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The means of design work. Models, sketches, and related objects in the creation of new technologies

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Abstract:

Design is understood in a pragmatist sense as a process of resolving uncertainty. Designers confront a vague initial design problem by stabilising the use and function of objects that do not yet exist in the world. An ethnographic study in a design laboratory reveals design activities as centred on certain means of work. These means include discussions, sketches and models that lend certainty to individual ideas, therefore stabilizing an object as it takes shape. Certainty in this sense, however, can only be derived from instability or uncertainty. The same means are thus vital, on other occasions, for constituting uncertainty as a central condition and resource of design. By sorting different aspects of uncertainties portrayed in discussions, sketches and models the designers create specific arcs of design work and actively manage the levels of certainty and uncertainty in their project.

Keywords:

Uncertainty - pragmatism - design research - means-ends relation - technology development - intermediaries

Content:

1 Introduction: Reversing the perspective on work and design

Unlike most studies on organisational practices, this article concentrates less on the incessant shaping and design of workplaces and entire organisations through practices of work. Instead, the primary thematic focus lies in examining how design professionals employ different *means of work* to anticipate future useful functions and objects in the development of new technological artefacts and the organisation of this process. Work in design projects[1] is characterised by a remarkably low division of labour. In their daily routines, designers perform tasks such as crafting, programming, inventing use scenarios, debugging electric circuits and much more. They create analogies, search for images online, mash up different ideas in sketches, or create various types of models. The low division of labour offers the rare chance to study the same actors working on very different problems, with entirely different means of work within the same project. This allows to compare their work practices and the means employed, as personal style, organisational setting, and financial background, along with other intervening factors, are kept stable over the course of the project.

My thesis is that design work can only be done in immediate interaction with arrangements of different materials and symbols that I refer to as *means of design*. Means always consist of both symbolic and material properties which enable and constrain the anticipation and construction of new technological artefacts. Designers need to solve abstract problems, in the case studied here how to 'help groups navigate in foreign cities', by constructing objects and procedures. Their project goals harbour uncertainties which first need to be created and are subsequently reduced over time as the design process continues. As this study emphasises, means of design vary in character as they hold different enabling and constraining features (what Gibson 1986 calls 'affordances'). Designers must therefore organise their projects and tasks in such a way that uncertainties can be addressed and possibilities activated by interacting with and through means that successively enable them to advance towards new designs.

In the first part of this paper, I discuss concepts and theoretical approaches to develop a sociological perspective on design work. In the second part, these ideas are then used to analyse three exemplary cases of design work. I start in section 2 by referring to John Dewey and his notion of work as a primal and enduring pursuit of creating certainty. Design – as any social action – is therefore understood as an ongoing and practical 'quest for certainty' following John Dewey's terminology. The interplay of indeterminacy and anticipation permits an understanding of interaction with the environment in general and, more specifically, interaction in design

[1] This notion of design derives from my experiences as an ethnographic researcher; nevertheless, design work in general seems to be less divided than in production, for example.

work. To move from the basic interactional level to organised activity in the design process, Anselm Strauss's concept of an 'arc of work' is used to highlight the interweaving of countless interaction sequences in the process of designing. This concept provides a vehicle for understanding the designer's work activities as an organised arc of work driven by anticipations and valuations of future objects. Complex and multi-layered work concerning interaction with others and actions directed towards objects, material and technology is best reflected in the notions of anticipation and object formulated by George H. Mead. In section 3, I provide a brief methodological commentary on the difficulty of finding constraints that derive from means of work while leaving intertwined social constraints aside. Section 4 presents three short empirical cases: the identification of related objects (1), the disassembly of well-known technologies to create new ones from their bits and pieces (2), and the construction of models (3). These cases all involve prototypical sequences of interaction, where words, visuals and models become means of design. I will analyse how the interactions with different means of design and their properties need to be orchestrated in order to finish the given design project. Controversial types and means of interaction in design then illustrate that different means address different types of tasks and problems in design. I conclude this study by postulating that the character of different means of design must be taken seriously in order to understand the different logics of social processes such as design work.

2 Accounting for socio-material work

My argument is based on the premise that the iteration of action and sensemaking is ubiquitous in all social processes and, therefore, in design work, too. Like any other process of action or work, design is composed of interactions that employ symbolic and material entities – most commonly: words, gestures, texts, sketeches, models and others. Deviating from a purely social constructivist stance toward technology, I argue that the means of design are not only "intermediaries" but relevant "mediators" in the process of work (Latour 2000: 18). This perspective is in keeping with one of Bruno Latour's central criticisms of social theory:

> "Soft humans and weak moralities are all sociologists can get. The society they try to recompose with bodies and norms constantly crumbles. Something is missing." (Latour 1992: 227)

Latour thus encounters a fundamental problem of mainstream social theory and offers his own solution. Though actor–network theory proposes a seemingly radical departure in promising to do away with the ontological differences between humans and the physical world, this break derives from a semiotic principle (Callon 1986: 82 FN4) and, lamentably, does not manage to

leave the realm of semiotics. Concepts such as delegation (Latour 1992: 248–254) or Latour's four forms of technical mediation (Latour 2002: 216–232) do mediate between symbolic and material properties of actors, but they primarily stress their significance for social action. Inherent properties of symbolic, visual, or material actants are secondary. Taking semiotic symmetry as starting point, however, ultimately erases decades of insightful and capable social theory that offers us numerous concepts for understanding and exploring socio-material situations. Pragmatism has a longstanding tradition of micro-level interaction analysis, especially in contexts of work. Drawing on the ideas of John Dewey, Anselm Strauss, and George H. Mead, I would like to develop a pragmatist/interactionist perspective on the affordances of the means – in this case of design work –, without abandoning the valuable sociological insights which actor–network theory sacrifices in the name of semiotic symmetry. This pragmatist views holds a second benefit: unlike the lens offered by actor–network theory, emerging technologies (Callon 1986; Latour 1983; Latour 1996) can be conceptualised in the same notions and vocabulary as technologies in use (Latour 1992; Latour 2000).

2.1 Dewey: Working out uncertainty

Design work, as any social action, is conducted to minimise the perils of existence by actively engaging with the environment and creating certainty out of indeterminate situations. Formulated by the American philosopher John Dewey in 1929, this basic assumption remains as striking today as it was then, because it has the potential to help us understand design work by fixing its relevant coordinates. In 'The Quest for Certainty', Dewey starts his argument by criticising his fellow philosophers, and their ancient Greek predecessors, for dividing knowledge into a sublime realm of philosophy and an inferior realm of knowledge about practical action and material artefacts. Dewey is doubtful about the existence of a purely philosophical, theoretical realm of knowledge. More fundamentally, he doubts the validity of a basic divide between practical and theoretical knowledge.

> "Philosophy in maintaining its claim to be a superior form of knowledge was compelled to take an invidious and so to say malicious attitude toward the conclusions of natural science." (Dewey 1929: 28)

Dewey's rigorous line of argumentation cuts across the established but artificial division that claims the superiority of theory and the lesser value of practical knowledge. He concludes that pure knowledge cannot exist by itself because every act, including an act of knowing, is always found in some practical context and situation. In this assumption lies the core of his argument for a single, united form of knowledge.

> "And it is a strict truism that no one would care about any exclusively theoretical uncertainty or certainty." (Dewey 1929: 38)

Dewey argues at length that, in the constant quest for certainty, only one form of practice and knowledge exists.[2] Hence the philosopher's elaborate and enduring efforts for 'pure', or theoretical, certainty are condemned to failure. As this argumentation cannot be elaborated here in detail for the design cases presented and discussed below, we must be satisfied with adopting this central assumption: uncertainty, along with its perils and risks, forms the bedrock of the work of social actors, conceptualised as an active and practical engagement with their environment. Every attempt to face uncertainty is rooted in practical action – the only way to overcome uncertain situations. Whether applied to the uncertainties of everyday life or to the uncertainties of scientific endeavours, this assumption leaves no room for differences between theoretical and practical knowledge. Dewey's line of argumentation unifies the notion of work into one condensed effort with a purely practical character at all times. This does not, of course, mean that work as a basic form of action does not find manifold ways and methods to actively face uncertainty, for example, in the development of new technologies.

> "In the absence of that organic guidance given by their structure to other animals, man had to find out what he was about, and he could find out only by studying the environment which constituted the means, obstacles and results of his behaviour. The desire for intellectual or cognitive understanding had no meaning except as a means of obtaining greater security as to the issues of action" (Dewey 1929: 38).

With an increasing security as to one's own and other actors' actions and their consequences, the relation between action and object becomes more predictable. Greater predictability, then, is the premise for planned and methodical action, for example in the context of work.

> "Henceforth the quest for certainty becomes the search for methods of control; that is, regulation of conditions of change with respect to their consequences." (Dewey 1929: 128)

Design work is also called on, as every form of action, to deal with uncertainty. Transforming uncertainty into a unified whole, as Dewey would have it, can be understood as advancing the design process insofar that the very open and vague situation that characterises early project

[2] One can find parallels between Dewey's efforts for a whole and unified understanding of acting and knowing and Bruno Latour's attempts, six decades later, to unlearn the difference between material and social logics as described in 'We Have Never Been Modern' (Latour 1993).

stages gradually acquires shape over time. This is typical for any work situation in Dewey's sense.

> "Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole." (Dewey 1938: 104f.)

The quote is striking for the efforts of designers described in the empirical part of this paper. At the very beginning of the six-month design process, none of the designers has a clue about what will result from their work. During the process, multiple certainties and uncertainties will be created, sorted, and perhaps even disappear completely. Later project conditions are more determinate insofar as relations between its elements become clearer and more unified, in other words: more certain. Up until this point, Dewey's conceptual framework fits perfectly for the case of a textile orientation device developed by two designers. I would like to note however that Dewey's concept of uncertainty can be extended by distinguishing two basic forms: intended and unintended uncertainties, in design these two forms are highly visible as uncertainty is an essential resource for the designers work. Both forms will be discussed in further detail below. Reversing Dewey's relation between work and certainty, it becomes obvious that the designers who challenge themselves to create certainty thrive on uncertainty as the raw material for their job: no uncertainty, no work. As will be shown, designers draw from a repertoire of methods to generate uncertainty, the aspects of which they resolve later in the process. Uncertainty thus becomes a resource for their work; it is actively and repeatedly increased and decreased over time. Especially in the early stages of design processes, the designers in my cases created their own uncertainties – a finding which goes beyond Dewey's conceptualisations as he mainly took uncertainty as given problem.

In the empirical study outlined on these pages, the designers aimed to create a meaningful and functional technology to help tourists navigate foreign cities. Their work therefore consisted of efforts to inquire into uncertain situations and explore promising uncertainties which, in turn, held the potential to be transformed into interesting solutions. An understanding of these processes of design work requires piecing together many different types of action, as work needs to be organised from countless interactions which actively modulate – increase and decrease – certainty. Starting with Dewey's insightful premise of work as practical problem solving, in the next step a notion of organised work is crucial to move from the basic level of general interactions to a more concrete notion of means and coordination in design.

2.2 Strauss: Aligning the designer's efforts

Anselm Strauss, who advanced many ideas of the Chicago School and who co-founded the method of grounded theory, also imported central insights from pragmatist philosophy into interactionist sociology. Besides his well-known and essential contributions to the field of methods, the logic of pragmatism can also be seen in the implementation of these methods in his own research on diverse kinds of work (Strauss 1959 and Glaser, Strauss 1965). In his studies on the work of medical practitioners (Becker, Geer, Hughes, Strauss 1961 and Glaser, Strauss 1965), Strauss developed a concept of work that bundles the countless interactions involved in medicine. His pragmatist notion of work is therefore almost as basic as action itself.[3]

> "Implicit in the Pragmatist theoretical action scheme is the idea of *work* – imagining, trying out, assessing actions or lines of actions involves "working things out," to use a common phrase. Work is entailed in the process of unblocking the blocked action, and moving along into the future." (Strauss 1993: 52)

The previous assumption of reducing uncertainty in design work thus perfectly matches Strauss's notion of work. Both notions define work as something that actively addresses the social and material world to increase the predictability of situations (Dewey) or "unblock" blocked actions (Strauss). Both notions, moreover, emphasise a chronological perspective, which is important to gain insight into the gradual evolution of design processes. Nevertheless, comparing the many similarities of the concepts is not the objective here, as it are their differences that hold interesting benefits for the present analysis: Dewey's instructive and exceedingly crucial understanding of work is rather too short-lived for the present context. In design projects, work needs to be organised; individual endeavours that seek and abate uncertainty must be interrelated with regard to project goals (e.g. creating new interactive navigation tools and furthering design knowledge) and project constraints (e.g. project schedules, financial constraints). Inherent similarities in these two concepts of work allow us to embed Dewey's philosophical notion of work in Strauss's sociological concepts of work and organising. According to Strauss, work is organised with reference to two organisational constraints: the permanent progression of time and activities that aim to unblock action. These two constraints will be outlined as an analytical frame for analysing design work in the empirical chapter. To summarise: Strauss defines work as a mode of organised interaction; the boundaries between work and other types of interactions such as play or fantasy are fuzzy

[3] In a rather innovative perspective in his day, Strauss set forth an understanding of organisation that viewed work – and not hierarchy or other elements of structure – as a major explanatory element of organisation: "The division of work among classes of persons may therefore be different during different phases of the project or trajectory, each successive one perhaps necessitating new classes with particular skills or relying on different skills of the same workers. It is the skills and actions which are the essential elements then, not simply the class of worker as such" (Strauss 1985: 4f.).

(Strauss 1993: 95). In order to expand this understanding of work and organising, his notions of *arc of work* and *line of work* are very helpful.

> "An arc for any given trajectory – or project – consists of the totality of tasks arrayed both sequentially and simultaneously along the course of the trajectory or project." (Strauss 1985: 4)

In the present study on design work, the design of a wearable computing device shall be understood as such an arc of work. This concept permits us to bundle the countless interactions that increase and decrease certainty in the process of designing this wearable navigation device. Strauss's broad notion of arcs in which work is organised with regard to time and socio-material constraints and opportunities allows us to go well beyond the basic interactionist perspective that insightfully describes the relation between action and certainty. With Strauss, Dewey's basic idea of work as a process of resolving (and creating) uncertainty can be extended by the notion of an *arc of design.*

Strauss's line of work then, on a higher level, relates several arcs of design (Strauss 1993: 14) to grasp wider work contexts such as multiple projects or an entire organisation. For this study, arcs of work are a crucial entity to combine an interactionist analysis of design activities with the effects of these interactions on the overall process of developing a new technology. To sum up, all actions and interactions pursue the objective of creating certainty – which, at times, also requires uncertainty. To understand multiple different actions and interactions in the context of design work, the notion of arc of design must stand up to in-depth scrutiny. Before going into the empirical details of the design process, a detailed understanding of means of design must also be elaborated, because work is not only organised around but also mediated by manifold semantic and material devices. In the next section, I will discuss the difference between object and symbol, as well as between anticipation and concreteness.

2.3 Mead: Objects and anticipations of work

Many interactions in design work are readily apparent to the empirical observer: discussion, enquiry, scribbling, comparing, building models, testing, debating, and so forth. In consequence, the means of this work are words, sketches, drawings or pictures, and objects. These means are created in the work situation itself or co-opted from other situations. They can be combined or divided, explored, made durable or scrapped, since these are the same means that are processed in the arc of design. For the purposes of this article, all of these entities intertwined in design-related interactions are referred to as means of design. They populate every arc of design in diverse forms such as anticipations, symbols, or tangible and malleable material objects. They derive from the designers' actions and shape them at the same time. Design thus draws from

diverse means occurring in manifold forms. To find a common thread in this empirical complexity, I will elaborate the conceptual framework of 'means' in the following.

Referring to Mead, objects (like palpable things) and symbols (like words) are matters of interaction. In most actions, objects and symbols are only dealt within an anticipatory sense. Anticipation can be understood as calling forth the properties of objects in one's mind while the objects themselves are distant or absent. At a distance, properties are anticipated[4] and, regardless of their accuracy, these anticipations form the basis for action as Wiliam I. Thomas and Dorothy S. Thomas have convincingly argued (Thomas 1928: 527). Every competent actor anticipates the meaning of a verbal symbol as he anticipates the properties of a wooden bridge before setting out to cross it, step by step. Anticipated properties can turn out to be correct, but it is here that the differences between symbolic and material entities become apparent. While symbols often belong to a realm of common knowledge, the material properties of objects can be verified through common or systematic investigation. In most everyday situations, meanings and properties are anticipated accurately and the differences between objects and symbols do not come to bear; for the process of design, however, where both meaning and material functions are still in the making, these differences do matter. Like symbols, objects are mostly referenced from a generalised perspective through thought or anticipation. Unlike symbols, material entities refer to something that Mead calls the 'physical object'. Similar to Latour (2006: 39), referring to a material world is a condition for every interaction with an object.[5]

> "The physical object is found to be that object to which there is no social response which calls out again a social response in the individual. The objects with which we cannot carry on social intercourse are the physical objects of the world." (Mead 1934: 184 fn)

For an analysis of design work, these different notions of objects must be sorted out: Building on physical objects, objects in general are mostly dealt with as "distant objects" (Mead 1932: 128f.). This means that, for example, when crossing a street, actors anticipate the resistance of the ground with every step, the height of the curb, the speed and relative distance of an approaching car, and so forth. The meaning of an approaching car, our resulting caution, and the significance of a possible crash is, in most cases, only anticipative, as most of us have never been involved in a pedestrian collision. Anticipation creates properties of objects at a distance

[4] Mead employs the notion of 'anticipation' for assumptions regarding the material world, whereas his well-known concept of 'role taking' holds the same idea, but applies it to the social sphere (Joas 1980: 152f.; Lüdtke 2011: 246). Mead developed the notion of 'taking the role of the other' for this same social mechanism in interactions involving a stronger degree of contingency. Insightful critic on Mead's *a priori* division between human actors and everything else can be found in Lüdtke (2011: 249f.). Lüdtke stresses that the ability to interact must be conceptualised as an attribute of actors and not based on a simple categorical (person, animal, robot etc.) ascription.

[5] Latour then stresses that with no exception materialities are to be found in contexts of action.

(distant objects), these properties lead to action, no matter their accuracy. According to Mead, every action is based on anticipation and experience, as actors continuously 'design' their relevant conditions for action. In contrast to symbols, distant objects relate to further notions of an object; most objects can become "contact reality" (Mead 1932: 131) through direct interaction, i.e. physical touch and observation.

> "The surface we call smooth calls out a tendency to stroke it, but that one may not do this until he has reached it and got hold of it means that the actual appearance of smoothness or pleasantness awaits the manipulatory resistance of the physical thing." (Mead 1932: 131)

The object is felt and seen in the very same moment, therefore enriching the actor's experience. Mead's notion of objects – despite most interaction taking place in the realm of anticipation – is squarely planted in a physical world. An object's meaning – in contrast to a symbol – is not entirely the product of the social construction of reality. Objects and their physicality exist and these properties are relevant for human-object interactions.[6] Mead's notion of objects and symbols comes together in the space that defines their shared and social meaning. This meaning is the motor that drives most actions involving objects and symbols. But contrary to symbols, objects do have a material side that can be accessed through physical contact and referenced repeatedly in interactions, e.g. in cutting with a knife or phone calls by wire. In the arc of design, symbols, 'distant objects' and 'objects in contact reality' are crucial entities, because they make up the means of design for the designers' work.[7]

By way of a brief summary before continuing to the empirical case: design work consists, as any social action, of relations between actors and objects. These relations are processed by discussions, texts, pictures, sketches, and models that I have termed the means of design. Employing means allows the designers to tackle (i.e. to create and reduce) the uncertainties of design work. Like any work, design work is characterised by unblocking of blocked actions and, from time to time, intentionally setting up 'roadblocks', in other words, manufacturing uncertainty, that can lead to creative problem solving. The means, however, are not simply employed to process uncertainties; they may also raise – whether intentionally or not – uncertainties, too, as every means has its own format. An empirical analysis reveals that the anticipation of objects does not always correspond to their actual properties or that the meaning

[6] Mead's pragmatist notion of objects depicted here can be easily related to Gibson's 'affordances' of objects, as the latter enable and constrain actors as well (Gibson 1986). Due to this similarity, Gibson is a good reference point, but Mead's understanding of objects allows to conceptualise constraining or enabling properties not as depending on the objects alone, but as features of action. Objects then become constituent features of social processes instead of external entities.

[7] All means of design are symbolic and material at the same time. In some cases, the designers tend to refer more to the physical side (e.g. in using scissors); in other cases, the symbolic properties are more important (e.g. in speaking).

of symbols or objects can vary among different individuals or sequences of action. Design work therefore does not usually go according to plan. In design, as in other forms of social action, meanings as well as material properties are created, validated, and proceeded upon. As this study shows, objects and symbols bring with them different formats that can, at turns, accelerate or decelerate the ongoing arc of design. Considering the data, it will be insightful to question whether the share of rather anticipatory means (words, pictures, usage scenarios) prevalent at the beginning of the process tends to shift towards more physical means (sketches, models, prototypes) near the end.

3. Some thoughts on methods to focus on means of design

To a sociologist it comes as no surprise that work in general implies countless social and organisational constraints which enable, impede, and therefore shape actions. Designers make many decisions; they have limited budgets, time, and manpower. As individuals they bring a unique socialisation and set of experiences, but they are also part of a hierarchical setting, faced with micro-political situations in an organisational context, and so forth. Work presents countless aspects and research questions for a sociologist when enquiring into the world of designers. For this study, however, the main focus lies in the constraints and possibilities that result from applying different means of design – all other sociological questions have to be left aside.

As Kalthoff stresses, qualitative research is about certain social phenomena and relations; a strictly technical approach and application of methods does not lead to a comprehensive understanding of social phenomena (Kalthoff 2010: 353). Because my interest lies in understanding how individuals do what they do and how their social and material situation evokes various interactions, an ethnographic perspective presented a promising possibility for my research questions (Kalthoff 2010: 358). Due to the multi-faceted work setting of the designers I observed, I decided to collect different types of data. Field notes, for example, helped me sketch out the broader arc of the process, but also record very detailed descriptions. I took photographs to clearly record all items and actors in certain situations and therefore facilitate the reconstruction of a certain situation. In addition, based on a few short videos, I could follow action sequences and discussions in great detail. ‘Technography’, a method developed by Werner Rammert and Cornelius Schubert, combines ethnography with a special interest for technology, it aims: “not to repeat the great tales of technology, but to tell the small exemplary technographies of diverse situations in detail” (Rammert and Schubert 2006: 12;

transl. by author). Independent from the method or the specific data collected, my interest was consistently devoted to the progressive development of uncertainty.

The following sequences from a six-month design project will not provide an understanding of the process as a whole, but will instead shed light on the details of design work or, more precisely, on how the initial design problem[8] becomes more or less determinate, at turns, through interactions with different means of design. Dewey's quest for certainty is implied as the goal of design work. Different means of design enable or constrain this goal in interaction. This study focuses on interactive work situations in detail, not on the overall design process.

4. Objects and symbols become means of design

Within the course of this study, I investigate the work of one professional designer (K.) and her student assistant designer (N.). Employed at the Universität der Künste Berlin (Berlin University of the Arts).[9] K. considers her work as 'research by/through design'[10]. Work in this lab currently involves creating new technological devices for interaction and developing methods of design, for instance in PhD theses and projects on design methods. K., a designer whom I accompanied over several projects, earned a PhD in design in 2014 and is specialised in interactive textile wearables that are sometimes embedded in familiar clothing or accessories such as scarves, beanies, or pullovers, or also contain new technologies in new forms. The latter might be inventions like textile globes or coin belts. As mentioned above the six-month project started with the problem of navigating in a new city for tourists, but the process of defining this initial problem is not covered here. I consider the invention and construction of one particular wearable device to be an *arc of design* (Strauss 1985: 4); the DRL's efforts to create new forms and objects of interaction constitute the broader *line of work* that cannot be examined here. In this exemplary case, K.'s student assistant works part time at the DRL alongside her Bachelor studies in fashion design. Both designers had parallel work obligations during the six-month project. In the following, I will describe the relation between waxing and waning (un)certainty in interactions by studying the details of three typical work sequences in one arc of design: brainstorming (1), sketching (2), and testing (3).

[8] Wolfgang Jonas (2001) asserts that, in contrast to my depiction, the design process does begin with the explicit statement of a design problem.

[9] I am very obliged and thankful for all the open doors and minds I found at the Design Research Lab at the Berlin University of the Arts, in particular I want to thank Dr. Katharina Bredies and her anonymous assistant for giving me insights into their pioneering work in the field of textile interfaces.

[10] Jonas (2007) provides a depiction of the interesting debate on the differences between 'research into/about design', 'research for design', and 'research through/by design'. For a broader view on the question of who designs design see Mareis, Held, and Joost (2013).

4.1 Brainstorming touristic affairs

The first excerpt from the design process is a brainstorming technique which is used as a means of design. The aim of this brainstorming approach is to find objects related to an initial design problem, to sort these ideas, and to make them relevant to the design problem at hand. The design problem that marked the start of this arc of work was in place before my investigation began. Because the DRL in Berlin is concerned with textile interfaces and wearable devices as a broader line of work, the problem of navigating with a wearable interface fits within this line. In the following, a brief narration will shed light on the brainstorming process and afterwards a conceptualisation follows.

At my second visit, the two designers performed a brainstorming method that appeared very familiar to K. As a participant observer, I sat at the table with K. and N. All three of us were holding black markers. K. explained the method while she unrolled a large sheet of white paper. At first we discussed anything which is typical for tourists, as the potential user groups for the navigation device. During and after the discussion, K. wrote down most of our ideas in keywords. A list of about 16 characteristics of tourists took shape. According to our vocalised perceptions, they included: being outdoors all day, seeing a lot, not speaking the local language, taking many pictures, carrying lots of equipment, showing up in groups, having to do everything on the move, and so forth. In the next step, K. chose seven of these characteristics and we began to seek other entities that share them. Again, we had many ideas; most of them were listed by K. who, unlike N. and me, constantly used her marker for writing. The second list of analogies covered people who spend a good deal of time outdoors: e.g. Eskimos, athletes, people in the Mediterranean region, and many more. Over the next two hours, seven lists emerged from our ideas and anecdotes – every single keyword in the list was related to one of the properties of tourists. Afterwards, we all chose about 25 of the conceived types of people from the seven lists as particularly promising. The chosen 25 were each written in the centre of extra sheets of paper. As a last common task, typical things and features of these chosen entities were noted. Sailors, for example, deal with containers, rum, knives, knots, compasses, and so forth. The afternoon's tasks ended with these various and somewhat curious collections of equipment and features. Following K.'s brainstorming method, we produced long lists of things that broadly relates to the properties of tourists.

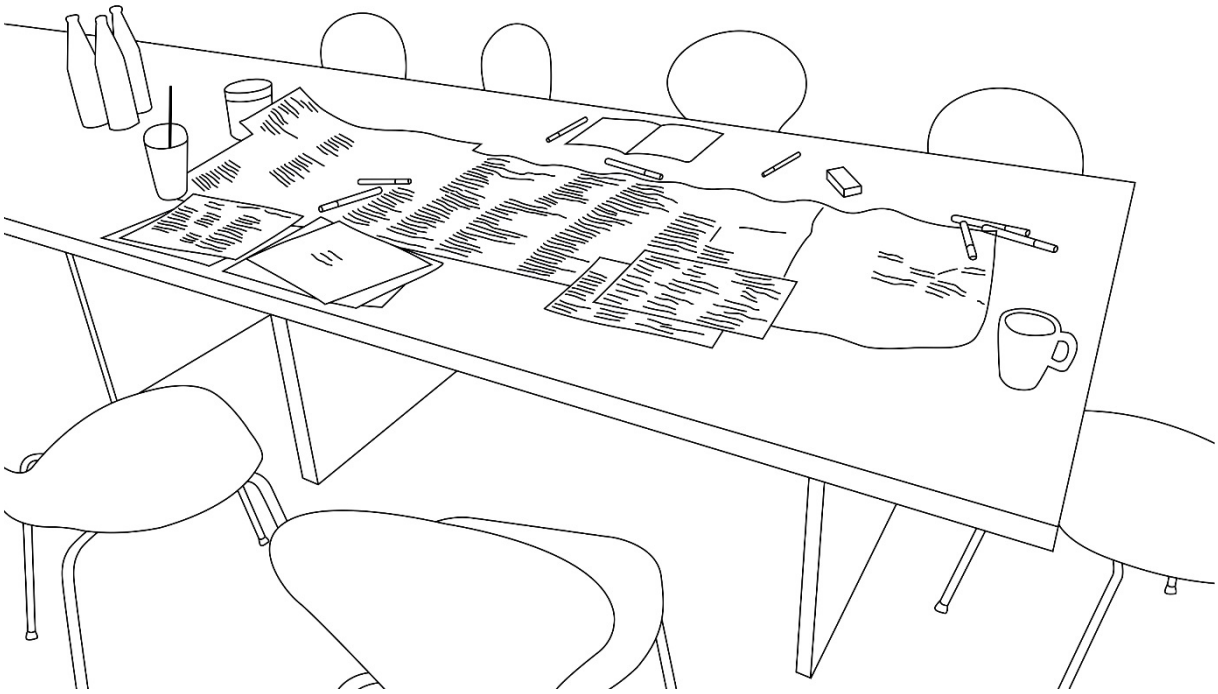

Figure 1: The wordy work of finding analogies

During the brainstorming process, all three of us spoke about many different situations, while K. decided whether to list a point or not. As this paper deals with the means of design, and not with decision making in projects or organisations, the decision-making process that occurred while brainstorming will not be addressed here. Instead, when working with uncertainty, the arc of design as a coordinating element composed of interactions and the means of design as the objects of interactions must be identified and related to one another.

At this very early point in the design process, there are still no sketches, models, or materials. Indeed, there is not much for the designers to work with except the initial problem as a reference point. Listing related objects is understood as an endeavour to generate and sort a field of related objects and users. By asking how these objects are used in what related practices, their uncertain relations become clearer. This helps the designer to comprehend a state of affairs. In other words, the designers tackle the uncertainty of an emerging field of objects and practices by sorting many existing examples that they relate to their problem. This is one segment in the arc of design; its actions address the uncertain relations between the recently generated collection of objects and make them more certain by linking them in different ways. The results of this session serve as a reference point later in the arc of design. Even more interesting is another question: what types of interaction are typical for this segment of the arc of design? Discussing,

writing, and ordering are generally performed in the realm of symbols, because spoken and written words, lists, and connecting lines are all symbolic entities. Written on paper with markers, these concrete trappings give the symbols form over time. As this session is one of the first of a larger process, it is fair to say that design in this context starts by predominantly working with symbolic means.

With regard to the means of design, the designers stayed in realm of symbols (written and spoken) to tackle uncertainties occurring at this point of the arc. As everyone was familiar with the function and meaning of these everyday objects, there was no need to test the physical properties of rum, containers, compasses, or other common objects. More precisely, the question of analogy here is about an analogy of meaning: which stuff makes sense for different but related people? The analogy does not concern analogies in design. Using symbolic entities is an advantage for the designers, because the exclusion of physical and material characteristics makes sorting and relating quicker and easier – technical details can be left aside. Subsequent tasks in this arc of design like the construction of models, as we will see later, are based on exploring physical properties. For spoken and written symbols as a means of design, we can sum up that symbols allow a quick and easy anticipation of all kind of objects and practices, no matter their material, construction, or technical function. This property of means is due to their symbolic character and does not come as a surprise, since symbols, by definition, are based on a common understanding that enables communication. Using primarily symbolic means frees the designers from the material constraints of the material constraints of the discussed objects. Written and spoken words make it possible for them to freely relate different meanings with relative ease. It is obvious, however, that K. needs to work with a pen and paper to organise all emerging relations. The uncertainty that is part of the navigation question is addressed by all the contributions, thus forming a short span in this arc of design; new elective affinities arose and therefore the question of how to navigate became a little bit less vague.

Facing this uncertainty is the major part in this segment of the designers' work. Uncertainty is also the starting point for their work, however, and at many occasions it becomes obvious that uncertainty is a product of their work, too. Questioning 'taken-for-granted' aspects of navigation is a necessary prerequisite to initiate and advance this and any other process of design. Without the ability to question normal functions and the resulting user and object relations, designing is impossible.

4.2 Sketching out future use scenarios

On entering the DRL some days later, I found the two designers in a seminar room. All tables had been placed in the middle of the room and covered with numerous photos. K. and N. were obviously enjoying their work of melting ideas from the pictured old objects into new concepts.

The task of the day was to transfer the aspects of the pictured objects into navigation, as K. explained. Because this task brings up many questions for me as a researcher, I carefully observe the two designers at work.

All sheets of paper on the table show one of 50 objects selected in the previously depicted brainstorming process. Besides each photo showing the objects, like sippy cups[11], bumper cars, rifles, dog whistles, and tents in situations of use, a brief list gives an overview of the individual object's properties, materials, design, users, and goals. K. and N. push the sheets around and sort them on the table. From time to time they scribble down a comic-like scene on paper in which a technology they just dreamt up is shown in use. While scribbling, they chat uninterruptedly about the pictured scenes and their own experiences with those objects. Again, everyone chimes in with amusing anecdotes about themselves or friends and families using – and sometimes cursing – the pictured items. These anecdotes seem trivial, but they are the raw material for the ongoing invention of new scenarios of use[12]. Unlike pictures, stories give insight into the details of practices intertwined with objects: as I start to chat with K. about a sippy cup shown in a picture and the interesting fact that infants always manage to keep the right side up with the opening pointing towards their mouth, she casually starts a new drawing: an infant holding a cup-like object in both hands is shown with the Berlin subway in the background. An arrow and a question mark symbolise the quest for orientation; K. describes the new object as leading visitors through the city, especially when decisions are necessary, for example, after finding the right subway line but accidentally taking the train going in the wrong direction. Or finding the right road but not knowing which way to turn. To sum up, the feature of orientation was extracted from the situation of drinking from a baby cup, magnified, re-contextualised, and then graphically visualised in a new situation, a situation where orientation is demanded, at once a reference to the initial design problem. By isolating features of well-known objects and reassembling them in new ways, about 25 sketches for navigation devices were created. All these ideas emerged through different stories and situations of use. Stories, personal anecdotes, and experiences breathe life into these ideas but, more importantly, such stories contain the practices, including the intentions, problems, and benefits, that go with the use of every object. With regard to the initial design problem and its inherent uncertainty, it is obvious that the new situation of use is beginning to take form.

Visualisations in photos and later in sketches enable K. and N. to develop scenarios of use. If K. does not understand one of N.'s sketches, more words, stories, and pen strokes are mobilised to

[11] A sippy cup or sprout cup helps young children to drink, as the cup's cover is moulded into a short, thick drinking straw.

[12] In my research, the question of what was being designed or invented here was harder to answer than expected. In this case, one could say use scenarios are invented, while in the brainstorming session, relations and analogies were developed.

create a shared understanding or, as Mead would have it, a significant symbol which holds a shared meaning. Again, various interactions counteract the uncertainty that stems from the initial design problem, though types of interaction vary. This segment of the arc of design is filled with different means of design, as the objects of interaction are not only spoken and written words, but also the photos and sketches used to illustrate scenes of future use. From now on, these sketches can be referred to again at any point in this and other arcs of design.

Like in the first sequence, the designers work with symbolic means to deconstruct pictures and assemble new sketches. Compared to the brainstorming session, however, these graphics and visuals allow the designers to go into the details of practices of use. How an infant holds a cup is expressed precisely in a sketch but difficult to describe in words (that is, without gestures). The means of design used here are somewhat less abstract and anticipative because they relate more to the material form and properties than the spoken and written words from the first exemplary sequence. Referring to Mead's notion of objects, words as well as pictures are significant objects; the design work discussed here makes it possible to further differentiate significant symbols according to their properties.

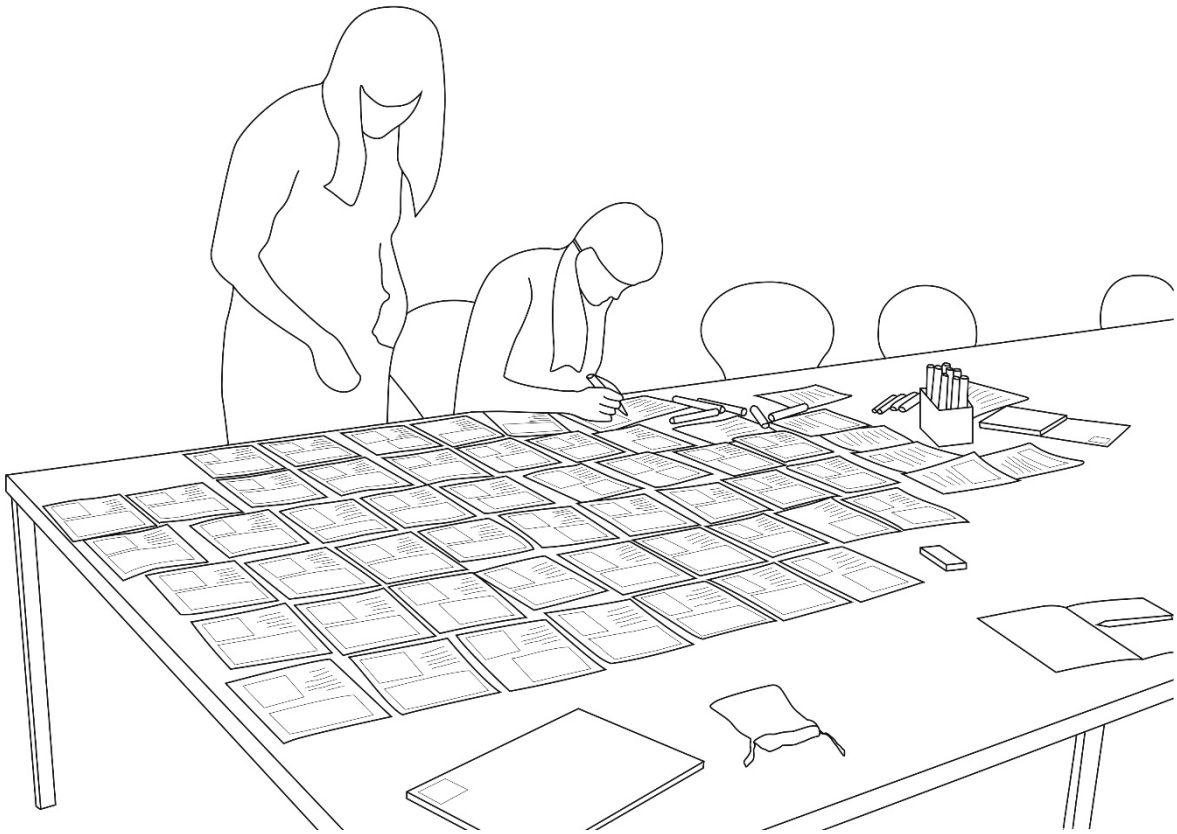

Figure 2: Disassembling and reassembling situations of use

While the pictures shown here are accompanied by countless words and descriptions, unlike words, they capture a complex situation in a brief, quick and accessible manner and are essential in research in general (Lynch 1988: 202). The observer understands the future use scenario created by K. and N. more quickly than any text-based description would allow. Because this notable property of visual means of design contrasts words and visuals, we can find that these two means share a different property: like in the first example, K. and N. are free of any material or functional constraints[13]. In this segment of the arc of work, the core activity is designing meaning for a future use by reassembling bits of old objects to form new ones. There is an important difference between symbols and objects or, as Mead would stress, distant objects and contact reality: a flying carpet or a T-shirt that changes its colour is easily drawn and its meaning understood, but realising contact reality, or a tangible product, is an entirely different task – often more elaborate than realising a draft. Far from adopting an easy approach by using pictures and sketches, working with means (here: different symbols) that permit creativity and meaningful and promising drafts seems to be an effective strategy for tackling uncertainty. Visual means therefore enable the designers to pursue the meaning of their drafts before having to deal with their material and functional properties. In my case, the designers tended to organise their work based on its meaning before moving on to technical design aspects.

4.3 From anticipation to testing

After further elaborating the ideas in the sketches, several were selected for further work; most efforts were directed at the idea of a colour-changing fabric as an indicator for orientation. Several weeks later, K. and N. had constructed two lines of functional models. The models were all variations of two basic technical solutions. The first electrical conductors and the second applied heat to induce a colour change. This colour change is intended to indicate an individual's position in relation to his or her group for example to create awareness of not getting lost on a sightseeing tour. The models differ in the electrical resistance of their circuits and in the chemical composition of the textile colours used for the models. For the draft discussed here, the designers anticipated the social meaning of a colour-changing sweatshirt on a sightseeing trip in detail and deemed it promising. Its technical implementation was discussed, drawn, and then even released to create an initial model. The actual sweatshirt that is created is based on experiences of the senior designer, on information from books and the Internet, as well as on discussions with colleagues. In the sophisticated modelling process, anticipation (of distant objects) is the starting point for every action, but contact reality with materials while

[13] Besides the constraints of pen and paper that can become highly relevant at times as Christian Kiesow pointed out for practices of visualisations in mathematics: "The visualization of an infinite number of real figures will always consist of a finite number of colored points, as every point takes a certain room. The inherent logics of mathematical structures cannot be materialised" (Kiesow 2013: 256 transl. by author).

working on the models complements this process and cannot be neglected. Colours, surfaces, and prints are not only anticipated, but of course seen and felt as the crafting process progresses. Hence, anticipation of distant objects and contact reality with different entities generally go hand in hand in the modelling phase. At this point in the arc of design, all components and technical links had been worked out, but the vital electrical function, the condition for the desired social meaning, had only been anticipated. In Mead's words, the circuits for colour-change remained a distant object existing only in anticipation – nevertheless the designers' work was organised with regard to the anticipation. The functional model is expected now to transfer this draft from an uncertain and anticipated reality to a concrete reality. A successful physical construction of these assumptions would reduce uncertainty significantly, as a new technology for navigation would take on a specific form. By looking in detail at a small segment of the arc of design here, I want to examine how N. and K. work to move their idea into the realm of concrete reality:

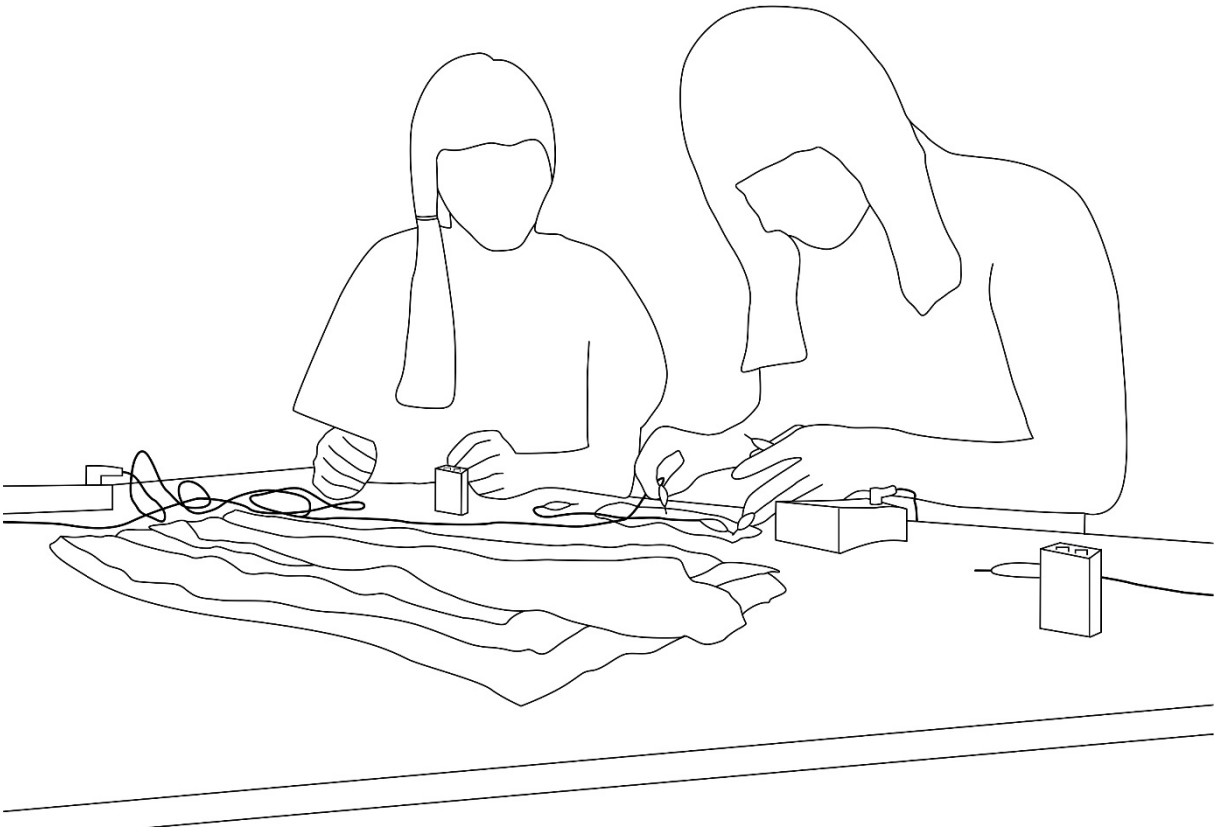

Figure 3: Approving anticipations

After several days of working in a silkscreen workshop, N., the assistant designer, returned to the DRL with about 20 technical models for the colour-change concept and minor electrical functions. Both designers immediately started to touch, feel, sort, and discuss the models.

Interactions between the designers and the objects remained free of any structured approach until K. took one of the models, placed it in front of them (Fig. 3), and began to measure the electrical resistance. For the measurements, she pressed the two contacts of a multimeter onto the textile while looking at the device display, changing the position of the contacts repeatedly before finally concluding that nothing was happening and that the electrical resistance was infinite. In other words: the circuit was non-functional; it had no electrical conductivity. These brief interactions in the form of measurements disproved the designers' assumptions about the model's electrical properties even though, as depicted above, this specific set of assumptions or anticipations of the models properties were discussed for two weeks and led to all the work of planning and producing the technical models. While the idea of electrical colour changes reduced the uncertainty related to wearables and navigation and endured numerous anticipations, the measurements and contact reality finally determined the quality of models. In this case, the arc of design came to an unexpected dead-end. The experiment clearly indicates that this effort to eliminate uncertainty does not work. K. and N. are confronted with an unexpected glitch in their arc of work; they have to find another solution, since it became very clear that this line of drafts was not heading in a fruitful direction.

Even though it seemed that a solution for the initial design problem was just around the corner, the designers' specific quest to increase certainty wound up doing the opposite. In the end, another type of navigation device was finally constructed after many hours of work. To understand design, it is essential to understand that the quest for certainty creates certainty *and* uncertainty, both intentional and unintentional. Many parts of this arc of design that aimed to create a navigation prototype ultimately served to uncover different sources of uncertainty instead of producing shared certainty that could withstand rigorous inspection. New uncertainty triggered the need for new plans and ideas to be worked out in the arc of design.

5. Conclusion: How to interact with right means at the right time

This study emphasises a particular perspective on design work and on work in general. Classical sociological literature identifies the structures, sometimes even 'iron cages', in which work is done. Organisations, then, are made of powerful structures (Weber 1978) or have to arrange themselves in structured fields of organisations (Hoffman 1999). Either way, powerful social constraints shape organisations and work. Newer studies, often based on rich ethnographic material, show that knowledge, coordination, and the flow of work are composed of situated actions and therefore kept running in action (Luff, Hindmarsch, Heath 2000 and Suchman et. al.

1999). This perspective is different as it views actions as situational and based on knowledge and meaning instead of social structures. Nevertheless, both concepts correspond in one elementary assumption: the social entities in question (organisation and work) are made purely of other social entities. Cause and consequence are entirely social. My intent in studying design work is to highlight other causes and means that are relevant in the social action of work.

The conceptual underpinnings of this study are formed by a simple assemblage of three pragmatist notions: work, organisation, and objects. Dewey's concept of ongoing practical endeavours to increase certainty forms the core of a notion of work in general and in design. Strauss's broad interactionist understanding of organising is useful to specify Dewey's universal assumptions with an organisational perspective. For Strauss, the countless interactions that make up work can be bundled into arcs of work; the specific efforts the designers take in the presented case are to be understood as arc of design. All project-based efforts to create a new object come together to form such an arc. Strauss helps us to understand that all of these actions in design are coordinated and organised towards achieving a common project goal. A third conceptual idea about objects formulated by Mead helps to understand and diversify the object of work. Like any social action, design relies on anticipating and experiencing social and material entities. In differentiating the material and symbolic properties of these entities, Meads notion allows a differentiated perspective, dividing interaction into an anticipative realm and a concrete realm which both contain the means that the designers use for their work.

This conception makes up the framework for a sociological understanding of design work. Implementing this framework may prove helpful to test and refine it. Considering the initial question of how to characterise work beyond the classical social constraints, the ethnographic data shows that design work is clustered around certain means. These means mark different types of interactions and are therefore highly relevant over the entire arc of design due to their benefits in the production of certainty. In the first example, the verbal and written analogies in their symbolic and anticipative form made it possible to create a web of similarities between various objects. Highly diverse objects and their users became relatives without ever having any one of them at hand. The criteria for these analogies were not made explicit. Spoken and written words as means of design provided enough certainty to elaborate lists and genealogical relationships. What is equally important: they also provided enough uncertainty to find quick and promising analogies without spending too much time or too many resources in debating the details. The second example also contained symbolic means of design, but in this case they were much more visual in their character. These visual means of design were processed in greater detail than the lists. While the lists from the first interaction sequence were used to record and sort well-known objects, with the pictures the designers could assemble new socio-technical situations from the stock gathered in the lists. In other words, as another means of design the

visuals allowed a far more detailed approach than the words in the first sequence. The designers were thus able to create something entirely new using this means. The second sequence shoes how the visualised objects were disassembled while highlighting some of their features, for example the orientation of the sippy cup. With pen and paper these objects could be disassembled and reassembled in new ways. Material and technical details were left aside (left uncertain), but the sketches and use scenarios helped work out various details of using the new designs. New ways to navigate the city became more certain. The third and last example examined the construction of several models whereas it became clear that models as means address different uncertainties in design work than visualisations. Various anticipations and visualisations of a colour-changeable textile materialised into technical models. Conductivity and other indispensable presuppositions were modelled in these new designs. After measuring these features and determined a lack of conductivity, this draft was scrapped. It did not make good on its promise. As means of design, the technical model helped to address and to work with this uncertainty.

Three short sequences cannot grasp design work as a social process in great detail, but the initial question of means of design and their capabilities can be answered. Words, visuals, and models addressed very different aspects of the overall uncertainty of design work. In this example, words as means allowed the boundaries of the field to be set. Visual means were capable of defining intersubjective perspectives on promising ideas. The models then, built to create certainty as to the crucial future product function, finally increased uncertainty again.[14]

This study does not permit a detailed picture of the social complexity of a design process as a whole. Quite the opposite, the social process of design work was reduced to the question of how different means were crucial for meeting different challenges in the course of the project. Aside from this, applying concepts enables a researcher to reflect on these cognitive tools: I briefly referenced Latour because his critique of a sociology that excludes questions of materiality (Latour 1992) is both very striking and very well-known. His ‘missing masses’ do not just condense the morals of a society in a physical form (Latour 1992: 227); they also demand that materials and other means be enacted and accounted for. In contrast to actor–network theory, interactionist social theory is equipped with established notions and concepts to delve into the details of all forms of interaction. Yet my simple framework that interweaves Dewey, Strauss, and Mead exhibited some shortcomings, too. Dewey can help us understand how actors grapple with uncertainty. Its crucial role in work, however, and attempts to use uncertainty as a resource seem to be common in design, but not in Dewey’s concept. Mead’s notions of anticipative and physical objects hold many insights for such an object-orientated field as

[14] One could point out that one option less gives more certainty, but I would stress that an infinite number of options minus one option still is infinite.

design. Nevertheless, his central notion of significant symbols would be even more helpful if different varieties of these symbols could be made more distinct. In my case, the difference between words and visuals should be reflected on in greater detail. Various activities that involve the rapid electronic processing and manipulation of words and visuals would also generally benefit from a differentiated understanding of symbols.

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