



Disability Studies Quarterly
the first journal in the field of disability studies

Universal Design Research as a New Materialist Practice

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Keywords:

Universal Design, accessibility, anthropometry, normate, misfit, 19th century science, eugenics, new materialism

Abstract

In Disability Studies, Universal Design (UD) is a concept that is often borrowed from an architectural or design context to mean an ideology of inclusion and flexibility with a range of applications in education, technology, and other milieus. This paper returns to UD as a design phenomenon, considering knowledge production practices as conditions of possibility for inclusive design. UD appropriates and redefines normalizing research methods, namely anthropometry, that were developed in the 19th century for uses that are contrary to disability rights and justice, such as eugenics, colonialism, and scientific racism. The paper argues that critical disability theory should understand work in UD research and design practice in order to formulate a nuanced, new materialist and historical disability epistemology, particularly in engagements with scientific knowledge.

Introduction

Universal Design (UD) is a phenomenon that combines scientific research and architectural design to promote the broad inclusion of diverse bodies in society. UD aims to maximize the built environment's accessibility to as many people as possible, regardless of ability, age, or sex. In contrast to the bureaucratic and legalistic approaches that make access an individual issue, such as those taken by the American's With Disabilities Act (1990), Universal Design understands that the design of the built environment collectively excludes bodies with varying abilities and disabilities.

UD responds to the existing built environment's privileging of able or healthy bodies

as presumed inhabitants of space, challenging this norm through designs that include a range of bodies. In addition to being a design phenomenon and philosophy, UD in the United States also constitutes an epistemic cultural milieu of architects, industrial designers, rehabilitation specialists, and researchers at universities and non-profit organizations. ¹ In the United States, this research has been historically funded through Rehabilitation Engineering Research Centers (RERC) grants to from the National Institute on Disability and Rehabilitation Research (NIDRR) under the U.S. Department of Education. This funding, in tandem with developments in U.S. accessibility laws, the disability rights movement, and professional design cultures, has created a UD milieu with different methods, goals, and objectives than its international counterparts.

This paper argues that Universal Design frames a regime of intelligibility in which the built environment is inseparable from knowledge about the bodies of potential users of space. While the demand for this knowledge production coincides with the rise of the U.S. disability rights movement in the 1960's and 1970's, epistemological reformulations of knowledge production within the design research professions are both a driving force and product of the conditions of UD's emergence with design, and should be considered within its history. In what follows, the paper explores the meanings of UD, demonstrating that it is a phenomenon that relies upon knowledge production about disability to enable access. It then historicizes one particular mode of knowledge production—the practice of anthropometry—and argues that UD engages in epistemic shifts that contribute to the development of disability epistemology.

UD as a political and material intervention

Within Disability Studies, the meaning of "Universal Design" has proliferated as a concept with ideological, political, and epistemological resonances beyond its original design context, where it also takes on a number of meanings and titles. ² That is, what "Universal Design" means in humanistic Disability Studies is not in contradiction with, but also not entirely co-extensive with the theory and practice of UD in the design disciplines. Disability theorists have used Universal Design as proof of the validity of *social models of disability*, according to which the built environment privileges certain bodies and excludes others by producing barriers that construct disability (Wendell 1996, 55; Davis 2002, 31). If the built environment can be made universally accessible by design, then the exclusion of pathologized bodies from social and built worlds is a construction of society rather than predetermined by biological lack or excess. Disability is a materialization of exclusions resulting from the imperceptibility or devaluation of the concerns of people whose bodies deviate from norms of health and wellness. In this usage, the availability of UD as a quality of the built environment operates as epistemic verification of a particular way of understanding disability.

Outside of Disability Studies, the academic literature on UD focuses on three primary areas: promoting best practices for accessibility to designers, assessing the efficacy of built products and spaces, and evaluating UD's implications for

policy and citizenship (Goldsmith 1963, 1997, 2000; Hall & Imrie 2001; Herwig 2008; Preiser & Ostroff, 2001; Preiser & Smith 2010; Sanford 2012; Steinfeld & Maisel 2012). This literature's theoretical base comprises a range of disciplines, including rehabilitation medicine, public health, architecture, ergonomics, and education. As Sanford (2012) has shown, UD's development and theoretical basis is as much a product of rehabilitation medicine and assistive technology as it is of the social model or disability rights movement.

While providing needed assessments of UD as a design phenomenon, attention has been diverted from the broader epistemological, ontological, and ethical implications of UD as a research practice, even in the work of advocates and professionals (Herwig 2008; Kawuchi 2009; Ostroff et al. 2002; Sandu 2001). Social model understandings of disability have been considered in the context of rehabilitation and environmental psychology, but not the history of science or medicine (Sanford 2012). By focusing on the economics or aesthetics of UD, few advocates have drawn upon tools from the critical humanities to consider the cultural, material, and scientific understandings of embodiment and knowledge at play in the phenomenon.

The absence of a richer exchange between humanistic critical Disability Studies and the design fields has produced some misperceptions about what Universal Design means and has meant in its original design context. The "Seven Principles of Universal Design" are often cited as the basis of UD ideology and practice. These Principles, however, are not without historical or professional context. They emerge through knowledge paradigms that pre-date UD and have been challenged and re-written, sometimes by their own authors. ³ It is important, therefore, for Disability Studies to have a perspective on UD that recognizes this history, which is entangled with the production and application of knowledge about disability produced through multidisciplinary contexts bringing together architecture with industrial and product design, human factors research (including biomechanics and environmental psychology), and rehabilitative medicine (Steinfeld and Maisel 2012, 87-88).

Universal Design as a Design Research Practice

While the emphasis on Universal Design as an ideology has been important to Disability Studies and should not be discounted, a better understanding of the overall UD phenomenon can offer epistemological tools for understanding the interrelation between knowledge about disability and the materialization of exclusion in the built environment. That is, it can help scholars understand what material and epistemic differences are made by collaborations between research and design. The history of Universal Design is not only a design history, but also a narrative about the emergence of scientific research and evidence-based practice as central components of user-centered design.

UD research responds to three epistemic regimes present in design. The first is a relatively recent regime of empirical knowledge produced through academic research. *Environmental design research*, a field co-produced alongside

user-centered design in late 1960's, promotes the intentional design of spaces and products based on empirical and often quantitative data derived through human factors research, encompassing biomechanics, ergonomics, environmental psychology, behavioral research, and ethnography (Moore et al. 1985). Professional organizations, such as the Environmental Design Research Association, the Industrial Designers Society of America, the Human Factors and Ergonomics Society, and the Rehabilitation Engineering and Assistive Technology Society of North America, lead this research.

Second, UD responds to design thinking that is at once intentional and intuitive (Depoy & Gilson 2010). Design knowledge is based on intuitive investigation and problem-solving by individual designers. Within design practice, "research" refers to the designer's drawings, studies, and models that explore possibilities for a design. Whereas scientific research describes an existing state of things, design is a process that researches potential futures by solving problems within the status quo (Lawson 1997, 113). Intuition guides designers through problem-solving processes, but does not necessarily introduce considerations of bodies, experiences, or other knowledge beyond that of the designer. In UD, scientific research is meant to promote evidence-based design by providing knowledge about other experiences and differently functioning bodies, serving as a corrective to design that relies upon intuition alone. [4](#)

Finally, UD responds to a schema, often depicted graphically, that I call the "normate template." Rosemarie Garland-Thomson's useful term, "normate," refers to a privileged and de-stigmatized body representing a universal or ideal type (Garland-Thomson 1996, 8). As a foil to this figure, Garland-Thomson has recently theorized the "mis-fit," a condition occupying the "truth of contingency" that is characterized by not having the "comfortable and unremarkable majority experience of material anonymity" characterizing the normate (Garland-Thomson 2011, 11). Normate and the mis-fit form a conceptual scheme that takes more common binary notions, such as normal and pathological, and gives them context within the built environment. Normates are unremarkable and perhaps even impossible figures, yet their intended presence permeates the world. Mis-fit is a material construct and a nearly universal experience that demands accountability by the built environment.

According to UD, architecture and industrial design utilize the normate as a template for the likely user of space. The normate template has its foundations in figures such as the Vitruvian Man and is institutionalized within U.S. architecture and industrial design through stock images in design handbooks representing average-sized bodies (Imrie, 2003; Dreyfuss 1960, 5). Rather than accounting for diverse body types, sizes, and abilities, the normate template privileges a small group of individuals in mainstream design, giving these individuals the appearance of normalcy or universality due to their fit in the environment. The resulting built environment is precisely what the social model criticizes—a world built without considering all ranges of ability.

Early UD Proponents: Defining Necessary Knowledge

Universal Design emerges alongside evidence-based practice in the late 1960's and early 1970's, when a liberalizing social and political climate began affecting the design professions and their emerging focus on users. The dedication of many early Universal Design proponents to the goals of the disability rights movement is well-documented (Ostroff, Limont, & Hunter 2002; Steinfeld & Maisel 2012, 15-18). The architect, Ron Mace, coined the term "Universal Design", in the early 1970's to describe budding socially inclusive design practices that privileged users in the design process rather than making them secondary to aesthetic or formal considerations (Kawuchi 2009, 7; Mace 1985; Steinfeld 2011). The term first appeared in print in an article by Mace in 1985 (Mace 1985).

While UD's emergence correlates with the civil rights movement era, and is an example of "value-explicit" design and research (Moore et al. 1985, 21), causality for its appearance on the scene of architecture and industrial design cannot be drawn from civil rights ideologies alone. Instead, it is useful to consider the entangled network of actors, epistemologies, and professional commitments that materialized UD. UD proponents did not only demand the protection of people with disabilities by a civil rights regime, but also worked on strategies for challenging the design profession's attitudes, norms, and values regarding the normate template (Dolmage 2005; Williamson 2011). Likewise, while the disability rights movement may have won legislative battles culminating in federal disability rights laws, it did not directly propose strategies for challenging the professional practices through which the design professions had adopted the normate as an ideal type. [5](#) Efforts to educate designers and challenge professional practices by UD advocates can be understood as a parallel movement to the direct action and legislative demands of the disability rights movement.

In the mid-1990's, a group of practitioners working on UD in the fields of architecture, industrial design, assistive technology, and environmental design research convened at North Carolina State University's Center for Universal Design to draft the "Seven Principles of Universal Design" (Center for Universal Design, 1997; Story 1988). The Principles' authors were researchers and practitioners in evidence-based fields such as ergonomics and human factors research, industrial design, gerontology, and rehabilitative medicine. [6](#) They drafted principles guiding the UD method toward designs that are flexible, equitable, simple, easily usable, and tolerant of error. While often cited as the basis of the UD design method and ideology, the Principles also reflected their authors' commitment to applied research as a design tool. For example, flexibility obliges designs to account for a range of user body sizes and functions. To understand the range of possible variations, designers can rely upon anthropometric data about bodily movement, reach, or size. This data influences the width of doorways, the height of cabinets, and the shape of door handles. Although not explicitly evidence-focused, the Principles made legible the need for bodies as evidence in UD.

UD As Evidence-based Design

Feminist science and technology studies scholar, Michelle Murphy (2001), has usefully borrowed from Michel Foucault the concept of the *regime of perceptibility* or intelligibility in order to elaborate upon the overlapping histories of design, science, and spatial users in the emergence of the phenomenon of sick building syndrome. Regimes of perceptibility are "the regular and sedimented contours of perception and imperception produced within a disciplinary or epistemological tradition" (Murphy 2001, 24). According to Foucault, new regimes of perceptibility do not replace but rather "supplant" or "superimpose" themselves upon previous regimes, creating space for the intelligibility of new objects and practices that were previously imperceptible (Foucault 1980, 106).

What kind of regime of intelligibility is evidence-based design and what is its epistemological significance for UD? The significance of knowledge production activity in UD can be traced back to a discourse developing between designers and researchers interested in evidence-based and user-centered practices in the late 1960's (Steinfeld & Maisel 2012, 34-35). Evidence-based design, like its counterpart, *evidence-based medicine*, relies upon the production of knowledge to address and solve practical problems (Moore and Geboy 2010, 106). Changes occurring in the civil rights era in architectural standards of evidence, as well as in the field of environmental design research, anticipated UD's emergence as a knowledge-producing counterpoint to mainstream design. This section charts two new directions within design epistemology and methodology: one advocated in order to encourage designers to use evidence and data rather than intuition, and another advocated to change the focus of the research that produces evidence for designers to include a user focus.

Early UD designers and researchers theorized that the lack of usable data about human body variation was in part responsible for the inaccessibility of existing designs (Mace et al. 1966; Preiser 1973; Preiser & Vischer, 1991; Salmen 2001, 181-182; Sandu 2001). The changing demographics of disability created uncertainty about the range of sizes and functions of bodies, serving as a barrier to meaningful accessibility standards (Story, Mueller, & Mace 1998, 6-7; Steinfeld & Tauke 2002, 166-167). Making evidence the basis of practice would, in turn, address uncertainties associated with the diversity of potential users by expanding the scope of what designers could know about disability.

The change in focus was not only about including both normates and mis-fits in research, but also about person-environment relations. Before evidence-based design, knowledge used by designers from outside the profession tended to be about the environment and not its interaction with users (Moore & Geboy 2010). Whereas mathematics and engineering knowledge previously informed architects about the materiality of buildings, and while biomedical knowledge independently located disability and medical diagnosis within bodies rather than their environments, evidence-based design

focused on the moments of chance interaction between human bodies and built, social, cultural, and natural environments.

The availability of evidence-based practice was necessary to the eventual emergence of UD as a design method. The UD Principles' insistence on flexibility, equity, and user needs became perceptible as design mandates of evidence-based and user-centered design in non-disability contexts. The U.S. military, for example, pioneered human factors and ergonomics research in order to flexibly design for the range of its soldiers in the early 20th century (Gordon & Friedl 1994). While focused on non-disabled military men, this research made users' bodies legible as evidence within design, rendering issues like aging and disability relevant to the built environment. Eventually, the emphasis on health, aging, and disability came to characterize much of evidence-based design because its research base drew upon available human factors research data and methods (Moore & Geboy 2010; Zeisel 2006). The legibility of concerns with the body, in turn, enabled UD advocates to argue that designers had an ethical responsibility for accessibility because architecture and industrial design impact everyday life (Preiser & Vischer 1991).

The shift to evidence-based practice was a shift in an architectural regime of perceptibility in which epistemological standards governed what designers perceived as the scope and inclusionary imperatives of practice. This does not mean that evidence-based practice completely replaced intuitive approaches to design, or even that it became successful in the displacement of this prior regime of perceptibility. Instead, it was an epistemic and methodological overlay producing the intelligibility of users as evidence to designers. [7](#) Tanya Titchkosky writes that access "is an interpretive relation between bodies" (Titchkosky 2011, 3). In UD, human bodies and behaviors became legible proofs of the normate template's inadequacies for design, creating an "interpretive relation" between bodies and environments. Human factors research testified to human-environment interactions as bodies and behaviors became useful and valid evidence for research-driven design.

The truth-telling qualities of bodies and behaviors, however, were not always immediately accessible. Rather, the methods and standards by which mis-fitting bodies became legible as privileged evidence emerged through specific, historical research practices. The next section describes one research practice of import to contemporary UD: anthropometry. UD anthropometry research exemplifies the call for multidisciplinary research in evidence-based practice. Understanding its history illuminates significant and otherwise imperceptible epistemic shifts within design and scientific research on disability.

Anthropometry: Rendering And Challenging The Normate Template

Anthropometry encompasses methods of measuring samples of human bodies

for the collection of data about size, ranges of motion, and other quantifiable spatial measurements. Its historical trajectory includes the use of bodies as evidence in establishing standards of positive science and quantification. Following anthropometry's history demonstrates that UD has responded to the normate template by re-conceptualizing research design methodologies and standards of data interpretation rather than simply changing its sources of evidence or the intentions of its practice.

Sociologist of science, Steven Epstein (2009), has noted the paradox that many marginalized groups since the late 20th century have demanded inclusion in scientific research that less than a century prior was used to segregate or eliminate these same populations. The same paradox is present in UD's use of anthropometry, the previous practice of which has been at odds with the goals of broad inclusion and social justice (Davis 2006, 4). Co-produced with 19th century positivism and eugenics, anthropometry provided evidence of the supposed excess or deficiency of bodies that deviated from the statistical average (such as disabled bodies and differentiated racial populations). It was entrenched in 19th century practices of measuring bodies to quantify normate and mis-fit.

Historian of science, Stephen J. Gould, attributes the biological determinism of 19th century sciences to their reduction of human bodies and anatomical features to measurements (Gould 1981, 25). Francis Galton, a key figure in the development of modern statistics, used anthropometry to measure intelligence through race and inheritance, laying the groundwork for the use of biometrics for racial differentiation and the establishment of the statistical law of normal distribution (Gould 1981, 76; Graves 2001, 92-93; Hacking 1990, 105-106; Kevles 1985, 18; Sekula 1986, 20-21). The logic of measuring and ordering bodies infused eugenics (Laughlin 1919, 55-61). This logic also enabled physical anthropologists and state officials, some working in the service of colonialism, to establish hierarchies of racial dominance through scientific measurement (Adebisi 2008; Hrdlicka 1919, 22-23; Phillip 2004, 99; Blanckaert 1988, 49).

The practice of anthropometry is co-produced with 19th century positivist epistemology. In developing statistical laws, Galton conflated norms and averages by relying upon Adolphe Quetelet's finding (via anthropometry) that larger proportions of the population are represented by the mean, making it possible to quantify the "average man" (Canguilhem 1989, 157; Davis 2006, 6). Nineteenth century anthropometry typifies what Georges Canguilhem describes as the false conflation of norms and averages. The norm is a state of equilibrium determined on an individual and qualitative basis, making it distinct from the statistical average, which is based upon a quantified data set derived from a population of individuals (Canguilhem 1989, 76, 151). When the statistical average is conflated with normalcy, deviations from the mean are characterized as both quantitatively and qualitatively deviant.

With the "average man" occupying the place of normalcy in Galton's eugenic

ideology, he developed the idea of statistical correlation (Stigler 1989; Cowan 1972, 509). Correlation allows the conflation of the average with the norm without consideration of the causal events through which bodies come to appear as normal or deviant. Standardization and correlation are foundational to eugenic anthropometry's claims to objectivity because they justify the validity of claims about the correlation of skull size to intelligence or body proportions to evolutionary desirability (Gould 1981, 256).

While eugenic anthropometry focused on measuring bodies as evidence of racial and ethnic superiority, the U.S military adopted anthropometric methods to make functional changes to weapons of war. Early 20th century military anthropometry in the U.S. tested the characteristics of soldiers with high performance and presumed high intelligence (Meister 1999, 148). After the war, anthropometric data obtained from approximately 100,000 soldiers were published and distributed for general knowledge (Meister 1999, 152-3). The military continued to use anthropometrics for the ergonomic design of cockpits and weapons (Wickens and Hollands 2000).

Eventually anthropometric data and ergonomics entered industrial design and civilian product design as evidence about potential users. The normate template for mainstream architecture was institutionalized by the mid-20th century industrial designer, Henry Dreyfuss, who used anthropometry data taken from young, able-bodied, military men for to develop anthropometric figures of supposedly average bodies for designers. In their early iterations, these figures displayed no data about disabled bodies, women, children, elderly people, or any other body not compliant with the normate template (Dreyfuss 1960; Hosey 2001; Serlin 2002, 65-8).

Dreyfuss distributed anthropometric data through images appearing in texts intended for designers. The images made the military data intelligible to designers who were not trained to interpret statistical data and tables. Other figures representing ideal geometric embodiment, such as the Vitruvian Man or Le Corbusier's Modulor, had guided architectural conceptions of the body long before Dreyfuss's anthropometric images (Hosey 2001; Wittkower 1949). By using images to convey knowledge to designers, Dreyfuss continued the tradition of depicting bodies graphically. As in this tradition, he represented a seemingly neutral body that in actually represented an impossible ideal type—the normate (Hosey 2001). Anthropometry entered architectural practice when the handbook of American architecture, the *Architectural Graphic Standards*, adopted images from Dreyfuss and others (Ramsey & Sleeper 1947). As a result, anthropometric images often serve as the primary available information about human bodies for architects in the mainstream, but primarily display data about average bodies (Hosey 2001).

The New Disability Anthropometry

Disability anthropometry as evidence for design is a recent epistemic and methodological challenge to the normate template and to anthropometry as a

scientific practice. By showing that the normate, constituted through exclusionary anthropometric data, is a socially and historically specific figure that is not generalizable to the whole population, disability anthropology undermines its seeming neutrality and objectivity. Central to the UD research strategy is establishing a regime of perceptibility whereby knowledge production makes excluded bodies apparent to designers while also shifting the meaning and methods of research.

Just prior to the shift toward human factors in environmental design research, the British architect, Selwyn Goldsmith, published *Designing for the Disabled* (1963) as a model for incorporating anthropometric data about people with disabilities into design as a corrective to existing data sets. Over a decade later, evidence-based design advocate and UD Principles author, Edward Steinfeld, received a grant from the U.S. Department of Housing and Urban Development to conduct a study on 60 wheelchair users that became the basis of the federal government's technical accessibility standards (Steinfeld, Schroeder, & Bishop, 1979). The resulting study, published in 1979, constituted a limited challenge to the normate template but became the basis of the American National Standards Institute access codes (Seelman 2005). This mobility anthropology data was not updated until the 2000's, when Steinfeld and a new team of researchers at SUNY-Buffalo's Center for Inclusive Design and Environmental Access (IDEA), which houses the RERC on Universal Design and the Built Environment, undertook a decade-long study with a much larger sample size, different targets and objectives of study, and improved research methods (Steinfeld et al. 2010). The final version, published in 2010, included 500 users of wheeled mobility devices, including manual and power wheelchairs and scooters (Steinfeld et al. 2010). It is to date the largest study of the anthropology of wheeled mobility devices.

While the study's report does not mention anthropology's problematic histories, it makes several epistemological interventions in the standards of knowledge around anthropology and statistics, and also develops methodologies that reinterpret standards of scientific rigor. First, the study historicizes existing disability anthropology within 20th century developments in assistive technology. It notes that the previous sample of only 60 wheelchair users was not only inadequate due to its small sample size, but also was inapplicable to technological advances in mobility technologies, such as powerchairs and scooters, since the 1970's (Steinfeld et al. 2002, 17; Steinfeld et al. 2010, 84). Recognizing technological change demonstrates a shifting understanding of possibilities for body-environment relations.

Second, the study challenges statistical methods by rejecting the notion of proportionate sampling that is central to the generalizability of quantitative research. Proportionate sampling conventionally means that if a general population includes 20% individuals of a certain category, the study sample must also include the same percentage of those individuals (Steinfeld et al. 2010, 17-18). Generalizing from a small sample to the whole population in this

way is a mechanism by which privileged figures, like the normate, become a legitimate representation of the supposedly average body.

Steinfeld et al.'s study did not endeavor to achieve this level of generalization because it would not be useful for designing for broad inclusion. As the authors note,

most people with severe disabilities fall outside [the representation of the whole population] when proportionate sampling schemes are used. This means that disability will be very underrepresented in conventional anthropometric studies. Some studies purposely exclude people with disabilities and older people to keep the results unaffected by 'outlying cases' or people who have widely divergent abilities and characteristics (Steinfeld et al. 2010, 17-18).

Steinfeld et al.'s study sought data that has been controlled out of other studies via sampling. Within the 2010 sample, researchers oversampled for previously underrepresented populations of power wheelchair users. Because more data already exists on manual wheelchair users (a significant portion of the population of mobility aid users), researchers concluded that oversampling power chair users who are least represented in previous studies would not distort their results, but rather ensure some representation of this group (Steinfeld et al. 2010, 83).

Third, the study develops methods for making body-environment systems and interactions the object of research. To do this, the study measured people performing "real world tasks" (Steinfeld et al. 2002, 13). As Steinfeld et al. note in the proceedings to a 2002 conference on disability anthropometry,

...structural measurements alone cannot fully predict human performance in real world settings where the body is usually in motion or under stress... This has added another level of complexity to anthropometry because free, or unloaded, movement is not always sufficient to capture the nature of performance in real world tasks (Steinfeld et al. 2002, 13).

Previous anthropometry used static measurements (called "structural" anthropometry) of bodies at rest and divorced from environmental context; the new anthropometry uses both static *and* dynamic ("functional") anthropometry of bodies relating to and using environments and technologies (Steinfeld et al. 2010, 2; Steinfeld et al. 2002, 16-17).

Studying body-environment interactions in real world tasks also shifted the way that evidence about bodies becomes valued within a data set. For functional anthropometry, bodies are irreducible to their measurements, and measurements are only meaningful when they convey information about how bodies and environments act in tandem. Disabled bodies are not merely objects of medical knowledge or curiosity (Mitchell and Snyder 2006, 28), but evidence of social inclusion that becomes perceptible when put into interaction

with the built environment. As evidence, inaccessibility and mis-fit become measurable and testify to the environment's fit to the body.

Fourth, whereas static anthropometry measures the aberrance of the body from a statistical *average*, functional anthropometry measures the environment's mis-fit with a *range* of bodies. ⁸ This range is depicted both graphically and in tables. Data about ranges makes it possible to design, for instance, desk chairs or tabletops that are adjustable to the height of multiple users. The range defies the notion of standardization, requiring flexible solutions to the built environment that accommodate multiple abilities and embodiments within a single design. Thus, the norm of representation within disability anthropology is the range rather than the average (Steinfeld et al. 2002, 33-34).

Valuing ranges as evidence requires adopting methodological reflexivity about the reliability of standard measurements. Steinfeld et al. (2002) found that the diversity in bodies, mobility devices, and environments in their study made it difficult to standardize measurements. Conventional anthropometry methods rely upon able-bodiedness as a norm, requiring subjects to remain upright in difficult poses during research and de facto excluding those who do not fit the experimental design (Steinfeld et al. 2002, 24). Also, the inability to standardize body landmarks for measurement across diverse bodies creates "barriers in translating research findings to standards development" (Steinfeld 2010, 4). The researchers adopted reflexivity by questioning the objectivity of quantified measurements based on the inadequacies of current methods to yield usable data. This reflexivity requires new accessibility standards to be flexible and reflect ranges of interactions between bodies and environments.

Finally, in Steinfeld et al.'s study, multidisciplinary research required anthropometry to be conducted alongside other methods. The process of defining "measurement variables and procedures" entailed, in Steinfeld et al.'s study, consultation with "experts in anthropometry and ergonomics, human modelers, architects and designers, and clinicians" (Steinfeld et al. 2010, 2). This meant that epistemic standards and methodologies from all of these fields entered the design of research.

Multidisciplinary shifts the terms of expertise and the value of sources providing valued knowledge for accessible design. Steinfeld et al. used surveys, focus groups, and ethnography alongside anthropometry to identify qualitative factors and preferences that are inaccessible to quantification alone, rendering legible the people whose bodies are being used as sources of evidence (Steinfeld et al. 2002, 21, 29). These qualitative studies rest upon the validity of the experiences and perspectives of spatial inhabitants as valuable knowledge and follow models for user-centered design created by people with disabilities specifically for architectural interventions (Lifchez 1987). For example, Steinfeld et al. conducted focus groups with potential anthropometry research subjects in order to define non-invasive research methods of contact with bodies (Steinfeld et al. 2010, 2). In this way, the bodies of people

measured by anthropometry also participated in designing research methods and defining their own consensual limits. This participation departs dramatically from the invasive and (often) coerced anthropometry conducted in eugenic, military, or physical anthropology contexts.

Toward a new materialist understanding of Universal Design

The previous sections have demonstrated that Universal Design, lauded as evidence of the social model of disability, both operates within a research paradigm with historical connections to 19th century attempts to cure or eliminate embodied difference and intervenes in these histories by establishing new epistemic practices that question the objectivity and neutrality of scientific research. This section argues that such an intervention is a *new materialist* practice that addresses the ethical relationship between epistemology and ontology. It shows that approaching scientific research with historical and epistemological perspective and drawing upon work in feminist science studies can make perceptible the ethical interventions enabled by UD research.

Feminist new materialism brings together work on feminist epistemology, science and technology studies, and even political theory to understand the active role that dynamic materialities—such as the built environment in its iterative stages of becoming—play in how society understands and acts upon phenomena like gender, disability, and race. ⁹ Many new materialists are critical of the focus of post-structuralist theories of knowledge on epistemology and language, seeking instead to bring considerations of ontology and matter back into debates about the social construction of material phenomena. Feminist physicist, Karen Barad, argues that the neglect of ontology has been due to a focus on language over matter (Barad 2007, 41). Her concept of ethico-onto-epistemology demonstrates that knowledge is not something constructed through language about a pre-existing reality, but fundamentally a part of the actual sedimentation of the material world (Barad 2007, 185).

Theories of social and material construction must understand the performativity of both objects of knowledge and ways of knowing them. Research is not a practice of objective, disinterested viewing from a distance, but rather an intervention and "direct material engagement with the world" (Barad 2007, 49). This means that even when a phenomenon—like disability—is a "social construct," it becomes so through the ways that knowledge circulates to create it. Likewise, practices of measurement, such as anthropometry, are material interventions. Drawing upon Niels Bohr's quantum physics, Barad demonstrates that "concepts are defined by the circumstances required for their measurement. That is, theoretical concepts are not ideational in character; they are specific physical arrangements" (Barad 2007, 109). Recalling Donna Haraway, Barad argues that the design and apparatuses of research are "specific material-discursive practices" that occur in particular historical and spatial contexts (Barad 2007, 146).

Barad's feminist new materialism can work in tandem with existing disability theories to produce new tools for approaching the ethico-onto-epistemological

implications of UD research. While Barad is critical of epistemological critiques of science that rely upon the construction of phenomena through language, she offers an ethico-onto-epistemological model of disability. Barad argues that the mis-fit of the body with the environment is an apparatus of the measure of ableism in society, making disability both a way of knowing and being (Barad 2007, 158). This conceptualization echoes Titchkosky's reminder that accessibility "is an interpretive relation between bodies" (Titchkosky 2011, 3). Understanding bodies as evidence of ableism, inaccessibility, and mis-fit, explains the underlying new materialist philosophy of UD research, which draws upon existing methods of quantifying and measuring bodies to make an intervention into the epistemic practices that materialize the built environment. It also explains how the shifts in what is meant by anthropometry, from the mid-19th century through the present, are as much epistemological as they are ontological, occurring along lines drawn by historically contingent understandings of scientific evidence and validity.

The social and medical models of disability, though challenged and qualified, and rarely existent in extreme form, [10](#) are ontological and epistemological models of material-discursive practices. [11](#) As ontological models, they define what disability is—a condition materialized by society and the environment, or a diagnosable category characterized by lack or excess. As epistemological models, they define how disability is best known — through accounts of personal experience, audits of the built environment, literature and art, or through scientific and medical knowledge. The social model has often adopted what feminist science studies scholar, Elizabeth Wilson, refers to as an "oppositional relationship" to scientific knowledge, no doubt because of the way such knowledge has historically been deployed to cure, eliminate, or rehabilitate disability (Wilson 2004, 200; Bordo 1993; Gilman 1985, 1996; Hubbard 1990; Parens 2006; Rothman & Rothman 2003; Stiker 2000; Wendell 1996). This opposition echoes feminist critiques of medicalization, scientific abuses of women's bodies in biomedical testing, and limited healthcare and reproductive rights.

Understanding UD research as a material and epistemic intervention requires a consideration of epistemology—albeit, not derived from linguistic constructivism—in new materialism. As the social and medical models of disability, as well as their permutations and critiques have demonstrated, such an epistemology is necessarily ethical and ontological. It appears impossible to even discuss the concept of disability without understanding its historical material-discursive construction through mis-fitting environments and practices of knowledge production that shape design professions and the law. [12](#) Nevertheless, discussions of epistemology within Disability Studies (such as sit-point theories and standpoint epistemologies) are often limited to either granting validity to sources of evidence outside of empirical research, or rejecting the validity of scientific knowledge production. [13](#) These epistemologies provide tools for arguing for the comparative value of personal experience as knowledge in the face of medical or diagnostic regimes.

Perspective-based epistemologies are not, however, designed to address

epistemological issues of validity, objectivity, research design, sampling, or historical epistemology that are raised by scientific research practices in human factors engineering, anthropometry, environmental psychology, and other applied fields. That is, these epistemologies provide a parallel source of epistemic validity to individual and marginalized knowledge, but they are not methods of exposing the ideologies or constructions within scientific research itself. They answer the question of what counts as knowledge, but are not meant to tell us how to evaluate the epistemological work of evidence or the material-discursive conditions of its validity or intelligibility. In order to critique scientific practices — whether in favor of their empiricism or not — a separate set of tools is necessary.

The primary type of epistemological analysis discussed here from a new materialist perspective asks how particular studies can intervene in the broader history of a scientific practice to change the production of meaning and environments. The research practices of disability anthropometry intervene in systems of knowledge, such as statistics, that have dominated medicine, eugenics, and positivist conceptions of objectivity more generally. They do this, not only by asking different questions, but also by adopting different material practices of research and apparatus design, sample selection, and data analysis. This, in turn, produces a disjuncture in the regime of intelligibility, rendering multiple sources of evidence—including the lived experience of mis-fit in the built environment—legible to researchers and designers.

By showing the historical situatedness of the intelligibility governing evidence available to designers, UD research also critiques the disinterested view from nowhere that (feminist critics have argued) characterize some scientific epistemologies (Haraway 1988; Harding 1986). In the particular case of anthropometry, which bears historical responsibility for the emergence of positive medicine and social science, as well as contemporary statistical understandings of normal bodies, UD intervenes in the history of the very concepts of the social and the scientific. Understanding UD research as this type of intervention is a project of historical epistemology informed by new materialism.

Conclusion: a new materialist diffractive methodology

An additional tool offered by new materialism that future UD research and disability theories can continue to develop in tandem is *diffractive*, an alternative to *reflexivity*. Barad develops this concept, initially introduced by Haraway, to show that the notion of reflexivity assumes the fixity of perspectives and objects of study without understanding the way in which these categories are mutually dependent (Barad 2007, 30). Diffraction, instead, "involves reading insights through one in another in ways that help illuminate differences as they emerge: how differences get made, what gets excluded, and how those exclusions matter" (Barad 2007, 30). She uses the concept of diffraction to show the entanglement of the natural and the social.

This paper has demonstrated the entanglement of the social and the medical and scientific in the context of UD. As UD research continues, and disability theory

develops epistemological tools for evaluating such research, it will be important not to limit analysis to a reflexive view that criticizes the inadequacies of past studies and situates new ones within the accumulation of valid knowledge about disability. This kind of reflexivity can be uncritical about the conditions of possibility for research that do not appear intelligible as progress. A diffractive understanding of Universal Design can instead entertain the iterative futures made possible by the ongoing production of knowledge for accessible design. It can do so by valuing studies and epistemologies that ask how existing concepts of the natural and the social, as well as the expert, the research participant, the body, the environment, and the universal, rely upon particular regimes of knowledge that render such concepts intelligible and govern belonging within them.

Research for this paper was made possible through generous support from the Social Science Research Council's Dissertation Prospectus Development Fellowship and through the Emory Laney Graduate School. Special thanks to Rosemarie Garland-Thomson, Sander Gilman, and Deboleena Roy for their guidance with the project, and to Rachel Dudley and Jennifer Sarrett for their comments and suggestions.

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Endnotes

1. See Karin Knorr-Cetina's (1999) notion of "epistemic cultures."

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2. See Steinfeld and Maisel (2012) on the proliferation of examples of Universal Design that do not use this label (xiv-xv, 23).

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3. See Steinfeld & Maisel (2012) on debates over the usage of the terms "universal," "all people," and "design for all" in the United States and Europe (28-29) and on the formulation of new evidence-based principles for UD (90). Also see Sanford (2012, 85-89) on proposed alternatives to the Principles,

Sandhu (2011) on the need for Universal Design to evolve to address emerging design problems, and Story (2011) on the history of the Principles as an intended "starting point" for UD (4.11).

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4. For the latest developments in evidence-based design in UD, see *The State of the Science in Universal Design Research: Emerging Research and Developments*, ed. Jordana Maisel. Bentham Publishers, 2010.

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5. Interventions in design education have constituted much of the labor of Universal Design. These interventions have ranged from design studios focused on UD to federally funded research, such as the Universal Design Education Project, funded by the National Endowment for the Arts (Steinfeld & Maisel 2012, 75).

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6. The authors were: Bettye Rose Connell (professor of medicine and health researcher), Mike Jones (rehabilitation engineer and researcher), Ron Mace (architect and accessibility standards developer), Jim Mueller (industrial designer and rehabilitation research scientist), Abir Mullick (industrial designer and researcher), Elaine Ostroff (architect and educator), Jon Sanford (architect, industrial designer, research architect, and assessment expert), Ed Steinfeld (architect and gerontologist), Molly Story (industrial designer), and Gregg Vanderheiden (systems and biomedical engineer).

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7. The concept of "knowledge translation" continues to be significant for UD evidence-based design. Steinfeld and Maisel (2012) argue that the successful implementation of the UD Principles requires connecting them to "a body of knowledge and consensus on best practices" that is intelligible to designers (89).

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8. Adopting the range rather than the average is in part a reaction to the aesthetics and politics of streamlining in industrial design and architecture. In her history of streamlined design and eugenics, Christina Cogdell demonstrates that optimized design in the 1930's with a "physical and ideological extensio[n] of streamlined bodies" (Cogdell 2004, 192). UD research disrupts the very notion of an ideal type by emphasizing flexibility and diversity.

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9. Here I mostly draw upon the work of Karen Barad. For other contributions to

the recent development of new materialism, see Coole and Frost (2010).

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10. See Shakespeare (2006) for an account of the way that these models operate as strawperson arguments in disability theory.

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11. There are, of course, other positions on the medical and social models in Disability Studies. See, for example, Corker & Shakespeare (2002) for the application of post-structuralist theories to disability, particularly around disability ontology.

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12. See, for example, Siebers (2001) discussion of bringing the material reality of the body back to disability theory

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13. Sitpoint theory is an epistemology that takes up feminist and Marxist standpoint epistemologies to argue for the privileged status of knowing from the perspective of disability. See Mairs (1996) and Garland-Thomson (2005).

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