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DELIMITING INCLUSIVE DESIGN

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1. Introduction

This paper addresses the question raised by my PhD dissertation, *Accessibility through user-centred and Inclusive Design processes*. That question is: can Inclusive Design (ID) be delimited by examining design for accessibility in the areas of assistive technology and public transport with reference to consumer product design? The literature on ID deals almost entirely with consumer product design and assistive technology (AT). There are a few papers (e.g. [Kaneko et al. 2009], [Langdon et al. 2009]) which hint at the role ID could play in the realm of public transport (PT), where accessibility is mandated by law. This paper takes product design, AT and PT as the key test areas of industrial design in its broadest sense, and it synthesises work done in three previous papers. The first paper [Herriott 2103] considered cases of ID and AT as reported in two major Inclusive Design conference series. The second paper consisted of an analysis of nine cases of design for PT [Herriott and Cook 2014a]. The third paper consisted of an analysis of nine cases of design for AT [Herriott and Cook 2014b]. Synthesising the three papers, I make the case that the extent to which users can participate directly in the design process determines how applicable Inclusive Design can be and in so doing separates the process (means) from its ends.

2. Background

In The Autopoiesis of Architecture, Schumacher [2012] discusses the balance between practice and theory in design. He posits that: “At a certain stage within a maturing avant-garde style, prevalent processes have to evolve into self-critical methods. This requires the rational reconstruction of the prevalent processes rather than the re-invention of new processes, or the imposition of abstract ideals of rationality” [Schumacher 2012, p. 257] ID has grown and matured with the development of a wide range of tools and a diverse literature, making a maturing ‘avant-garde’ style. The ID literature, which distinguishes the ID approach from ‘mainstream design’ is, for the most part, has a vantage point within the field. Only a few exceptions look analytically at what ID actually is (e.g. [D´Souza 2004]) from outside the field . With Inclusive Design well into its second decade, perhaps it is appropriate now, in Schumacher´s terms, to sketch out some self-critical methods.

ID originated in the realm of consumer product design. It is a variant of the rational, soft-systems design processes described by Broadbent [2003] and is defined as a “comprehensive, integrated design approach which encompasses all aspects of a product used by consumers of diverse age and capability in a wide range of contexts” [BS 7000:6 2005, section 0.2]. The goal of accessibility makes ID attractive to professionals in the fields of both AT and product design.

Accessibility is also a key concern for PT. The European Union is signatory to the UN Convention on the Rights of Persons with Disabilities, a convention that imposes legally binding obligations for accessibility. PT is defined as comprising “all transport systems in which the passengers do not travel in their own vehicles” [International Union of Public Transport 2013]. Informally, the concept of the

"public" includes people of a very wide variety of capabilities. Consequently, PT joins AT and product design as the third discipline in my consideration of design for accessibility.
Unlike product design and AT, PT does not have well-documented processes for attaining inclusivity. What Inclusive Design processes currently used in product design and AT might also be applicable to PT? Is the process of Inclusive Design as generally applicable as it first appears? Given that accessibility is a fundamental requirement of PT, what do designers of PT do to achieve this goal? Where do their processes differ from ID and AT?
In the following sections are presented the standard and ID processes; there is an examination of the three areas that demand accessible, inclusive design using examples from previous work; then there is an analysis to see whether and how ID differs from area to area. Finally, ID is delimited on the basis of the extent to which the user is or can be directly involved in the design process.

3. Design Process

Before discussing an 'Inclusive Design' process, one must have a reference to the 'normal design process' that is the most obvious alternative. Dong et al. [2003, p. 54] synthesised four commercial design firms´ processes into a general model for "normal" design. These processes "reflected that the client-designer relationship is emphasised, but the users are ignored" [Dong et al. 2003, p. 54]. The "normal" design process was as follows [Dong et al. 2003, p. 54]. Users are involved at a preliminary stage when market research is carried out for or by the clients. Thus "...consultant designers are most likely to depend on their clients for carrying out user research" [Dong et al. 2003, p. 50]. These are not different in any important respects from the engineering and architectural processes described by Jones [1970, p. 24] in which feasibility research, preliminary design, detailed design and planning are the main steps. The main character of these processes is derived from the fact that the end product is known from the outset.

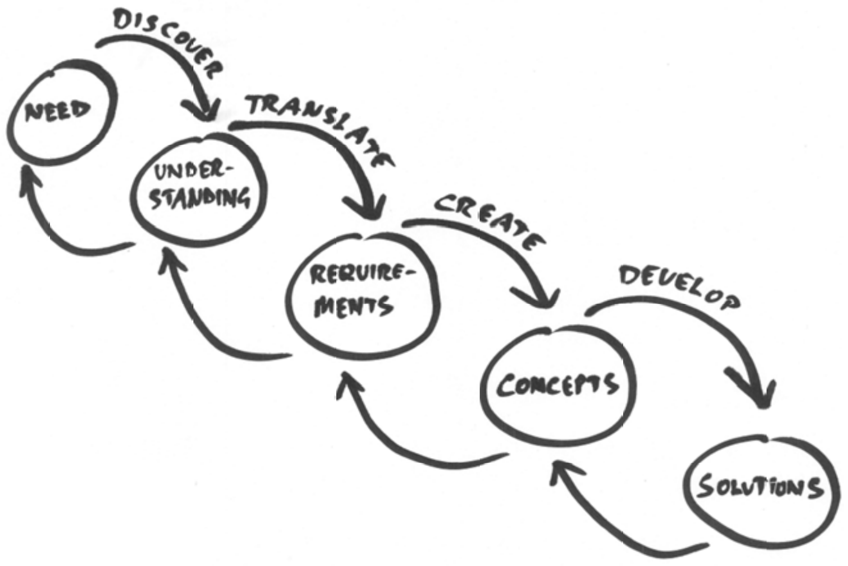

Figure 1. EDC Inclusive Design Process (after [EDC 2007])

The EDC process (see Figure 1) is front-loaded with most user-information gathering expected at the very start of the five-step process. Much of what differentiates it from a standard hard-systems model is user-centred research using a wide variety of tools. Additionally, users are kept involved all the way through the process by means of cross-checking and further use of the aforesaid tools (focus groups, questionnaires, etc.) to ensure that the end requirements genuinely meet the demands of the users.
It is necessary to point out that the EDC model was revised in 2013, after the research in this paper was carried out. The projects discussed were conducted prior to the revision therefore it is still relevant

to examine these in relation to the earlier, contemporary model. The implications of the re-design on the findings and recommendations of the research are discussed below in section 5.

4. Consumer Product Design, Public Transport and Assistive Technology

Although universal design (of which ID is a branch) has been deployed in product design, architecture, urban design, and systems of media and information technology [D´Souza 2004] I have restricted my field of investigation. A larger array of fields was beyond the scope of my research.

The three fields under consideration for this paper are consumer product design, rail carriage interiors and assistive technology. I have assumed that consumer product design is targeted at a customer who is the purchaser or is a paying user of a moveable object which is not a mode of transport. This includes, for example, kitchen appliances, communication devices and vending machines but excludes private motor vehicles and PT. Though strictly a branch of consumer product design, automotive design is a large and complex discipline warranting its own class. I have also excluded buildings and furniture although an item of furniture is moveable and not intended for transport. Assistive technology is already associated with Inclusive Design: ideas flow back and forth between the fields. Public transport has a requirement for accessibility but has not been studied extensively with respect to Inclusive Design. I have focused on rail rather than road, air or water transport as the problems of rail are most widely applicable to other areas of PT. This rationale then leaves consumer product design, PT and AT as the three classes under consideration. This is done in the awareness that classification is always imperfect. Categories should ideally be precisely defined, exclusive and should exhaust the set of possibilities. This way, any entity in the given classification system should belong unequivocally to one, and only one, of the proposed categories. However, even with the most exacting definitions, this is seldom entirely the case, and such a stringent requirement is beyond the scope of this paper.

Underlying this work is the assumption that Inclusive Design is potentially a process that can be widely applied and is presented as such (e.g. [Newell 2003]). The literature on ID design processes for consumer product design is extensive and will not be recapped here. Overlapping with ID for consumer products is AT [Newell 2003]. A standard definition of AT is “any item, piece of equipment or product system whether acquired commercially off the shelf, modified, or customized that is used to increase, maintain or improve functional capabilities of individuals with disabilities” [US Public Law 1988]. This is an empirical rather than logical overlap, based on the co-appearance of AT design research with product design research in the ID literature e.g. the Include conference series hosted by the RCA, London, Clarkson et al. [2003] and Coleman et al. [2007]. It is also because some researchers and designers outside AT have looked to AT for inspiration [Newell 2003]. By extension, through its requirement for accessibility, design for PT can be considered as a possible area to apply ID. In fact, in some respects AT and PT have more in common with each other than either has with consumer product design, as I will now show.

There are commonalities between PT and AT. First, consider the matter of choice. Users are often not the choosers of AT [Ravneberg 2009], while rail service providers rather than passengers select the carriages operated on the network. The volume of production of AT tends towards the small scale [Lewis and Yoky 2010], while the number of carriages produced is in the hundreds or low thousands. For example, 150 units of the Alstom C751A have been made; 1100 Citadis train sets are in service. 270 units were produced in 2012 [Railway Bulletin 2013].

Among the differences between AT and PT are the costs and complexity. A low volume AT product must achieve acceptable performance at a modest cost e.g. an arm support might cost £95 [Harner et al. 2001]. A locomotive set costs orders of magnitude more: 270 Hitachi intercity trains cost £1.2 billion [Hitachi 2013] and must conform to a high standard of production quality, safety and comfort. In terms of complexity, a crutch might have nine parts and an arm support 50 parts. The number of components in a carriage runs to the thousands. The scales of the organisations involved also differ. A small design consultancy of fewer than ten employees might oversee the entire design process of an AT product. Within the context of rail carriage design, development requires a much larger and more complex organisational structure where the appearance of the product, as well as its functionality are negotiated among many stakeholders. Consumer product design, for which ID was first envisaged, exists between the extremes described for AT and PT design. The common elements among the three areas are that accessibility and a means to achieve this end are required.

	PRODUCT DESIGN	ASSISTIVE TECHNOLOGY	PUBLIC TRANSPORT
SIZE OF FIRM	small to large	small-medium	large
VOLUMES	100,000s	1000s	1000s
CHOICE	yes	no	no
SCALE	cm	cm	m
NO. OF COMPONENTS	10-100s	10-100s	1000s
COST	€10-100s	€10-100s	€millions
ACCESSIBILITY REQUIREMENT	moderate	high	high
USER INVOLVEMENT	direct	indirect and direct	indirect* and direct
LEAD TIME	6-18 months	6-18 months	2-4 years
IS USER THE CHOOSER?	yes	yes/no	no

Figure 2. Comparison of Product design, PT and AT

4.1 Mainstream Inclusive Design

This section describes the norm of mainstream ID against which the other two categories, AT and PT are to be compared, with the process deployed in the context for which it is envisaged. Even if the design steps described below deviate from the EDC model, they stand as representative of "routine" Inclusive Design.

Herriott [2013] compared ID and AT design processes, primarily investigating non-commercial design cases conducted by academics and researchers. The findings were that most of the reported design activity in ID was in the first stages of the design process. 86 % of the cases related to the discovery of needs, with a wide variety of design methods reported. 35 % of cases provided information on their "translate" step but this mostly involved reporting the step´s execution and little more. Just under 15 % of the cases focused on idea creation. Prototyping was used early in the design process as a means to assist the discovery of needs. The remainder of the instances where prototyping was cited were towards the end of the ID process, under "concepts" and "develop", which is where prototyping is expected to occur under the EDC model. Ergonomics did not feature strongly in the cases, being cited four times unambiguously, at the "needs/discover" step of the ID process. The overall conclusion of the study was that the steps of the EDC model were deployed but not usually in the order in which they are listed by the ECD model. Finally, users are involved most obviously in the initial stages of data gathering but their presence drops off later on and they are undetectable in the final stage, except in one instance, a design for software [Dewsbury et al. 2006]. This was also described as a co-design project and as such the presence of the users is a defining requirement of co-design. Moreover, software design explicitly requires the involvement of users in the stage of defining requirements [Rudd et al. 1996], [Maguire and Bevan 2002]. The designs were not outsourced to outside agencies as in some cases of the AT and PT described below.

4.2 Design for PT

Herriott and Cook [2014a] conducted semi-structured expert interviews (with reference to [Christmann 2009]) at nine firms involved in rail transport: five design consultancies, two manufacturers and two operators. The design processes were reconstructed from the interview contents. Other forms of PT such as road-going multi-passenger vehicles and aerospace were not considered in order to reduce variability in the sample group. It was shown that the design processes of the nine firms differed from the model proposed by the EDC. The design consultancies used a more complex process structure and tended to involve users at more stages than the manufacturers and operators. The two manufacturing firms adhered to an orthodox engineering design process. Such user-centred techniques as were deployed by the consultancies were at the beginning of development. Less frequently, some user-involvement took place later for validation purposes. It was the firms that owned and operated rail systems that showed the highest level of user involvement. These firms used design consultancies to execute their plans rather than to originate ideas or to oversee the entire process. They could be considered as “zombie” design houses rather than as autonomous ones that deliver a complete, original concept to the client.

Intriguingly, the firm with the highest-level of user inclusion in their design process, the Scandinavian light rail operator, did not have a process that was recognisable as ID. A formalised and highly documented system was used to track the design process. User inputs featured open forum public consultation, focus groups, consultation with user groups in advance of the design process plus ongoing consultation about the products of the design process. Unsatisfactory solutions were revised. In this way the users and the operator interact on an ongoing basis, modifying the system. The operators were further distinguished from the producers by the presence of a “user champion” in the form of the chief project designer, whose role was, in the words of one of them, to “ensure that we have the best conditions for the passenger, including accessibility for all groups in the vehicle”. This compensated for the indirect involvement of the users during some phases of the design process, such as requirements definition.

There are a number of grounds for PT firms’ reluctance to use ID processes and tools. One reason is that there is a weaker link between the user and the producer, reducing the incentive to appeal to their needs. Another is pointed out by Lillis [2002]: large companies have many sub-sections. Communication between them is formalised, as is the process itself. ID assumes iterative design and reaction to contingency. Large companies tend to be less flexible. User studies are usually conducted for validation rather than to inspire design. Additionally, there exist tightly defined standards for what is a mature product. The rail producers referred to these standards as providing insurance that accessibility was attained. A UK- based manufacturer interviewed said: “I think generally on our projects the legislation and standards are the key thing that we use....but clearly we´re very active as an organisation in writing those standards in the first place so we work with various bodies when we are developing those standards (...) rather than always working project by project”. A German manufacturer responded as follows: “In some countries there are existing standards or laws regarding the disabled. We have to consider that, and sometimes special requirements from our customers. If we have no requirements, we use our standards from old projects”. The design consultancies referred to standards as a minimum requirement, an important difference in approach. One industrial design consultancy noted the problem with standards was not only that they could be rigid but they were often in internal conflict. A French design firm noted: “...for example for the dimensions of the handles on seats, sometimes they give you a specific height you should not exceed and then they give another dimension for the back rest of the seat and the back rest must not be below this dimension...and so on and when you cross the two regulations for the handle and the backrest you just realise that it is impossible because the rules have been set separately and when you put them together it just does not fit so you have to talk about that with some specialised people belonging to the regulations committee in Europe and you can wait for the answer for quite a long time (...) something that is a bit disturbing... ” Law et al. [2007, p. 10] describe another difficulty with standards which is that they are not themselves useability tested so they can be hard to interpret, even for experts.

From these results one could conclude that for such products as rail carriages the model of ID is incomplete, since it assumes a means to co-ordinate the process within a large corporation.

Alternatively, the role of user-insight gatherer must be taken over by the customer (operator) if such activities do not fit within the standard practice of the manufacturer. In which case, the operator becomes a proxy for the user´s presence in the design process. This can be problematic for the stage of validation, since users are likely to be in a country other than that of the manufacturer. Inclusive Design processes assume the physical presence of the user, and indeed are centred on their presence. Solutions or workarounds to this involve a revised set of tools for validation, which in concrete terms imply means to communicate the design output to distant users. Logistical and cost hurdles mean that access to a prototype built in one country but used in another are difficult to overcome without a will to do so on the part of the customer. However, it might be argued that the cost of shipping prototypes would be very modest in the context of the typically very large budgets associated with rail projects.

4.3 Design for AT

Herriott and Cook [2014b] reported the activities of designers of AT products. Semi-structured expert interviews were used as the research tool, with reference to Christmann [2009]. From the interviews the design process was reconstructed. The work examined where design energy was expended and how the processes deviated from ID practice. Three projects presented particular difficulties in working with users: a respirator, sanitary ware and personal care products. The users of the respirator product could not participate extensively in the design process and the planned ID-inspired design process was abandoned, and the designers had to improvise workarounds. The design path turned out to be convoluted and far from the one intended: "(the process) turns out to be like spaghetti and meatballs sauce thing because it was very difficult to divide the few things, the techniques from the aesthetics, from the problems the users (have)". The designers had to rely on restricted consultation with a super-user for validation and needed to do self-testing where possible and appropriate. Most parts of the device could be trialled on healthy subjects, leaving only the most critical parts for the super-user to validate. For the personal care products an ethnographer was used to communicate between the users and the designers. This protected the subjects from excessive intrusion and also worked around the often poor communication skills of many of the intended users. The sanitary ware producer had to rely on field observations and in-situ testing. Since the users were dementia sufferers, many of the tools of user-centred design were inappropriate. Carers and physiotherapists had to be the proxies. A tailored AT equipment project lacked a planned design process. It was a case closely approximating to the concept of DesignFor (Every)one, [De Couvreur 2009]. In that project, surrogates (ergotherapists) had an important role. Each of the projects carried out steps found in the EDC process but the sequencing was different with some steps omitted and some blended. The processes were also somewhat non-linear and improvisatory but still produced workable, usable and accessible products.

Three products were re-designs prepared by consultancies: a wheeled walking frame, a reacher and a wheel-chair. Here the overlap with ID was closest in terms of the scale of the project and the relationship between the designer and the client. The project to design a wheeled walking frame was unusual in that the designer ended up being responsible for commissioning production. In this sense, the designer had "captured" production. They were able to ensure fidelity to the design specification right through to the stage of design for production. This was one of the rare examples where the designer was in charge to such a high degree. The translation into requirements was not user-centred. The subject was asked whether users came into this translation process. The answer was: "I think it´s very important how you use the users… When we talk about the users we are talking about the end – user, the elderly person (...) because sometimes they don´t know what is better for them". Other stakeholders were consulted instead. In contrast with the wheeled walking frame project, the wheelchair and the reacher projects were characterised by tension between the designer, the client and other stakeholders. In the case of the children's wheelchair, the physiotherapists wanted it to accommodate a broad range of ages and disabilities. The reacher product faced restrictions in the number of parts permitted and while the client felt adjustability mattered, users were indifferent to this capability. One length was sufficient.

The two stair-lift projects differed in their approaches. One conformed to an academic, ergonomic process. It was run by researchers from a university design department. The other was driven by industry norms and processes and was run by a commercial firm. Their process was described by the interview subject as having a product strategy followed by an ideas review process to suggest new proposals. These proposals go into the concept development which is a two stage process of ideas research and ideas generation. Selected ideas are then tested for viability. In the case of the manufacturer, there were multiple phases of user-testing which ensured the users were represented. However, the initial idea was not user-inspired. The academic project is notable for the use of prototypes all the way through the project, from the investigation phase onward.

The conclusion of Herriott and Cook [2014b] was that considerable energy is expended on prototyping, more so than was indicated in the 2013 meta-study [Herriott 2013]. The other observed difference was that the AT designers deployed concept creation and development at various points in the design process. Here the EDC definition of development is used, namely, the activities that are ideally supposed to take place between "create" and "solutions" [EDC 2013]. A detailed look at the activities shows that there is considerable blending of the three final stages, but the particular activity of making incremental improvements and changes (development) is not confined to the last part of the design process.

5. Conclusion and Discussion

What emerges from the work described in this paper is that the user is the limiting factor in Inclusive Design. The following discussion (1) compares the differences in user availability in the three areas of design considered in the paper; (2) alternatives for direct user-involvement such as proxies; (3) the question of requirements definition and (4) a general comment on the utility of process diagrams for soft-system design problems.

Turning to (1), Inclusive Design begins with an exploratory phase concerned with finding out what the user needs [Coleman et al. 2007, p. 5]. In consumer product design this may be a very open question. In AT the initial research is less likely to be open, given that the product typically relates to a compelling need to compensate for reduced capability of a very specific nature. The product may be a redesign of an existing device. In some cases, new technology is applied to an old problem, in which case there may be no history of best approaches. In AT design the user may have no voice due to physical or cognitive disabilities or due to matters of privacy. For PT, the product is a very mature one with a narrower range of possibilities and the user is absent in a different way. Structurally, it is hard to connect potential users in all their diversity to the actual users of the end product. The lead-times are also long. Retaining the same set of users over a long development period is not feasible. The products are mature and heavily regulated. The physical distance between the site of design and the users, the scale of the product and the weak consumer feedback all militate against using full Inclusive Design processes. The risks to large firms of inappropriate design decisions, non-iterative design processes and lack of innovative solutions correspond to the challenges pointed out by Gill [2009] when discussing the challenges facing user-oriented design. Gill also notes that small firms (e.g. the design consultancies) also face risks: small firms can be too small to drive the design agenda.

Turning to (2), this paper makes the case that there is a limitation to Inclusive Design, if Inclusive Design is defined by the extent to which the user can be directly involved. In the field of mainstream product design, the scale of the companies, the lead-times and the rapid feedback of market signals mean user-centred, Inclusive Design processes and methods face the fewest obstacles. In the field of assistive technology the user may be unable or unwilling to communicate their needs, in which case the information-gathering tools available to designers are fewer, and the means to cross-check and verify the decisions throughout the design process are more limited. Proxies must be used. The process is still "user-centred" in that the goal is to take their needs into account but it could be termed a parallel inclusive design approach, where other stakeholders are shadowing the users through observation. The insights gained through experience can stand in for what the user can ´t express. For public transport, accessible design depends on consistent management procedures to unify the dispersed design chain found in that field. In that context design is reduced to one to be treated as a hard-systems issue.

Regarding (3), the data on PT draws attention to the matter of requirements definition. Inclusive Design recommends the participation of users in the drawing up of requirements. But for PT,

requirements specification is a means to convey information to engineers and designers. The lay user is not the intended reader of the document. As a result the user and the product are not likely to properly matched. Product requirements can be presented as a text, as CAD data or as a realistic prototype [Kangas and Kinnunen 2005]. If it is a text, the terms of the language can be difficult for users to comprehend. There is a gap between the explicit terms of the requirements document and the implicit terms such that the user can´t grasp what is meant by the terms of the document. If it is a prototype or CAD model, the certain assumptions may be built-in too soon in the design process. Presenting this requirements information to users in such a way as to be graspable by the layman is difficult. The issue is essentially one of accessible coding: using terms that mean the same to users, designers, engineer and other stakeholders. Further work needs to be done on the commonalities and differences of the language of users, designers, engineers and other stakeholders. This is still needed despite the fact that working prototypes tested at the right stage can overcome language barriers. Correct requirements definition ensures the prototype is testing the right aspects of the design.
And dealing with (4): a by-product of this paper is the finding that many design models are of limited use in dealing with the unforeseeable and idiosyncratic problems of design. The EDC model of 2007 was in particular, too prescriptive. The conditions it assumed do not tend to occur in public transport design. This is not to say that accessible design is not possible. The Copenhagen Metro is a case in point. And recently, Norwegian rail brought an inclusively design train set into service, designed by Stadler (who declined to participate in the interviews for this research). Further investigation of this project is required to see if it is the exception that proves the rule or if it weakens the essential thrust of this paper. The revised EDC model of 2013 is looser and less prescriptive than the original model, but based on the research conducted here, its emphasis would appear to still focus on defined steps carried out in a defined order rather than tools used in the course of problem identification and solving.
It may seem to be self-evident to some that design process diagrams and recommendations are merely approximations. But a very great many are offered (in good faith) without making the necessary caveats very, very clear indeed. I might go so far as to say that the caveats are not attached because in the light of the findings here and of a general reading of design literature, the caveats are so numerous they serve to annul the meaning of the recommendation: “This is what we recommend but it´s probably not what you will do or can do or what is possible”. But this reduction in emphasis on recommended processes makes more apparent the value of sub-processes and serves as a useful warning that the complex and very contingent nature of design throws up problems that can´t be planned for.
To conclude, in Section 2 I asked whether the process of Inclusive Design is as generally applicable as it first appears. The tentative answer is that it is not as generally applicable. This doesn´t mean accessibility it not achievable but that user-centred design is dependent on the practical involvement of users in the process. As it is structured, PT design can result in accessible products but without using orthodox ID methods. Ideally, the operator, designer and manufacturer are all committed to ID if the user can be accommodated and included meaningfully from beginning to end of the design chain. This condition is not what is observed. As it stands, the Inclusive Design process is designed for situations where design and manufacture are under one roof and not spread across numerous firms, as tends to be the case in PT design. The research also shows that Inclusive Design is not wholly transferrable to AT in that the user is sometimes voiceless. The emphasis then falls on the tools that extract user-information from surrogates and proxies rather than the users themselves. The designs are accessible but the design process is only partially conforming to the ideal of Inclusive Design. From this we can conclude that even as flexible a process as user-centred Inclusive Design is dependent on the user being a presence in the design process.

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