Published as:

Heylighen, A., Nijs, G. (2014). Designing in the absence of sight: Design cognition re-articulated. *Design Studies, 35*, 113-132.

Designing in the absence of sight:
Design cognition re-articulated

Ann Heylighen & Greg Nijs

KU Leuven, Dept. of Architecture, Research[x]Design

(accepted for publication in *Design Studies*)

Abstract. Starting from the study of an architect who designs in the absence of sight, we question to what extent prevailing notions of design may be complemented with alternative articulations. In doing so, we point at the cognitivist understanding of human cognition underlying design researchers' outspoken attention for 'visual thinking', and contrast this with more situated understandings of human cognition. The ontological and epistemological differences between both raise questions about how design research is produced, and consequently *what design can* also *be*. By accounting for how a blind architect re-articulates prevailing notions of design, we invite researchers to keep the discussion open and call for an ontological and epistemological re-articulation in design research.

Keywords: design cognition, design research, epistemology

Key to design ability is said to be a characteristic form of cognition, generally coined 'visual thinking': designers are notoriously visually aware and sensitive, and use models and codes heavily relying on graphic image. In designing architecture, for instance, the visual is so important that architecture students have been dubbed "the vis kids of architecture" (Goldschmidt 1994). Even authors arguing that 'visual thinking' in design is a philosophical construct which can be dispensed with, acknowledge that this does not undermine the significance of the visual dimension (Moore 2003).

Given the central role of 'visual thinking' in design, it is hard to imagine that someone can design in the absence of sight. Blindness seems at odds with the visual modes of thinking and communicating considered to be at the core of design ability. More so, designing might even seem *impossible* without sight given its heavy reliance on sketching.

Numerous studies on the role of sketching all have emphasized its inherent power as design aid. Some (*e.g.*, Suwa *et al.* 1997) have tried to further articulate why sketching is so

powerful and essential for crystallizing design ideas, by examining what information architects think of and read off from their own freehand sketches, and how they perceptually interact with and benefit from them. Overall, these studies conclude that "*[t]he key 'tool' to assist design cognition remains the traditional sketch. It seems to support and facilitate the uncertain, ambiguous and exploratory nature of conceptual design activity*" (Cross 2006).[i] Sketching is found to be tied-in closely with generating and exploring tentative concepts, and recognizing emergent features (*e.g.*, Goldschmidt 1991; Goel 1995; Cross 2006). Besides studies on traditional sketches, these findings also have triggered research on new computational technologies to advance sketch-based design tools (Yang & Burak Kara 2012).

In the absence of sight, making a sketch may still be possible to some extent, yet reading off information from it and recognizing emergent features in it is certainly not. Nevertheless, this article builds upon a study of an architect who continues designing after having lost his sight. His work offers an interesting opportunity to expand our understanding of design and design research. The fact that someone designs in the absence of sight raises questions as to what extent 'visual thinking' and its support by free-hand sketching—or other prevailing notions of design ability, for that matter—may be complemented with alternative articulations of design.

Therefore, this article starts by investigating where design researchers' outspoken attention for these aspects comes from, and indicates how it ties in with a particular, *c.q.*, cognitivist understanding of human cognition. Compared to other understandings, we point out, cognivitism comes with an ontological and epistemological disarticulation, which in turn raises questions as to how design research is being produced. Finally we present, by way of example, a study that allows for and enacts alternative design realities, by accounting for how a blind architect re-articulates, and makes us, researchers, re-articulate prevailing notions of design.

Traditionally, the word 'articulation' means 'the action of putting into words ideas or feelings'. For anthropologist of science and technology Bruno Latour, however, articulation is not so much a feature of human language, but rather an "ontological property of the universe" (1999:323). For Latour, "[a]n inarticulate subject is someone who whatever the other says or acts always feels, acts and says the same thing [...]. In contrast, an articulate subject is someone that learns to be affected by the others —*not by itself*" (2004:210, emphasis in original). He explains that "a subject only becomes interesting, deep, profound, worthwhile when it resonates with others, is effected, moved, put into motion by new entities whose differences are registered in new and unexpected ways." The decisive advantage of

articulation is that there is no end to it where there is an end to accuracy: whereas validation of the correspondence between a statement and the state of affairs is the end of the story, "articulation [...] does not expect accounts to *converge* into one single version that will *close* the discussion with a statement that would be nothing but a mere replication of the original." Transposed to this article, articulation thus does not expect to converge into a single version of what design *is* or what role 'visual thinking' plays therein. Instead, it keeps the discussion open as to what design *may* or *can* also be, by registering and accounting for unexpected differences in design practice. And that is precisely what this article invites design researchers to do.

To this end, we draw on science and technology studies (STS), and actor-network theory (ANT) more particularly. For over three decades now, STS has proven to be capable of informing a wide range of disciplines, domains and issues of study. Starting out with studies of science, mostly laboratory studies (Latour & Woolgar 1986), recently STS-inspired research moved to other sites of study, including engineering design (*e.g.*, Henderson 1991), architectural design (*e.g.*, Yaneva 2009) and product design (*e.g.*, Storni 2010). For our purposes, we draw on ANT for its low-normative epistemological basis, where researchers hold no a priori definitions, but explanations emerge and are accounted for from the actors and practices under study (Storni 2010; Yaneva 2009). We further make use of valuable insights offered by studies in cognitive science and cognitive anthropology (Suchman 2006; Hutchins 1995; Ingold 2000; Malafouris 2004), emphasizing situated and embodied practices.

1 Prevailing notions of design

In this article we are interested in why one might find it surprising that an architect continues designing in the absence of sight. In order to think about this, we first trace back where design researchers' outspoken attention for 'visual thinking' comes from, and what it comes with. In recent years, design research has been the subject of enquiry, both qualitative (*e.g.*, Cross 1982, 2007) and quantitative (*e.g.*, Chai & Xiao 2012). While we acknowledge the on-going theoretical, epistemological and methodological debates among design researchers, taking a closer look at these enquiries suggests that this outspoken attention resonates with a particular, *c.q.*, cognitivist, understanding of human cognition.

1.1 Borrowing from computer techniques

The emergence of design research is commonly associated with the launch of the design methods movement in the 1960s. Nigel Cross situates its origins further back "in the

application of novel, ‘scientific’ methods to the novel and pressing problems of the 2nd World War—from which came operational research and management decision-making techniques—and in the development of creativity techniques in the 1950s” (2007:1). These origins, combined with the beginnings of computer programs for problem solving in the 1960s, challenged the at that time prevailing notions of design. As Bruce Archer (1965) observed: “The most fundamental challenge to conventional ideas on design has been the growing advocacy of systematic methods of problem solving, borrowed from computer techniques and management theory, for the assessment of design problems and the development of design solutions.”

In the 1970s, however, design methods movement pioneers turned their back on this challenge. John Christopher Jones (1977:57) expressed his critique as follows:

> “I dislike the machine language the behaviourism, the
> continual attempt to fix the whole of life into a
> logical framework.”

These critiques resonated with evolutions in psychology, where behaviourism had raised the objection that, as a theory, it was incomplete: “the simple linkage of stimulus and response was considered insufficient to account for the knowledgeability of actors or the productivity of their actions” (Ingold 2000:165). Moreover, fundamental issues were raised by Horst Rittel and Melvin Webber (1973), who characterised design problems as “wicked”, profoundly un-amenable to the techniques of science. Rittel (1973) therefore suggested that, after the “first generation” of the 1960s, a new ‘second generation’ was emerging, moving away from the desire to ‘scientise’ design towards the ambition to understand design in its own terms (Cross 1982, 2007).

1.2 Computational theory of mind

The founding axiom of this ‘second generation’ was formulated by Bruce Archer: “Design has its own distinct things to know, ways of knowing them and ways of finding out about them” (RCA 1979), distinct from the commonly recognised scientific and scholarly ways of knowing. At the core of design, Archer situated the ‘language’ of ‘modelling’, equivalent to the ‘language’ of sciences (numeracy) and humanities (literacy). In an article entitled ‘Designerly ways of knowing’, Nigel Cross advanced this axiom as the ‘touch-stone theory’ around which the ‘research programme’ he called for would build “a ‘defensive’ network of related theories, ideas and knowledge”: “We need more research and enquiry: first into the designerly ways of knowing; second into the scope, limits and nature of innate cognitive

abilities relevant to design; and third into the ways of enhancing and developing these abilities through education" (1982:226).

Cross' article was published as part of a series aiming at establishing the theoretical bases for treating design as a coherent discipline of study. In the next decades, the second generation's contributions to this discipline would strongly resonate with developments in cognitive science, which meanwhile had emerged alongside the development of the digital computer, and promised a way out of behaviourism's incompleteness. The doctrinaire view within cognitive science is dubbed 'cognitivism' (Dreyfus 1992[1972]). Its founding axiom is "that people come to know what is 'out there' in the world by representing it in the mind, in the form of 'mental models'" which result from "a computational process working upon information received by the senses" (Ingold 2000:163). Epistemologically and methodologically, adopting this axiom implies a "focus on the individual cognizer in isolation from the "real world", which is studied most effectively with controlled laboratory research design (Osbeck 2009:17). Implicit in this view is thus a disarticulation between cognition on the one hand and body, environment, and real world problems on the other (Johnson & Rohrer 2007).

Cognitivism was quickly adopted by design researchers, especially in the form of Newell and Simon's (1972) Information Processing Theory (Goel 1995 gives an overview of studies from different design domains). This adoption, we argue, may explain at least in part design researchers' outspoken attention for 'visual thinking'. As anthropologist Tim Ingold (2000:15) points out, basic to the entire project of cognitivism is the Cartesian ontology, "an ontology that divorces the activity of the mind from that of the body in the world. Thus the body continues to be regarded as nothing more than an input device whose role is to receive information to be 'processed' by the mind, rather than playing any part in cognition itself." Although cognitivism's founding axiom suggests that, in principle, all sensory organs could receive information to be processed into 'mental models', in Western thought it is the eye that has been attributed the objectifying qualities deemed necessary for this task (Ingold 2000:253).

1.3 Cognitivism challenged

Over the past decades, however, cognitive science underwent important transformations. Criticisms on the individualistic framework and dualist implications of studying mind in isolation fuelled important work on the situated nature of cognition (Osbeck 2009:17), paving the way for an alternative paradigm in cognitive science. Understandings like situated

(Suchman 2006), embodied (Lakoff & Johnson 1999), or distributed cognition (Hutchins 1995) extend the models of the cognitive processes that characterize learning, memory and intelligence from the individual brain to the surrounding social and material environment. Unlike cognitivism, they articulate cognition, perception, action/activity, bodies, objects—without presenting unnecessary ontological or epistemological disjunctions.

Cognitivism was challenged primarily because of its presupposition stemming from Cartesian ontology that an internal/external split exists between mind, body, and world. This split implies a separation between the mind or cognition, and the experience one has of the surrounding world. Because of its alleged characteristics of distance and directionality, vision is associated with the former and, as such, often contrasted with hearing and touch, which are attributed subjective qualities because of their encompassing nature or proximity (Vermeersch 2013:12). Rather than a representational process in our head, however, perception is an embodied practice in which multiple perceptual systems interact. The alleged superiority of vision over other senses—in design research and beyond—should thus be understood not so much as that of one sense over another, but as that of cognition over sensation (Ingold 2000:255) that comes with adopting a cognitivist view of human cognition.

The proponents of a situated understanding, by contrast, consider cognition as anchored in our sensory-motor and bodily engagement with the world, and as such refute the ontological internal/external split. As cognitive anthropologist Lambros Malafouris writes: "The relationship between the world and human cognition is not one of abstract representation or some other form of action at a distance but one of *ontological inseparability*. That is, what we have traditionally construed as an active or passive but always clearly separated external stimulus for setting an internal mechanism into motion, may be after all a *continuous part* of the machinery itself" (2004:58; emphasis added).

As early as in 1896, philosopher John Dewey (1896) already criticized "disjointed psychology" because it fails to see "the unity of activity." Instead of disconnected existences, sensation, idea, and motor response are to be considered as interdependent terms of a single coordinative action complex. A similar sound can be heard with William James (1907[1975]), Dewey's pragmatist contemporary. James warns for treating knowing—*i.e.*, the relation that connects an idea with reality—as 'saltatory'. If an account of cognition denies the worldly object one is trying to know and the experiential intermediaries that brings one closer to knowing the object—*i.e.*, *jumps* from object to idea by abstracting one from the other—it risks an 'epistemological chasm': "The relation between idea and object, thus made abstract and saltatory, is thenceforth opposed, as being more essential and previous, to its own

ambulatory self […] The bridge of intermediaries, actual or possible, which in every real case is what carries and defines the knowing, gets treated as an episodic complication which need not even potentially be there" (*ibid*.: 248). James therefore suggests to treat knowing as an 'ambulatory' relation, "*made* by the ambulation through the intervening experiences" (*ibid*.:246). It may be convenient to talk about cognition's results (*i.e.*, ideas about an object gained through intervening experiences) only in abstract terms, "[b]ut if, not merely passively ignoring the intermediaries, you actively deny them to be even potential requisites for the results you are so struck by," he warns, "your epistemology goes to irremediable smash" (*ibid*.:249).

Rather than a rupture between mind, body, and world, cognitivism's opponents argue, there is ontological inseparability and epistemological continuity. Here Latour's notion of articulation can help to further the point. Instead of taking for granted and continuing the Cartesian internal/external split between mind, body and world, it may be more adequate to look (and account) for the intermediaries that actually make the knowing: it may be interesting to account articulations, in which "articulation takes the place left vacant by the dichotomy between the object and the subject or between the exterior world and the mind" (Latour 1999:323).

If cognition is not fundamentally cut off from perception and action (*i.e.*, the body), nor from the world, it cannot be considered to be isolated in (or isolable to) the individual human mind. On the contrary, it is always situated in a socio-material environment, inhabited by other co-implied participants, the material artefacts engaged and the physical structure of the space wherein the situation takes place (Suchman 2006). Moreover, cognition is distributed in that its properties are not that of an individual mind, but that of a group, which is often involved with sense making, striving for shared meaning in and subsequently manipulating representational artefacts (Hutchins 1995; Henderson 1991).

In design contexts, these representational artefacts may be exemplified by sketches and drawings, but also by physical or digital models, renderings, photographs, diagrams, graphs, data sheets, *etc*. Objects, in this view, play a role in the emergence, development, working, and transfer of individual and collective cognition—as scaffold, support, resource, *etc*. In on-going courses of action, they can get endowed with agency, performing a mediating rather than intermediary role: "A mediator can transform, translate, distort, and modify meaning; it is unpredictable and cannot serve as a reification of the social like many faithful and predictable intermediaries; a mediator can constitute, recreate and modify the social relationships established by design" (Yaneva 2009:118). Representational artefacts in design

often can be said to be mediators. We can think of sketches as “epistemic objects” acquiring an agential role as they embed or inscribe knowledge, but also unfold in uncharted directions (Ewenstein & Whyte 2009); diagrams as “phenomenological agents within the cognitive process” that create or subvert meaning and provide linkages between symbolic fields (Knoespel 2002), or foam models that act as “quick design cognition” making designers “think in the moment of cutting instead of anticipating in advance” whereby “a lot of unexpected events occur” (Yaneva 2009:27).

1.4 Implications for design research

In further clarifying the implications for design research of understanding human cognition in a cognitivist versus situated way, we rely on a recent study which investigated the core themes, evolution and future trends in this field (Chai & Xiao 2011). Through a bibliometric analysis of citations of *Design Studies* articles, the authors identified a list of core literature in design research for three time periods (1996-2000, 2001-2005, 2006-2010). Three “top publications” are highly cited across all three periods (Schön 1983; Goel 1995; Goldschmidt 1991).

Interestingly, the oldest “top publication” resonates with a situated understanding of human cognition. One year after Cross’ article, Donald Schön (1983) publishes a study of a desk ‘crit’—a conversation between a design tutor and architecture student. The right study at the right time, so it seems, as it explicitly challenges the positivist doctrine underlying much of the first generation’s work, which yielded disappointing results so far, and offers a constructivist paradigm instead. Based on his observations of the desk ‘crit’, Schön comments that, through sketches, “[the designer] shapes the situation, in accordance with his initial appreciation of it; the situation ‘talks back’, and he responds to the backtalk” (1983:79). He demonstrates that the language of designing is made up of drawing and talking, and that the non-verbal and verbal dimensions are closely connected. In his analysis, Schön studies the practice of thinking *and* doing (instead of disconnecting mind and body), and acknowledges the mediating role of objects in this practice. By introducing the notion of “backtalk”, he underlines that objects play more than an intermediary role: they add something to designers’ thought processes, and even have the capacity to transform them. Moreover, he shows an outspoken attention for the situation in which the design process unfolds, *c.q.*, a design studio.

In another “top publication” Gabriela Goldschmidt (1991) investigates what kind of reasoning is represented by free-hand sketching in architectural design. To this end, she relies on data collected by asking designers to “think aloud” while sketching, making recordings

and transcribing these. Analysis of the transcripts and sketches makes Goldschmidt conclude that, at least in architectural design, "the inherently creative process of form-production […] seems to result from a special systematic, causal relationship between two modalities of visual reasoning, induced by sketching," *i.e.*, "seeing as" and "seeing that" (1991:140). Compared to Schön's study, Goldschmidt's resonates more with a cognitivist understanding of human cognition, in its rather narrow, de-contextualised focus (Ball & Omerod 2000:148) on the cognitive mechanisms introduced by free-hand sketching.

The same holds true for Chai and Xiao's (2011) third "top publication". Vinod Goel (1995:xi) starts by criticizing the computational theory of mind for its inability to accommodate imprecise, ambiguous, fluid, amorphous, indeterminate thoughts. Yet, because "it is the only game in town" (1995:xii), he does not question this theory as such, but rather the properties of the mental representations it is committed to. His resolution, therefore, is not to articulate human cognition in an alternative way, but to go as far with the computational theory of mind as possible, and reconstruct the notions of computation and representation such that they do justice to the full range of human symbolic activity. To this end, Goel focuses on variables like the type of problem that is being tackled (*c.q.*, ill-structured and well-structured), and relies on single-subject "think aloud" protocol studies, both resonating with a cognitivist understanding of human cognition.

This cognitivist mode of understanding, it can be argued, actually comes with an ontological and epistemological disarticulation. Compared to Schön's study, studies like Goldschmidt's or Goel's disjoint or disarticulate the agent under study from the full-blown design situation and the aspects it is made up of. That is, they disarticulate designers from their own bodies (or their *multi*sensory embodiment), their richly structured environment, other agents present in the design situation, and, to some extent, the mediation of the objects they use. And it is this cognitivist stance which, as we have argued, may help to explain design researchers' outspoken attention for 'visual thinking'.

2 Challenging the "hinterland" of design research

Tracing back where prevailing notions of design come from, and what they come with, in turn raises questions about how design research is (being) produced. Design researchers' outspoken attention for 'visual thinking' and its support by free-hand sketching is but one example of how the nature of design is stabilized in particular models, and not others. As demonstrated above, in the past decades, considerable effort has been put into empirically nailing down how designers work, leading to statements about what design reality is. This

should not be too problematic as long as these statements are not presented as independent from the methods used to 'discover' them, as neutral reports on the objective reality 'out there'. Because, as sociologist John Law (2004:143) reminds us: "Method is not […] a more or less successful set of procedures for reporting on a given reality. Rather it is performative. It helps to produce realities."

If method is performative, then different methods will bring into being different (design) realities. Yet the more a particular set of methods is used, *c.q.*, those supporting and utilizing prevailing notions of design, the more a certain design reality is produced. While making this and not that reality, other realities are *un*-made, up to the point that they may seem unreasonable, invalid, not significant, or worse, unthinkable.

Revealing in this respect is the study of scientific practices (Latour & Woolgar 1986), and the lessons Law draws from it in terms of methods and the realities they describe, or rather produce. In this context, Law introduces the notion of "hinterland". In scientific practice, he points out, statements are not made in a vacuum: "if a statement is to last it needs to draw on—and perhaps contribute to—an appropriate hinterland" (2004:28). The "hinterland" of a scientific statement consists of other related statements, but also a network of inscription devices, *i.e.*, technologies, instruments or other sets of arrangements for labelling, naming and counting. Since such apparatuses are already in place, Law points out, scientific reality is relatively stable.

Within design research, the most cited research method is protocol analysis (Chai & Xiao 2011). In trying to gain information about the course of designers' cognitive processes, researchers use this experimental technique in order to "probe the subjects' internal states by verbal methods" (Ericsson & Simon 1984:1). Although it is claimed that verbal protocol data can be collected *in situ* without interfering with task performance, design researchers typically use it to understand single-person cognition in socially impoverished environments, rather than multi-agent cognition in full-blown people-rich environments (Ball & Ormerod 2000:148). To start with, concurrent verbalization has been demonstrated to handle some aspects of design thinking effectively, but to fail in eliciting others, such as perception and insight (Lloyd *et al*. 1995). Moreover, we would argue, using it in such a laboratory-style way isolates designers from the contingencies of the real world design situation and the other agents present in it.

Certain consequences follow, which are relevant in the context of this article. First, if the apparatuses in place—the "hinterland"—produce more or less stable realities and statements about those realities, this implies that countless other realities are being *un-made* at

the same time, other realities "that are not, so to speak, real, that would indeed have been so if the apparatus of reality-production had been very slightly different" (Law 2004:33-34). Furthermore, Law points out, "the hinterland produces certain *classes* of realities and reality-statements—but not others. (…) Some classes of [reality-]possibilities are made thinkable and real. Some are made less thinkable and less real. And yet others are rendered completely unthinkable and completely unreal" (2004:34, original emphasis).

This, then, may help explain why we might find it surprising, even unthinkable that an architect designs in the absence of sight. One could say that statements about 'visual thinking' being key to design ability, and the sketch being the key 'tool' to assist design thinking, have become unqualified, have stabilised. They are part and parcel of design researchers' "hinterland" today.

Furthermore, studies of scientific practices suggest that it is easier and cheaper for design researchers to create new statements by building on to these unqualified statements, than to bring into being other, alternative realities. This is not to say that statements about 'visual thinking' in design or its support by free-hand sketching are wrong: "[t]o say that something has been 'constructed' along the way is not to deny that it is real" (Law 2004:39). The point we want to make is that these statements—and any other unqualified, stabilized statements about design for that matter —enable and constrain any work in design research: they set limits to conditions of design research possibility, to what design *can be*.

3 Re-articulating design by designing in the absence of sight

By way of example, we now turn to our study of a blind architect, which triggered the questions addressed in this article in the first place. This study makes the effort to account for and enact other, alternative design realities. And by doing so, makes risky accounts of what design can (also) be, risking our questions to be requalified by the human and nonhuman entities under study.[ii]

After studying architecture, and working with architects like Aires Mateus, Gonçalo Byrne, Toni Geser and Renzo Piano, Carlos Mourão Pereira established his own firm and started teaching in an architecture school. Eight years later, he lost his sight and since then maintains his professional activity, in architectural practice, teaching and research. The work he designed after losing his sight has been the subject of international exhibitions and publications (*e.g.*, Lowther & Schultz 2008).

We study Pereira's work based on a focused ethnography (Knoblauch 2005), which combines personal conversations and more formal audio-taped interviews—with Pereira and

his co-workers; document and artefact analysis; and video-recordings of his embodied interactions with different spaces, and with architecture students while reviewing their design work.

When asked how he works since having lost his sight, Pereira responds that his way of working is not different, but also very different from before. Major differences relate to the designer's "conversation with the material design situation" (Schön 1992); in case of architecture, this includes both the building site and representations of the designed building.

3.1 Documenting the building site

Across the board, architects tend to photograph the building site in order to have references to work with during design. Pereira and his co-workers do so too, but use the pictures taken on site in variously altered ways. When pictures are discussed at the office, their content is not conveyed in a direct perceptual manner, since Pereira has no sensory (*i.e.*, visual) access to their iconic properties. Instead their intelligibility is accomplished interactionally: rather than direct visual access, Pereira gets an indexical translation of what is in the picture through his co-workers' descriptions. Moreover, these descriptions tend to exceed the usual, visual apprehension of a building site. The co-workers pay explicit attention to tactile qualities present in the picture and, even in describing visual qualities, try to evoke the site's embodied experience. As one co-worker explains: "I try to describe the images the best I can. I don't describe them as 2-D compositions, but I try to put Carlos inside the picture". In more conventional discussions of building site pictures, this embodied nature of visual apprehension on site may be taken for granted.

Besides pictures, Pereira and his co-workers take along additional aspects of the site that correspond to other, non-visual sensory modalities. Often these seem to belong to other, non-visual, or non-representational epistemologies, witness Pereira's transportation and use of sound/acoustic qualities and of shape/tactile qualities of building site details.

Pereira's co-workers make audio-recordings of the site that he can listen to at his office. For sound, he points out, changes a lot: "a market place at 4 pm is completely different from one at 3 pm." These audio recordings can play a determining role in the design process, as illustrated by Pereira's design of a river bathing facility. Originally, he had imagined locating the facility very near to the falls, where users would have a good view of them and feel the water drops. Yet, eventually, he decided to change the location. Listening to tapes recorded at different distances from the falls, he realized that users would be unable to

comfortably engage in a conversation; the falls' sound would become too noisy. Whence the decision to locate the facility further away, at the appropriate *auditory* distance, so that *both* view and soundscape would coincide in a pleasant user experience.

Interesting to note when accounting this practice, is that the site first gets known in a non-visual (*c.q.*, auditory) way, that this knowledge is transported within its own sensory idiom (through audio-recordings rather than visual representations of the site's auditory qualities), and that this non-visual knowledge through the mediation of non-visual technology also serves to assess qualities of the design proposal differently (based primarily on auditory distance instead of Euclidean distance) and ground design decisions in this knowledge. In short, this practice has all the necessary components to account it as a full-fledged epistemology. Moreover, this knowing, knowledge transfer, assessment and grounding of design decisions is done in combination with visual apprehension (for pictures were taken, and design decisions were also based on visual assessment), thus adding up into a composite epistemology, with both distinct ways of knowing, recording, assessing and decision-making working together towards a composed sensory user experience.

In addition to pictures and sound, Pereira also uses touch to document the building site. To take along building details (*e.g.*, door stills, the shape of a handrail, transitions between building elements), a co-worker used to make perspective drawings of them. As Pereira notes, however, "I see, but there is an error". Now he uses a simple lead wire instead: "I'm taking a sample of the building, not a drawing […]". By moulding with his fingers a lead wire over the building parts considered he takes "a sample of the building". Under his fingers, the wire traces whatever shape comes along, and translates the detail's 3-D material form literally into a full-scale 2-D section. He then puts the moulded wire into a cardboard folder, to transport it without deformation. Back at the office, the lead wired shape can be either copied onto paper through drawing or digitalized through scanning. Once in the computer, Pereira's colleagues can transform and manipulate the shape, *e.g.*, by scaling or editing it, or superposing it onto other shapes, thus enjoying the possibilities of optical consistency.

With this practice, too, Pereira shifts and re-articulates the relations between material world, sensory apprehension, knowledge representation and transportation, and eventually manipulation. There is a shift, first, from visual to tactile apprehension of a building detail, touching instead of looking at it; and, second, in the way this sensory apprehension (or knowledge acquired through it) becomes fixed in the 'technology' to transport it: not seeing-drawing-seeing leading up to a perspective drawing, but touching-moulding-touching leading up to a lead-wired building detail. Both the apprehension and its fixing, it can be argued,

reside within the performative realm, for touching corresponds to “pro imal knowledge”, which is performative rather than representational (Hetherington,2003). Thus, we can talk about a world-sensory-cognitive re-articulation, a non-representational one that is. Still, the re-articulation in Pereira’s practice is at least double: he manages to apprehend and fix tactile knowledge in a tactile way and through a tactile technology; and—by necessity or for collaborative ease—the non-visual representation is translated to more customary (*i.e.*, visual) design technologies and cognition (drawings or computer renderings), after which it can be manipulated further in this idiom. The tactile knowledge is translated and aligned literally ‘intact’ from one sensory and epistemological idiom into another, thereby re-articulating both idioms for their proper strengths in terms of (present-day) technological affordances.

3.2 Gesturing design ideas

What has also changed after losing his sight, Pereira mentions, is the way he communicates design ideas. The most important way for him, he contends, has become gesture.

The use of gesture is common in sighted practice, in design (*e.g.*, Visser & Maher 2011) as in other domains. In collaborative settings, human actors typically gather around representational artefacts, to which part of the collective cognition is delegated. As the gazes of different interlocutors in the discussion are relatively untraceable to one another, indexical gestures are used to point out what one is talking about. With deictic gestures, interlocutors single out a ‘current’ selection, situationally constructing a phenomenal field of scrutiny for the others to see. Other, more elaborate, gestures serve as representational gestures “to annotate the graphical model” (Becvar *et al*. 2008:128). Through these gestures, static representations are rendered dynamic (Becvar *et al.* 2008; Murphy 2005).

Pereira’s way of working further extends this gestural practice. When discussing a given design, he and his co-workers also use representational artefacts (*e.g.*, models in cardboard, clay or Lego) on which they point out things in their own way (*e.g.*, by pointing to or tracing lines together). At other times, Pereira forms his hands in a given shape, after which a co-worker points to aspects of the design on Pereira’s hand, or manipulates it as to change its shape. “It is very effective!”, it is contended. Although they already used gestures before Pereira got blind—as do most architects (*cf.* Murphy 2005)—“that was in a less conscious way”. Being more attentive to gestures (*i.e.*, through reflexive re-articulation), they also become more precise. The advantage is that Pereira’s hands are “very sensitive”. Moreover, a co-worker adds, the communication “is directly to the mind”, “it’s like physical expressions

of thoughts". The hands are versatile, multifigurational representational tools: "the hand can become anything! From a handrail to a construction site."

Although we would not go as far as to contend that the communication "is directly to the mind", we do acknowledge that this tactile, hand-to-hand engagement articulates perception, cognition and action differently. In performing these gestures Pereira and his co-workers both produce meaning and understand the meaning that is produced. They employ their bodies, *c.q.*, their hands, to find out about the design. Rather than only indexical in character, their gesturing thus can be considered *action as cognition* (Alač & Hutchins 2004).

3.3 Sketching revisited

Finally—and perhaps most interestingly in the context of this article—Pereira sought alternatives for the traditional sketch. In doing so, he puts the role of sketching in design into an entirely different perspective.

In the absence of sight, the free-hand pencil-and-paper sketch loses its power to communicate design ideas, with oneself and with co-workers. To Pereira it is perceptually inaccessible. In searching for alternatives, he first turned to what he calls "tactile sketches": when he draws with a sharply pointed pen on translucent onionskin paper, the traces become embossed and white, and thus discernible for both him (through touch) and his co-workers (white lines standing out against the translucent background) (Figure 1). This technique closely resembles traditional sketching, in that it supports "quick design cognition"(Yaneva 2009)—quickly testing design ideas and receiving external "backtalk" from the sketch—and acts as a "conscription device" (Henderson 1991)—allowing to inscribe and communicate design ideas non-verbally, in order to explain them to others, and annotate or change design content. However, this technique, according to Pereira, loosens the articulation between sensory and cognitive apprehension for him. When multiplying in an on-going discussion, the lines in the "tactile sketch" become far more difficult to recognize and remember for him. There is too much "informational clutter". Rather than lowering the cognitive load for those perceiving and manipulating the information it (re)presents, the sketch *augments* the cognitive load for him: Pereira has to *search* in the "tactile sketch" in order to find and recognize what they are talking about. Depicting ideas physically by way of inscription on paper may be the first cognitive function of a sketch, but immediately recognizing content and being able to remember it are as indispensable for representational artefacts if they are to work. If sketching has the advantage to quickly produce immediately recognisable graphic information, here it passes its purpose. For Pereira, cognition and perception get poorly articulated.

Pereira continued looking for an alternative to sketching, and soon discovered another mode of representation that re-articulates his perception and cognition of the depicted information. By cutting the forms and design ideas under discussion with scissors out of 1mm cardboard, he started making "cardboard sketches" (Figure 2). Pen-and-paper got replaced by scissors-and-cardboard, drawing by cutting. Rather than starting from sketching, rooted in visual practice, Pereira reworks model making into a drawing technique. In doing this, he re-articulates both a technique of representation—by voicing another possible 'utterance' of model making (*i.e.*, for it to become a drawing technique instead), and the representational-cognitive functions it can serve—bearing the advantages of the haptic[iii] qualities cardboard models can afford. Indeed, as representational resources, the "cardboard sketches" share an important cognitive feature with traditional cardboard models: they are manipulatable haptically. Their spatial outlines (unlike the flat drawn outlines of traditional or "tactile" sketches), and their possibility to be held up in—or between—both hands (allowing to be rotated around different spatial axes), afford another cognitive grasp than their visual and tactile counterparts. Compared to the latter two, they rely less on visual cognition (although still affording it to co-workers) than on spatial cognition. Moreover, the haptic "backtalk" (Schön 1983), with the possibility of active manipulation, not only articulates perception and cognition differently—for sensory-motor couplings get activated in an embodied way, there is also an active engagement between the designer as manipulator and the representational artefact manipulated, *i.e.*, the interaction has additional performative virtues (Jacucci & Wagner 2007).

As re-articulation of design this can count. Many design studies are motivated by what are considered sketches' strengths: unqualified statements like "The key 'tool' to assist design cognition remains the traditional sketch" (Cross 2006:92) seem to have stabilized to the extent that many design researchers take them for granted and draw upon them. Pereira's search for alternatives to sketching that work in the absence of sight, however, suggests that these statements may not hold in all or as many situations as assumed. In this respect, his use of "tactile" and "cardboard sketches" introduces a threefold re-articulation of design. First, Pereira's use of other senses than vision to interact with his "sketches" reminds us that the essence of non-verbal media in design is their ability to temporarily fix an idea and "talk back" (Schön 1983), and, at the same time, demonstrates that this temporary fixation and "backtalk" (*ibid.*) may occur through other senses than vision (Heylighen 2011). Second, it extends the focus of attention in design research from the more-or-less stabilized traditional sketches to other mediating objects that can support the uncertain, ambiguous and exploratory

nature of conceptual design activity. Third, it re-articulates cognition and perception, instead of converging them into the notion of 'visual thinking'. Through this threefold re-articulation, Pereira's work opens the door for a whole range of articulations of design that used to be less thinkable before.

4 Conclusion

Building upon the study of a blind architect, we questioned why we might find it surprising, even unthinkable that someone designs in the absence of sight, and we traced back where the outspoken attention for 'visual thinking' and its support by sketching in design research comes from. This attention, so it seems, has to be understood in the context of the research programme to "build a network of arguments and evidence for these 'designerly ways of knowing'" (Cross 2006:v), and ties in with a cognitivist understanding of human cognition. Statements about the importance of these aspects—and that of other aspects of design, for that matter—seem to have achieved relative stability in the sense that they have become part of the "hinterland" in design research, in other words, that it is much easier or costs less effort to create new statements that build upon them than to create alternative ones.

In reflecting upon this attempt, we called in Law's work to show that questions can be raised about current methods in design research (as in other research fields). "Current methods," Law argues, "have many strengths, but they are also blinkered. (…) they both presuppose and enact a specific set of metaphysical assumptions—assumptions that can and (or so I suggest) should be eroded" (2004:251). But what does this mean in practice—the practice of design research? According to Law, "[t]he answer, of course, is that there *is* no single answer. There *could* be no single answer. And, indeed, it is also that the ability to pose the question is at least as important as any particular answers we might come up with" (2004:251).

Rather than trying to come up with particular answers, we presented by way of example a study that made the effort to account for and enact alternative design realities. In presenting this effort, we invite design researchers to keep the "network of arguments and evidence" (Cross 2006:v) 'open', *e.g.*, by complementing a cognitivist stance with a more situated one, rather than pursuing a singular, unambiguous way to nail down what design is. An invitation that applies to the "network of arguments and evidence" (*ibid.*) built upon in this article as well. Not everyone may be willing to accept the invitation. However, if we are to enrich our understanding of design, and be more articulate about its nature, it seems at least worth the effort.

Acknowledgements

This study has received funding from the European Research Council under the European Community's Seventh Framework Programme (FP7/2007e2013)/ERC grant agreement n_ 201673, and from the KU Leuven Research Fund. We would like to thank Megan Strickfaden and Peter-Willem Vermeersch for their share in the data collection, and Catherine Elsen for her comments on an earlier version of this article. Last but not least, we would like to thank Carlos Mourão Pereira for his time, enthusiasm, patience and honesty.

Figure captions

Fig. 1 'Tactile sketch' on onionskin paper © Carlos Mourão Pereira

Fig. 2 'Cardboard sketch' cut out of 1mm cardboard © Carlos Mourão Pereira

References

Alač, M., Hutchins, E. (2004). I See What You Are Saying. *Journal of Cognition and Culture* 4(3-4):629-661.

Archer, L.B. (1965). *Systematic Method for Designer*. London: The Design Council; cited in (Cross 2007).

Athavankar, U. (1997). Mental Imagery as a Design Tool. *Cybernetics and Systems* 28(1): 25-42.

Ball, L.J., Ormerod, T.C. (2000). Putting ethnography to work. *IJHCS* 53:147-168.

Becvar, A. *et al*. (2008). Representational Gestures as Cognitive Artifacts for Developing Theories in a Scientific Laboratory. In Ackerman, M.S. et al. (eds.) *Resources, Co-Evolution and Artifacts* (pp.117-143). London: Springer.

Bilda, Z., Gero J.S., Purcell, T. (2006). To sketch or not to sketch? *Design Studies* 27 (5): 587-613.

Chai, K.-H., & Xiao, X. (2012). Understanding design research. *Design Studies* 33:24-43.

Cross, N. (1982). Designerly Ways of Knowing. *Design Studies* 3(4):221-227.

Cross, N. (2006). *Designerly Ways of Knowing*. London: Springer-Verlag.

Cross, N. (2007). Forty years of design research. *Design Studies* 28:1-4.

Dewey, J. (1896) The reflex arc concept in psychology. *The Psychological Review* III(4):357-370

Donovan, J. *et al.* (2011) Getting the point. *AIEDAM* 25(3):221-235.

Dreyfus, H. (1992[[1]1972]). *What computers still can't do.* Cambridge: MIT Press; cited in (Osbeck 2009).

Ericsson, K.A., Simon, H. (1984). Protocol Analysis. London: MIT Press.

Ewenstein, B. & Whyte, J. (2009) Knowledge Practices in Design. *Organization Studies* 30(01):07-30

French, S. (1992) Simulation Exercises in Disability Awareness Training, *Disability, Handicap & Society* 7(3):257-266.

Goel, V. (1995). *Sketches of thought*. Cambridge: MIT Press.

Goldschmidt, G. (1991). The dialectics of sketching. *Creativity research journal* 4:123-143.

Goldschmidt, G. (1994). On visual design thinking. *Design Studies* 15(2):158-174.

Henderson, K. (1991) Flexible Sketches and Inflexible Data Bases. *STHV* 16:448-473.

Hetherington, K. (2003). Spatial textures. *Environment and Planning A* 35:1933-1944.

Heylighen, A. (2011). Studying the unthinkable designer: designing in the absence of sight. In J. Gero (Ed.), Design computing and cognition DCC'10 (pp. 23-34).

Hutchins, E. (1995) *Cognition in the Wild*. Cambridge: MIT Press.

Ingold, T. (2000) *The Perception of the Environment*. New York: Routledge.

Jacucci, G., Wagner, I. (2007) Performative Roles of Materiality for Collective Creativity. *C&C'07*, Washington, DC

James, W. (1907[[1]1975]) *Pragmatism* and *The Meaning of Truth*. Cambridge: HUP.

Johnson, M., Rohrer, T. (2007) We Are Live Creatures. In J. Zlatev *et al.* (Eds.), *Body, Language, and Mind*, vol.1 (pp.17-54). Berlin: Mouton de Guyter.

Jones, J.C. (1977). How my thoughts about design methods have changed during the years. *Design Methods and Theories* 11(1):48-62.

Knoblauch, H. (2005), Focused Ethnography. *Forum* 6(3):art.44.

Knoespel, K.J. (2002) Diagrammatic Transformation of Architectural Space. *Philosophica* 70:11-36.

Lakoff, G., Johnson, M. (1999) *Philosophy in the Flesh*. New York: Basic Books

Latour, B. (1999) *Pandora's Hope*. Cambridge: HUP.

Latour, B. (2004). How to talk about the body? *Body & Society* 10(2-3):205-229.

Latour, B., Woolgar, S. (1986). *Laboratory life*. Princeton: PUP.

Law, J. (2004). *After Method.* London: Routledge.

Lloyd, P., Lawson, B., Scott, P. (1995). Can concurrent verbalization reveal design cognition? *Design Studies* 16:237-259.

Loomis, J.M., Lederman, S.J. (1986). Tactual perception. In K.R. Boff *et al.* (Eds.), *Handbook of perception and human performance*, vol.2 (pp.31.1-31.41). New York: John Wiley.

Lowther, C., Schultz, S. (Eds.) (2008). *Beachlife*. Amsterdam: Frame.

Malafouris, L. (2004) The Cognitive Basis of Material Engagement. In E. DeMarrais *et al.* (Eds.), *Rethinking Materiality* (pp.53-62). Cambridge: McDonald Institute for Archeological Research.

Moore, K. (2003). Overlooking the visual. *The Journal of Architecture* 8:25-40.

Murphy, K.M. (2005). Collaborative imagining. *Semiotica*, 156(1/4):113-145.

Newell, A., Simon, H.A. (1972). *Human problem solving*. Englewood Cliffs: Prentice Hall.

Osbeck, L.M. (2009). Transformations in Cognitive Science, *Journal of Theoretical and Philosophical Psychology* 29(1):16–33.

RCA (1979) *Design in General Education*. London: Department of Design Research, RCA; cited in (Cross 1982).

Rittel, H. (1973) The state of the art in design methods, *Design Research and Methods* 7(2):143-147; cited in (Cross 2007).

Rittel, H.W.J., Webber, M.M. (1973) Dilemmas in a General Theory of Planning, *Policy Sciences* 4(2):155-169.

Schön, D.A. (1983). *The Reflective Practitioner*. New York: Basic Books.

Schön, D.A. (1992). Designing as reflective conversation with the materials of a design situation. *Knowledge-Based Systems* 5(1):3-14.

Storni, C. (2010) Unpacking Design Practices. *STHV* 37(1):88-123.

Suchman, L. (2006) *Human-Machine Reconfigurations. 2nd Edition*. Cambridge: CUP

Suwa, M., Tversky, B. (1997). What do architects and students perceive in their design sketches? *Design Studies* 18(4):385-403.

Vermeersch, P.W. (2013). *Less Vision, More Senses*. PhD Dissertation, Leuven: KU Leuven.

Verstijnen, I.M. et al. (1998). Creative discovery in imagery and perception. *Acta Psychologica* 99(2):177-200.

Visser, W., Maher, M.L. (2011) The role of gesture in designing. *AIEDAM* 25(3):213-220.

Yaneva, A. (2009).*The Making of a Building.* Oxford: Peter Lang.

Yang, M., Burak Kara, L. (2012). Sketching and pen-based design interaction. *AIEDAM* 26:241-243.

[i] Exceptions to this rule are studies which suggest that sketching is unnecessary for certain design aspects or stages, based on comparisons between "imagery-alone and externalization conditions" (Verstijnen *et al.* 1998) or blindfolding designers (Athavankar 1997; Bilda *et al*. 2006). However, these studies are rare, as compared with studies that confirm the key role of sketching in design. Moreover, simulation exercises like blindfolding turn out to fail in simulating impairment correctly, as they address neither the coping strategies nor the skills disabled people develop (French 1992).

[ii] For a full discussion of a new normative touchstone in research that corresponds to articulate epistemology, see (Latour 2004).

[iii] Haptic perception is defined as a combination of tactile and kinaesthetic perception (Loomis & Lederman 1986). The former is mediated by variations in cutaneous stimulation, providing information through receptors in the skin about *e.g.*, temperature, roughness or texture; the latter is mediated by variations in kinaesthetic stimulation, informing about dynamic and static body posture by the relative positioning of head, torso and limbs.

Figure 1

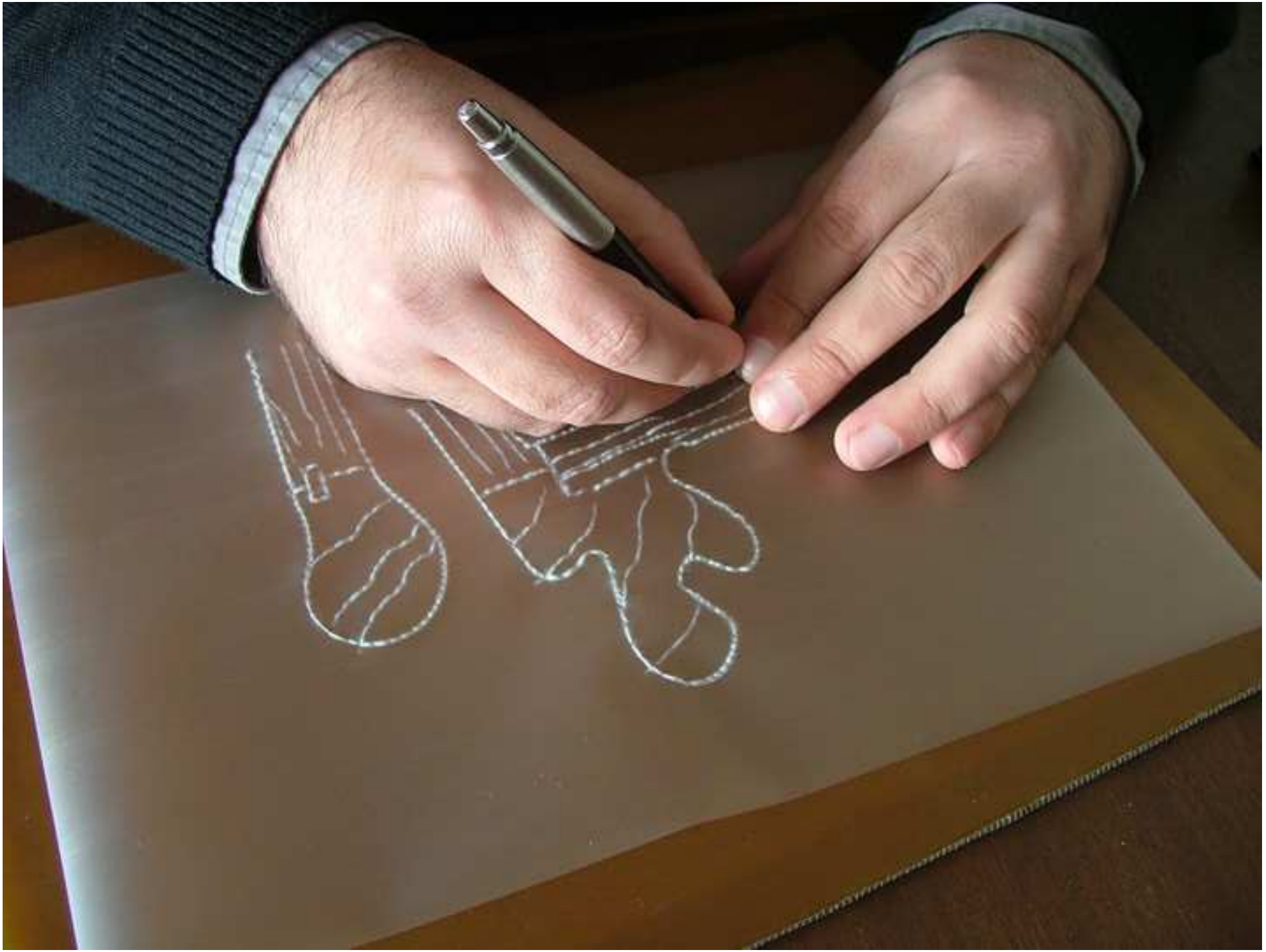

Figure 2