Design Guideline Gap and 2 Feedback Loop Limitation:

Two issues in Design and Emotion theory, research and practice.

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Abstract

This paper identifies and describes two issues, Design Guideline Gap and 2 Feedback Loop Limitation that expose problems in the Design and Emotion field and more widely challenge the validity of design theory, research findings and design practices. The paper describes the issues by way of examples, draws out the implications for design research, theory and practice and identifies preliminary approaches to addressing the problems exposed.

Keywords

Design epistemology, systems design, biological limitations to emotion

Introduction

Interest at the conjunction of Design and Emotion can be considered to have commenced strongly prior to the current 50 year old interest in more general design research; see, for example, the work of Dewey, James, Tonnies, Whiting, Coase, Fielden, O'Doherty, Gregory, Sprott, Eastman, Westcott, Maslow, Forrester and Rapoport [1-15]. . It can also be seen in the origins of Socio-Technical Systems design (STS) in the Tavistock Clinic (from 1914)[16], the studies of computer supported cooperative work (CSCW), community development and youth work program design from the 70s and 80s. Alongside, interest in the conjunction of emotional responses and design has also occurred in a variety of traditional areas of study in fields such as Advertising, film making, literature, history and theology, This interest in Design and Emotion research and design activity has more lately become focused around organisations such as the Design and Emotion Society[17] and Cognition and Affect programs such as that developed by Aaron Sloman[18].

This paper identifies and describes two issues at present unaddressed in Design and Emotion fields that potentially challenge validity of broad swathes of design theory, research findings and design

practices in the Design and Emotion arena. These two theory issues emerged from the author's research relating to Design and Emotion over the last two decades. He has coined the two issues as :

- The 'Design Guideline Gap'
- The '2 Feedback Loop Limitation'

The first, The 'Design Guideline Gap' emerged from straightforward epistemological analysis of design theory based on prior research by the author into validity and coherency of concepts and theory relationships in the design literature[19, 20].The second emerged from research undertaken by the author in a long-term research program investigating the arbitrage of systems design and research methods into design research field, especially in areas involving emotionally-based cognition[see, for example, 21, 22-30].

Evidence for the first issue is found in parallel arguments by a variety of design related theorists including Popper and Alexander (not detailed here for brevity). Evidence for the second issue are supported widely in the systems design realm by researchers including Forrester[31, 32], Sterman[33] and Meadows[34].

In both cases, the analyses and findings result from observation supported by information relating to theory limitations already well known in fields addressing similar issues to Design and Emotion and drawing out their implications for Design and Emotion. This is critical theory analysis more appropriate to an earlier stage of development of Design and Emotion theory. The lack of attention to these issues earlier has resulted in theory in Design and Emotion that in some cases is underjustified and potentially false[35, 36].

The structure of the paper is as follows. After this introduction, each of the two issues will be described in the following two sections. Each includes two short examples that illustrate the problematique. In section four of the paper, the implications of the two issues for Design and Emotion field will be described. The concluding section of the paper will outline initial pathways to address potential weaknesses in theory and practice.

Design Guideline Gap

Since its origins in the 1960s, the primary role of design research has been to develop theory that in the limit will automate design. This approach has been highly successful and had lead to the automation of a very large number of design activities including many creative activities that were previously regarded as purely intuitive and the sole province of human designers.

The outcomes of this 40 years of design research work can be seen in the computer software that designers use in Art and Design, engineering design, information systems design, systems design , business process design, design optimisation, chip design, software architectural design etc.(see, for

example - list of software (refs)). A macro view indicates that the benefit has been improvements in efficiency of designers of an order or more and a significant improvement in quality of designed outputs whilst, by observation, a significant reduction in design failures, especially in fields such as industrial/product design and graphic design.

Taking a helicopter view, design research outcomes have resulted from empirical research that has made explicit tacit design knowledge of designers whilst at the same time deeply analysing design problem contexts and solutions to produce design principles and specific practical design guidelines that enable computer software to develop specific design solutions. The specificity of these design guidelines is of the form 'Use this font, with this leading and place the text in this way in this design situation' or 'display these images, with this kind of pan and zoom at these timings' or 'the maximum piston speed for these piston and bore material is 300fpm' or 'the optimal layout for these chips is the following'.

A crucial aspect of this process is having a process that makes a deterministic link between the generic information about design situations, tacit knowledge, design problems etc and the design guidelines. This process must take the general information and convert it into specific design instructions such as add a red band across the web page in this place.'

Whilst this activity and the development of these processes has proceeded apace in the field of software development for designers, it is substantially absent from manual human-based design activity. This is especially so in the Design and Emotion fields.

In Design and Emotion, there has been a strong development of research methods to gather generic information about individuals emotional responses to designed outputs and some of these have been developed into generic design principles. What are missing, however, – the Design Guideline Gap – are formal explicit processes that link this information about emotional responses to designs to the generation of design guidelines and to existing design guidelines. This issue was raised peripherally in the critiques by Love (ref 2001 and 2009) of the Design and Emotion literatures. (See Love, 2001, 2009 refs).

From observation, this Design Guideline Gap has remained 'hidden in full view' because of two factors both associated with a relatively egotistic view of design activity by designers and researchers:

- Ignoring that the primary output of design research has been in automation via computer design systems (i.e. assuming that design research is primarily about improving how humans design)
- Lack of awareness that there is a gap between information provided to designers (e.g. findings about users' emotional responses) and decisions about specific design details.

In essence, the core of the problem in Design and Emotion is a misunderstanding, erroneous belief, or faulty claim (depending on where one is standing epistemologically) that the design tools and methods of the field produce direct design guidelines in the same manner as those developed in other design fields that enable automated design outcomes

The following two examples illustrate the above using Design and Emotion tools and methods from the knowledgebase of the Design and Emotion Society website. The tools and methods are separated into f five categories: understand user/market; explore ideas and concepts; design specification; test and evaluate; and market implementation. The tools and methods chosen for the two examples are sampled randomly from those catalogued as appropriate to 'design specification' i.e. the exact area that the above Design Guideline Gap is identified.

Example 1: Cabinet Keller, Delft University)

Overview of the tool/method

a) Problem being addressed: Designers collect visual material for inspiration in their design process. In practice they keep two collections, a digital that is used in the actual design process for collages and mood boards and a physical collection that they gather and organize to keep them sensitive to new insights. The two collections do not meet or interact well with each other and computer tools do not provide inspiration.

b) Solution provided: The divide between the physical and digital collections is bridged by on one hand enabling easy capturing of physical material and on the other hand offering a direct physical interaction with the digital collection. No words are needed in the interaction with both collections.

c) Description: Cabinet is a table-sized interaction device that allows designers to collect and organize collections of both physical and digital visual material. Cabinet captures
material by taking a picture from above or digital images can be added with a USB flash drive. Images can be organized spatially in stacks and compositions using the
whole length of the arm. Cabinet blends the physical world and digital world very smoothly through its interaction and smooth transitions from the physical to the digital realm.

d) Limitations:no limitations

e) Theoretical background: theories/models underlying the tool/method

Figure 1: Description of 'Cabinet' tool/method from the Design and Emotion Society website (see http://www.designandemotion.org/society/knowledge_base/template.html?item=120)

As can be seen from the above description, the cabinet method is a data collection method. It enables a human designer to access digitalised samples of digital and physical samples of ideas, objects, designs and the like.

No part of its functioning, however, includes any means of determining parts of a future or new design for the designer. There is a 'gap' between the output of the 'Cabinet' tool/method and the specification of individual design features of a new design. The 'Cabinet' tool/method has a 'Design Guideline Gap'.

Example 2: Vision in Product Design

Overview of the tool/method

a) Problem being addressed:
1. Designers have difficulties coming up with radical innovations because they are driven by problem solving; companies suffer similar problems because they are driven by market information. In both cases, (experiences with) existing products dominate venues for future products, thereby limiting what may be possible.

2. Current design methods disregard the designer as a creative, personal, and intuitive mind whose choices and decisions do and should affect the outcome of any design process.

b) Solution provided:
Vision in Product design (ViP) is a 6-stage design method that increases the likelihood of generating innovative ideas by focusing on what is possible instead of what is wrong, and by creating space for the designer to feel and incorporate values and opinions in the process.

c) Description:
The ViP method places human-product interaction, defined as the way a product is perceived, used, and experienced, at the centre of the design process.

Given a certain design task, the designer first has to 'deconstruct' what she already thinks she knows about the product that comes to mind as an existing solution. In this way he regresses to the context level where we no longer talk about products or interactions with products, but the set of starting points or factors that underlie them. This brings the designer to the first step in the design phase (see model below), building a context on the basis of all sorts of possible, relevant, and interesting starting points. Everything can be a starting point: trends in the behavior of (groups of) people or social, technological, or cultural developments, principles about human needs, their functioning or thinking, and laws of nature. Based on this contextual view, a position statement is formulated and next translated into first, a vision on the to-be-designed human-product interaction, and second, a product vision incorporating the qualitative characteristics the product has to embody. The context view and the visions together form a strong basis for generating innovative ideas and make it easy to see whether a particular idea is appropriate.

d) Limitations:
Designing with this method:
1. can be time-consuming because you take the 'outside curve',
2. requires a lot of conceptual thinking and feeling from the designer,
3. is not easy: especially the transition from context to interaction is tough.

e) Theoretical background: theories/models underlying the tool/method
- Theories on problem solving and creativity (e.g., Smith, Ward, & Finke (1995). The creative cognition approach. Cambridge, Mass: MIT Press).
- Studies on design fixation (e.g. Jansson & Smith, (1991). Design fixation. Design Studies, 12, 3-11).
- Models of the design process and design methods (e.g. Jones (1992). Design Methods. New York: Wiley).
- Simon, H.A. (1998). The Sciences of the Artificial (3rd ed.). Cambridge: MIT Press.

Images

Please click the thumbnail(s) to enlarge.

Model of the ViP approach.

(On the left side, from bottom to top is the 'deconstruction' phase; on the right from top to bottom is the design phase).

Application: where and how has this tool/method been used/tested?

The ViP method has been applied in a great number of graduation projects and courses at our Faculty of Industrial Design Engineering in Delft, as well as in many workshops and design projects for design firms and the industry. Companies who have tried and tested and/or still work with the method are: Adidas, Audi, BMW, Fabrique, Gispen, G-Star, KLM, KVD, Océ, Philips, Pininfarina, Procter & Gamble, Siemens, Sony-Ericsson, and others.

Figure 2: Description of 'Vision in Product Design' tool/method from the Design and Emotion Society website (see www.designandemotion.org/society/knowledge_base/template.html?item=127)

As can be seen from the above description, the 'Vision in Product Design' tool/method is an 'idea/seed/concept generating' method. Its purpose is to generate innovative ideas based on first developing (in some simple format) a starting point indicating a context. Then a position statement is developed from this context 'seed' and a vision of a human-product interaction is created along with a vision of the qualitative properties of the product.

None of the intermediate processes appear to be specified or deterministic. The primary characteristic of the 'Vision in Product Design' tool/method is a business process flowchart centred on various steps of vision generation

No part of the functioning of the 'Vision in Product Design' tool/method, however, includes any means of deterministically prescribing parts of the future or new design for the designer on the basis of the tool itself. All such activities, although implicitly part of the tool, are solely in the human activity realm and totally independent of the tool/method.

There is a 'gap' between the outputs of the 'Vision in Product Design' tool/method and the specification of individual design features of a new design. The 'Vision in Product Design' tool/method has a 'Design Guideline Gap'.

Other tools in this category in the Design and Emotion Society tools and Methods Knowledgebase have made limited incidental attempts to bridge the Design Guideline Gap. For example the Kn6 IBV Kansei method attempts a brute force approach to linking user information to gross design elements. The attempt is to create a very large database of design elements and products with user perception data about them. The aim is to use associative statistical analysis on this data to help forecast optimal design element outcomes. This approach is, however, *associative* in nature with all the statistical problems that are associated with this approach compared to identifying the causal relations that would give accurate prediction of the sort needed to create accurate deterministic design guidelines to be used either by human designers, or, better, included in design software. More typically, other Design and Emotion tools/methods in this design specification space are post-facto. The underlying approach is that the designer first designs something and then the tool is used to help record what sample users felt happy or unhappy with about it. The problem again, is that this process does not describe a method to obtain design guidelines that prescribe exactly the details of a design.

To summarise, all of the methods described in the 'design specification' section of the Design and Emotion Society website illustrate the problem of the Design Guideline Gap.

In the next section, the paper describes the '2 Feedback Loop Limitation' of design. This is a parallel and linked problem of design and emotion research and design practice that goes some way to explaining why addressing the 'Design Guideline Gap' is difficult and has been hidden.

2 Feedback Loop Limitation in Design

Awareness of the human cognitive constraint which the author has called the '2 Feedback Loop Limitation' emerged during research undertaken by the author and Dr Trudi Cooper in the mid-2000s into the design of complex socio-technical systems. With hindsight, it was obvious in earlier research analyses by the author in the mid-1990s. Earlier still, systems researchers had identified a raft of characteristic problems in system design. The contribution of the author was to realise these and a

wide variety of other design issues have a similar source and to formulate it into a single criteria. The '2 Feedback Loop Limitation' poses that:

Humans unaided **CAN** predict behaviour of simple situations

with **less than 2 feedback loops**

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Humans unaided **CANNOT** predict behaviour of complex situations

with **2 or more feedback loops**

Figure 3: The 2 Feedback Loop Limitation

This ability to predict behaviour is important in Design. Prediction of behaviour of a designed outcome is one of the core competencies of design as a professional activity, as in all other professional activities. Without the behaviour to predict the behaviour of designed outcomes, designers are guessing; charging fees in a situation that opens them to financial litigation and civil and criminal claims against them on the grounds of incompetence.

The 2 Feedback Loop Limitation appears to be a simple consequence of human biological limitations. In the same way that humans cannot unaided jump twenty meters into the air, humans can think com0licated thoughts up and including a single feedback loop. Forecasting or understanding the dynamic behaviour of design situations with 2 or more interlinked feedback loops requires some form of representational modelling process in which designers are limited to being able to observe outcomes, rather than understand or predict outcomes. This limitation was identified by the author as a result of reviewing a variety of problems that occur in complex systems design and correlating these with findings emerging from neuro-cognitive studies and with simple tests (it is effortless to demonstrate human limitations at addressing multiple feedback problems). In addition, inspection of the informatic structure of behaviour identification offers a deep insight to suggest these situations are intrinsically insoluble in terms of predicting the dynamic behaviour of design outcomes. This latter issue is the subject of a different paper. In essence, evidence from the systems field over a long period and across a wide variety of subject fields together with deictic empirical testing strongly demonstrates the validity of the 2 Feedback Loop Limitation across all humans, regardless of personal skill, intuition, cognitive ability or education. A formal large-scale trial is currently awaiting confirmation of funding as cross-institutional research collaboration.

This 2 Feedback Loop Limitation suggests that there are deep failures in design theory across all design fields. It provides a simple and well justified explanation for many, or perhaps most, design failures. In addition, it marks a simple boundary that defines the limits of applicability of traditional design approaches, including design thinking, collaborative design, participatory design and intuitive/creativity-based design.

This is a significant issue in design practice and research at this moment as it has recently become fashionable for designers and design researchers to claim that designerly ways of thinking, design thinking and traditional design methods form the Art and Design fields are applicable more widely to for example business processes, business strategy, health systems, innovation systems, information systems and other systems that involve two or more feedback loops.

The 2 Feedback loop Limitation indicates that these claims are false, or rather, that if conventional Art and Design design approaches are used in situations with 2 or more feedback loops then regardless of any immediate success, the outcome will quickly fail due to unanticipated changes of design solution and design context caused by the action of the feedback loops. This is obvious and predictable, and hence lays designers open to prosecution for incompetence.

Early and simple forms of designed outcomes that were foundational to the development of traditional design practices and modes of design thinking do not have any feedback loops (see, Figure 4).

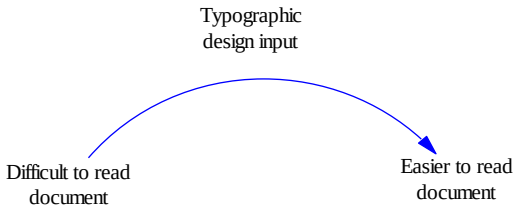

Figure 4: Simple design activity without feedback loops

With the increased exposure of the public to mechatronic control devices such as thermostats, the awareness of single feedback loop models spread form the technical domains of engineering design into other areas of design where it became relatively commonplace. An example is the classic design process with feedback.

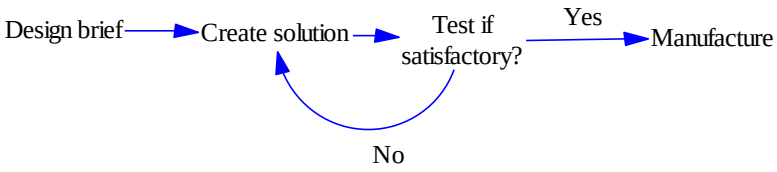

Figure 5: Simple design process with a single feedback loop

It is found in a much earlier form in the Shewart cycle

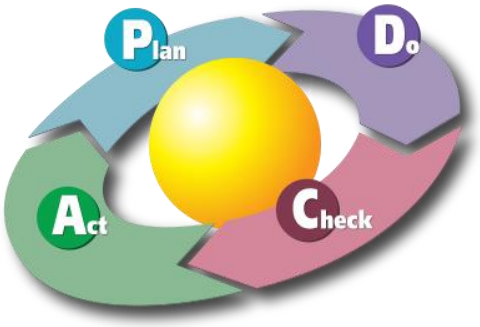

Figure 6: Shewart cycle (PDCA cycle) (source: http://en.wikipedia.org/wiki/File:PDCA_Cycle.svg)

The dominant tradition as illustrated by the literature of the Art and Design design fields and in the Design and Emotion field has been to assume that ALL design situations are of this form of having no or only one feedback loop.

The design tools, approaches methods and theory concepts as well as design research approaches predominately and problematically assume:

- All design problems that will be addressed by designers will have no feedback loops or only one feedback loop
- Any design problem can be assumed that it can be converted unproblematically to a design situation with no feedback loops or only one feedback loop
- That traditional design approaches (including design thinking, design intuition, creativity, and feeling-based design) can be applied to any design situation

Elsewhere, I have pointed out that these beliefs are supported by a cognitive delusion/illusion in which when individuals apply inappropriate design methods to situations they feel that they are appropriate and that designs are successful (refs 2001, 2010).

In essence, the 2Feedback Loop Limitation marks a difference between *complex* and merely *complicated* design situations:

- *Simple* design situation - low numbers of design elements/functions and no feedback loops or only one feedback loop
- *Complicated* design situation – higher number of design elements/functions with no feedback loops or only one feedback loop or with multiple independent subsystems each with at maximum one feedback loop
- *Complex* design situations – low or high number of design elements/functions with 2 or more interrelated feedback loops

The 2 Feedback Loop Limitation suggests that traditional design approaches only work with simple and complicated design situations and not with complex design situations with multiple feedback loops.

An example of a complicated design situation is shown in Figures 7 and 8 below:

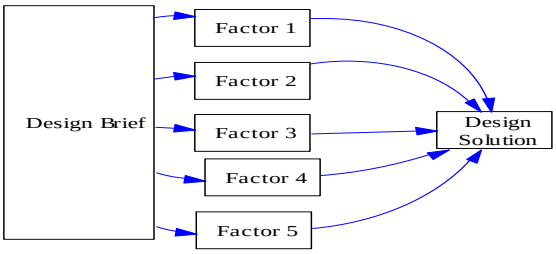

Figure 7: 'Complicated' rather than 'Complex' design situation – multiple single factors

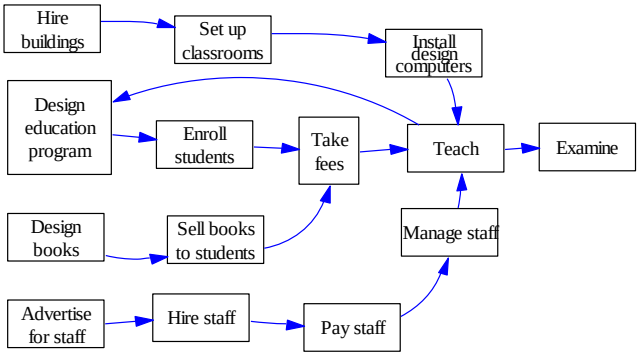

Figure 8: 'Complicated' rather than 'Complex' design situation – multiple single factors with a single feedback loop

The above *simple* and *complicated* design situations contrast with *complex* design situations as shown in Figures 9 and 10 below. Figure 10 shows a design situation obviously in the Design and Emotion design space to which current Design and Emotion design research and practice approaches do not apply. It is the design context of designing interventions to reduce overeating and obesity – similar in form to other addiction-related design interventions

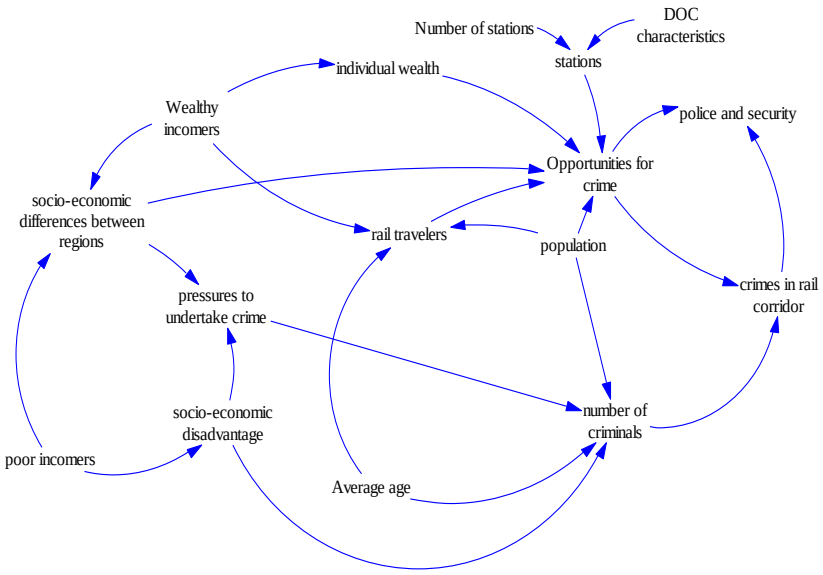

Figure 9: Complex design situation - Preliminary design relationships affecting crime in a rail corridor (unpublished Love, T, Cooper, T, Cozens, P, Morgan, F and Clare, J)

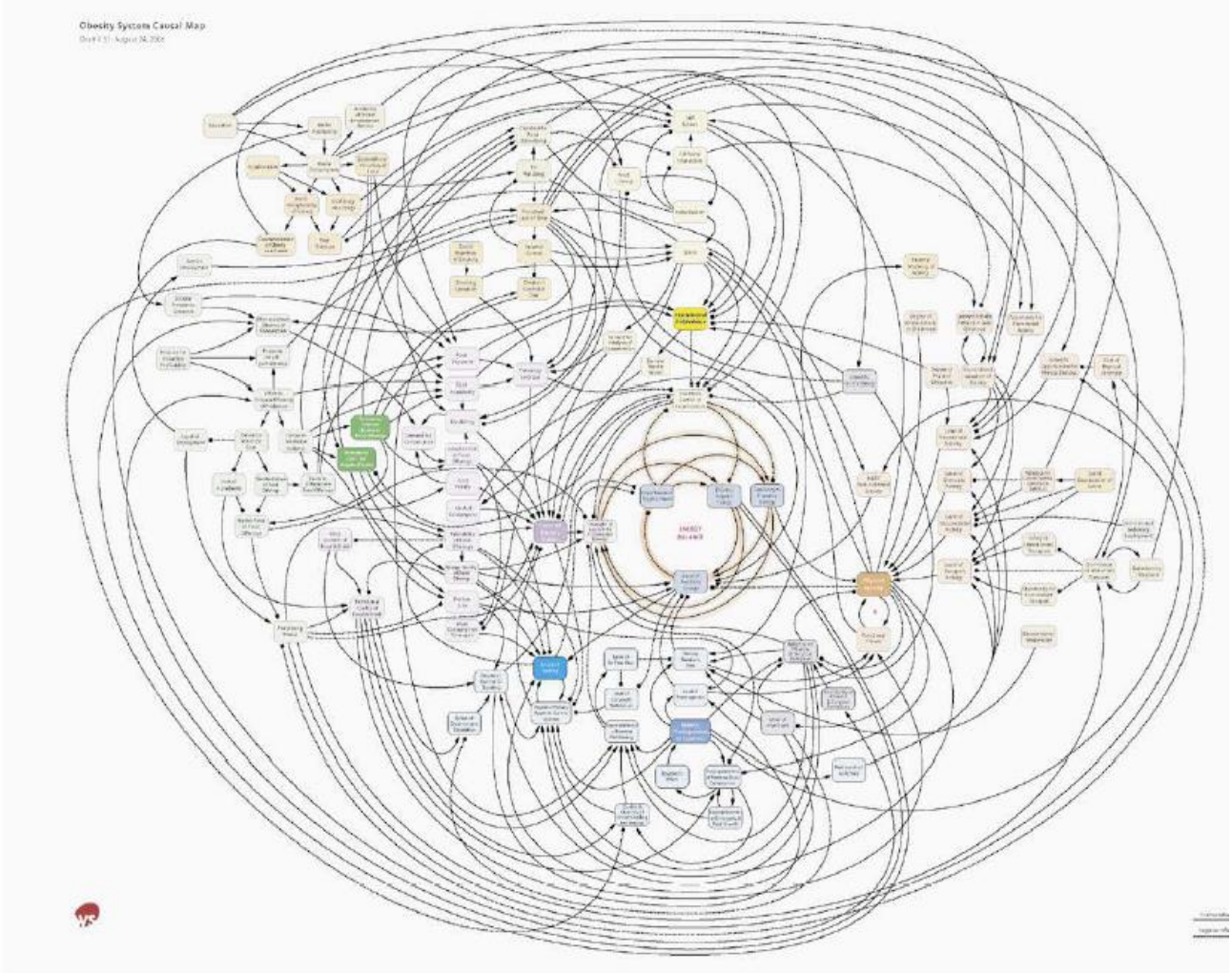

Figure 10: Complex design situaiotn- design of obesity reduction: simplified model of multiple interrelated feedback loops http://www.foresight.gov.uk/Obesity/12.pdf

To summarise, the 2 Feedback Loop Limitation challenges a range of widely uninspected assumptions about the applicability of design and research methods in the Design and Emotion field and its literature.

Implications

The above sections have outlined two issues that have potentially deep implications for the Design and Emotion field, the literature, its research methods and design practices.

The two issues are highly interlinked. The lack of awareness of the design guidelines gap in design research and practice in Design and Emotion and other design fields may be held to be because of 2 Feedback Loop Limitations. Awareness of the Design Guideline Gap requires viewing design theory development and use epistemologically in terms of multiple feedback loops as a complex design context.

Similarly, the picture of design activity is simplified to a single feedback loop model if the dominant design outcome effects of the design research and design software development are ignored and design is presumed to be an individual or social pursuit. It is by including the less romantic but obvious other significant factors that start to expose the weaknesses in the existing traditions of research and practice and claims for territory.

What are the implications for Design and Emotion as a field? For brevity, it is easiest to list them. First, the implications of identifying the Design Guideline Gap include:

- Addressing the Design Guideline Gap opens up a new area of research and practice in Design and Emotion
- Addressing the Design Guideline Gap conceptually relocates some of the current concepts, research findings, theories and design practices
- Testing for the Design Guidelines Gap will indicate areas of work still to be undertaken in relation to many design and research approaches in Design and Emotion.
- Testing for the Design Guidelines Gap will indicate where claims for ability to provide design specification are invalid.
- Challenges claims by user-based design approaches that user-based analysis is sufficient to define design solutions.

Identifying the 2 Feedback Loop Limitation has rather deeper implications as it challenges and potentially invalidates several deeply held beliefs across all design fields including Design and Emotion. The implications include:

- Limitation of conventional design practices involving for example design thinking, intuition, conventional design methods, creativity to simple and complicated design situations with less than one feedback loop.
- Challenges the validity of claims that conventional design thinking and Art and Design design practices and research methods apply to complex areas of design such as business strategy, health systems, information systems, public governance, security and similar complex design situations
- Suggests that the use of participatory design, collaborative design, crowd sourcing and the like are limited in usefulness to situations with less than two feedback loops. More, it suggests that the outcomes of using such methods increase the likely hood of faulty design solutions in situations that are dynamically shaped by multiple feedback loops. This is especially significant, because currently participatory design, collaborative design, crowd sourcing and the like are widely proposed as the most appropriate approach!

- Redefinition of wicked problems as being straightforward to address rather than impossible (this issue has been addressed by the author in other papers). Predominately, 'wicked' design problems are those with multiple feedback loops and hence cannot be solved using approaches suitable to no feedback loops or only one feedback loop. In essence, this is partial proof of the 2 Feedback Loop Limitation.
- Challenges the belief that humans can intuit, feel or have correct insights about complex design situations. At a personal level, the 2 Feedback Loop Limitation challenges the experienced delusion of designers and researchers that they can think, feel or intuit their way around complex design situations. This draws attention to a major self-delusion of design and design research the assumption about the absence of which has been a core presumption of substantial amount of design theory making about design skills, practices and cognition.
- Challenges the validity of much of the design theory and design literature as it applies to complex design situations (and wicked design problems)
- Challenges claims by the Design and Emotion sub-field, that complex design situations can be addressed via research into user's emotional responses.
- Provides justification for an alternative design method that resolves all the problems raised by the above challenges.

The effect of these implications potentially multiplies further because of the high level of linking between theories and assumptions in design fields.

Solutions and Conclusion

There is potential for solutions to the issues raised above. The Design Guideline Gap has already been addressed in other areas of design and design research that involve less feedback loops than the Design and Emotion arena. In the more deterministic design fields, the Design Guideline Gap is closed in design research leading to software that produces design solutions such as those provided by Intergraph for the Oil and Gas industry, AutoCAD, SolidWorks, and Blast Maker. The difficulty with Design and Emotion is that there are many simultaneous feedback loops of learning and interpretation in the ways users and designers interact with objects and systems. By implication of the 2 Feedback Loop Limitation, this means that the typical approaches used to research and design in the realm of Design and Emotion (including human design thinking and intuition or participatory design) are likely to be unsuccessful in anything other than very simple cases.

There are three obvious approaches to addressing and resolving the 2 Feedback Loop Limitation:

- Use modelling. This is a well established approach in complex systems design. The three primary modelling tools are causal loop diagrams, systems dynamic models and agent models. All three require substantial research support. Causal loop modelling is restricted as it provides

only a snapshot and cannot provide understanding or forecasting of dynamic outcomes. For Systems Dynamic modelling and agent-based modelling of design situations with multiple interlinked feedback loops, then the prediction of the behaviour of the designed outcome is only available by watching the system play out in real time. This is a causally-based approach

- Have a pattern equivalent that one already knows the behaviour. This is an associative modelling approach that us is widely used in for example weather forecasting where a pattern of several days weather is compared with similar weather snips from earlier decades. The limitation of this approach is indicated by for example, global warming rendering current weather patterns incommensurate with earlier patterns. It demonstrates the limitations of associated approaches to modelling as the causal mechanisms have changed.
- Undertake research to develop an understanding of the causal mechanisms at a causally more detailed scale. An example would be to understand the biological mechanisms that shape human emotional responses on the basis of their perception of the detail of objects and systems.

To summarise, this paper has described two concepts that have been recently identified that have implications for design research and practice particularly in relation to Design and Emotion fields. The paper has sketched out the implications of them for design theory, research and practice and outlined a preliminary suite of solutions that address the design research, theory and practice problems exposed as a result of identifying the above two issues.

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