shown to provide a coherent dashboard of visual results that, when combined with a transcript of the conversations and concurrent image feedback from the tool, provide design researchers and practitioners with novel means for analysing the multimodal context of design ideation.

10.2.3 What is the exclusionary potential of design ideation tools and practices

augmented by consumer AI and web technologies? In considering the potential for exclusion in the context of augmented design ideation, the use of computational prototypes enables some of the specific exclusionary effects associated with the foundational technologies of these prototypes, to be studied. Technologies with well identified exclusionary properties, such as internet search (Noble, 2018) are seen to be present in the augmented design ideation technologies that this research imagines and tests. These technologies are found to accelerate exclusion in novel ways in the augmented design ideation context, as explained further in the contributions section below. This use of experimental computational prototypes is found to produce valuable insights where design, HCI and technology research intersect, when exploring the associated phenomena generated by the practice of augmented design ideation.

10.2.4 How can multimodal interaction be used to explore augmented design practices?

Multimodality and multimodal interactions are found to be relevant for describing the broad context of augmented design ideation and the complex relationships between experimental tools, people and design activity. As identified by Dourish, embodied interaction (Dourish, 1997) enables these relationships to be considered holistically, in any given moment. Expanding Dourish's idea of *context* to include different modes of communication and system data arising from augmented design activities has been found to enable an approach to augmented design practice that can describe both the local and networked dynamics of augmented design ideation. Furthermore, using Dourish's idea of context in this way enables features – such as anthropomorphic approaches to augmented design ideation tools developed

by people doing augmented design – to be considered as material elements for describing and researching augmented design practice. The use of multimodality in this context has been found to enable the study of design activity at the level of human interaction and to explore the meaning of the transient artefacts of design ideation as resources for meaning making.

10.3 Contributions

The contributions to knowledge that are presented in the research are located within three main areas: the augmentation of collaborative design ideation with computational systems; multimodal practices for the study of design ideation; and design thinking, augmented design tools and exclusion. In this section I outline each of these in turn.

10.3.1 Augmentation of Collaborative Design Ideation with Computational Systems

The study of design ideation augmented by experimental prototypes with the formal properties presented here is an original position. Formal properties include the mix of the tool's component technologies, both hardware and software; the design of the interaction model; the visual design of the system feedback; and the associated system heuristics when these elements are brought together. Augmented design ideation is explored through the iterative development of experimental augmented design ideation prototypes and by the qualitative study of their use within education and professional contexts. The research offers original findings concerning collaborative design ideation with computational tools from the

position of design research.

In design research, design ideation has often been studied in relation to its associated practices such as sketching (Coyne, Park and Wiszniewski, 2002; Jonson, 2005; Bilda, Gero and Purcell, 2006), and co-creation (Sanders and Stappers, 2008). There has also been an interest in the effect and utility of digital tools on practices such as sketching (Verstijnen et al., 1998; Coyne, Park and Wiszniewski, 2002; Bilda and Demirkan, 2003). Furthermore, there has been interest in cognitive heuristics in design ideation (Yilmaz and Seifert, 2010) and the mechanics of problem framing in the context of ideation (Silk et al., 2021) with such work building on earlier work exploring the expertise of designers in general (Cross, 2004). Though highly relevant, this body of research does not directly address the potential for ambient technology to augment design ideation and does not integrate the development of prototype tools for design ideation.

In HCI, there has been recent interest in computational systems to augment design ideation specifically. These often explore specific technology approaches such as sketching robots (Lin et al., 2020), digital pens (Webb, 2015) and digital sticky notes (Jensen et al., 2018). However, these studies do not address, apply, or situate the investigation of augmented design ideation technologies within practice-based design research involving design students and professionals.

In the design science research community (Papalambros, 2015), design ideation also includes work that contributes to an understating of specific elements of design ideation practice, such

as external stimuli during ideation (Gonçalves, Cardoso and Badke-Schaub, 2016) and the design heuristics across disciplines in the ideation phase (Yilmaz et al., 2015). This community has produced research that explores computational tools for design ideation in specific contexts and which typically focuses on computational approaches that demonstrate the opportunities for singular augmentation approaches (Han et al., 2018). Furthermore, this community has also considered the context of open design (design shaped by internet platforms and crowd source approaches) (Boisseau, Omhover and Bouchard, 2018). However, this body of research has not examined how the multimodal description of augmented design environments and their effects can be integrated into design practice.

10.3.2 Multimodal Practices for the Study of Design Ideation

Multimodality as a research method (Jewitt, Bezemer and O'Halloran, 2016) has not been widely used in study of design activity. There is currently scant use of multimodality regarding design ideation with professional designers. This research presents an original and novel use of visual ethnographic multimodal methods and perspectives to explore how meaning is produced in design ideation contexts. Furthermore, this study presents novel multimodal texts which integrate both computational and non-computational semiotic resources (dialogue, camera footage, sensor data and ideation tool informatics) to develop insights into augmented design contexts and practices.

There has been some interest in specific aspects of multimodal research methods in the study of design such as *Participatory Design with Children* (Derboven, Van Mechelen and Slegers,

2015b) and the exploration of the multimodality as a stimulant to design creativity (Miller and Mair, 2006). This work, however, does not approach the augmented context that my research focuses on and does not integrate computationally generated components within multimodal analysis.

The potential for multimodality to include computational elements has been a matter of some study (Voigt et al., 2016) but this does not address the context of design ideation. The integration of multimodal data from machine sources and media sources presented in this study is an original application of this approach and offers insights for researchers attempting to study the design and application of prototype tools and their meaning for designers simultaneously.

10.3.3 Design Thinking, Augmented Design Systems and Exclusion

The degree to which harmful constructions of design thinking become embedded in systems of augmented design ideation is found to be important and understudied. Scholars have explored how design can evolve to produce social good (Ansari, 2018; Escobar, 2018b; Mareis, 2020), but the specific case of design augmentation by computational means as described in this research has not yet been explored. In reflecting on this research, I show that there is a potential for systems of augmented design ideation to produce multiple forms of injustice. Design is often considered to be a form of world building (Costanza-Chock, 2020) through its production of material ecologies. Worlds built using such systems also have the potential to further instil these injustices within our global material culture.

The research identifies how the presence of machine learning technologies in augmented design ideation tools has the potential to amplify these issues. This concern stems from several places, including bias in training datasets (Crawford and Paglen, 2021), representation bias in informatics; lack of diversity in language recognition leading to exclusion of voices in automatic design prompt recognition; extractivist practices concerning crowd design in connected systems (Chagnon, Hagolani-Albov and Hokkanen, 2021); harmful encoding of false physiognomies of multimodal communication (Stark and Hutson, 2022b); and the degree to which such systems can be co-opted for surveillance capitalism (Zuboff, 2019). In this context, this research makes a contribution to the understanding of how design ideation leveraging these problematic technologies could potentially produce further exclusion for our global design ecology. This contribution also highlights the fuzzy awareness of these issues in the technology industry, supporting the development of assistive technologies for the design domain. My case studies demonstrate that there is an awareness amongst the participants that these issues exist even if the specifics are obscured. This occlusion is also expressed explicitly in case study three as a concern and shown to be a common feature of platform technologies (Bratton, 2016). What the case studies demonstrate consistently is that the participants were concerned about exclusion and the compound impact of technology support of this kind on design ideation process, but lacked a consistent framework to describe their concerns.

10.4 Future Work

Several areas for future work can be identified within the findings of this research and in relation to current trajectories associated with augmented design ideation discourse and the development of computational tools for augmenting design practice.

10.4.1 Generative Machine Learning for Augmented Design Ideation

Significant advances in generative machine learning systems that have occurred during the period in which this research was undertaken, including tools and frameworks for image generation, such as DALL-E (DALL·E: Creating Images from Text, 2021), pose both exciting and concerning possibilities for augmented design practices, including design ideation. Just what these technologies will mean for design ideation will be of significant interest to both design practitioners and design corporations in the industrialised global design industries. This research suggests that corporate interest is likely to be focused on efficiency, team performance, the leveraging corporate knowledge corpuses and anxiety about IP protection and derivative work. Design practitioners in this context will, this research suggests, have additional interests which include the changing nature of their creative agency, the exclusionary potentials of augmented design ideation accelerated by platform technologies, and similar anxiety about IP protection and derivative work. These interests will be reflected in the design research community as it seeks to explore the complex relationships between these concerns that are shown in this research to be shaping design ideation activity.

10.4.2 Computational Multimodality for Augmented Design Ideation

The degree to which multimodal research methods will evolve to include computational encoding of embodied experiences is unknown. However, this research points to the integration of computationally generated elements in multimodal texts being of use to those wishing to study design cognition and design activity in general. As tools for assembling augmented design environments become more commonplace, the approach of integrating data from such tools into multimodal texts may increase and future work may be required to adapt multimodal methods for the study of computationally augmented design more holistically.

10.4.3 Fairness and Inclusion in Computationally Augmented Design Practices

As highlighted in this research, the degree to which computationally augmented design practices produce fairness and inclusion or further entrenches exclusion and unfairness is considered an important area of further study. This would seem a prescient area of future work in that the better we understand the possibilities for discrimination within design ideation, the better chance we have at producing a material ecology that is more inclusive and fair. This research contends that identified criticisms of design thinking, of which design ideation practices are substantially derived, do not fully encompass the scope of design ideation augmented by computational means as described here. Future work is needed to further identify how the material properties of technologies such as generative AI and internet search can compound issues of fairness and exclusion within augmented design ideation. This research highlights that this work will need to happen in several discreet areas. These include but are not limited to: more inclusive practices for the development of augmented design

ideation tools; more inclusive approaches to the foundational technologies such as generative AI and internet search for this context; and the development of more robust case studies to specifically explore fairness and inclusion in the context of augmented design ideation from within the design community.

End.

Appendix 1: Design Briefs for ideation events.

Shown below are the two design briefs given to participants in case studies 2 and 3.

Brief 1

Personal AI

Please generate initial responses that imagine use cases for personal AI products and services on a 5, 10 and 15 time horizons.

Please consider:

- Who is using personal AI
- Why they are using personal AI
- What are they doing with personal AI

Client:

Collaboration between, Large Tech & Consumer Electronics Manufacturer

Brief 2

Online Harm

Please generate initial responses that imagine an exhibition to raise awareness of online harm.

Please consider:

- Who is being harmed
- Why they are being harmed
- What might the exhibition contain

Client:

National Museum



Brief 1 shown in situ.

Shown below are the three design briefs given to participants used in case study one and the pilot study (briefs: Social Object, Expanded Cinema and Narrative Environments).






Important Definitions

Internet of Things
interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure.

Sociable objects are devices that share. They can talk to each other, gain information about their context and react accordingly.
Robert Faludi

Low Tech / High Tech is an approach to technology where you are asked to combine or contrast different type of technologies together to build new objects. You will try to connect past and future, physical and digital, nostalgia and speculation. You can use practices from the real world into the digital or try to apply computational thinking into the real world. Kevin Walker

Part 1: Social Object

Imagine looking at an object not for its artistic or historical significance but for its ability to spark conversation. Nina Simon (The Participatory Museum)

The term, Internet of Things, seems to confuse connecting devices with their having any kind of useful social/communal awareness, mores, or relationship. Bill Buxton (@wasbuxton) - 7/1/2015.

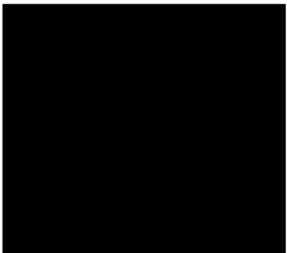
A social object is one that connects the people who create, own, use, critique, or consume it. Social objects are transactional, they facilitate exchanges among those who encounter them. According to Nina Simon, in a museum, a social object can be personal (an object that looks like one that you own), active (an object that does the same thing regularly), provocative (a disobedient object) or relational (explicitly invite interpersonal use).

For this brief, you'll be asked to find, define, refine and then make a social object. Make an object whose purpose is to connect with other objects or people using physical computing as an agent. Your object will have to be tangible and have an aura. Objects, like individuals, may have their own

space, which can be limited (a room) or virtually unlimited (the internet). Your object may be a social lubricant, socialising the autonomic, protect aloneness, allow remote intimacy or to expand / restrict participation (with other species or human with disability such as autism).

Consider the low tech / high tech approach when making your object. Focus on people, their relationship with objects at first rather than the technology.

Limitation: for this brief, programming is restricted to the Arduino language.



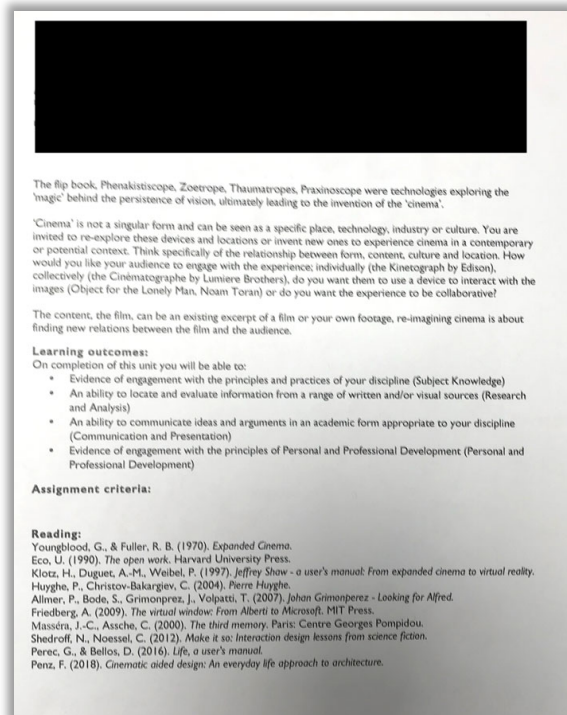
Links with theory and research:

The Participatory Museum (Nina Simon)
The System of objects (Jean Baudrillard)
Disobedient objects (Catherine Flood, Gavin Grindon)
Design Noir: The Secret Life of Electronic Objects (A Dunne, F Raby)
Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design (A Dunne)
Behavior in Public Places (Erving Goffman)
Reassembling the Social: An Introduction to Actor-Network-Theory (Bruno Latour)
The Practice Turn in Contemporary Theory (Karin Knorr Cetina, Theodore R. Schatzki, Eike von Savigny)
The Epic Struggle of the Internet of Things (Bruce Sterling)
Designing Connected Products (Claire Rowland)
Tales of Things research (<http://talesofthings.com>)
Provocative Awareness (Bill Gaver)

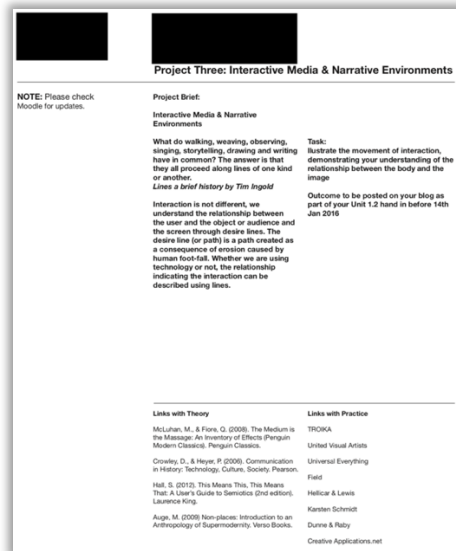
Links with practice:

Skube - A Last.fm & Spotify Radio (Andrew Spitz)
<http://www.soundplusdesign.com/?p=5516>
Good night lamp (Alexandra Deschamps-Sovino)
<http://goodnightlamp.com>
Hello Lamp Post (Pan Studio)
<http://panstudio.co.uk/folio/hello-lamp-post/>
Music Memory Box (Chloe Meineck)
<http://www.watershed.co.uk/ished/projects/music-memory-box>
Money no Object (Heidi Hinder)
<http://www.moneynoobject.co.uk>
Fuck Yeah Internet Fridge
<http://fuckyeahinternetfridge.tumblr.com>
RemoteHome - Tobl Schneider
<https://www.ti.se/projects/remoteframe>
Summer house (2008), Oliver Assayas

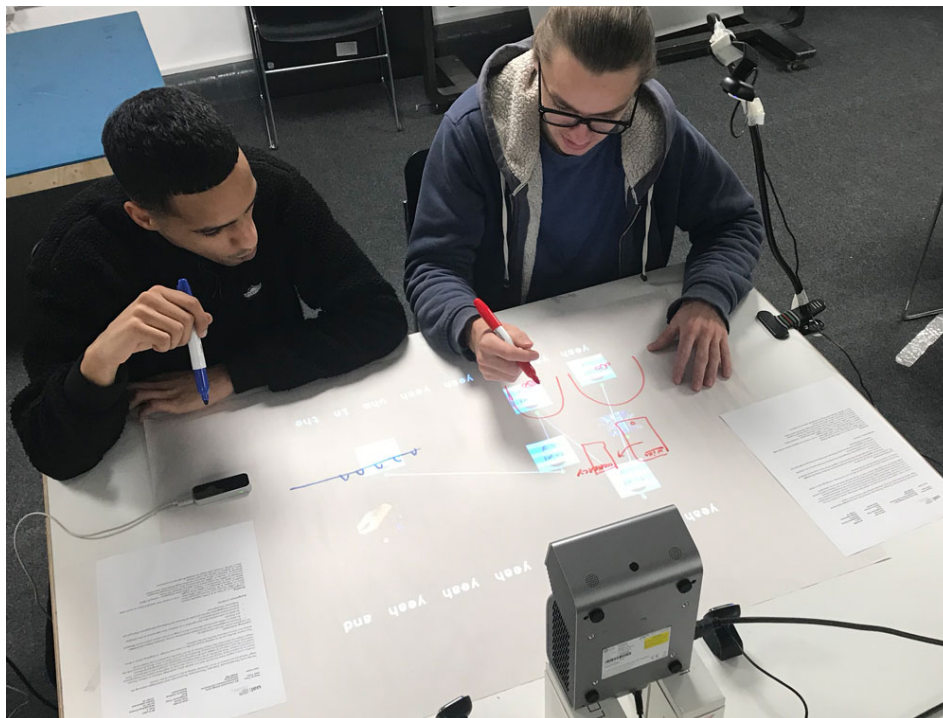
Brief: Social Object



Brief: Expanded Cinema



Brief: Narrative Environments



Brief (Expanded Cinema) shown in situ.

Appendix 2: Selected Case Study 1 transcripts, dialogue and interview excerpts and notes.

Selected transcripts from pilot study at the RCA (Case Study 1)

ideation event interview (graduate students)

interview excerpt 1

Ben: So, I'm looking at ... record this. So, how did you find it useful? Was it strange?

Participant 2: It's kind of stressful. Kind of stressful. Not like terrifying me a bit.

Participant 1: Yeah.

Participant 2: It puts things in a, like encourages you to try and pushes you to make connections. I think.

Participant 1: Yeah, it does that, but it also does [00:01:00] that serendipitous magpie artists design process that goes, "Oh, there's something interesting there that I'm sure I can make it connect." So, it creates that opportunity for connections. And then it also gives you all this free space in between where you've got all these eyes and you've got no idea what I'm doing.

Participant 2: Yeah yeah yeah. Forces you, yeah, yeah, yeah.

[Except 1 END]

Interview excerpt 2

Participant 1: I didn't read anything, so actually.

Ben: You didn't read, so the words prompts were.

Participant 1: I didn't read. Didn't read a thing.

Ben: It was all the [00:01:30] visual stuff.

Participant 1: All the visual stuff. Absolutely nothing to do with any of the words at all. It matters less.

Ben: And how did you, um, did you kind of take any notice of that screen stuff happening?

Participant 1: No.

Ben: And that how did you see performance so that [inaudible 00:01:53]

Participant 1: Didn't even see it.

Participant 2: Very into that, yeah. Because this is the place that you're talking with your hands, isn't it. You were like were pointing and drawing and [00:02:00] leaning it. A lot of that.

[Except 2 END]

Interview excerpt 3

Participant 1: What's all there?

Participant 2: It sees your hands and perhaps their movement. Do you see that? And another hand comes in there.

Participant 1: Yeah.

Participant 2: The idea is that they should ... [00:02:30] should see your gestures. Right? So if you're being quite expansive gives you a wide range of things. You're being very like, you know, deep, I think this should give you a [inaudible 00:02:45]

Ben: It's interesting that I still found this might be listening to us in the background. But do you think it ... as you said, faulted. So, kind of force you to kind of perform some kind of a sketching,

[00:03:00] stuff like that. I mean, you know. It's difficult thing isn't it? Is it better or no. Is it more intense. Sounds like you mentioned more intense.

Participant 1: I think the frame looks brief from not quite understanding what the hell that was all about just means that the improvisational capacity of those images makes it incredibly easy to start in place of dissecting what it is that you are expecting your time to get off of that.

Ben: It gets you up and running?

Participant 1: So actually moves you directly into the visual [00:03:30] thinking and the glory of the lines.

Ben: It's some of that emotion it seems it was once, so have pins and start pins, you kind of oh look at you know this ...

Participant 1: Yeah.

Ben: It looks like you're shaking out is what I'm saying. That the boards sort of nudge you sideways or to finally knock over the relationship.

Participant 1: I love it when sort of like they appear on sub leashes. When you've got methods that might be trial here and it's like, okay that's the best, but because that's controlling those people. Then the camera is set right on top of it.

Ben: Yes.

Participant 1: I thought that was actually really nice [00:04:00] to then start thinking-thinking about it. I don't think that we necessarily covered very much to do with lines. There are some of the ...

[Except 3 End]

Interview excerpt 4

Participant 1: It's fucking annoying when it disappears. It's just sketching something (laughing) And I think it's like do [00:05:30] I carry on with every face that I see here, or do I stop because it's now somebody else.

Ben: But that's just ... that's just soon, because then that kind of allows you, you get stuck and you get possessive. [inaudible 00:05:51] So I want to stop this now, but out of a, so now you've seen it. [inaudible 00:05:59]

Participant 1: [00:06:00] No.

Ben: Well that's interesting.

Participant 1: No, not at all. In the way that you describe it, it's so abstracted from something that moves fast. Then you describe it sounds like something long, tedious and in depth.

Ben: Yeah, yeah, yeah.

Participant 1: And what this is is actually tragically, dynamic, swift, accessible mechanism. And a brilliant thought process.

[Except 4 End.]

Interview excerpt 5

Ben: You sat down and used it. There was no [instruction]. And I didn't tell you anything.

Participant 1: No.

Ben: Right.

Participant 1: Yeah.

Ben: Just like that. Yeah. So it was [00:07:00] using some text. Trying to draw us. Used it.

Participant 1: Yeah, and if it comes as a visual conversationist, I don't ... I can't do things unless I have a problem. I can't express, unless I can draw it. But and that may be another something incredibly useful application is enabling people who doesn't understand visual thinking.

Ben: Yeah. And also now you've got now. There's a full record of what you just did. So you [00:07:30] can go back through it. Look at what you're doing. You know. See what all associate in the things you're talking about as a ... Right?

[Except 5 End.]

Selected transcripts from pilot study at the LCC (Case Study 1)

Post ideation event interview (under graduate students).

Ben: Right, so how did that feel?

Participant 1: Uh, towards the end it felt like a game show. Um, like the questions (laughter) I had to answer them really quickly before the time was up and, um, but I did enjoy, um, the second part of the exercise where I getting visual references to maybe, um, start new ideas and rather I think the first time around being, like, numbed by one idea and being fixate on that idea to kind of, [00:00:30] um, try and make it work as hard as we can or make it...

Ben: Yeah.

Participant 1: ...as great as you can but when you've got different visual references to kind of make it all right cool I need to work from that. Maybe posters, um, gym flicks like seeing people exercise took you off in a new direction. So that was cool I liked that aspect of having my own screen.

Participant 2: Yeah like the arbitrariness of the photos was amusing because it kind of like they... because they weren't related to what we were saying it kind of forced you to try and wrap your mind around a way of making them [00:01:00] relate to what you're saying and that almost... that definitely opens up some ideas which are new and interesting.

Participant 1: Yeah.

Ben: Is it... Does it... Did it, um, so is this quite a common thing when you get a brief right? You sit down and you kinda sketch initial ideas and stuff like that. Um. Do... Do you think that it's kind of helpful to have some visual feedback to play against?

Participant 2: I do. Especially in a collaborative setting.

Ben: Yeah.

Participant 1: Yeah.

Participant 2: Um I know, from my last brief we got given, ah, you know a collaboration file of the people we were given a list of [00:01:30] sort of five or six arbitrary... they were supposed to be the names of the game we were supposed to come up with. But it really helped was it sort of gave us, like every time the conversation sort of went off on like...

Participant 1: Mm-hmm (affirmative)-

Participant 2: ...a tangent and stopped being sort of productive we could be like okay now how's this relating to this? And then it sort of gave us some structure and I think having these things...

Participant 1: Yeah cuz it can really digress a lot on one...

Participant 2: Idea.

Participant 1: ...thing. Idea. And everyone sits back and... I can see how that works out in collaborative pieces where you sit back and someone gives an idea and then everyone's just tryin to kind [00:02:00] of see where they can go from there but if you're... if you have multiple people in a room who are throwing ideas together at once and you can just see a mind map of that exploding into different kind of things.

Participant 2: I also like the fact that they just didn't... they were the same images and they kept coming back.

Participant 1: Mm-hmm (affirmative)-

Participant 2: Because it was like this person running and I was like this seems totally irrelevant and yet it kept coming back so I felt like we had to just... up... from...

Ben: Mm-hmm (affirmative)-

Participant 2: ...just actually deal with it...

Participant 1: Yeah.

Participant 2: ...eventually. And then we did...

Participant 1: Yeah.

Participant 2: You know. Um...

Ben: Cool. Uh, what do you, um... What do [00:02:30] you say that... you know you probably, uh, you produce more... it kind of... it urged you produced more in this, uh, situation than you would if it you were just you two and a piece of paper? Or was it about the same? Or how would you...

Participant 1: I guess having... because there were certain restrictions so we had to, uh, the time restriction, um, as well as... I... I guess being urged but it...

Ben: Did it Force you?

Participant 1: ...to kind of, because you knew you was on a time scale, to kind of get something done within that [00:03:00] amount of time. So, but I... I would say having the visual aid of having, um, thing just thrown at you did help me kind of idea generate much more quicker.

Ben: Okay. And did you... did you feel it, uh, responding to you? How did that feel? Or was it just you didn't actually think about that that much and you were just sketching and now and again you were picking things out that...

Participant 2: It felt very arbitrary. Um, like it sort of changed sporadically and it wasn't obvious why it changed or what it changed and it also wasn't [00:03:30] obvious, uh, whether the pictures were relevant. To me it felt like it could have been a slideshow of...

Ben: Yeah.

Participant 2: ...things going past, um, set on a timer.

Ben: Did you, um, where there moments where you thought oh that image does relate that's coming from our conversation?

Participant 2: Mmmm.

Participant 1: I think, for me may... the gallery one the most...

Participant 2: That's true, there was a gallery picture.

Participant 1: Yeah. I know cuz we talked about having the scram live and then maybe walking into a space [00:04:00] and may... eh, so maybe talking about film in space.

Participant 2: Yeah.

Participant 1: How that might have functioned to get, ah, an image of a gallery to come up and in that kind... that kind of stemmed a new idea. That's the only one I kind of saw that maybe had a correlation between the conversations that we were having on our first idea to... what came on the screen after...

Ben: And if... okay... if you were to describe this to someone else what would you say it was?

Participant 1: Um... uh... a [00:04:30] visual aid id generation... um, those are just keywords I'm throwing together but I don't know...

Ben: That's fine.

Participant 1: Um... yeah... uh.

Participant 2: Um...

Participant 1: A visual aid experience.

Participant 2: If I were to describe this to someone... um...

Participant 1: But then again it picked up on the voices. Picking up on the voices and conversations. So it's not...

Participant 2: I'd say it wasn't just, um, a... [00:05:00] a... a...

Participant 1: It did voice.

Participant 2: It was like a... basically you get to draw on a surface where a bunch of the most arbitrary images pop up which give you potentially I... can potentially give you ideas if your... talk to think about your ideas in relation to the images.

Ben: Okay. Cool. Would you... Do you think that, um, so the tool produces a record of what you... of your conversation. Um, and that means that you could, ah, go back to it [00:05:30] and look at any point of your conversation and look at what you were talking about and see what you were sketching. Do you think that is an exceptionally useful thing? Can you imagine that being useful?

Participant 1: I...

Ben: To you?

Participant 1: I think so. I think it... it can be but at the same time when I am idea generating with people I... I... I'd like to think that I've already taken note down of everything that we've been talking about.

Ben: Mm-hmm (affirmative)-

Participant 1: So I don't know...

Participant 2: Yeah I would never want to return to a conversation I've had in collaboration issue. Like not even early because you... you just spout a bunch of rubbish [00:06:00] for... for a while and

then anything that... all of you I think that this is kind of an interesting idea normally you write it down somewhere.

Ben: Yeah.

Participant 2: So I'd never want to return to the actual conversation. Um, oh I mean I've never had an experience of wanting to do that at least.

Participant 1: Yeah.

Participant 2: In my memory.

Participant 1: But I think having the access to maybe doing so mi... you might pick up on things that you probably forgot... like say stream of consciousness when you're just speaking about things and then you go and you jot down things that you thought, like, are relevant to why you're doing them but you might have left something out.

Participant 2: [00:06:30] I'm sceptical that would really... like rarely ever come up like I know that I've used Slack a lot and it's kind of got that capability like if you're doing a project you can quickly search through conversations you've had but I just do that... every time I do that a lot less than I think that I'm going to want to do that. Um, there are the couple... there are the odd time where it's actually super handy to have that as a feature. Um...

Participant 1: Like yeah... I...

Participant 2: ...but it doesn't come up that much.

Participant 1: I'd argue but only because, say if I'm taking notes down on a project I'm working on in my notebook and then I... I sift through... [00:07:00] back though just to see where... what I was thinking at a certain point of time and then I pick up on bits of references that I'm like oh crap I [inaudible 00:07:10] but something else ran on that could go in that direction. But I've written it down so long ago that I've forgotten about it now I just looked back through my notebook. So maybe having those conversations where you're talking about an idea and then maybe going back onto might spark something else along the lines that he had...

Participant 2: But would you want to do that? Would you say you... if you had recording of you... [00:07:30] your whole conversations... people you... you... generally want to go through and listen to the whole conversation thought?

Participant 1: In case I'm... In case... say I get into a stage on the project where it's kind of numb and I don't know where I'm going forward to the project I may be backtracking a bit just to see where my, uh, state of mind was at when I started off in this project might be beneficial. I could see how it could have...

Participant 2: I mean I've listened to, like, recorded conversations I've had with people...

Participant 1: Yeah.

Participant 2: ...and it's been quite painful to listen to.

Participant 1: (laughter)

Participant 2: So I just... I know that I wouldn't...

Ben: So, um...

Participant 1: Depends on the content I guess.

Ben: That...

Participant 2: Mm-hmm (affirmative)-

Appendix 3: Selected Case Study 2 transcripts, dialogue and interview

excerpts and notes.

Selected transcripts from pilot study at Superflux (Case Study 2)

Post ideation event interview (design professionals)

Interview excerpt 5

*Ben (07:20): Brilliant. Um, the next ones, uh, are a bit less about what you did and a bit more about what you think. Um, so what- what are the- **what do you think of the potentials of these kinds of systems?***

Participant two (07:35): Um, in terms of...

Ben (07:38): Well, I- I just think- not- not necessarily what- that work exactly like this, but- but ambient systems that sort of aid conv- problem solving conversations. And I'm sort of interested in this because, you know, you work in a design studio, so you do a lot of this kind of stuff. How- you know, how does it- what does it- what does that- what- what potentials can you see for those things?

Participant one (08:01): I mean, thinking quite selfishly about it, I think one of the things that I think, especially 'cause I- I find these kind of- these parts of the process quite, uh, frustrating in terms of like trying to kind of push an idea through a kind of a- a development process and things like that. I- I think one thing it, ideally that I- (laughs) I would like these things to do, is I want that kind of, once I've hit a kind of a- a point where I feel like I can't push an idea any more, it would almost like kind of take all the- all the kind of things that kind of have been discussed already, and- and then kind of prompt you or- or kind of bringing all that stuff back to kind of prompt you on where it could go next, and meet like a new context or a- or a new kind of angle on it, in a way.

Participant two (08:42): Yeah, 'cause I mean I- I often use, in that sense, like you know, Pinterest has a-

Participant one (08:42): Mmm.

Participant two (08:49): ... a thing where you create a board and then you get to the- like from that collection of images, it kind of prompts you with more images that are kind of referencing the stuff that you've already selected for their model. And that, I find that actually quite useful. I don't really find Pinterest useful in other ways, but that specifically, because it kind of like- it- you've- you've narrowed down to a- to a thing that your conceptually happy with. And then it opens it back out so you- rather than it going from the begi- I feel like if you started from the very beginning, it might be too broad to find- to find a narrow point. But once you've got that initial narrow point to open up again, I think it's super useful.

Participant one (09:32): And on that point- so- so on that point of like narrow, um, expanding out from kind of narrow viewpoints, I think one of the things that would be really, I think would be really interesting with this kind of technology would be kind of if you were having almost like a kind of, you know, reciting a- a part for a project or- or kind of discussing a- a- a project with someone else, or is this kind of [inaudible 00:09:53] with this kind of technology. Um, kind of taking- taking what you've kind of got or what you've worked on and somehow kind of like- a way of kind of put- you know, for a- for a thing to like reduce or eliminate bias. [inaudible 00:10:07] kind of putting your thinking and your kind of, um, ideation process up to that point through... and will start expanding that out to kind of incorporate kind of other kind of viewpoints other- otherwise that you might not have considered. You know, it's like giving you promp- prompts based on viewpoints that you probably wouldn't think of immediately.

Participant two (10:27): Yeah. [crosstalk 00:10:29]

*Ben (10:28): **So sort of thinking from a dif- from not- enabling you to sort of do this kind of work from a different perspective?***

Participant two (10:34): Yeah.

Participant one (10:35): Yeah.

Ben (10:35): With a different set of values?

Participant one (10:35): Yeah.

Participant two (10:38): Yeah. Or at least like- like open up to, yeah, questions from those different viewpoints.

Participant one (10:43):

Mmm.

Participant two (10:43): It's kind of definitely interesting.

Ben (10:45): Brilliant. Okay. That- that's helpful. And then I guess, I- I was just, actually we talking a little bit about, there's a bit of me that you- I mean, from this kind of stuff like you could generate all sorts of-

Participant one (10:58): Mmm.

Ben (10:59): ... visual data that you could, you know, you could just give to you clients and say, "Yeah, we've been thinking about this for you." (laughs)

Participant one (10:59): Yeah.

Ben (11:04): Do you know what I mean? There's a- there's a sort of- there's a thing there that- because this bit, the process is really nebulous to clients, right?

Participant two (11:10): Yeah.

Ben (11:10): They don't- they sort of don't believe it. [crosstalk 00:11:13]

Participant one (11:10): Yeah. They don't understand how- (laughs)

Ben (11:16): So there's a bit of me that thinks, you know, those kinds of systems provide a- a temporal sort of chart of what's being discussed in- in a way that might be quite useful. [crosstalk 00:11:27]

Participant two (11:26): Yeah. Yeah.

Ben (11:28): Um, anyway, um, you've talked about this where in Pinterest, this can be short, but do you encounter these kinds of things, or things that feel like this in current design software?

Participant one (11:39): I think there are are things that I think based on what P2 was saying about the Pinterest, I think there are things that are trying to do it. I think there- there are- there are- I think there are things that are, um, that are attempting to kind of almost like enga- engage you with kind of like, basically kind of almost like algorithmically generated, or kind of rec-recommendations and, um, points for further investigation based on, um, what- what you've looked at or- or what you've kind of been listening to, or- or... but a lot of that is- but is- is almost kind of like, it's very surface level. Like it- it doesn't engage with... Almost like- almost like it- it- how it does that thing in isolation. Like you take- like that singular thing you look at, it takes that in isolation and it's like, "Oh, you- you listen to like... or you looked at one thing." Based around this, or you've been discussing one thing around this. So that means you must be interested in, you know, all this other kind of like rap music, or, um, you know, geopolitical kind of crises.

Um, whereas the fact that you're just trying to find out like, you know, why- why- you might- you might be trying to find out, yeah, why the pound is down against the dollar or something because you're going on holiday to America or something.

Participant two (12:57): Yeah.

Participant one (13:00): (laughs) And so I think- I think there are definitely kind of things that are t- and technologies like that are being employed in- in- in, you know, by kind of big companies that I think are trying it, but I don't think they're kind of doing it with any kind of- like, uh, I don't feel like they're doing it with any kind of purpose other than to just k- keep you engaged with their platform.

Participant two (13:17): I think that's the main thing. Like especially I was thinking about the YouTube like- like they're- YouTube used to be you had- you subscribed to people, and then you'd get the feed of people you've been subscribed to. And so you made that active de- dec- decision to follow those people. And then it changed to becoming it's only recommended.

Participant one (13:38): Mmm.

Participant two (13:38): And, uh, it's really like there's part of it which I find useful in that it's like opening you up to some kind of interesting stuff based on things you already know als- as well as maybe some like left field stuff that it's kind of like trying to enter you into a new space. But at the same time, it is ultimately there because it's trying to make as much money out of you as possible, and it's trying to

keep you engaged. And so, and it does- for me personally, it does it so well that I can spend like seven hours on YouTube without even really like considering it. And that's like my time wasted. And because like they've like nailed the like dopamine hit so well that it's like- you just like keep coming back and it becomes addictive. And that's obviously not a- it's- it's not productive way of using that sort of thing. Well it's productive for them. It's not productive [crosstalk 00:14:30]
 Ben (14:29): Yeah. It's not generative for you. [crosstalk 00:14:31]
 Participant two (14:31): Yeah. Exactly.
 Ben (14:32): It's, yeah, it just breeds more engagement for them.
 Participant two (14:34): Yeah.
 Ben (14:34): And more ads watched.
 Participant one (14:36): Yeah. So I think almost like kind of prompts are, uh, less superficial and more insightful, is- is what I would- what I'd like to say.
 Ben (14:43): Is- so, uh, part of- part of this research is-
 Participant two (14:50): Yeah.
 Ben (14:50): ... you know, designers use lots of digital things.
 Participant two (14:54): Yeah.
 Ben (14:54): In other words, the things were really designed for designers, by designers, right?
 Participant one (14:54): Mmm.
 Ben (15:00): And designed for engagement and entertainment, and blah blah blah. And, uh, you know, some of this, not the prototypes, but some of- the thesis is that the systems would have a different set of values, and a- and a- and a s- and a sort of, the heuristics of them would be slightly different potentially. And- and- and where is the space where designers can talk about kind of systems that feel good to them. [crosstalk 00:15:26]
 Participant one (15:26): Yeah. Yeah.

Interview excerpt 6

Ben (15:27): Um, so that brings me to my final question.
 Participant two (15:28): Yeah.
 Ben (15:29): **Which is, how do you feel about ML/AI tools assisting design, ideation, thinking?** creative- you know. The concept forming stage of design. Not the generative bit of form making, but the bit of ideas. How do you feel about AI, ML tools assisting that?
 Participant two (15:48): Um...
 Participant one (15:50): Oh. (laughs)
 Participant two (15:51): It's tricky isn't it? Because like- like that is often, you feel like that's the bit where you have like that's- that's sort of your insight. So there's obviously like an ego attached to it, but at the same time, we're already being influenced by all of these systems already. So that's just kind of a façade, ultimately, you're putting. But then, you're still like parsing that data and creating something from it. So it's definitely like, it's a grey area. It's useful.
 Participant one (16:23): Mmm.
 Participant two (16:23): I don't know whether it's- I don't know how much more like insightful it has made us. Or whether like- because you know, we look at sort of historical work, and it's incredible. But it's been filtered. I mean, is it like 0.1% of all of the work created? So we don't really know what everything else was at the time. And maybe we have more access to stuff so that people can be more creative, generally. Don't know, it's just a... (laughs)
 Ben (16:54): [crosstalk 00:16:54]
 Participant one (16:54): Yeah, it's [crosstalk 00:16:55]
 Ben (16:54): That's the point.
 Participant two (16:54): Yeah. (laughs)
 Participant one (16:56): Yeah. I mean, it is- it is- (laughs) I could say that it- it- it's a really tricky thing. I mean, it makes me quite- I get quite, not squeamish, but a bit kind of nervous about, like that whole thing to me... I think if it- if it's doing it in a way that kind of is properly kind of like assisting, and not like-
 Ben (17:17): Yeah.

Participant one (17:17): ... usurping. In a- in a way that some of these kind of automation kind of conversations kind of end up going. Um, like if- if it has like genuine insights to help designers kind of make, you know, connections and, um, and leaps that they, you know, would probably take them much long to... if it can kind of crunch that and- and make that kind of process easier and kind of almost make that differ, I mean kind of like the- the kind of- the grind of the- the conceptual thinking, if it can make that kind of intuit- and- and flow more seamlessly, I think- I think I'd be all for that. But I mean, it is an interesting thing, because it- it's just like how... (laughs) How- how- how far can it go before it almost like kind of like starts to almost like it become like our instincts in a way.

Because it concerns what we did in this kind of... [inaudible 00:18:12] kind of cheats to- to chase or be interested in. It's kind of based on basically like our instincts, and kind of what we- what we feel is interesting. So, I think that's the other big kind of (laughs) nervous or- or- or apprehensive. And it was like kind of chasing those leads for me. And kind of like it- it starts being almost like kind of...

Ben (18:29): It's- yeah, it's- it's funny, isn't it? 'Cause like, 'cause I think, I mean those are the- I think when you ask someone a direct question, tho- those feelings come up.

Participant one (18:29): Yeah.

Ben (18:37): But I think your point is exactly right. That what's in our libraries and how our libraries work are just as powerful in terms of what visual culture we have access to, right? [crosstalk 00:18:47] Or have been in the past, or what's on TV, and who owns the TV channels?

Participant two (18:50): Yeah.

Ben (18:51): And blah blah blah. So-

Participant two (18:52): Yeah.

Ben (18:53): It just because it's delivered through a sort of ambient, computational thing it doesn't make it any less- it doesn't make- or many- any more effortless, so even how we- how culture is constructed broadly.

Participant two (19:06): Yeah.

Ben (19:07): Um, it just, I think there are just few who are involved, so-

Participant one (19:11): Yeah.

Ben (19:12): I think that's part of the anxiety isn't it? Um, and- and there are, yeah. The concentrations of that control are b- are bigger than ever.

Participant two (19:20): And I wonder if there's like- like- like two things on that. Like because often times when I'm doing sort of this first stage, I'll not look at any external stimuli to try and be as internal as possible and get all that out first. So it feels really much as like it's my own archive of things I've been absorbed to. And then- then go out and from that point, look at something. So I wonder whether there's like a new type of work flow that's developed. Or like a s- sequence of- of steps. Maybe it's like that these tools are being used in the background monitoring conversations developing. Like piecing together these stimuli or stuff. Building an archive. And then that's dipped into from time to time. Maybe as- or retrospectively in terms of get a point and maybe take that out. As opposed to it being a live collaborative thing as such. So it feels more like there's a- there's- there's- it's actively being used as opposed to just being- just being fed.

Ben (20:26): That's interesting, because, you know [inaudible 00:20:28] has a archive. A library and a university to do exactly that.

Participant two (20:26): Right.

Ben (20:32): Because you've got 100 offices around the world.

Participant one (20:34): Yeah.

Ben (20:36): And 100 years of practise.

Participant two (20:38): Yeah.

Ben (20:38): Do- you- you know, you- you attend to the knowledge you've created and you want to use that-

Participant two (20:42): Yeah. Yeah.

Ben (20:43): ... so- so there are contexts where larger organisations, I imagine, could have di- would have different use cases. [crosstalk 00:20:51]

Participant two (20:51): Yeah.

Appendix 4: Selected Case Study 3 transcripts, dialogue and interview

excerpts and notes.

Selected transcripts from pilot study at Arup London (Case Study 3)

Post ideation event interview (design professionals)

Interview Excerpt 5

Cont. Ben (06:56): . Um, so, this isn't, this isn't really about your experience, this is more about a sort of broad context for this kind of stuff. So, given that we've just done that task, **what do you think the potential for these kinds of systems are?**

Participant 1 (07:17): Well, in the work that we do there's a lot of potential for, like, generating ideas, right? And there's a lot of people who are doing research that's very similar to do with three dimensional generation of ideas as well. So for, like, architectural and built environment purposes, I know that there's lots of PhD or similar projects that focus on specifically feeding exactly this dataset, but, using a 3-D generator to sketch out your ideas as you talk about them.

Participant 2 (07:52): Mm-hmm (affirmative).

Participant 1 (07:52): ... and it's like you choosing the different images that you think are accurate, and you kind of narrow-

Participant 2 (07:57): Mm-hmm (affirmative).

Participant 1 (07:57): ...down your sketch of your building, essentially, which I find really interesting. Um, so it's like, I find that interesting as like a conversational tool. But, on the f- So, that's kind of one application that I can think about, this kind of conversational tool. And then, on the other one, is I like the... Sometimes you just need, like, a feed of things, and I like the, the [inaudible 00:08:26] cards, because they kind of get you to just re-

Participant 2 (08:30): Think outside your-

Participant 1 (08:30): ...wire.

Mm-hmm (affirmative).

Participant 2 (08:32): ...your natural pathways and tendencies.

Participant 1 (08:34): Yeah.

Participant 2 (08:34): Mm-hmm (affirmative).

Participant 1 (08:35): So, I can definitely see the application, and I like the, the imagery as well, um, because I think it's really powerful. But then, I do question where this imagery is coming from and, and what kind of, um, biases that brings, and- Participant 2 (08:35):

Mm-hmm (affirmative).

Participant 1 (08:53): ... you know, what's the kind of top 10 Google search of things, and will I always be shown a particular type of person, or a particular type of messaging. So...

Participant 2 (09:04): Yeah.

Participant 1 (09:05): That's probably my-

Ben (09:06): And, that's interesting-

Participant 1 (09:07): ...reflection.

Ben (09:08): ...because in the, in the built environment formal CAD thing-

Participant 1 (09:08): Mm-hmm (affirmative).

Ben (09:11): ...context you're talking about, that's based on very formal structures. And so, there is a sort of large, but finite, world of things.

Participant 1 (09:20):

Yeah, you say, like, "Oh, I think, you know, this pavilion should be, um, elliptical. It should have transparency to it, but a solid roof."

Ben (09:20): Yup.

Participant 1 (09:28): And then, you know, the machine learning is building up a blob, or a kind of set of things that kind of fit that description. And then, you can start refining it by, by saying, "it should have a colonnade, um, and a transparency in the walls. And, it should have, um, a very deep roof." And, you know, you can, like, start then thinking about, and it should be twice as tall as a person. So, you can kind of see where, where that can go.

Ben (09:55): Yeah, totally.

Participant 1 (09:55): And, then-

Ben (09:56): Where's, where's this where you're in the, you're in the concept formation stage-

Participant 1 (10:00): Mm-hmm (affirmative).

Ben (10:00): ...obviously you're sort of... you haven't got those parameters.

Participant 1 (10:03): Yeah.

Ben (10:03): So, it is broad, and that's why, I think, that feeling of, you know, who's represented matters.

Participant 1 (10:10): Mm-hmm (affirmative).

Ben (10:11): Because, you know what's represented, and who's represented.

Participant 1 (10:12): Yeah.

Ben (10:13): And it's in a different, quite different way, I think, in a, in something that's more general, at least.

Participant 1 (10:17): Yup.

Interview Excerpt 6

Ben (10:18): Um, so we've talked a bit about this, but I'll, I'll ask you as direct question. **So, do you encounter these kinds of ideas in current design software?**

Participant 1 (10:18): Um...

Ben (10:30): And, I'm thinking any-anything from, like, um, clippy

Participant 1 (10:36):

Mm-hmm (affirmative).

Ben (10:37): ...upwards, really.

Participant 1 (10:37): Mm-hmm (affirmative).

Participant 2 (10:41): Um, I'm not sure about these sorts of ideas. I mean, like I said, like the using prompts and things is, is a familiar way, but I haven't seen it done like this before. Like a GPT3 sort of generator thing. Because sometimes, you know, it wouldn't make sense, but sometimes it would throw out things that were quite specific, but, you know, that you wouldn't get on a normal, on a normal prompt card, like, thinking about a landscape, or something. Um, and, yeah. And the sort of... Often, it would make, um, like, references and things to things that I wouldn't have heard of before, so. I mean, I get that from talking to other people, but I don't have something that would necessarily generate that, um...

And then, the thing I quite like to that, the images as well, is that, you know, if you do use software like Google Images or Pinterest or something, it-it, it just shows you what you've, exactly what you search for. That's... That feels a bit more curated.

So, it's like you've got this idea in your head, and it will reflect it back to you. Where as this is something that's quite, you know, different (laughs). So... Yeah. I think that's the, the main difference with this one for me.

Ben (12:05): And, and, and just sort of tracing that, [Inessa 00:12:06], we talked about [Miro 00:12:08] [inaudible 00:12:08]. Participant 2 (12:07):

Mm-hmm (affirmative). Ben (12:08): It's sort of become a ubiquitous experience for (laughs) [inaudible 00:12:12] design.

Participant 1 (12:12): Mm-hmm (affirmative).

Ben (12:13): Can you imagine this, these kinds of things in Miro?

Participant 1 (12:18): Yeah. I do imagine that being, like-

Participant 2 (12:18): Mm-hmm (affirmative).

Participant 1 (12:19): ...a plug-in, or a kind of, an assistant, that you can turn on and off, or like a function that you can turn on and off-

Participant 2 (12:19): Yeah.

Participant 1 (12:29): ... or use in your, um, ideation sessions.

Participant 2 (12:33): Yeah. I mean, we also run a lot of online workshops and things in Miro, so I can imagine this being, like, maybe a 10-minute exercise that you do with a client, or something. Um...

Participant 1 (12:45): Yeah, I think it would-

Participant 2 (12:45): ...in some way.

Participant 1 (12:46): ...get, take some getting used to in-

Participant 2 (12:46): Mm-hmm (affirmative).

Participant 1 (12:49): ...the format. But maybe, because you'd be already in Miro, and it would, it's already a digital interface, you wouldn't have this-
[...]

Participant 1 (13:04): Um... To, yeah, to kind of jump through. So, yeah, I can, I can definitely see that.

Ben (13:12): Brilliant. And, to mark the end of you being lab rats for the day (laughs).

Participant 2 (13:12): (laughs).

Interview Excerpt 7

Ben (13:15): I've got one more question.

Participant 1 (13:15): Mm-hmm (affirmative).

Ben (13:16): So, um **how do you feel about ML and AI tools assisting design ideation?** You sort of talked a bit about it there, but how, how do you it in general.

Participant 1 (13:25): Um, I think this... I think I really like the aspect that I mentioned, with the kind of spatializing things, because I think it could tap into some things that are more, um, that become more about, um, equitable and accessible spaces, in a sense, that it would make our language around the built environment easier to offer people to communicate about and understand. And, it might open up conversations about architecture, not just being this kind of ornamental façade, but actually it would take something that people were, like, very deeply th- feel and think about in terms of spaces when they imagine a space, but it wouldn't take me to sit and design a room for a week, and render it at the end of the week to show you what I, I'm imaging in terms of s-, you know, the-the-the light quality, and the textures, and the materials, and the size of the space. But actually, we would be able to have a conversation about this. I feel like there's huge potential for it to become this really powerful tool that can-

Ben (14:45): Yes, and sort of have designers in session-

Participant 1 (14:45): ...m-

Ben (14:45): ...with non designers.

Participant 2 (14:45): Mm-hmm (affirmative).

Participant 1 (14:48): Yeah. Non designers, and with each, like, with designers, to come up with something that we otherwise wouldn't have come up with, because we would be tapping into something that's... that we, as designers, know, and architects know really, really well. So, space, but actually showing it in a very different, maybe more, like, human understanding. More, kind of um, basic, I guess, then just having to go through the process of using 3D modelling, um, software.

Ben (15:15): So, there's a sort of naturalistic... Like, the conversational bit of this-

Participant 1 (15:15): Mm-hmm (affirmative).

Ben (15:20): ...is, seems quite natural to me.

Participant 2 (15:20): Mm-hmm (affirmative).

Participant 1 (15:21): Mm-hmm (affirmative).

Ben (15:21): So, having something that-

Participant 1 (15:22):

Yeah.

Ben (15:22): ...is built from there.

Participant 1 (15:23): It is like...

Participant 2 (15:23): Mm-hmm (affirmative).

Participant 1 (15:24): It is like using Leap Motion in, in Miro. Both are in VR, right? Like you-

Ben (15:24): Yeah.

Participant 1 (15:30): You're just using hands, you're not using controllers, and I think it's the same for Revit or CAD in that sense.

Interview Excerpt 8

Ben (15:37): Cool. Um, so, taking something that you said earlier about the sort of biases, and stuff like that, can you talk a little bit more about... Do you... **Are you anxious that things contain biases** or are liable... or have, or you know, are potentially liable to, sort of, narrow-

Participant 1 (15:37): Definitely.

Ben (15:37): ...things.

Participant 2 (15:37): Mm-hmm (affirmative).

Participant 1 (15:57): I feel like, if this could be replaced with more abstract representations of images, I would feel less like I am looking at a direct database that's lifting something that's already got lots of biases. In a way, that I'm kind of saying this conversational tool could just be about describing words like circle and square, that don't have, um... well, they do also contain some bias, but there is much less of that inherently when you talk about kind of quality of something, and emotion or attachment to space.

Participant 2 (16:33): Yeah. I think-

Participant 1 (16:34): [inaudible 00:16:34] that are hiding.

Participant 2 (16:35): Yeah. In terms of, uh, biases, a thing like this, thinking about this tool, that I think, like, thinking about the accessibility of some of the language, I think as well that that is generated, and whether, whether that's something that would be, you know, accessible to all audiences or people, or more for people who have design backgrounds, or a certain knowledge or understanding of technology in the first place. But also, thinking about, like, Dali and the, um-

Participant 1 (17:09): Cultural references.

Participant 2 (17:10): The cultural references and things. And then the, but, you know, the potential for that to sort of create defects, or what sort of... Yeah. What could the potential be if people were to try and apply things like this for, for bad uses. Um, that worries me. (laughs)

Ben (17:30): Well, [inaudible 00:17:32]. I mean, I, when I started this research, Dali and [inaudible 00:17:35]-

Participant 2 (17:30): Mm-hmm (affirmative).

Ben (17:35): ...didn't exist, right? And, as it's ballooned, I did think about, um, an image generation component of this.

Participant 2 (17:44): Mm-hmm (affirmative).

Ben (17:45): And I think that's a natural thing to explore, but it's just now a scope for me. But, at this time, this you can how-

Participant 2 (17:50): Mm-hmm (affirmative).

Ben (17:51): ...you know, kind of prompts of things you're talking about can be visualised by things like that, I mean, really quickly.

Participant 2 (17:51): Mm-hmm (affirmative).

Ben (17:58): But I... I mean, I think you're dead right in that whatever biases exist in the system that you're using, you'd be just inheriting-

Participant 1 (18:03): Mm-hmm (affirmative).

Participant 2 (18:03): Mm-hmm (affirmative).

Ben (18:03): ...to these things. And that is quite dangerous when you're, um, you reckon that you're doing something that is a sort of global design solution for a thing, you're suddenly lifting up those biases into something that might have a really wide deployment in a really uncritical way, right? So, I think that the... I mean, I think the discerning p- the discerning bit of that loop is the people. You know, it's not... It doesn't give you solutions, right? It's sort of a conversational aid in that way.

Participant 1 (18:29): Mm-hmm (affirmative).

Ben (18:29): But, I think those, those things are unsolved.

Participant 2 (18:32): Mm-hmm (affirmative).

Ben (18:33): [inaudible 00:18:33] there's, there is some tricky questions in there. And, you know, in other, other people that have done this study, and talked about the fact, well I mean there's already just by, just the things that exist online in photographic forms, already-

Participant 2 (18:49): That's what I mean, yes.

Participant 1 (18:50): Mm-hmm (affirmative).

Participant 2 (18:50): But that's, yeah. That's what you're kind of tapping into. So, by default, you're, that's your legacy issue of-

Ben (18:57): Yeah.

Participant 2 (18:57): ...that happening.

Ben (18:57): And, and then you've got [inaudible 00:19:00]. So, it's a [inaudible 00:19:00] as well. Um, it's-it's not unproblematic, I don't think.

Participant 1 (18:57): Mm-hmm (affirmative).

Participant 2 (18:57): Mm-hmm (affirmative).

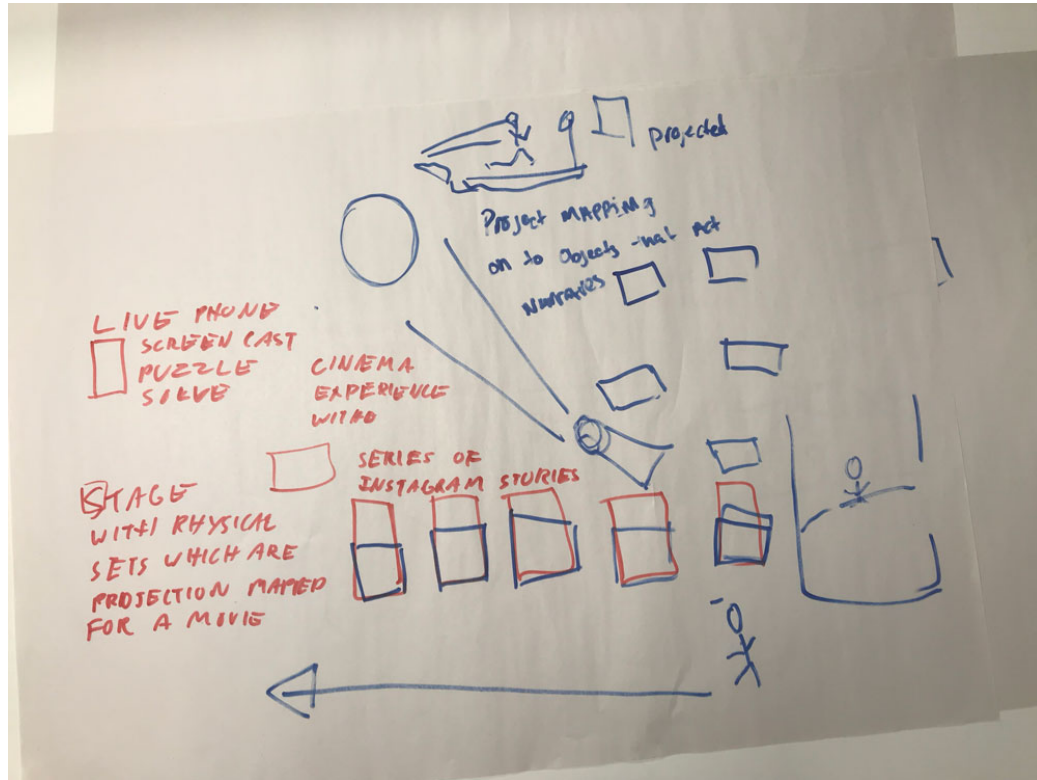
Ben (19:05): Brilliant. So, that's all my questions. Is there anything you want to ask me?

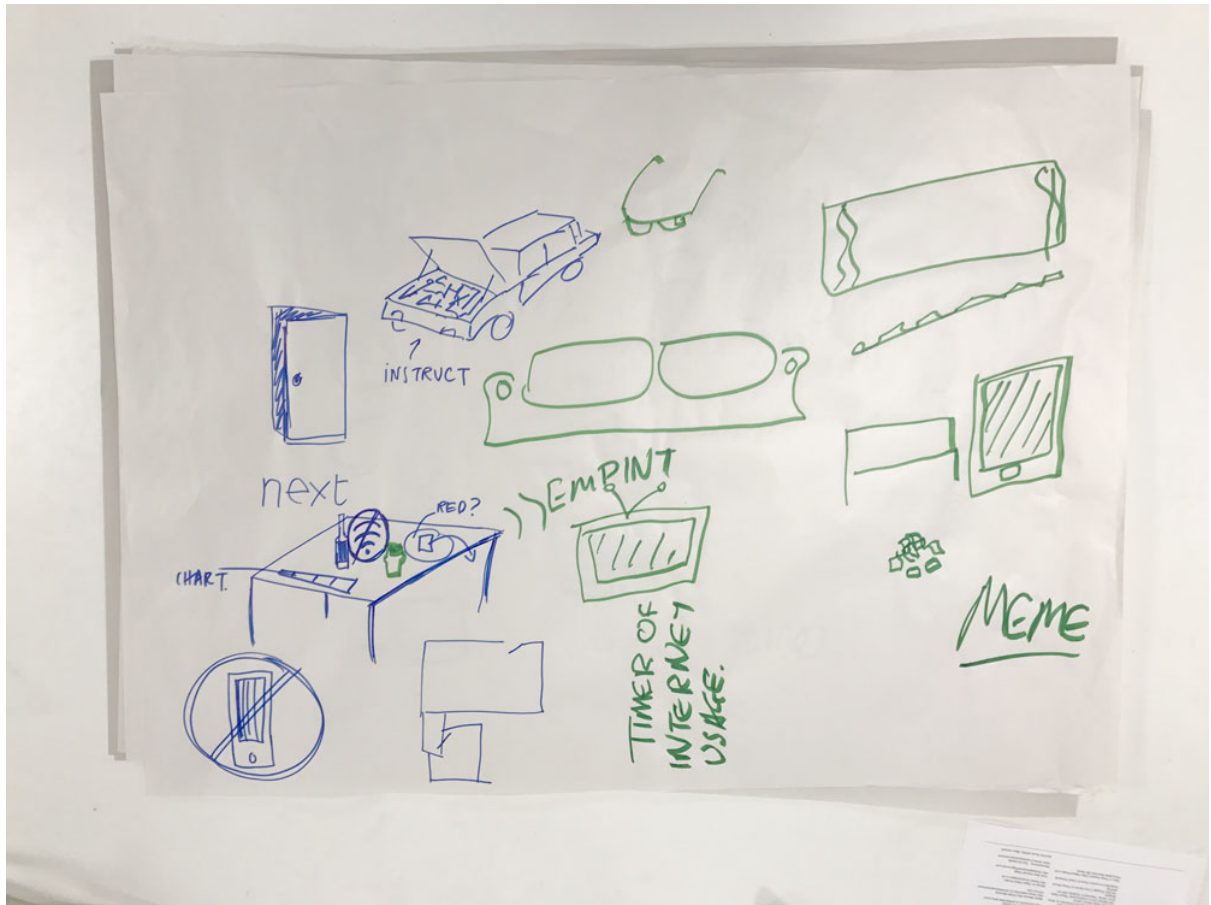
[...]

Ben (22:07): Thank you so much for your time.

Appendix 5: Sample of augmented sketches.

Case Study 1





Appendix 6: Sample of multimodal transcripts.

Case study 1

The screenshot displays a software interface for a multimodal transcript. On the left, a vertical sidebar shows a sequence of thumbnail images. The main area is divided into three columns. The first column contains three video frames showing a person interacting with a large screen displaying a network diagram. The second column contains a text transcript of the conversation. The third column contains three network diagrams, each with the text "yeah yeah yeah yeah yeah in the" above it. The transcript text is as follows:

Luisa: I have no idea what a trumpet looks like right [00:05:00] now. I'm really hoping [crosstalk 00:05:00]

Clovis: Maybe, it's not really like-

Luisa: ... show me one but ...

Clovis: A kettle ... Dance. Yeah. Energetic, young.

Luisa: Maybe, elephant?

Clovis: Uh, starter packs. Um.

Luisa: (Laughs) Yeah.

Clovis: We should make, uh ... We should make one, an Elephant and Castle starter pack.

Luisa: Elephant and Castle starter pack.

Clovis: Yeah. Called [crosstalk 00:05:22].

Luisa: [crosstalk 00:05:22] Station.

Clovis: Yeah.

Luisa: (Laughing).

Clovis: Um.

Ben (Observer): Right, a minute and a half. Get, get as much sketching on the page as you can get.

Luisa: Anything to ... The electric information [inaudible 00:05:36]. I've just, got like-

The screenshot displays a software interface for a multimodal transcript. On the left, a vertical sidebar shows a sequence of thumbnail images. The main area is divided into three columns. The first column contains three video frames showing a person interacting with a large screen displaying a network diagram. The second column contains a text transcript of the conversation. The third column contains three network diagrams, each with the text "yeah yeah yeah yeah yeah in the" above it. The transcript text is as follows:

[00:05:30] so again try and look at the things that are being suggested and integrate those into your drawings or-

Abdulla: Is that why-

Dan: Um, Martin, power under him [inaudible 00:05:43].

Abdulla: What's the-

Dan: That's not the phone.

Abdulla: So, is that going off what we already spoke about before, or has that just come up now? But it's connected to wi-fi or blu?

Dan: [inaudible 00:05:54] um-

Abdulla: Food.

Case study 2

The screenshot displays a research tool interface with three main sections: **Tool Graph**, **Transcript**, and **Tool Results**.

Tool Graph: This section shows a series of small video thumbnails arranged in a grid, representing different moments in the study. Below each thumbnail is a small bar chart.

Transcript: This section contains a list of participant comments:

- Participant two (05:03): Uh, the Anne Boleyn.
- Participant one (05:04): Yeah. And just constant barrage of just, like, information with you. I mean, like...
- Participant two (05:09): Yeah, like information overload.
- Participant one (05:12): 'Cause it's not, it's kind of like that kind, tha- that kind of thing of information overload, coupled with what we're sort of- about having all the instant, like, the kind of constant kind of, like, y'know, need to kind of, like, post things... Bu- but you basically got, like, an entire generation that have been kind of re-wired to think like publicists. Like they... p- people put out-

Tool Results: This section shows a large, detailed diagram of a network or process flow, with various nodes and connecting lines, illustrating the results of the tool's analysis.

The screenshot displays a research tool interface with three main sections: **Tool Graph**, **Transcript**, and **Tool Results**.

Tool Graph: This section shows a series of small video thumbnails arranged in a grid, representing different moments in the study. Below each thumbnail is a small bar chart.

Transcript: This section contains a list of participant comments:

- Participant one (01:23): Yeah. So, I mean, I think there's an... something that's interesting thing, though, about those specific, I think, memes, there... the m-y'know, the meme-ification of, I don't know, the constant kind of feedback that comes through, um, the constant kind of feedback that comes back through the internet, so, y- y'know, so- there was that thing about, um, uh, the woman that posted a- a, an insensitive tweet and then it bombed, and then she got on a plane and-
- Participant two (01:33): Oh, yeah, yeah.
- Participant one (01:35): -by the time she got to South Africa, o- or she got to Africa-
- Participant two (01:35): Oh yeah, yeah.
- Participant one (01:37): By the time she got to Africa, she's been about cancelled by the internet.

Tool Results: This section shows a large, detailed diagram of a network or process flow, with various nodes and connecting lines, illustrating the results of the tool's analysis.

Case study 3

The screenshot displays a research tool interface with three main panels. On the left is a sidebar with a list of thumbnails. The central panel is divided into three sections: 'Tool Graph' (top), 'Transcript' (middle), and 'Tool Results' (bottom). The 'Tool Graph' section shows a video call with two participants and a network diagram. The 'Transcript' section contains a list of dialogue snippets with timestamps. The 'Tool Results' section shows a network diagram with nodes and edges, and a list of text snippets.

Transcript

Participant 1 (09:36):
Mm-hmm.

Participant 2 (09:37):
And if it's a large tech company.

Participant 1 (09:41):
Yeah. It was... I'll be listening to your conversations. Are they collecting them?

Participant 2 (09:41):
Mm.

Participant 1 (09:41):
To improve their technologies.

Participant 2 (09:51):
So what the- what are they use cases just to like recap? What do we think?

Participant 1 (09:57):
Um...

Participant 2 (09:57):
Lack of idea.

Participant 1 (09:57):
Anyone, this, that...

Tool Results

now I mean not everybody how long did

it take yeah to me means for strange

now I mean not everybody how long did

it take yeah to me means for strange

it take yeah to me means for strange

it take yeah to me means for strange

yeah the control thing is like privacy I'm

The screenshot displays a research tool interface with three main panels. On the left is a sidebar with a list of thumbnails. The central panel is divided into three sections: 'Tool Graph' (top), 'Transcript' (middle), and 'Tool Results' (bottom). The 'Tool Graph' section shows a video call with two participants and a network diagram. The 'Transcript' section contains a list of dialogue snippets with timestamps. The 'Tool Results' section shows a network diagram with nodes and edges, and a list of text snippets.

Transcript

Participant 1 (01:01):
Mm.

Participant 2 (01:01):
So, you're, like, writing it, and then ag- I guess a little bit like-

Participant 1 (01:07):
Like this.

Participant 2 (01:07):
... well, this (laughs).

Participant 1 (01:07):
(laughs).

Participant 2 (01:09):
Like, actually having, you know, like a, there's, like, almost, like, two sides to the exhibition. There's, like, one side where the person's here, like, submitting the stories-

Participant 1 (01:30):
Mm-hmm.

Participant 2 (01:30):
... and, like, writing them, and then on the opposite side, you have people, like, watching-

Participant 1 (01:37):
Yeah.

Participant 2 (01:38):
might contain storeys like Costas potentially

that okay it's a projector yeah there you

might contain storeys like Costas potentially

that okay it's a projector yeah there you

might contain storeys like Costas potentially

that okay it's a projector yeah there you

might contain storeys like Costas potentially

Appendix 7: List of publications.

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