How We Talk About Interactivity: Modes and Meanings in HCI Research

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Interactivity is central to digital products, systems and experiences. It has long been studied from different disciplinary perspectives but while applications continue to be described as 'more' or 'less' interactive, there is a lack of consensus on its meaning. One approach to improving understanding is to focus on the different ways we talk about it rather than pursuing a single all-purpose definition. This study examines how interactivity is treated in a sample of Human Computer Interaction (HCI) research papers ($N = 117$). We use a combined content and discourse analysis approach to explore the range of definitions and technical configurations associated with the concept and unpick the wider discourses around it. We find it frequently described as a characteristic of technologies, an instrumental approach that suits quantitative measurement, but is acknowledged to miss other qualities. We also find qualitative user assessments that measure a spectrum of low to high interactivity, which are interpreted in different ways due to a lack of explicit definitions. The analysis reveals rich discursive material where different layered conceptions of interactivity arise, which we describe as 'modes' of interactivity. The dominant mode in HCI is 'empowerment', also found most frequently in public discourse. We offer modes of interactivity as a design and evaluation tool for more conscious consideration of this multidimensional concept.

RESEARCH HIGHLIGHTS

- Almost 10% of HCI research papers make reference to 'interactivity'—some involve assessment of levels of interactivity (low to high) in applications.
- The few explicit definitions of the concept we found suit quantitative measurement but acknowledge that they do not adequately reflect its total qualities.
- The discourse reveals more multidimensional meanings in circulation but also influences from research in other disciplines like advertising and marketing.
- Modes offer a way to understand and describe different dimensions or layers of interactivity in research, design and evaluation of digital technologies.
- *Empowerment* is the most frequent mode of interactivity and relates to strategies and outcomes of communication and their lasting effects, not just potential actions and context, while *Social* interactivity is a new representation.

1. INTRODUCTION

Interactivity is integral to digital communications and a ubiquitous and fundamental concept in Human Computer Interaction (HCI) and media and communications studies (Sundar *et al.*, 2010). Yet, despite its central role in so many social, entertainment, educational, commercial and creative digital applications, it has a long history of dispute and debate (see Kiousis, 2002; Rafaeli and Ariel, 2007), being a notoriously 'slippery' concept (Klastrup, 2003) and 'difficult to define' (Jensen, 2005). The literature reflects an on-going search for a

universal operationalization, either as a characteristic of digital technology, a function of design/context, a perception of users or possibly all three (Kiousis, 2002). It is certainly a multidimensional concept (Kweon *et al.*, 2008) but despite many conceptual tools used in HCI, the *added value of interactivity* has yet to be fully understood (Lim *et al.*, 2009). Researchers have called for clarity around the concept to improve its design, reception and evaluation (Rafaeli and Ariel, 2007; Sundar *et al.*, 2012).

Much debate on interactivity centres on identifying where it resides (Bucy, 2004), a complex task with a moving target of continuously evolving technologies. For example, tweeting about live TV or using Google Glass both involve 'interactivity', yet both facilitate myriad connected interactivities behind different technological interfaces, with effects going far beyond primary uses and users. Complex communication paradigms like 'second screening' involve layered technologies that require more flexible conceptual models to understand what exactly is underway (Lim and Rogers, 2008). If the contemporary classroom is a 'fluid environment with fuzzy and permeable boundaries that are constantly transversed by flows of data' (Aagard, 2016, p. 7), the same could be said of homes, workplaces and public spaces and yet our treatment of 'interactivity' remains anchored to locating it in static physical technologies and their individual uses. Today's interactivities incorporate multiple mechanisms, interfaces, systems, usages and experiences. Each invites a different set of theories and discourses around the concept, which need to be fully teased out to talk about it meaningfully.

Studies show that some interactive applications fail to capitalize on their potential (Kiousis, 2002), unforeseen interactivity can produce costs as well as benefits (Rafaeli and Ariel, 2007) and in certain contexts, successful interactivity happens more often 'by luck' than by design (Heath and vom Lehn, 2008). This suggests a mismatch between academic theory and the concept in practice in everyday life, which may explain gaps between intended design and reception. Indeed, recent studies have found that while interactivity research continues in search of a single generalizable definition, multiple meanings seem to coexist comfortably in public discourse (e.g. Barry, 2012b). In his study of interactivity 'in the wild', Jensen (2005) notes that 'different notions of interactivity may be passed back and forth, and negotiated, between discourses of marketing, public debate and practical design' (*ibid*, p.11), calling for more research into the circulation of ideas around interactivity because of its practical value. This study addresses the differences between the literature on interactivity and the discourse around it in HCI to explore these negotiated notions where we reveal our understanding of a concept. We aim to investigate if what is presented as a 'problem' in the literature could be regarded as an 'opportunity' in discourse.

Lack of consensus indicates a 'problematization' that can benefit from analysis of discourses (Howarth, 2000). Each research and design process in which interactivity arises generates meanings that mediate our understanding of the concept. By specifically considering these different meanings, we gain a better view of how it is understood. If interactivity is considered elemental to an application or system, then meaning is key to both design and assessment, especially as evaluation of HCI design should be 'appropriate for the actual problem or research question under consideration' (Greenberg and Buxton, 2008). Thus, in order to sustain claims about the role of interactivity in digital applications, we need be more precise about its meaning.

In this study, we survey the interactivity literature from a multidisciplinary perspective to examine the methodologies, technologies, contexts and fields of enquiry that have shaped research into this concept. We introduce a methodological approach using a combined content and discourse analysis (DA), which examines discourse as communication through the expression of 'meaning and beliefs' by discourse communities (after Van Dijk, 2011). We then analyse a sample of HCI research papers to explore how interactivity arises in practice and describe the quantitative and qualitative features of discourse, comparing results to prior studies of public discourses on interactivity. The study reveals a range of discourses around interactivity through the definitions, locations, methodologies and technical configurations associated with it in HCI. The findings show a tendency for HCI researchers to utilize narrow operational definitions for research design and evaluation. However, more nuanced multilayered representations also arise in discussion that recognize multiple meanings or 'modes' of interactivity, similar to those found in public discourses, which offer an opportunity for reconceptualisation. We describe these modes of interactivity as tools for thinking and talking about the concept in the design and evaluation of interactive technologies and systems. Through discussion of the findings, we show how this more refined and holistic approach to interactivity can acknowledge its multidimensional aspects and accommodate a layered experience, to more accurately describe what can and does occur in interactive communications across interconnected digital applications.

1.1. Practical and theoretical framework

Digital media practitioners design both with and for interactivity and so their success depends on how it is defined. For example, if interactivity is considered a characteristic of technology, the responsibility lies in the design of hardware, software or middleware. If it is a function of specific applications, responsibility may reside in the interface or 'front end' design, which attempts to cater for all foreseeable events in a closed loop. But if it is a perception of users, then there must be coherence between designers, developers and users upon expectations and outcomes. With ubiquitous computing, the interactivity loop is increasingly always open and all conceptualizations

arise, each provoking questions during the design process such as 'How interactive should it be?' or 'What do you mean by interactivity?'.[1]

A practitioner's area of expertise is also relevant to meaning. This is so whether s/he is in interface (or 'interactive') design, software engineering, HCI, games development, research or indeed the many other creative and non-technical areas of knowledge (information architecture, interactive narrative, sound composition, project management and so on) whose input is not emphasized as often as the technological skills of digital production (Preston *et al.*, 2009). The effect of competing discourses of expertise impacts on the potential success of interactivity. This points to a need for conventions and principles, to get beyond the 'wow factor' or 'I know it when I see it' approach, especially prevalent in digital media and games design (Polaine, 2005). However, measures used within professional design processes can just as often follow Laurel's (1993) very 'rudimentary measure of interactivity':

> …you either feel yourself to be participating in the ongoing action of the representation or you don't (*ibid*, p. 20–21).

Each research and design process in which interactivity discourses arise generates meanings that mediate our understanding of the concept. By specifically considering these different meanings, we gain a better view of how it is understood. This study builds on previous efforts to find a way of describing interactivity regardless of its forms (Jensen, 2005; Lim *et al.*, 2009). Jenkins (2000) successfully argued for a critical discourse around digital games, in order to improve design, education, critique, generational transfer of knowledge, audience building and as a 'buffer against criticism' (cited in Salen & Zimmerman, 2004, p. 2). A critical discourse of interactivity can offer similar possibilities and aligns with perspectives on critical design in HCI (after Bardzell and Bardzell, 2016) and 'interaction criticism' (Bardzell, 2009), not by offering another explanation or definition, but a new way of understanding and talking about interactivity. Research and design can then focus less on what interactivity *is* and more on why interactivity *matters* (Rafaeli and Ariel, 2007).

2. INTERACTIVITY THEORY

For over half a century, interactivity has been examined from a variety of perspectives in computing, the social sciences and humanities. As a multidisciplinary concept, it has benefited from a wide variety of literature, methodologies and theoretical frameworks. However, different definitions emerge from the structures of academic discipline as much as from contextual, social and political structures of technology and media and their uses (Sundar, 2004). Historically, for example, HCI has focused on interactivity in relation to task performance and efficiency (Lister *et al.*, 2009), psychology perspectives emphasize its cognitive and immersive qualities, while marketing research targets its persuasive attributes (Stewart and Pavlou, 2002) and media researchers tend to emphasize its transformative role in communication culture (Sundar, 2004).

Interactivity research reflects the search for a single bounded definition where studies tend to define it as (i) characteristic of the medium, (ii) dependent on the context in which messages are exchanged or (iii) a perception in users' minds (Heeter, 1989; Kiousis, 2002; McMillan, 2002; Quiring, 2009; Reinhard, 2011). Alternative perspectives identify a spectrum of low to high interactivity (Downes and McMillan, 2000; Jensen, 1998; Koolstra and Bos, 2009; Liu and Shrum, 2002) and further multidimensional approaches describe its generative potential to produce further interactivities (Richards, 2006), e.g. user-generated content. Others focus on the layering of 'interactivities' where several distinct phenomena occur in individual communication events (Jensen, 2005; Reinhard, 2011), e.g. social interaction via MMORPGs. Critical studies suggest that a proliferation of taxonomies only encourage 'haphazard use' of the concept (Bucy, 2004). Such differences in emphasis have taken up much energy in debates between rival camps (Hales, 2002; Kiousis, 2002), without producing a cohesive practical theory for application in design and research.

2.1. Methodologies, technologies and effects

Interactivity research has used a relatively narrow selection of methodologies to date and studies of online users tend to dominate the field (Barry and Doherty, 2016). User studies invite subjective evaluation and their findings can be difficult to generalize to other applications, particularly where participants have different strategic aims. Sohn and Choi (2013) found that the perceptions of digitally literate users are affected by preconceptions and expectations of interactivity, confirming earlier suspicions (Quiring, 2009; Sohn *et al.*, 2007). Definitions emphasizing user perceptions are also potentially limiting where they arise in a structured research context (e.g. surveys involving subjective reflection on a technical configuration), which may contain built-in preconceptions (Jensen, 2005; Koolstra and Bos, 2009).

Definitions of interactivity are also frequently, though not exclusively, determined by the technology under review. For example: website research emphasizes user perceptions and potential benefits (Downes and McMillan, 2000); computer-mediated-communication (CMC) research focuses on analysing messages and feedback (Shultz, 2000); game studies target user experience, aligning interactivity with concepts like agency and flow (Salen and Zimmerman, 2004); new media perspectives examine its role in dramatic games (Mateas, 2001) and 'interactive' narrative (Koenitz *et al.*, 2015). But theories

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[1]This research is partially motivated by M. Barry's personal professional experience of the digital media industry from 2001 to 2013.

and definitions that rely on the characteristics of a particular technology are only narrowly applicable beyond it (Barry and Doherty, 2016) and quickly go out of date (Jensen, 1998).

Where interactivity is considered a facet of design, in games, art advertising or education, definitions are frequently informed by a set of predetermined outcomes assuming beneficial effects. These can reflect positivist perspectives on science in society (Barry, 1998) or assumptions that interactivity promotes learning (Domagk et al., 2010; Gillen et al., 2007). Civic engagement perspectives underline empowering and disruptive aspects of interactivity (Flanagin et al., 2010; Stromer-Galley, 2004). Indeed, previous work shows that 'empowerment' dominates public discourses on interactivity (Barry and Doherty, 2016). Some studies have found negative effects where interactivity promotes 'impulsive and insufficiently informed action' (Stewart and Pavlou, 2002), cognitive overload (Jones et al., 2004) and emotional disorientation (Bucy, 2004), provoking calls for more serious research into both its costs and benefits (Rafaeli and Ariel, 2007).

Studies designed specifically for comparing digital interactivity to social or 'human' interaction assume normative standards that are inappropriate for digital communications (Baym, 2002). There are important differences between humans and machines 'as interactional partners' (Suchman, 2007) that present everyday challenges for HCI.

2.2. Interactivity theory in HCI

Interactivity is central to the field of HCI and arises in the detailed and intimate knowledge produced daily in research and design. The concept has changed the relationship between human and machine (Jensen, 1998; Suchman, 1987), requiring less physical and more cognitive effort by users (Sundar and Nass, 2000); it relates to the 'feel' of a WIMP environment (Dix et al., 2004) and has evolved through electrical, textual, graphic and embodied interaction (Dourish, 2001); it is a dynamic aspect or invisible quality of interaction (Dix et al., 2004; Lim et al., 2009), converting a system into a medium 'by eliciting user interaction with the interface' (Sundar et al., 2012); it describes a multidimensional concept, beyond the technology in use (Kweon et al., 2008).

Interactivity studies in HCI have engaged deeply with other disciplines, for example psychology and media and communications theory (see Lim et al., 2007, Sundar et al., 2010). As an interdisciplinary field, the challenges of appropriating concepts, methodologies and practices from other disciplines are well known (Bardzell, 2009; Sengers et al., 2006). Yet this traffic has not only been one-way. For over 20 years 'new media' studies have adopted many concepts from HCI, not least interactivity, implicating it in debates around technological determinism and hype (Winston, 1998). Although HCI has broadened its interests far beyond usability and productivity concerns to aspects of experience, engagement,

sustainability and ethics (e.g. Blythe et al., 2010; Fallman, 2011), new media research continues to associate HCI with a technical view of 'interactivity as control' (Lister et al., 2009). This may be because operational definitions of interactivity frequently arise in HCI for the purpose of assessing particular systems and applications. For example, Domagk et al. (2010) propose a definition specifically for the context of 'multimedia learning':

> Though defining interactivity is a critical first step, the concept must also be operationalized in order to be applied in research and design.

Similarly, Park et al.'s (2011) study of the relationship between motion feedback on touchscreen interfaces and affect, offers a specific instrumental definition suited to the research design:

> …interactivity in touchscreen user interfaces occurs in response to the two dimensional position, path and speed of the [finger] input action….

Alternatively, Petrie and Power's (2012) study of usability problems on 'highly interactive' websites recognizes a spectrum of experience with interactivity without requiring any definition. These examples reflect HCI interests in planned actions and achievable goals (Heath and vom Lehn, 2009; Suchman, 2007) and have the effect of 'taming' interactivity as an object of enquiry (after Boehner et al., 2007) for pragmatic purposes.

Overall, interactivity theory appears to have paused across disciplines at a similar point, being regarded as a characteristic of technology, context or user perceptions or is narrowly operationalized for specific applications. Even though it is core to HCI interests, a more refined interpretation is difficult to discern. Indeed, Sundar et al. (2012) restate a persistent research question—'what kinds of interactivity work in which ways under what circumstances?' We suggest that the discourses that circulate around research and design can help answer this question and present a valuable resource for advancing theory on interactivity. Discourse contains layers of definitions, mechanisms, usages, evaluation and experiences in context through language that requires a transfer of meaning within a community. Analysing it allows us to cultivate a greater critical awareness of how we talk about interactivity in HCI without instrumental restrictions.

2.3. Modes of interactivity in public discourse

Studies on interactivity in public discourses show that different styles or 'modes' of interactivity are in circulation 'in the wild' (through media) and that several modes can be identified in individual interactive communication events, demonstrating a layered and multidimensional concept (Barry and Doherty, 2016; Barry, 2012b). These modes include *Empowerment*—interactivity is said to 'enable', 'allow' or 'offer' possibilities

Table 1. The proportion of total papers for each publication that returns results for keyword 'interactivity' in 2014.

Publication title	Total papers	With reference to 'interactivity'	As % of total
CHI Proceedings	466	42	9%
Computers in Human Behavior	643	61	9.5%
Transactions of CHI (TOCHI)	27	3	11.1%
Interacting with Computers	39	4	10.2%
Human–Computer Interaction Journal	17	5	29.4%
International Journal of Human Computer Studies	80	2	2.5%
Total	1272	117	9.2%

such as access, action or further 'channelling' of communication opportunities; *Aesthetic* –interactivity associated with sensory aspects of experience and also where artists (as designers) may control such potential for their own ends; *Ludological*—a play or game-like style, even in serious applications; *Commercial*—a revenue-generating or marketing capacity; *Pedagogical*—interactivity relates to teaching and learning; *Futuropia*—interactivity as a defining feature of utopian visions of future technologies; *Hula-Hoop*—'y'know, for kids!'[2]; *Sceptical*—discourse questions the value/existence of interactivity. For example, discourses on 'interactive' science exhibits describe *ludological* and *aesthetic* modes in support of a *pedagogical* mode of interactivity (Barry, 2012a), while discourses on *aesthetic* and *ludological* interactivities arise in discussion of artworks in museum and galleries (Barry, 2014). The *empowering* mode of interactivity spans different combinations of potential for *action*, *context*, *strategies* and *outcomes* of communication for participants (Barry and Doherty, 2016). This illustrates the spectrum of empowerment possible through interactivity from superficial access to information to deeper engagement and channelling effects beyond individual events (*ibid*).

These modes offer a way of understanding interactivity beyond the specific affordances of individual technologies that tend to generate constrained definitions in the literature. Modes acknowledge a wider range of participants than the 'users' of user studies, often viewed as the only party to the interactivity. For example, website users are often constructed in research as abstract ideal or 'intensional' users (Bardzell, 2009) rather than actual users whose responses to interactivity are 'necessarily strategic' (Sundar, 2004). Thus, a website can offer access to exclusive information and detailed search facilities, whose interactivity may be empowering for some users, while its advertising and cookies present different empowering and *commercial* modes of interactivity for other parties often invisible to 'users'. This has been described as the 'price consumers pay for the benefits they receive' in information or service provision online (Stewart and Pavlou, 2002). Modes offer a useful way to assess how we talk about interactivity, whether in design or evaluation, that reveal wider operations and effects. In this study, we examine in particular if and how these and possibly other modes of interactivity arise and are revealed in a sample of HCI research discourse.

3. THE STUDY

To examine and describe HCI discourses on interactivity, we use the top ranking publication outlets for HCI research in 2014: the *Proc. SIGCHI*, the most important conference in the HCI community (Bartneck and Hu, 2009) used in several surveys of HCI research (Barkhuus and Rode, 2007; Law et al., 2009; Quinn and Bederson, 2011) and five prominent journals (according to Scopus rankings) with accessible material for 2014 (see Table 1). This particular year represents the most recent complete data set available for analysis with regard to publication restrictions and embargos. It also allows for comparison to public discourses on interactivity (Barry and Doherty, 2016), which we consider an important connection to make as public discourse is implicated in the public understanding of science (Bauer, 2009). Differences between academic and public discourses could reflect on the reception of HCI research and practice in everyday life. A different data set could produce different materials for analysis, but may not impact adversely on findings in relation to the meanings in circulation, as previous research has found these to be relatively consistent over time (Barry, 2012b).

The sample was collected via a keyword search for the term 'interactivity', chosen deliberately as it refers specifically to the concept, indicating engagement on a discursive level. The terms 'interactive' and 'interaction' are obviously also highly relevant as search terms but return an impractically large data set and so instead form a key variable of within sample analysis. In total, 117 papers were retrieved: 42 papers from *CHI Proceedings* and 75 papers from *HCI Journals* (see Appendix A), reflecting c.9% of the total corpus.

3.1. Methodology

We use a combined methodology of content and discourse analysis to examine quantitative and qualitative features of the sample following Jorgensen and Phillips (2002). Content analysis

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[2]In *The Hudsucker Proxy* (1994), when Norville Barnes has to explain his new invention, the 'hula-hoop', he uses this phrase. His audience may not understand the product but they appreciate a child's innate ability to 'get' new technologies. McLuhan (1959) also used the 'hula-hoop' to explain the notion that children may instinctively understand technology before adults do.

(CA) is an appropriate tool for quantifying a large number of texts and making broad inferences about representation (Deacon *et al.*, 2007), while DA helps examine 'the carriers of meanings in circulation' in more detail (Dahlgren, 2013) and is especially useful when the meaning of a concept is problematic. Our approach to DA looks at text 'above the level of sentences' to examine how certain phenomena are represented (Krippendorf, 2004, p.16), such as used in a variety of studies to track the 'marketization' of the language of higher education (Fairclough, 2009), to assess the circulation of the 'Knowledge-Based Society' concept in social discourse (Wodak and Meyer, 2009), to explore how children make sense of media content (Tobin, 2000) or to examine research on sexuality in the field of HCI (Kannabiran *et al.*, 2011). According to Van Dijk (2011), CA is one of the methodologies used in discourse studies generally, and a qualitative analysis of discourse structure is well suited to being combined with quantitative analysis. We follow this approach in focusing particularly on 'discourse as communication' (*ibid*, p.4) in order to grasp how interactivity is represented in HCI.

Language is not neutral and texts can become 'sites of struggle' that show traces of differing discourses or ideologies competing for dominance (Wodak and Meyer, 2009). DA is useful for showing 'why people draw on some discourses rather than others in specific situations' (Jorgensen and Phillips, 2002). It can reveal aspects of meaning formation in formal communications that are not necessarily apparent in a conventional literature review. An additional motivation for our methodological approach is to illustrate that a contested concept in the literature may actually be a reflection of multiple meanings circulating in discourse, which offer opportunities for re-evaluating efforts at theory building.

This study draws in particular on the approach of Jorgensen and Phillips (2002) to empirical DA, where the goal of analysis is neither critique nor a search for truth, but a widening of discussion towards better understanding. DA emphasizes the role of language as 'performance' in a social context (Deacon *et al.*, 2007; van Leeuwen. 1995), which in this case is HCI research. We therefore use DA to show how paying attention to language reveals opportunities for more detailed conceptualization.

3.2. Framework for analysis

The quantitative analysis follows a detailed coding framework of up to 22 variables drawing on a previous study of public discourses on interactivity (Barry and Doherty, 2016) and each individual research article was coded as a unit of analysis (see Appendix B for details on codebook variables, values and software for analysis). Quantitative features include frequency of keywords, technical configurations, locations of use, methodologies utilized in research and overt inclusion/use of definitions. Further variables such as depth of reference, definition types, reference/citation use and 'modes' of interactivity have qualitative

aspects that are acknowledged to have a more subjective measurement for the purposes of research. We identify different modes of interactivity through thematic 'construals' (after Fairclough, 2009) in discourse, arising from choice of vocabulary, metaphors, comparative analyses and so on. Modes are coded thematically following those found in public discourses (*Empowerment*, *Aesthetic, Ludological*, *Commercial, Pedagogical Futuropia*, *Hula-Hoop*, *Sceptical*) but also for further themes arising from the HCI data. Although inter-coder reliability is not critical to interpretation of this data, we follow Riffe *et al.* (2005) in agreeing coding protocol on variables, categories and values according to the study goals and coding was verified by two individuals, following Krippendorff (2004), for probability of agreement and consistency with prior work.

The methodical and systematic features of CA provide the reliability and validity required for DA in relation to the qualitative aspects of the findings, in particular the modes of interactivity. Unlike the relatively stable methodological requirements of CA, there is no single established method of conducting DA (Howarth, 2000). But if CA can be described as breaking up data into its constituent parts to describe the key ingredients, DA can be seen as trying to restore the sense of semantic complexity and agency within the sample, to see what is behind these ingredients and how language use relates to wider discourses in circulation (Deacon *et al.*, 2007, p.156). We pay particular attention to the 'order of discourse' in the data under analysis. This refers to how a concept is formed by 'networks of social practices which constitute fields, institutions, organisations' (Fairclough, 2009). In practice, this means attempting to trace the origins of a construal that appears in discourse, through references and so on. Disciplinary fields, like news genres, are not 'neutral containers' (after van Leeuwen, 2010), therefore references are considered contextual elements relevant for DA (Tobin, 2000).

There is no widely accepted formula for validating particular DA text choices, so the quantitative findings from CA are used to provide a rationale for inclusion in the analysis, according to the following criteria: (i) frequency and use of keywords, (ii) relevance of keywords to or location in content, (iii) qualitative representation of individual variables (exemplary discourses), (iv) quantitative representation of the whole data set (most frequent definitions, modes etc.), (v) relevance and richness of intertextual discourse material (use of citations and references) and so on. From the sample, 12 papers meet these criteria and are used to interpret the analysis, while another 17 papers contribute further illustrative material (see Appendix B for details). Both the quantitative and qualitative analyses offer a broad picture of how HCI treats interactivity in research. We first present some outline frequencies of the quantitative variables in relation to keyword references, methodologies, locations and configurations represented in the sample. This is followed by more detailed combined quantitative and qualitative analyses around definitions offered, definition types and 'levels' of interactivity in

discourse. Finally, we present a detailed analysis of how the modes of interactivity arise in discourse in a sample paper, in order to illustrate how it describes a layered and multidimensional experience.

4. FINDINGS

Due to structural and publication frequency differences between *CHI Proceedings* and the *HCI Journals*, the quantitative findings for both are presented separately. This allows for examination of some differences between the two subsets of research and comparison to public discourses where relevant. Citations of sample papers are numbered [N] and listed in Appendix A to differentiate them from the literature.

References: the keyword appears 100 times across the CHI papers and 554 times in the *HCI Journals*. Even accounting for the larger sample size, the *HCI Journals* contain many more references to the concept—13 papers contain over 10 references each, with 4 papers containing 94, 75, 59 and 58 references, respectively. Meanwhile, four papers in each of the HCI journal and CHI subsets refer to interactivity only in references and almost a third contain just one reference in text. But multiple references do not automatically create rich discourse material, while papers with minimal references can contain many related terms (interactive, interaction) and fruitful material for discussion. Therefore, as noted, a combination of coding variables is used for DA.

Methodology: user studies are the most frequent methodology for CHI at 28% (see Table 2), reflecting the dominance of this methodology in HCI research (Bartneck and Hu, 2009; Bargas-Avila and Hornbaek, 2011) and noted generally in interactivity research. While only 12% of HCI journal papers record user studies, almost a quarter report from surveys

(24%). Meanwhile, 25% of CHI papers employ 'Prototype', with 'Experiment' at 11%. Theoretical research and evaluation appear relatively infrequently in this CHI sample but should not be considered reflective of CHI papers overall. Only 1% of HCI journal papers use 'Prototype' but 24% utilize experiments, most likely reflecting the noted structural and stylistic differences between the two subsets.

Location: the most common location for interactivity is a 'laboratory' (44% CHI and 40% HCI), with implications for the application of related findings 'in the wild'. Although the research focus is not interactivity *per se*, discourse around it is constrained by an artificially constructed context. Meanwhile, 33% of CHI references reflect real-world locations (school, care home, etc.) and a further 22% take place 'online', where discourse on interactivity may differ (see Table 3). However, *HCI Journals* most frequently locate interactivity online (43%) and present few other contexts. Again this reflects stylistic differences between study types in each subset. Proof of concept and experimental technologies in CHI papers require field-testing, while experiments and surveys in HCI journal papers favours laboratory and online work.

Configuration: there are significant differences between HCI and public discourses in the variety of configurations (see Table 4). The most frequent in HCI discourses is Web/ Browser (17% CHI, 21% HCI), followed by Social Media for HCI journal papers (18%)—reflecting the frequency of laboratory/online locations—and Prototype configurations for CHI papers (15%). Software and Games are next (10–12% each), while the rest cover a range of configurations from Large Displays to Motion Capture to Interactive Whiteboards (IWBs). However, public discourses focus more on 'Apps' (10%), museum exhibits (10%) and 'General Digital' (10%) reflecting the continuing association of interactivity with consumer technologies and museums and as a generic descriptor (Barry and Doherty, 2016). Apps and Exhibits do not feature in the HCI sample at all possibly due to the specifics of discourse structure, content and audience types, but there are implications for interactivity theory building in the field. Laboratory-based and online research of prototype or browser applications may neglect crucial aspects of context and

Table 2. Methodology of research used in papers referring to interactivity in *CHI Proceedings* (N = 91) and HCI Journals (N =116).

Methodology	CHI	HCI
User studies	28%	12%
Prototype	25%	1%
Experiment	13%	24%
Interviews	5%	7%
Field studies	5%	2%
Proof of concept	4%	1%
Case study	3%	3%
Data analysis	1%	16%
Randomized trial	3%	0%
Theoretical research	5%	4%
Survey	6%	24%
Comparative evaluation	1%	4%
Formal evaluation	1%	0%
Focus group	0%	2%

Table 3. Location of interactivity in research papers (N = 117).

Location	CHI	HCI
Laboratory	44%	40%
Online	22%	43%
Home	10%	4%
Public space/venue	7%	1.4%
School	5%	8%
Workplace	5%	1.4%
Care home	2%	0%
Museum/gallery	2%	0%
Cinema	2%	0%
Mobile	0%	1.4%

Table 4. Configurations of interactivity arising in Public discourse ($N = 224$), CHI and HCI journal discourses ($N = 136$).

Configuration	CHI papers	HCI Journals	Public discourse
Web/browser application	17%	21%	8%
Social media platform	5%	18%	8%
Prototype configuration	15%	3%	0%
Game console/device	12%	11%	8%
Software	12%	10%	1%
Smartphone	7%	3%	5%
Large displays	7%	1.25%	See 'Other'
VR/VE/VW	5%	8%	0%
Adapted configuration	5%	0%	0%
Sensor/motion capture	5%	1.25%	0%
General digital (unspecified)	2%	7%	10%
Tablet	2%	0%	2%
E-Learning application	0%	6%	2%
E-book/E-reader	0%	1.25%	4%
Interactive Whiteboard (IWB)	2%	0%	See 'Other'
CMC	0%	4%	0%
AI/robotics	0%	1.25%	0%
Other (≤2 PD, =1 CHI/HCI)	4%	4%	4%
Advertisement	0%	0%	3%
Touchscreen	0%	0%	See 'Other'
Laptop	0%	0%	0%
Museum exhibit	0%	0%	10%
App	0%	0%	10%
TV	0%	0%	6%
Artwork	0%	0%	6%
[Non-digital]	0%	0%	13%

strategy that are relevant to understanding what kinds of interactivity work in which ways and why.

Overall, HCI makes a clearer distinction than the public discourses, between context and configuration, focusing on technical considerations under review. While appropriate for research publication, this has implications for wider theoretical development. Configuration alone offers insights into *what* is in use, but a deeper analysis of *why* and towards which outcomes require focus on the context and strategies of communication. Furthermore, interactivity is associated with a wide variety of configurations in HCI and public discourse than those that arise in the interactivity literature. This suggests potential actions, contexts, strategies and outcomes not yet adequately reflected in research.

4.1. Defining interactivity

A quarter of the sample does not define interactivity (27% of CHI and 24% of *HCI Journals*). This is unsurprising in papers where it appears only in references, but occasionally where a definition might be expected, it does not arise. For example, a study on dissociative experiences in 3D games references 'interactivity' in relation to 'spatial presence' [28].

The author cites Steuer's (1992) argument that a technology induces presence through two factors, 'vividness and interactivity', and follows this with a definition of vividness, but not of interactivity. This may be due to a common assumption that interactivity is the 'defining feature of games' (Deen, 2011) and needs no introduction. However, Skalski *et al.* (2011) argue that, as a 'form variable', interactivity should not be generalized (see also Newman, 2002).

Just 10% of HCI journal papers and only one CHI paper offer an explicit definition. This difference may be attributed again to structural variations, with more space for theoretical discussion in HCI journal papers, while the tighter format of CHI papers favours technical review and results. Most papers present an implicit definition (71% of CHI and 66% of *HCI Journals*).

4.1.1. Explicit vs. implicit definitions
The only CHI paper to give an explicit definition of interactivity states the following:

> *Interactivity*: We define this mainly as input/output with a human. Example: an ATM's interactivity includes a range of simple, well defined linear tasks accomplished using a numeric keypad with a few function keys, a screen, a credit card slot, a cash dispenser, etc. [4]

This definition is exceptionally broad in terms of potential contexts and uses to which it can be applied, echoing Sundar *et al.*'s (2010) description of technologies that 'elicit user interaction'. It presents the instrumental view of interactivity as a characteristic of technology—found in the ATM's 'well-defined' tasks and physical features. This definition precludes interactivities *without* humans, such as that between interface and system or between bank network and specific account data, which although clearly relevant to outcomes are not considered part of the context. The surprisingly mundane example of an ATM, in the only explicit definition in CHI, illustrates the history and ubiquity of interactivity in HCI. It contrasts with the more frequently found novel technologies elsewhere in the sample, offering complex interactivities without definition.

Seven HCI journal papers give an explicit definition, including six of the papers with the most numerous references to the concept. For example, Matthew *et al.* [12] state:

> Although definitions of interactivity vary, most researchers agree that website interactivity includes the degree to which the website facilitates exchanges of information (i.e. with the website) or interpersonal messages (i.e. with other visitors), permits a visitor to control the functionality or information available on the website, and is responsive to the visitor's requests…

This echoes the literature where interactivity is frequently conflated with 'website' interactivity, a configuration with specific affordances but also many hidden layers, not reflected in this description. An unqualified reference to the agreement of 'most researchers' suggests a discourse that seeks to avoid conflict or debate rather than unpack the effect of differences over the 'degree' of interactivity.

Elsewhere, more specifically, interactivity is defined as 'the extent to which … microblogging communication represents a two-way conversation' [2]. Meanwhile, Kruikemeier [18] relies on Liu and Shrum's (2002) definition, citing it as:

> The degree to which two or more communication parties can act on each other, on the communication medium, and on the messages and the degree to which such influences are synchronized. (p. 54)

This citation from advertising research represents a clearly influential field in HCI research, employed to support a number of definitions throughout the sample and an example of how the 'order of discourse' can shape discussion. Advertising has a very specific set of strategies for communication, requiring consistent measurement for interactivity as a direct link to (revenue) outcomes. While useful, the application of such discourses in other contexts of communication in HCI—such as political, health or business communications on the web and social media—overlooks their different strategies and outcomes.

4.1.2.   Types of definition 'vary drastically'

Definitions were also coded by type and half define interactivity as a 'characteristic of technology' (50% of both CHI and HCI journal papers), aligning with much of the literature. For example, a teacher uses 'a separate tablet to drive the interactivity of the [IWB] boards' [20], while 'public displays have advanced from isolated and non-interactive "ad" displays which show images and videos to displays that are networked, interactive, and open to a wide variety of content and applications' [7]. The latter evokes evolutionary discourses, found frequently in media and communications studies, where interactivity differentiates 'old' media from 'new' (Lister *et al.*, 2009). Yet there are no attempts to discuss what this 'advance' means in practice or the implications for design and research.

If interactivity is a technical characteristic, it can be measured as an affordance of technology. This arises frequently in methodological descriptions, for example in [19] where a controlled experiment has four conditions involving 'high to low' variations of interactivity according to speed, functionality and so on. Interactivity itself is not the focus of research but is a characteristic of a technology that can be controlled for the purpose of examining behavioural intentions in relation to physical activity. Therefore, its definition impinges on the findings.

As measurement friendly definitions of interactivity are more frequently used, they receive more attention than complex multidimensional typologies or variable 'perception of user' measures. Indeed some researchers make their definition explicit for this very reason:

> Interactivity is not a novel concept and has been defined in different ways; in the current experiments, it is defined as an attribute of technology—an affordance that provides real-time feedback to the user (Sims, 1997; Sundar, 2004) rather than perceived interactivity which may vary drastically from one user to another even when using the same device. [1]

This rationale for the choice of definition is useful if unusual. It is arguable that 'drastic' differences in user perceptions should, of course, be of interest to HCI because it relates directly to user reception and evaluation. However, researchers continue to shape experiments to avoid this conceptualization for pragmatic purposes.

Over a third of both HCI and CHI papers (34% and 40%, respectively) regard interactivity as a 'facet of context/design', an important finding in relation to bridging gaps between design and reception. Several papers cite Sundar's (2008) MAIN model [19, 8], which describes interactivity as one of four affordances (along with Modality, Agency and Navigation) of digital technologies, which users evaluate through 'heuristic cues' such as choice, control, flow, etc. While a useful framing device, this reveals little about the specific contribution of interactivity.

Just 13% of HCI journal papers and 7% of CHI define interactivity as a perception in user's minds, mostly studies which elicit qualitative evaluation of experience from participants e.g.: 'it wasn't as interactive as I would have hoped' [26]. However, Matthew *et al.* [12] repeat concerns about perception measurements:

> This inconsistency between perceptual measures and more objective measures has been previously observed (e.g. Voorveld *et al.*, 2011)

such that discrepancies in assessments of interactivity were found when evaluated on the basis of features or rating scales.

The supporting reference (Voorveld *et al.*, 2011) again comes from advertising research where further studies have reported that user preconceptions about interactivity from other experiences impact on its evaluation in subsequent research (Sohn and Choi, 2013). This illustrates the porous boundaries between public discourse, which produces expectations of interactivity and HCI discourse, which seeks to produce experiences of it. The prevalence of models and meanings in HCI research, which depend on user critique, whether perceived or actual, further supports the need for a more critical discourse of interactivity.

A small number of 'other' definitions arise (3% each), mostly reflecting discourses on interactivity as an ingredient of another concept, for example, Yang *et al.* [29] describe how 'the state of flow … is enhanced by interactivity and telepresence'. This link between interactivity and flow is a recurring theme but further analysis is beyond the scope of this paper.

4.2.   Acknowledging a spectrum of experience

About half of the sample (53% CHI, 47% *HCI Journals*) makes reference to a qualitative spectrum of interactivity e.g.: 'flexible technologies have added *varying levels* of interactivity to the World Wide Web' [24]; '[systems] often have *poor interactivity* and may require large or fixed spaces …' [3]. This echoes attempts in the literature to describe a spectrum of interactivity (Koolstra and Bos, 2009). But without giving explicit definitions, these scales lack a baseline for evaluation and rely on subjective perceptions for analysis. For example, one study asked participants to evaluate 'simultaneous game gestures that can promote *higher interactivity* in game situations' [25]. A Likert scale assesses game gestures according to purpose, ease and exertion, thus relying on user perceptions (agree, disagree) to evaluate levels of interactivity. The aim of research involves a measure of interactivity but offers no explicit definition upon which to base evaluation. Researchers simply concede that defining user experiences of interactive systems 'is not simple', again closing off opportunities for discussion.

Meanwhile, another CHI paper distinguishes the 'higher' interactivity of a prototype from previous iterations:

> [Time-frequency visualization] displays allow users to easily visualize, zoom, scroll, playback, and select regions of a recording all within a highly interactive feedback loop. This high degree of interactivity promotes and nourishes content creation in ways previously impossible… [5]

The implied definition is 'characteristic of technology', but this new 'higher' interactivity alludes to previous 'lower' manifestations. Thus, evolutionary discourses persist in distinguishing the interactive from non-interactive, while the new higher interactivity 'promotes and nourishes' creative action, suggesting increased *potential* in the technology.

The association with 'feedback' introduces a cybernetic discourse, which media and communications theory has explicitly linked with a higher quality of communication and control (Fiske, 2011). The paper cites research from what it describes as the 'intersection between HCI… and interactive machine learning (IML)', while the concern with feedback connects the paper to algorithmic discourses on interactivity where the concept is linked to speed of processing (Fails and Olsen, 2003). Several CHI papers associate interactivity with perceived speed of data delivery and manipulation in 'real-time', e.g.: 'the addition of real-time interactivity enabled them to freely explore the data at multiple LOD' [5]; 'various real-time interactive technologies were deployed to create a "disembodied performance" …' [27]; 'more interactivity features including real-time error recognition and guidance' [10]. This suggests that CHI discourses associate the spectrum of interactivity with differences in input technologies and the speed of a system, carrying an implicit definition of interactivity as a characteristic of technology. This offers quantitative evaluation options but again, the discourse associates differences of experience with contextual characteristics and user perceptions, better suited to qualitative assessment. No references are made to the negative issues with speed of response discussed in some interactivity studies (Stewart and Pavlou, 2002; Rafaeli and Ariel, 2007).

Elsewhere, feedback and learning of the human variety are relevant to levels of interactivity in a more considered study, which finds that different performance tasks in multimedia learning environments can be 'conceptualized as different types of interactivity' [23]. This paper, with 56 references to 'interactivity' (among the highest frequency of keywords in the sample), notes the literature—mostly from multimedia learning and cognitive psychology—reflects either 'outcome-oriented', 'performance–oriented' or 'embodied' interactivity approaches to conceptualization. Their findings, though based on specific 'characteristic of technology' instances of clicking and dragging, assert that planning and executive control are crucial parts of the interactive 'process' *along with* the outcomes more frequently the focus of multimedia learning studies (see 4.3 for further discussion on the *Pedagogical* mode).

4.3.   Modes of interactivity in HCI

Over 70% of CHI papers and just under half of HCI papers display two or more modes of interactivity, acknowledging its layered nature in individual events. The most frequent mode is *Empowerment*, found in over a third of papers, which is also the most frequent mode in public discourse (see Table 5). This is illustrated for example where 'Kinect-based interaction has *enabled* more natural and intuitive input for video games' [25], or where 'interactivity *promotes and nourishes* content creation in ways previously impossible' [5], reflecting the vocabulary of empowerment in interactivity found elsewhere (Barry and Doherty, 2016).

Table 5. Modes of interactivity found in papers of the CHI ('14) proceedings (N = 80), HCI Journals (N = 112) and public discourses 2014 (N = 331).

Mode	CHI	HCI	Public discourse
Empowering	39%	36%	31%
Aesthetic	21%	16%	19%
Ludological	16%	8%	11%
Pedagogical	14%	20%	9%
Commercial	9%	7%	22%
Hula hoop	1%	0%	5%
Social	0%	12%	0%
Futuropia	0%	0%	2%
Sceptical	0%	0%	1%

The second most frequent mode in CHI papers is *Aesthetic* (21%), with an emphasis on interface and input design and on novel technologies. For example, in a study where an interface includes 'more interactivity such as whole-body motion detection rather than single-point motion detection, participants felt more present in the virtual environment' [16], it implies that *aesthetic* interactivity is an extra layer of added value to the experience.

The *Ludological* mode accounts for 16% of references in CHI papers, often concerning gaming technologies, play contexts and games theory, for example a study into 'public displays, *playful* interaction and media spaces' [21]. But this mode is only half as frequent in HCI journal papers (8%), where the *Pedagogical* mode is more frequent (at 20%), due to the focus on digital technologies and learning. One HCI journal paper [9] notes 'differing views on the nature of learning and the meaning of "interactivity" [*sic*]'. The inclusion of 'scare quotes' around the term hints at discomfort in discourse with a concept (Haack, 2003). Another paper focused on 'interactive learning' (noted in 4.2), gives a detailed explication of this issue, noting that this association 'frequently goes unchallenged and under-investigated' [23]. Then, a CHI paper appears to affirm the point by stating (with only supporting citations) that 'higher interactivity with instructional content *aids learning*' [15] implying consensus on the issue. This illustrates the value of teasing out potentially conflicting positions in discourse, to consider how interactivity might be manifested in different modes.

The *Commercial* mode arises in just 7–9% of HCI research compared with 22% of public discourse, again reflecting different genres of communication. Public discourse is more exposed to commercial influences and studies note an increasingly promotional tone in technology journalism over time (Barry, 2012b). HCI research may offer a more objective view on commercial strategies by addressing negative as well as positive outcomes. For example, a study on user acceptance of e-books concludes that 'interactivity might become a key factor in achieving a competitive edge' [13], while a study on smartphone advertising, cites findings that 'interactivity may be perceived as a threat for customer privacy (Stewart and Pavlou, 2002)' [14].

Hula hoop interactivity is the least frequent mode—few papers in this particular HCI sample have children as participants. But an experiment with a video communication system which does include children illustrates how 'Children ages 6–11 were the most engaged and get the 'what I see is what you see' mirror metaphor' [11]. When users 'get' a design metaphor, it succeeds without explanation, a goal HCI struggles to replicate universally.

The *Social* mode of interactivity is a new addition to the coding scheme, arising from the significant number of articles in *HCI Journals* discussing interactivity in terms of social behaviour, frequently but not always, involving research into social media. References coded with this mode note how interactivity supports social skills of participants [22], makes social cues available in actions and context [6] facilitates extroversion and self-efficacy strategies [8] or produces 'social capital' [17]. This mode is likely to increase in frequency along with the use of social media, as is reflected in the large number of research papers focusing on this configuration. However, the social mode can arise with other configurations, while popular social media could be represented in other commercial or empowering modes. This illustrates how the modes can be a tool for guiding discussion on interactivity, where definitions relating solely on configurations and affordances may not address all aspects of its role in communication.

4.4. A layered experience—empowering and aesthetic interactivity

One sample paper presents a good example of the multimodal *nature* of interactivity in HCI discourse. It concerns a novel prototype technology explicitly designed to 'empower opera singers on stage' [27]. We selected it because of its multiple references to 'interactive' (47) and interaction (17) along with two keyword instances, and its detailed discussion, which specifically uses the terms 'aesthetic' and 'empowerment'. It also contains rich intertextual material revealing influential references from other fields, providing a useful example of the 'orders of discourse' in action.

The paper cites research pointing to forms of digital interactivity that 'put artists, musicians and singers in charge of the overall aesthetic', thus linking both *empowering* and *aesthetic* modes of interactivity to participant outcomes. The language asserts that the combined modes of interactivity amplify the effect for opera singers, literally and metaphorically. It acknowledges and cites research on 'empowerment in on-stage performance' including theory from music and performance studies as well as HCI, further enriching the general pool of discourse around interactivity.

The paper cites interactive technologies for performance from previous research—implying a characteristic of technology definition—but differentiates itself from these by its 'aim' to empower. This reveals the strategy behind the interactivity design, an

important aspect often neglected when studies focus only on actions and contexts. Strategy points to a desired outcome, which is more effective for evaluating interactivity. Furthermore, the study claims that the interactivity 'challenges century-old power structures … letting singers actively take part in shaping performance'. The empowerment goes beyond one instance of interactivity to its continuing use in each subsequent performance. The prototype is described as an exemplar for 'emancipation of the artist through the use of an interactive instrument', thus linking such empowering interactivity to lasting effects on participants, similar to the enduring empowering effects of interactivity found in public discourses (Barry and Doherty, 2016).

The paper notes the design brief for an 'autonomous, interactive embodied performance, where visuals and accompaniment came together in a homogenous gestalt'. This describes a style of interactivity where the body is both interface and input. References to autonomy and embodiment recall the actions facilitated by interactivity in games discourses on interactivity (Deen, 2011). However, the term 'gestalt' refers both to the physical 'form' of the instrument and the psychology of perception and its application in graphic design and HCI. It specifically cites the theory of 'interaction gestalt' in HCI, defined as what emerges between a user and an interactive artefact but going beyond user experience (Lim *et al.*, 2007). Aesthetic interactivity addresses this space in a similar way, referring to the sensory aspects of interactivity produced through experiencing interface design.

The testing phase in both laboratory and theatre reveals 'unforeseen obstacles that interacting with the device offers' which challenges the performer/user, illustrating how interactivity impacts on the role of participants and the contexts of use. The researchers see this positively as qualitative evidence of 'different forms of sense making through performing interactively', another strategic outcome implying that each use empowers by producing a new performance. Finally, the instrument is evaluated as a success by 'expert' users (singers) noting the positive impact on vocal performance, while acknowledging empowerment in the ability to 'follow … instinct to create'. The combination of empowering and aesthetic modes of interactivity creates a layered experience over the time of the interaction but also across subsequent interactivities, amplifying its effect.

This paper illustrates how empowerment can be represented explicitly and implicitly through choice of language and reference, in a richly discursive style. It shows the range of disciplines feeding into the meanings of interactivity in circulation in HCI. Meanings arise from general features of HCI research—prototype configuration, use of both laboratory and real-world context, lack of formal definition for or research emphasis on interactivity itself. However, the focus on testing in context on actual 'extensional' users (after Bardzell, 2009) with a design strategy oriented towards specific outcomes produces more nuanced understanding of interactivity. It shows

that paying attention 'critically' to discourse can improve our understanding of the concept in HCI.

5. DISCUSSION

Interactivity arises frequently in HCI—in almost a tenth of studies—but inconsistently, with many configurations across different locations of use within diverse research methodologies. Much HCI research is laboratory-based and focuses heavily on interactivity online, which misses opportunities to discuss different strategies and outcomes of interactivity found in other contexts. User studies and surveys dominate research, as in the wider literature, with implications for how user preconceptions of interactivity might influence findings. However, there are a greater variety of configurations for interactivity in HCI than in the general literature, and these differ markedly from those in public discourse, suggesting that rich opportunities exist for more detailed conceptualization within the field.

Despite a preference to operationalize interactivity instrumentally for specific research purposes, a significant proportion of the sample offers no definition of it at all. Implicit descriptions suggest it is a characteristic of technology, a pragmatic approach that suits quantitative evaluation. Where studies utilize qualitative user assessments of scales of interactivity, they offer no basis for its evaluation, although the difficulty in measuring perceptions of users is noted and qualitative dimensions of interactivity are acknowledged.

However, the qualitative analysis reveals more nuanced discussion, beyond instrumental perspectives arising from quantitative findings and usually associated with HCI in the literature. We find different discourses feeding into implied definitions and acknowledgment of a spectrum of interactivity. Similar 'modes' of interactivity arise in HCI as in public discourse and the focus on *strategies* and *outcomes* of communication flesh out the more traditional operational focus on *actions* and *context*. HCI discourses display at least seven modes of interactivity, most frequently 'empowerment', which can amplify other modes for a range of participants, towards lasting outcomes in interactive communication, particularly in discourses around prototype technologies and experimental methodologies. HCI research also reveals a new mode of 'social' interactivity, not found in public discourses to date, which offers further opportunities to explore distinct strategies and outcomes.

Multidisciplinary influences on HCI discourse are highly visible in the sample, whether from game studies, music theory or psychology, and advertising research is particularly influential in discussions of user experience. Such perspectives may overlook the different strategies and outcomes appropriate to the many non-commercial contexts arising in HCI. The multimodal approach, however, foregrounds these

aspects and offers a framework for a *critical* interdisciplinary discourse around design and reception of interactivity.

There are of course limitations in this study, as utilizing a recent constrained sample can only begin a process of examination of HCI discourses on interactivity. A larger sample, combined with a systematic cross-disciplinary literature review could provide further valuable historical perspectives on discourse over time, in particular to ascertain if and how changes in the technological landscape affect the meanings in circulation. Further analysis could also explore more deeply the links between interactivity and other important concepts for HCI such as 'flow' or 'social capital', which arose in this sample. While a critical DA perspective (following Wodak and Meyer, 2009) is beyond the scope of this paper, such an approach could further examine the influence of institutional and social power structures and their implications for meaning, and a formal Foucauldian analysis (see Howarth, 2000) could critically assess disciplinary knowledge structures. These additional approaches from discourse studies would enrich the explanation of contextual aspects of meaning making around interactivity.

There are many valid ways of talking about interactivity in HCI. Taken together, the constrained operational definitions arising in this sample are insufficient for general application. But the discourse around them is valuable for how it differs from the single definition trajectory of the wider literature, reflecting potential for multiple meanings and acknowledging a multidimensional concept. Crucially, it allows for combinations and permutations of different modes of interactivity combining the strategy, outcome, action and context of communication. This approach can assist designers and help answer Sundar *et al.* (2010) in exploring what kinds of interactivity work for different participants in particular ways under which circumstances. Interactivity can move from being a problem concept to providing opportunities for deeper engagement in discourse around research and design.

6. CONCLUSION

This study has examined for the first time how we talk about interactivity in HCI, when interactivity is not necessarily the *focus* of research, and finds some differences between the literature and discourse around it. It shows a more dynamic account of interactivity in research, where discourse goes beyond specific physical, technical and cognitive actions and contexts. Multiple meanings circulate around the role of interactivity in the strategies and outcomes of digital communications that arise in various mechanisms, configurations and experiences, and require different qualitative evaluation techniques. This presents an opportunity to shift discussion away from theoretical difficulties with interactivity towards embracing its flexibility as a discursive tool.

We have found rich and layered interpretations of interactivity in HCI research, in discourses around innovative and unique technologies, which do not arise in public discourse. We illustrate how the 'modes' of interactivity provide a way to convey meaning and describe its role in research, design and evaluation of these applications, while also revealing influential 'orders of discourse' behind its interpretation. While HCI research presents different configurations of interactivity and locations of use, there are similarities to public discourses in its modes of representation. Empowerment is a universally dominant mode and allows for common ground in how we talk about interactivity, which can benefit the public communication of HCI research. We also identify a new 'social' mode of interactivity, which offers further opportunities for HCI research to contribute fresh layers of meaning to the concept for use in other fields of research.

This multidimensional framework for understanding interactivity reveals pedagogical, aesthetic, social, ludological, empowering and other features. It allows HCI research to assess and locate responsibility and accountability for particular strategies and outcomes of interactivity, arising across important domains of practice and use in HCI such as learning or healthcare. In this way, the modes reflect both how we talk about interactivity and what it can do for us.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Interacting with Computers* online.

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APPENDIX A—SAMPLE

The following numbered list contains articles from data sample cited in this paper—the complete data set is available as supplementary material. Those marked with an asterisk (∗) were selected for qualitative discourse analysis:

1. Sun Joo (Grace) Ahn, Jeremy N. Bailenson and Dooyeon Park Short and long-term effects of embodied experiences in immersive virtual environments on environmental locus of control and behaviour. *Comput. Human Behav.* 39:235–245.∗∗
2. Ibrahim A. Alghawi, Jun Yan and Chuan Wei (2014) Professional or interactive: CEOs' image strategies in the micro-blogging context. *Comput. Human Behav.* 41: 184–189.∗∗
3. Mobolaji Ayoade and Lynne Baillie (2014) A Novel Knee Rehabilitation System for the Home. *Proceedings of CHI'14:* 2521–2530.
4. Jeffrey Bardzell, Shaowen Bardzell and Erik Stolterman (2014) Reading Critical Designs: Supporting Reasoned Interpretations of Critical Design. *Proceedings of CHI'14:* 1951–1960.∗∗
5. Nicholas J. Bryan, Gautham J. Mysore and Ge Wang (2014) ISSE: An Interactive Source Separation Editor. *Proceedings of CHI'14:* 257–266.
6. Gina Masullo Chen and Zainul Abedin (2014) Exploring differences in how men and women respond to threats to positive face on social media. *Comput. Human Behav.* 38:118–126.
7. Miriam Greis, Florian Alt, Niels Henze and Nemanja Memarovic (2014) I Can Wait a Minute: Uncovering the Optimal Delay Time for Pre-Moderated User-Generated Content on Public Displays. *Proceedings of CHI'14:* 1435–1438.
8. Kristin Page Hocevar, Andrew J. Flanagin and Miriam J. Metzger (2014) Social media self-efficacy and information evaluation online. *Comput. Human Behav.* 39:254–262.
9. Bruce D. Homer and Jan L. Plass (2014) Level of interactivity and executive functions as predictors of learning in computer-based chemistry simulations. *Comput. Human Behav.* 36:365–375.∗∗
10. Kevin Huang, Patrick J. Sparto and Sara Kiesler (2014) A Technology Probe of Wearable In-Home Computer-Assisted Physical Therapy. *Proceedings of CHI'14:* 2541–2550.
11. Seth Hunter, Pattie Maes, Anthony Tang, Kori Inkpen and Sue Hessey. WAaZam! Supporting Creative Play at a distance in customized video environments. *Proceedings of CHI'14:* 1197–1206.
12. Matthew L. Jensen, Norah E. Dunbar, M. Shane Connelly, William D. Taylor, Michael Hughes, Bradley Adame and Bobby Rozzell (2014) Organizational balancing of website interactivity and control: An examination of ideological groups and the duality of goals. *Comput. Human Behav.* 38:43–54.∗∗
13. Chang-Hyun Jin (2014) Adoption of e-book among college students: The perspective of an integrated TAM. *Comput.Human Behav.* 41: 471–477.
14. Yoo Jung Kim and JinYoung Han (2014) Why smartphone advertising attracts customers: A model of Web advertising, flow, and personalization. *Comput. Human Behav.* 33: 256–269.
15. Yoo Jung Kim, JinYoung Han, Juho Kim, Phu Nguyen, Sarah Weir, Philip J.Guo, Robert C. Miller and Krzysztof Z. Gajos (2014) Crowdsourcing Step-by-step Information Extraction to enhance existing How-to videos. *Proceedings of CHI'14:* 4017–4026.
16. Sung Yeun (Su) Kim, Nathan Prestopnik and Frank A. Biocca (2014) Body in the interactive game: How interface embodiment affects physical activity and health behavior change. *Comput. Human Behav.* 36: 376–384.∗∗
17. Jordan Kraemer (2014) Friend or Freund: Social Media and Transnational Connections in Berlin, *Human-Comput.Interact.* 29: 53–77.∗∗
18. Sanne Kruikemeier (2014) How political candidates use Twitter and the impact on votes. *Comput. Human Behav.* 34:131–139.∗∗

19. Yu Lu, Youjeong Kim, Xue (Yuki) Dou and Sonali Kumar (2014) Promote physical activity among college students: Using media richness and interactivity in web design. *Comput. Human Behav.* 41:40–50.∗∗

20. Michelle Lui, Alex Kuhn, Alisa Acosta, Chris Quintana and James D. Slotta (2014) Supporting Learners in Collecting and Exploring Data from Immersive Simulations in Collective Inquiry. *Proceedings of CHI'14:* 2103–2112.

21. Jorg Müller, Dieter Eberle and Konrad Tollmar (2014) Communiplay: A Field Study of a Public Display Media Space *Proceedings of CHI'14:* 1415–1424.

22. Chang Woo Nam (2014) The effects of trust and constructive controversy on student achievement and attitude in online cooperative learning environments. *Comput. Human Behav.* 37: 237–248.

23. Schwartz, R.N. and Plass, J.L. (2014) Click versus drag: User-performed tasks and the enactment effect in an interactive multimedia environment. *Comput. Human Behav.* 33:242–255.∗∗

24. Mirjam Seckler, Silvia Heinz, Javier A. Bargas-Avila, Klaus Opwis and Alexandre N. Tuch (2014) Designing Usable Web Forms—Empirical Evaluation of Web Form Improvement Guidelines. *Proceedings of CHI'14:* 1275–1284.

25. Chaklam Silpasuwanchai and Xiangshi Ren (2014) Jump and Shoot! Prioritizing Primary and AlternativeBody Gestures for Intense Gameplay. *Proceedings of CHI'14:* 951–954.

26. Hyewon Suh, John R. Porter, Alexis Hiniker and Julie A. Kientz (2014) @BabySteps: Design and Evaluation of a System for using Twitter for Tracking Children's Developmental Milestones. *Proceedings of CHI'14:* 2279–2288.∗∗

27. Carl Unander-Scharin. Åsa Unander-Scharin. Kristina Höök. The Vocal Chorder—Empowering Opera Singers with a Large Interactive Instrument. *Proceedings of CHI'14:* 1001–1010.∗∗

28. Kevin D. Williams. The effects of dissociation game controllers and 3D versus 2D on presence and enjoyment *Comput. Human Behav.* 38:42–50.

29. Shuiqing Yang, Yaobin Lu, Bin Wang and Ling Zhao (2014) The benefits and dangers of flow experience in high school students' internet usage: The role of parental support. *Comput. Human Behav.* 41: 504–513.

APPENDIX B—CODEBOOK AND ANALYSIS

The data were compiled and analysed using Excel and Dedoose (v7.5.), an online open source qualitative analysis package. This list outlines the main coding variables and values used in the analysis. Further codes and description options were also used including notes, text samples, quotes and so on, which are included in the text coding for the data set and utilized for discussion, but not for quantitative analysis.

	Variable	Value
1	Unit no	Each paper given ordinal unit number
2	Ref (interactivity)	Number of references to 'interactivity' in body text
3	Refs (interactive)	Number of references to 'interactive' in body text
4	Refs (interaction)	Number of references to 'interaction' in body text
5	Reference	Relevance of reference—depth of engagement values 1–3
6	Meth 1	Methodology utilized in research—values derived from sample∗
7	Meth 2	2nd methodology utilized in research—same values as Meth 1
8	Meth 3	3rd methodology utilized in research—same values as Meth 1
9	Loc	Location/venue of interactivity—values derived from sample∗
10	Level impl	Reference to levels or spectrum of interactivity—values 1,0
11	No. of modes	Number of modes coded—values 1–3
12	Mode 1	1st mode read from construals in text—values∗∗
13	Mode 2	2nd mode if available—same values
14	Mode 3	3rd mode if available—same values
15	Config 1	Main technical configuration/application of reference∗
16	Config 2	2nd configuration—same values
17	Config 3	3rd configuration—same values
18	Country 1	Country of origin of 1st author
19	Country 2	2nd country—same values
20	Country 3	3rd country—same values
21	KW Refs	Author keywords
22	Definition	Definition in text—values 1 = explicit, 2 = implicit, 3 = null

The following variable or category values are categorized using text descriptions from the sample itself (i.e. not produced subjectively, therefore values that are unclear = 0):

Methodologies—User studies, Experiment, Field study, Prototype design/build, Reflexive analysis, Interview—semi-structured/general, Proof of concept/feasibility study, Comparative research/evaluation, Case study/pilot study, Crowdsourcing feedback (MT), Survey, Formal evaluation/classification tool, Data analysis, Randomized trial, Theoretical research.

[The value 'data analysis' is listed as a separate methodology as it is stated as such in sample papers, although clearly would be a feature of many methodologies. Each paper is coded for up to 3 types of methodology, which was the maximum found in any sample paper and which allows for overlap between methodological types].

Locations—Lab, Home, Online, School, Care home, Workplace, Museum, Public space (outdoors/transit), Cinema.

Configurations—Software, Web/browser application, IWB, Smartphone, Camera/sensor/motion, iPad, Display screen, VR, Touchscreen, Tablet , Laptop, Adapted configuration, Prototype configuration, Other technology (<1), General digital media (unspecific), Artwork.

Modes—Empowerment, Pedagogical, Aesthetic, Commercial, Ludological, Hula Hoop, Sceptical and Social (as outlined in main text).