Perspectives On The Role Of The Body In The Design Process.

Observations From An Experiment.
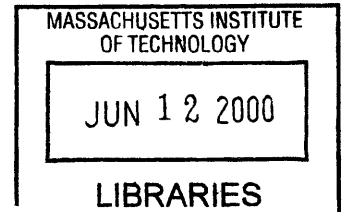
by

Patrick P. Charles

Architecte Diplomé Par Le Gouvernement, 1990
Ecole d'Architecture de Nancy, France

Submitted to the Department of Architecture
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Signature of Author: _____

Department of Architecture
May 18, 2000

Certified by: _____

William L. Porter
Norman B. and Muriel Leventhal Professor of Architecture and Planning
Thesis Supervisor

Accepted by: _____

Roy Strickland
Principal Research Scientist in Architecture
Chairman, Department Committee on Graduate Students

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Observations From An Experiment.

Thesis Reader: Edith Ackermann
Title: Visiting Professor

Thesis Reader: Whitman Richards
Title: Professor, Department of Brain and Cognitive Science.

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Abstract:

This thesis explores the role of the body in the design process. Its underlying assumptions are that there is
bodily thinking in the design process, and that observing what designers draw, tell and do/gesture, can tell
us something of the design process at large. A design-task-based experiment involving three student-
designers was run. The analysis of the data (video, sketches and transcripts) of the trials shows that the
activity of design is grounded in part by our bodily existence, and in our power of acting and perceiving.
The thesis presents the hypothesis that the hand itself imposes certain limitations. It also presents examples
of interworking of the body and the mind in design activities like measuring and dimensioning, framing the
problem verbally, and engaging the artifact through the actual environment.
The thesis insists on the idea that our body is at the interface between the world and our multimodal self. It
is through the body that we construct external representations (embodied in drawings or gestures) that are
essential to the design thinking process. The conclusion considers how these observations should impact
design inquiry undertakings, in particular the necessity of fostering a more global view that includes the
role played by the body in the design process/thinking.

Thesis Supervisor: William L. Porter
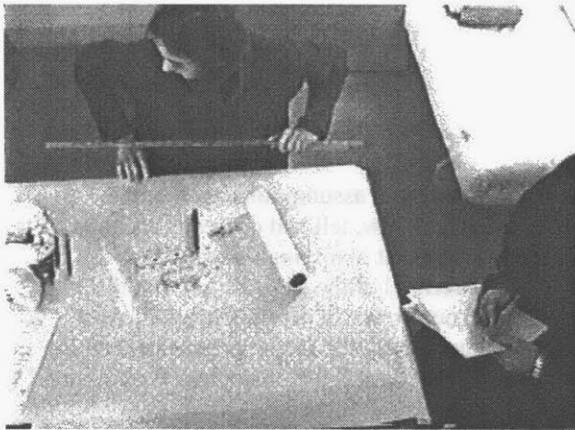Title: Norman B. and Muriel Leventhal Professor of Architecture and Planning

Fig.1   at 11min.45s.   Fig.2   at 49min.09s

Forewords

Comments on the two images.

A key to the question of the role of the body in the design process?

Two images taken from a trial of the experiment I have run are placed side by side. They depict a designer at work: one early in the design session, the other, toward the end of the session. The two images are not identical although in both cases, the designer is measuring with a folded yardstick. But the gestures are not the same. And very likely, the reasons underlying the bodily posture/the gesture in each image are also not exactly the same. Nonetheless, these reasons (that I will explain later in this thesis), are close enough, in my interpretation, to justify this pairing.

For me, what significantly distinguishes these two pictures is the way in which the designer takes the measure. In the first one, the designer measures herself, her "elbow room", egocentrically, from her central axis, holding the yardstick in one hand: the yardstick is placed in the designer's coordinate frame.
In the second one, the yardstick is placed on the table, and the designer measures how much space she would 'fit in' sitting at the table: the designer places herself in the (table+yardstick) coordinate frame.

In my view, the position of the folded yardstick and the way the design is related to it makes a serious difference and indeed a reversal:
the first image shows **THE BODY SHAPES THE DESIGN** while the
second image shows **THE DESIGN SHAPES THE BODY**.

In my interpretation, this reversal is a key to understanding the design process. The design process is about the progessive –but not linear—constitution of a design, which first receives and absorbs information and later radiates its coherence and imposes its own rules. I think that the bodily postures in these two images reveal this reversal.

This "body shapes the design/the design shapes the body" example is placed here because, in one way or another, each section in this thesis will refer to it --more or less directly-- or to what it represents: the transformation/integration process from aggregation to cohesion that takes place during the design process.
In addition to providing this document with a connecting thread/ a unifying element, it will also, by bringing us back to the interpretation of a particular case, counterbalance the generality of certain assertions or conclusions.

Acknowledgements

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Introduction

This thesis is directly interested in the design process(es) (its dynamic). It approaches it by taking a path that, to my knowledge, has been little followed, and which consists of investigating the role of the body in the design process. More precisely, the actual question of this study is: what does investigating the role of the body in the design process tell us (or suggest to us) of the design process?

The central **hypothesis** is that design thinking and the design process draw heavily on bodily thinking. Bodily thinking designates here thinking through one's acting or sensing body. The underlying **assumption** in this thesis is that it is possible to gain a greater knowledge of the design process by observing simultaneously what designers draw, tell and do/gesture.

Overall, the broad region of concern of this study is situated somewhere between design process, bodily thinking/body cognition and thinking.
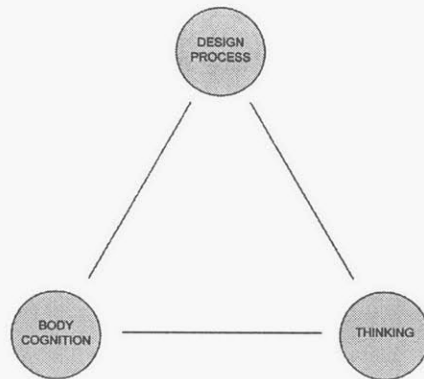
Fig.3: Telling the role of the body in the design process.

My **interest** in this question originated in my broader concern with exploring avenues of the design process in architecture. Perhaps my interest also originated into my taking of the term "move" very literally, and displacing the widely used term in the design studies/design inquiry literature from its ground in the game theory.[1] My interest was also "excited" by my limited exposure to puzzling accounts in cognitive science.[2] But above all, this study is a **designer's inquiry** into driving forces of the design process as designers practice it. To observe how designers use or rely on their body while designing or more generally to investigate how the body and the mind come together in the design process, I formulated an experiment.

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[1] From [Schön, 1988], through [Habraken, 1987] to [Goldschmidt, 1989], the concept of 'move' plays a founding role in current accounts of the design process.

[2] For example, regarding how motor and conceptual capabilities interact: the theory of the two visual pathways (see note in section "Gestural routines" in part B) according to which the making of a drawing suggests an interesting interworking of the 2 pathways? Or other example, regarding arithmetic counting, the demonstration that precise counting and approximate counting call upon different capabilities -embodied into different centers in the brain— associated with verbal and visual capabilities respectively. See [Dehaene, 1999].

This experiment (45min.long,+/- 15min), in which 3 graduate students took part, consisted of a design task requesting subjects to design a dinning table accommodating 10-12 persons in an friendly atmosphere. The protocols that were followed were slightly modified after each trial in order to improve it.

The assumption underlying the experiment was that by studying relatively novice designers, more of the overt behavior of the interworking of bodily and conceptual levels of design thinking would be observable.

The data collected consists of video recordings, sketches, and transcripts of the verbalizations. This method enables one to pays particular attention to aspects of the design process that are usually absent in the analyses of design based on studies of sketches only.

Complementary to this data, other documents of an interpretative nature have been produced: a narrative of the session based on an interpretation of its design phases, a synopsis of the session, and in the case of the third trial, a diagram depicting the design session.

The outcomes of the trials are documented in the Appendix.

The approach in this research has consisted first of running the experiment, and then analyzing the outcome of the trials in order to have a sense of what were the main design phases in each session.[3] This initial global understanding of the design process was a necessary step in order to be able to replace/situate the observed manifestations of the body in their context and, beyond, to hypothesize on its role in the design process. In a sense, the presence of the foreword section is meant to contrast with the "step by step"/"what is the immediate next move" approach often used in the analysis, which runs the risk of 'finding' a necessity of each step in the preceding one.

The thesis is organized in three parts: 'Gestures', 'Hand, Line, Sketch, Overlay', and 'Grounded'.

- 'Gestures' lists at a large-scale level of observation the actions designers do during the sessions. By doing so, it provides a glimpse into the density and difficulty of the question.
- 'Hand, Line, Sketch, Overlay' observes the 'traces' (the drawings) left by the hand and reflects on them by considering certain constraints on drawing brought by the 'bodily machinery' itself.
- 'Grounded' is concerned with the act of designing at large and attempts to articulate specific moments observed during the sessions with larger hypotheses regarding the process of design. These moments are: engaging the artifact through the actual environment or one's repertoire, measuring and dimensioning, and framing and revisiting the problem verbally.

'Hand' sometimes gives the feeling that the hand is driving itself alone. In contrast in 'Grounded', there is a designer that drives the hand.

---

[3] Trial #3 received more attention than the two others because of its protocol including a pre-design verbalization session.

ADDING TO A DRAWING
WHILE VERBALIZING

ADDING TO A DRAWING
WHILE NOT VERBALIZING

TRACING ON
THE TABLE

USING A TOOL
(SCALE DRAWING)

LISTENING

CALCULATING

CORRECTING

TALKING

REINFORCING LINES

DRAWING

INCLINING HEAD

LEANING OVER DRAWING

GESTURES
(MOVEMENTS
GESTURES
ACTIONS)

GESTURING WHILE DRAWING

JOINING HANDS

MOVING LEGS

GESTURING WHILE NOT DRAWING

STANDING UP

LEANING
BACKWARDS

DEFINING VISUAL
BOUNDARY

FLATTENING TRACE
RAISING TRACE

HOLDING
AN OBJECT

TOUCHING
SOMETHING

WRITING
NOTING

FOLDING/UNFOLDING

FOR ITS TACTILE
FEEDBACK

HOLDING

OVERLAYING

GRASPING TRACE

ADJUSTING

IN RELATION TO
THE PAPER

CUTTING A PIECE
OF DRAWING

PLACING TRACE
ON THE FLOOR

MEASURING

CLEARING TABLE

ORGANIZING
WORKING SPACE

MEASURING

MEASURING WITH
A TOOL/ ONE'S BODY

LISTENING, TALKING,LAUGHING

IN RELATION TO
THE DRAWING

FREEZING
ONE'S
MOVEMENT

USING A PEN
TO SEE AN AXIS

NOT IN RELATION
TO THE PAPER

LOOKING AT
THE TABLE

SILENT
TRACES

POINTING AT
SOMETHING

LOOKING IN
THE DSITANCE

POINTING AT
SOMETHING,
POSITION OF HAND
INDICATING
ATTENTION
POINT

SHOWING
TO ONESELF

PLAYING
WITH PEN,
WITH ROLL

USING
TOOLS
(FOLDED
YARDSTICK)

FOCUSING
ATTENTION

TOUCH ONE'S FACE
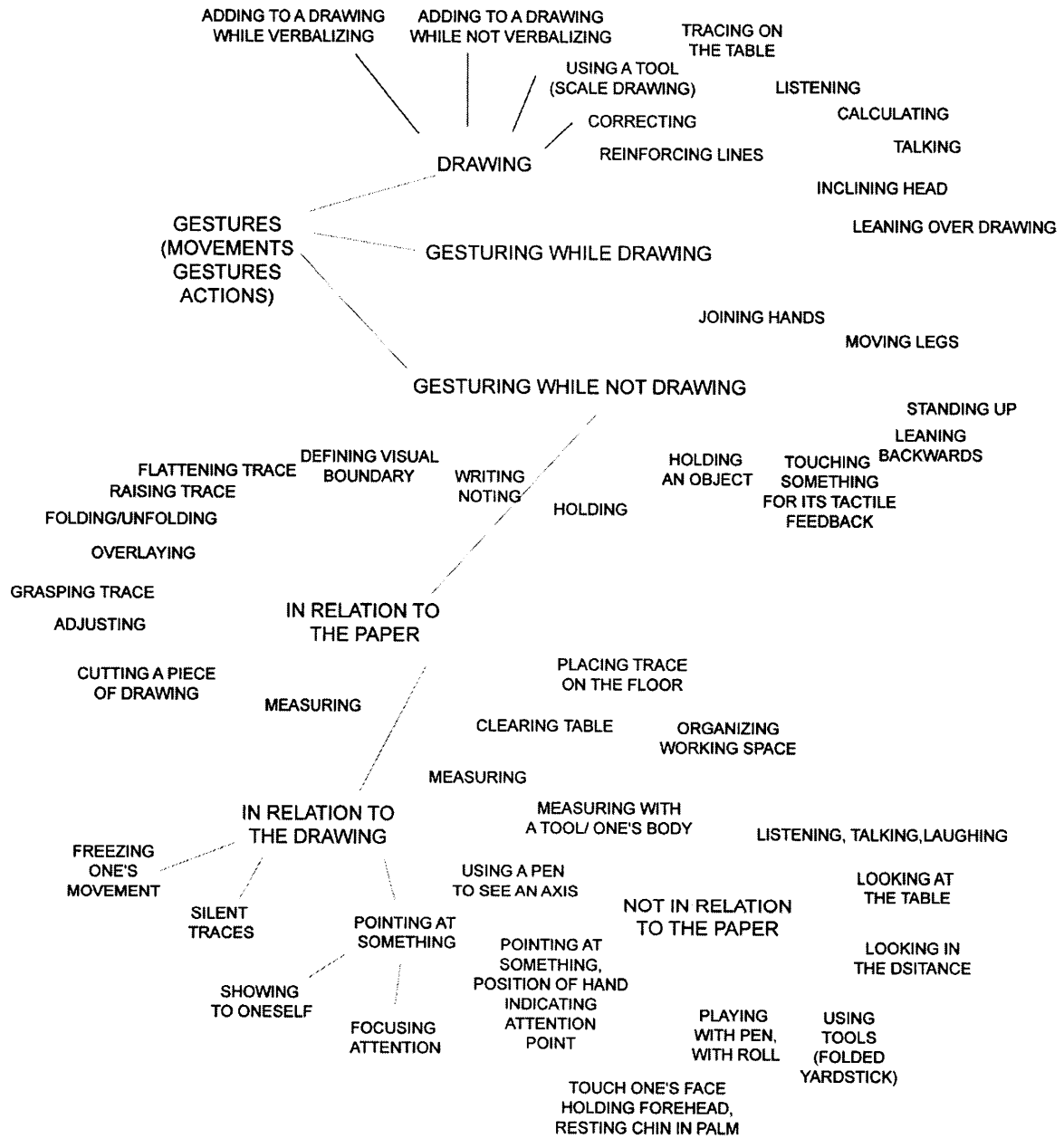HOLDING FOREHEAD,
RESTING CHIN IN PALM

Fig.4 : Tentative map of gestures, movements and actions observed in the trials.

Part A: Gestures

In the forewords, in the "body shapes the design/the design shapes the body" example, at first glance, the action seems to be the same: measuring oneself. i claim that this appearance is deceiving, that beyond it is a different level of engagement of the body with the thinking. The question of what is observed is then set.

A study interested in investigating the role of the body in the design process, must pay some attention to the **gestures** that take place along the design process, that is, in the experimental setting of this study, during the design session. 'Gestures' is used here in a very broad sense that covers movements, gestures,[4] actions and even bodily postures.

Observing designers behave, draw, gesture, etc, provides a wealth of data of great density. If one attempts to answer the question of what gestures were observable during the trials, one would certainly start listing different types of gestures one could recall after viewing the videos of the trials, and perhaps, one would start grouping them and organizing them graphically in a diagrammatic/tree- like form. Fig. 4 on the opposite page provides this sort of first approximation, a 'tree'/space of the different instances of gestures. Equivalently, the listing presented at the end of this part is beginning to look consistently at different groups of gesture observed during the sessions.

But both documents raise several problems. A first problem regards the scale of observation

Both are of course tentative; the placement of many instances of gestures on the 'tree' remains questionable and would deserve additional study. That is why the tree' is branchless, and is only a spatial arrangement based on proximity to labels/...

One of the **problems** raised by this sort of representation concerns actually the **validity** of the **categorization** of entries. For example, to label a node "voluntary gestures" might not provide a clear boundary!

In my opinion, to assume that the gestures observable along the process of design are significant of/signify 'something' of the design process does not mean that gestures are the 'words' or 'propositions' of a language of gestures of the design process. Of course, during the session certain gestures are communicational events. They are oriented either towards the experimenter --who requested the subjects to think aloud—or towards the designer him/herself. "Communication" (to other or to self) could be the organizing factor/the line of divide between different gestures in another listing or diagram.

I am not aiming at delivering a definitive classification/categorization of gesture or a comprehensive list. This would be premature at this point. On the contrary, I will look at particular gestures almost independently, with no ambition of tying them together into one general system, but with the aim at relating them to the design process.

The fact that it is not easy to decipher what gestures are properly **communication** with **oneself** or with the **experimenter** might even not be a problem: both types of communication should be considered significant and valid for our observation. The communication with the experimenter is also part of a movement of 'explicitation'/externalization of the designer's thought that helps the designer to clarify his/her own ideas and questions and helps set the problem at hand in understandable terms for him/herself too.

From my **observation** of the 3 trials of this experiment, I can conclude that designers use gestures –in addition to the highly skilled gesture that drawing is -- f or various reasons and in various contexts. There are gestures taking place when engaging the medium –paper or trace--. There are gestures related to the engagement with the physical environment of the experiment. There are gestures that take place simultaneously with talking, with drawing.

The body is at the interface between the world and the mind: through the body, designers are enabled to act on the world and to receive feedback from it. My assumption is that designers think through their actions too; their actions help them to think. Sometimes though, they suspend/freeze their action –to interrupt the flow of feedback— to help them think. Therefore, the 'non-gesture' is another instance, in addition to the gesture, of how the mind and the body come together in the design process, and thus, is an important element to pay attention to.

A list of gestures observed in the 3 trials:

This is a tentative, non-comprehensive list, just one step beyond the degree zero of the observation/description: 'designers talk, draw and gesture.'

- Use of instruments/tools as extensions of our capabilities: examples
  - Using a pen for **marking** down (writing/drawing) for **external memory** purpose
  - Using a pen for **pointing** at something: to **focus attention** or to help **remember** where to look for information while attending somewhere else
  - Using a ruler or folded yardstick to obtain precise **measurement**
  - Using a folded yardstick to **visualize** the size of an object (tabletop)
  - Using an object -e.g. a cup- to **simulate** a situation
  - Marking down something while recollecting one's thought (help organize and "hierarchize" thought units) [5]
  - Using a piece of an overlay as a tool to study a variable (after cutting it)
- Use of the environment to provide feedback when evoking qualities
  - Gesture signifying horizontal continuity of the plane/surface of the table top (arm and hand horizontally)

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[4] In the [McNeill, 1992] sense, as accompanying narrative or conversation.

[5] For example in trial 3, at 44min 50s. while recalculating the size of the table, subject 3 draws three segments 'one at the end of the other' to accompany "ok, this was 35, this was 45, this was 50" and help make sure she is not missing a number.

- o Touching the paper table cloth of the desk to call up a tactile image
- o Evoking a color in association with a tactile image (gesture consisting of opposite fingers contact)
- o Gesture when evoking a quality of a material
- o Use of the environment to support projection of oneself in the design-as-it-would-be or to support a simulation. (calling upon reality)
  - o Placing one's hand horizontally above the desk for comparison in order to evaluate a new height.
  - o Comparing a dimension obtained by a calculation with an object in the environment (table)
- o Related to the paper/medium
  - o Cutting an overlay
  - o Folding tracing paper with one's hands to enable copying
  - o Flattening the tracing paper with one's hand to increase its transparency, (this is also used as preparation or concentration gesture, raise of the level of attention by sharpening the image.
  - o the converse, raising the tracing paper to read the sketch on the top overlay only (usually accompanied by a standing back movement from the torso, movement of appreciation/evaluation, with sometimes movements of the head lightly inclined to the left and to the right alternatively, verbalization is then often delayed until after this period of observation)
- o Related to working space organization
  - o Cutting, flattening, adjusting one sheet over another, etc, for organization
  - o Placing format on the table for consultation or on the floor for non-consultation (clearing the desk)
- o Related to what is inscribed on the paper
  - o Drawing
  - o Different ways of holding the pen
  - o Reinforcing lines already present on paper [to add to its visual weight, to reload it in memory, or to wait for a feedback]
  - o Following a path with the pen tip above drawing without actually tracing, (I call them the 'silent traces')
  - o Moving on from one drawing to another. Here there are many sub-cases depending on the context and the state of mind of the designer (satisfied or not with the state of the design or with the actual sketch)
    - Changing the mode of representation (plan, section, perspective/axonometric, calculation, written notes
    - Superimposing two schemes in one same sketch
    - Pursuing the investigation of the same idea in another drawing (vertical/horizontal move). (with or without overlay)
    - Investigating another alternative/idea (lateral move) because the previous sketch was either conclusive or unsatisfying (starting anew, recapitulating or using previous sketch as base)
    - Feeling that adding more to a particular sketch would weaken its current clarity
    -
  - o Looking ('blindly') in the distance in an effort to imagine something
- o Ways of placing one's body to engage with what is inscribed on the paper
  - o Placing one's head right above the format to limit the visual field to the sketches only for concentration/focus intensification purpose
  - o Looking from closer to gain a greater visual acuity
  - o
- o Related to the designer's attitude/postures
  - o Acting, simulating (elbow room, proximity with a neighbor, distance across table, height or length of something,) representing the shape of something at a scale that is suggestive
  - o Picking/choosing/changing pens and medium
  - o Varying one's sitting posture for comfort purpose, and other gesture (reordering one's hair, etc)
  - o Contemplating, standing back in an questioning attitude

- o listening to the experimenter and talking to him
- o Related to the designer narrative/explanation/description of his design
    - o Action: pass a plate, clean the surface, look at other people across the table, touch the material
    - o gesture to help the idea out while searching for a word.
        - o ...
- o ...

Again, one could think of an infinite number of way of grouping these gestures:

- based on communication (already mentioned)

- based on a **division by body parts** involved in what context.[6]

- based on purpose[7] : boundary making, emphasizing, indexing, vision 'modulating', marking, pointing, communicating, space handling, etc

- etc

No more than the 'tree' in fig.4 , does this listing of gestures provide a vivid image of how these gestures contribute to the design process. Therefore, alternative ways of describing/identifying the gestures should be investigated.

Later in this thesis, I will give a more precise account of certain operations of the design process that involve several of these gestures along with the production of verbalization and sketches. (Dimensioning, in the drawings, reinforcing lines, superimposing 2 schemes in one same sketch, using a piece of drawing as 'tool', etc).

BSD/DSB

> "The Body Shapes the Design/the Design Shapes the Body" example in the forewords is not only about measuring. It is of course also about the difference of gesture observable in the two images. But, what I want to point at here is that both gestures are held/suspended for an instant: to perform the action of measure requires to focus on it, to stop moving, to stop doing something else. Does that tell us something about gestures/actions/movements?
>
> This provides an illustration of the quasi-infinite unfolding of layers of possible description.

The next part looks at what seem to be the central/essential activity of the design process: drawing.

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[6] Obviously, the top part of the designer's body plays a large role in looking, drawing, measuring, contemplating,...but my assumption is that when the designer thinks of the leg room, his behavior explores the "feeling" of a leg
[7] see [McNeill, 1992] regarding such classification in the domain of language communication (iconic, beat, metaphoric, and deictic gestures).

PART B: Hand, Line, Sketch, Overlay

The traditional understanding in cognitive science regarding drawing in design is that drawings hold the function of a working memory embodied in images. Representations being primarily mental images, drawings are therefore external representations. In this text, my approach to external representations attempts to go beyond this traditional understanding by trying to answer the question: what role does the body play in the drawing activity? Because we draw with our hand, one aspect of this question is: what constraints on drawing come from the hand itself? What sort of limitations does the hand impose on the type of graphic representation used in the early design stages?

Hand,

Preliminary remarks on external representation (The role of drawing as)

A minimal definition of representation could be: something that stands for something else. With the following example: an ambassador represents a country, one can clearly understand that the two parts involved in the representation do not have the same nature. In the design context of the experiment, we see sketches made of lines and curves stand in a homothetic relation to a tabletop (its shape). An external representation, as exemplified by these sketches, is a representation that one can see, and thus appreciate or judge. By being externalized, it is placed in the position of being re-injected into (the loop of) our perceptual systems. It becomes then clear why designers do not design with internal representations only: because they do not possess certain qualities of external representations: for example, they do not last and are forgotten, they are not easy to communicate (verbally) to other people, they are not good at inscribing spatial relationships among objects.

> *In all trials, the co-presence on the paper of sketches and notes*
> *(writings) illustrates the role of working memory they both play.*

Designers draw to enable themselves to see what they have drawn.

Preliminary remarks on design, drawings, sketches and hand

First, it is important to notice that it is difficult to answer precisely the question: when does design start and when does drawing start? The trials are full of examples where a drawing is started, then left aside for a moment, then added to, then intertwined with another drawing, then... Obviously, there is a big difference between considering the "drawing-result" (something you can put in a frame) and the "drawing-action" (the tracing of the drawing and the thinking that comes with it: something far more difficult to isolate). For example, how do we classify the tentative movements -corresponding to lines or 'itineraries'- made above

the paper without actually leaving a trace on it?[8] These are really part of the "drawing-action" although they are not visible in the final "drawing-result".[9]

The second preliminary remark, is acknowledging that there are no clear boundaries between a drawing and a sketch besides the common admission that sketches are preparatory to drawings and that they are the kind of drawing that is frequently observed at the beginning of a design process, accompanying the ideation process.

If drawings and sketches are difficult to distinguish, they nonetheless have a point in common: they are the product of an action/gesture carried out by the hand (the arm, the shoulder, etc). Because the hand is this privileged vector of delivery of the external representations, it therefore makes sense to investigate how the hand might influence or constraint the production of external representation.

Gestural routine...

Hands are very precise instruments and when hands are used to draw, they usually are in the drawer's visual field, so the person can see what he/she draws. As important as it is in order to make sure that a line starts from the right location in the drawing, the vision of the pen tracing on the paper is apparently not necessary to draw simple shapes. To be convinced of this, one can repeat the little experiment that consists of drawing circles, squares, grids of various size, or even a simple perspective, with closed eyes to acknowledge that this is not difficult with the help of some imagination/mental visualization! This means that a reasonably trained designer's hand knows how to draw these simple shapes without paying attention to the drawing. In other words, there seems to be a certain kind of **gestural routine** in the activity of drawing that does not require full time on-line guidance by the visual system.[10]

Having provided this context, I will now present observations related to the experiment run in support of this study.

... and other routines (line tracing, eye placing, pen holding)

Although this would require a much more detailed account, overall, the sketches produced during the trials were very conventional, the graphic representation were homogeneous, mostly planar and respecting the rules of orthogonal projection (plans and sections only, rare examples of 3D in trial #3).[11] Each designer had his/her graphic code or mode of

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[8] I will come back to what I call the "silent traces" later on in section 03 of this document.

[9] Fortunately, the way the experiment has been set up in this study with both collection of sketches and video recording enabled collecting data at both levels (action and result).

[10] This remark regarding the necessity of an on-line control of the action of drawing by the visual system draws upon Goodale's development of the two visual pathways theory first formulated in a PhD Thesis, at MIT in 1966 by Schneider, studying hamsters. [Goodale, 1995] explains that the retinal/visual input follows two different pathways: one dedicated to visual recognition (of symbols, objects, faces) and another in charge of the control of motor action (like reaching, grasping or computing one's position in space while in movement).. The first system/pathway answers the question "**what** is what I see?" and is concerned with long-term viewpoint-independent and light-condition-independent representations. The second system/pathway works on-line/in real-time to 'guide'/coordinate movement and answers the question "**Where** is that thing and **How** do I interact with it?"

[11] See for example Pousin and Boudon on the categorization of the traces. [Boudon, 1988].

graphic representation and maintained it throughout the trial. [It would be interesting to investigate if that was a consequence of the nature of the design task and due to the fact that the design of the tabletop was perceived as a 2D problem.[12]]

Consistencies in the way designers drew lines in sketches were observable.

Subject 3 for example -right handed- draws all vertical lines from the top of the page to the bottom of the page (that is: going toward herself) and horizontal lines from left to right. Interestingly, this pattern of action reproduces the general movement of writing but more importantly, is it the one pattern that provides S3 with a good visual control over what she is doing.[13] Only when reinforcing existing lines does subject 3 traces equally in one direction or the other.

Unsurprisingly, the position adopted by the designers enabled a good vision of the sketching hand and the sketches: the triangle of hand-brain-eye is placed in an optimum condition. Sometimes the hand is placed to one side to allow a better appraisal of the drawing in its context.[14]

There were also observable consistencies in the way designers held their pen/pencil and placed their head according to the level of satisfaction or involvement with a particular option or to how demanding the drawing task was in terms of attention, precision, etc.

For example, when engaged in a more precision-demanding sketch, subject 3 1) held the pen closer to the tip and 2) placed her face closer to the sketch (reducing the average eye-tip of the pen distance by almost half)[for example while preparing the small scale drawing A2.10p]

Designers showed a changing level of attention/engagement to the sketch they were drawing. Sometimes they only drew and were very focussed; some other times they were more relaxed and talked and sketched at the same time. The degree to which designers were able to talk while sketching was not studied.[15]

Different ways of holding the pen or pencil of course generated different types/qualities of lines, on which I will not comment here.

Use of paper space,

Designers that took part in the experiment had general strategies of use of the **paper space** that overall favored visual comfort and therefore efficiency of the communication with oneself. Indeed, across trials, designers clearly used the format that would **facilitate** future **consultation** by for example, maintaining the direction of reading, that is, sketches respected a same **orientation**.[16] Additionally, because the format is

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[12] However, the second scheme of subject 1 started challenging this conception, by proposing a raised surface in the center. And, although the 2 schemes by subject 2 involved tables with different height.

[13] To be more precise, with this pattern, one can see what the hand has traced (from left to right). With the "vertical" movement, the masking effect by the hand plays is not so important. Noticeably, the pattern is not the same in the two directions ('vertical' and 'horizontal'), which suggests that optimum visual range is not the point here, but comfort or routine.

[14] I will not develop the idea here that the presence of the hand in the visual field perhaps provides a reference to appreciate the scale/size of the sketch and that, conversely, placing one's hand away from the drawing introduces a different way of perceiving the sketch.

[15] For example, a study could look at how one task might 'mask' the other.

[16] No 'frenetic' use of the paper space was observable across the 3 trials, perhaps due to the context of the experiment: limited time, drawings are kept afterwards by experimenter (therefore loosing their 'privacy'). Or, perhaps is it attributable to the nature of the phases (systematic, orderly exploration?), or simply designers' styles.

relatively large compared the size of the hand,[17] sketches tended to be drawn in the format that would leave the lower strip/part of the overlay empty for the **hand to move without masking** anything of its content.

> *In the case of subject3, not only is the lower part of the overlay reserved for hand movement, but also, the space left for use is actually -quasi consistently- organized. The top strip is often dedicated to particular sketches (describing the 'ideal') or calculation, leaving the central three- fifths of the horizontal format for the plans and sections of the tabletop and legs.*

Although it is difficult to actually evaluate the direct impact of such procedures/routines on the design, however, the impact is real, at least in terms of how the designer relates to the drawing: an 'object' that is fully integrated within his/her coordinate frame.

In "the Body Shapes the Design/the Design Shapes the Body" case, the use of space seems to be the same in the two images: a tabula rasa (at 49min09 the previously drawn overlays are placed on the floor to the subject's right to leave the table clear from past drawings). A closer look at the second image tells us two things. One, in this phase of synthesis, the new sketch (#A4.1p), is laid over a previous one (#A3.5p), and it shows a different way to relate to the drawing. Two, not only the body but also the tracing paper roll itself is now placed in the coordinate frame of the table, which shows, in my view, how the level of formation of the design at this point and its relation to the actual desk-table inform the way the subject organize her space and her relation to it

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[17] 12, 11 or 8.5 inches, depending on the cases.

The "easy size" hypothesis or how the size of drawings depends on the hand
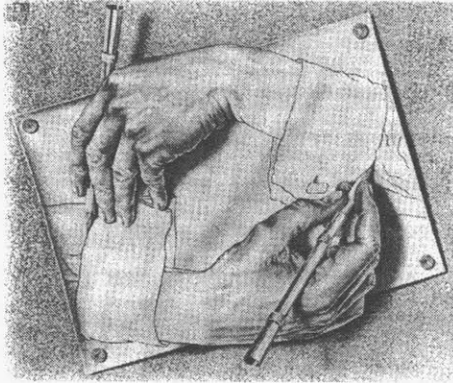

Fig. 5 M.C. Escher, "Drawing hands" (1948)

Cognitive "transparency"

During ideation phases, it is in the designer's interest to have the most fluid/seamless way of 'putting his ideas down on paper'; sketches seem to fulfill this role: they are flexible, they do not emphasize precision (which would be another constraint on the flow of ideas). [18] An idealized and necessarily simplifying way of putting it could be to say that sketches are cognitively "transparent" to a certain degree that enables the designer to concentrate on his project only.

This cognitive 'transparency' is nonetheless constrained by the hand: the 'transparency' operates within the range of comfort/confidence of the hand. One can argue that a well-trained hand will be more cognitively 'transparent', and therefore, will enable the designer to convey more of the substance of his/her ideas in a sketch. It seems that we are at a crucial point here, where hand and mind –both the idea and the motor control-- ideally are (to be) attuned as well as possible. This seems to be comparable to mastering an instrument.

The "easy size" hypothesis

Interestingly, across designers and trials of the experiment, the size of the sketches was quite consistent.

> *Subject 1 and 2 maintained exactly the same size throughout their design session because they were drawing by overlay, therefore always at the same scale. Subject 3 maintained a consistent size of sketches in the first part of the design. Later on, subject 3 sketched at different scales, thus providing a larger range of size of sketches (ratio 1:6).*

In this context, it is interesting to compare the size of the first sketch across trials and ask why were they so similar in size? I will leave aside the possible impact of the medium (paper format) and I argue that this similarity is related to the different types of gesture and the control over these gestures. From this view, a drawing made of lines traced by simple rotation of the wrist and collapse of the hand on itself is radically

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[18] Various studies have looked at why the 'undefinition'/'sketchiness' of sketches is a necessary ingredient of the preliminary design. See [Goel, 1995] among recent others.

different from a drawing made of lines traced by larger gestures involving the arm, shoulder and upper body.

The hypothesis here is that each designer's hand has an "easy size" of drawing: a size of drawing with which the hand is comfortable and with which the exchange between hand and mind while sketching is highly fluid. According to this hypothesis, the hand imposes direct constraints on the design. But one must conceive this constraint as not absolutely rigid: otherwise, how to account for the change in size of the drawings during the design session in trial #3? Part of the explanation could be the acquired gestural routine due to the greater familiarity with the form drawn repeatedly.[19] Part of the explanation is that a change in size requires the designers to engage a different activity: a reconstruction/regeneration of the drawing based on the consideration of what features from the previous sketches should be maintained.

> *I think that it is illustrative of this different nature of task, that during the first part of the design session, subject 3 drew different sketches, consistent in scale and size (without copying from one overlay onto the another) and that later on when she engage a phase of synthesis, she then started employing overlays to generate larger drawings.*

According to the 'easy size' hypothesis, one can assume different ways of approaching the making of sketches depending on their size: when this sketch is above 'easy size', the size limit within which the designer is confident, then the task demands that the designer approach it differently. At a gestural level, a greater concentration for greater motor control should be observable.

The "Body Shapes the Design/the Design Shapes the Body" situation provides the single case of the larger sketch observable across the 3 trials. (Sketch A3.5p overlaid in A4.1p in trial #3). Nonetheless, the size of the sketch can be interpreted as a result of the way of making the drawing, which consisted of folding the tracing paper into 4 parts, in order to symmetrically copy one-quarter of the shape of the tabletop. The resultant final sketch is twice as big in both directions as the initial one-quarter sketch. But the initial sketch itself – the ¼ shape—was still, interestingly, in the 'easy size' range observed across sketches before this one.

Obviously, generating a larger drawing is a response to the need to integrate more details into it in a readable way that a smaller drawing could not afford/provide. But my point is here to observe that the change in size corresponds to a change in the making and in the demand on the capabilities called upon to draw it: motor control, attention to certain structural features of the previous drawings, etc

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[19] A study by [Kirsh, 1995] on "complementary strategies" testing counting could perhaps support this argument. It shows that once the subjects of his counting experiment have adopted a counting strategy (like moving the coins or grouping them), they tend to maintain it even if the conditions of action/cognitive task have changed. The adaptation of a strategy does not follow a linear curve of change: there are plateaus in the use of these strategies that correspond to trade-offs and acceptability/relative efficiency in the operation performance.

Explaining the absence of overlapping of sketches with the "easy size" hypothesis

Overlapping is when two sketches overlap, 'collide'. Noticeably, there are no cases of overlapping sketches in any of the three trials.[20]

> *The fact might be interesting to investigate further, although it might seem anecdotal at first. As already mentioned, when drawing a sketch Subject 3 followed the pattern of writing (left-right, top-down) but her successive placement of drawings on the tracing paper followed a right to left pattern, which makes the 'risk' of overlap of sketches higher.(she was holding the roll in her left hand)*

In my interpretation, the absence of overlapping and the general 'clean' organization of the formats suggest 3 possible explanations. The first one is that the designer must have paid attention to compute how much space he/she would need to draw in order to place his/her hand accordingly (to start the drawing at the right spot). The second one is that the designer acquires rapidly the gestural awareness of how big the drawings he/she is drawing are, and repeats a gesture he/she just learned (varying only other parameters in the sketch). The third one extends the hypothesis of the "easy size", the size of drawing that does not require the designer to think about it, but enables him/her to focus on his/her idea. This third explanation simply considers that this "easy size" for the hand is not only known from the hand but also from the rest of the body/arm, which moves accordingly to place the hand in the location at which to start a new sketch.

These three explanations are not exclusive one of one another; additional studies would be necessary to verify and refine the "easy size" hypothesis and to measure its level of interaction with voluntary behaviors in the process of design. Such studies could, for example, compare the size of sketches produced for the design of objects or buildings of very different magnitude.

The next section focuses on a particular instance of overlapping: exact overlapping, when sketches share exactly the same system of coordinates and scale: that is, superimposition.

Superimposition

Overlapping does not presuppose an "intention". In contrast, the various instances of superimposition assume an intention from the designer. This section briefly presents the superimposition of two schemes, the reinforcement of existing lines, the 'silent traces' and the copy by overlay.

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[20] One case may be taken into account in trial #3, a very small drawing A3.3p is included into the 6 times larger A3.5p, but this does not contradict the point I want to make here. Actually, the only real cases of overlap are calculations/additions that sometimes 'invade' sketches.

Superimposition of 2 schemes in the same sketch

Overall, the trials provide very few examples of superimposition of two alternative schemes in one sketch. In this section I will present the superimposition as a case where the hand plays an important role in association with vision. The idea is that the readability of the superimposed design is supported in part by the sketching gesture and its 'short term' memory.

Drawings superimposing two or more schemes are interesting: they not only show that the designer is considering different alternatives, but they indicate that the situation was such at that particular moment that the second alternative came to be drawn and top of the previous one. What could this particular situation mean?

Obviously, superimposing two schemes enable the designer to compare them immediately and "point for point". One way of looking at it is to consider that it is cognitively economical because the designer does not have to think of everything, the context and the size being already provided. For the designer, It is faster than an overlay. The superimposition indicates that a trade-off has taken place between the readability/legibility of the new alternative and the direct comparison that is afforded. Actually, if one looks closely at it, a superimposition is not a balanced comparison. First there is one scheme "below" and one scheme "on top". Immediately after sketching the second alternative, the designer benefits from both the visual memory of the pen tracing it and the –hypothetical?-- gestural memory of the movement of tracing it. As tenuous –or non-existent?-- these short term memories can be, they nonetheless enable the designer to perceive the superimposed alternative in a more vivid way.[21] The hypothesis here is that when the movement is very recent, the design still reads visually more clearly. On the contrary, when the gesture is ancient, ("gesturally forgotten"?), the superimposition then reads differently: less articulate, more confusing. This latter assumption is a good explanation of why the same superimposed alternative is redrawn next in a very identical way, but in a separate drawing.

> *The story of one of the rare examples, sketch A1.6p in trial # 3 interesting. Two plans of the tabletop were superimposed, the superimposition was not immediate: the second alternative was drawn after that subject 3 had drawn another drawing depicting ideal cases in a situation with smaller table. It was drawn in this early phase during which subject 3 did not use overlays: although the need for comparing the two schemes could have triggered one. In the general context of the process of design in trial #3, this 'event' signified the abandon of the alternative 'below' while the alternative 'above' would survive.*

In the case that has been investigated (Subject's 3 sketch A1.6p), superimposition is an important intentional step towards a new alternative scheme in the design. This type of radical step, chosen for its cognitive benefit and its immediacy, seems to take advantage of the proximity --in time and perceptually— to the drawing gesture.

Reinforcing lines

Although I have not focused my observation on this aspect of the "drawing-action", I will succinctly present several types of lines being reinforced I observed during the trials.

Some lines are being re-drawn on top of existing lines because they are important in the design. They enable to insist on particularly significant lines in terms of what they correspond to in the projected world. Some of these lines might even be re-drawn over and over throughout the design session. They constitute a reference point/trace. It seems that the redrawing corresponds to pointing at the line not only visually but also gesturally while re-consulting the ancient sketch. In that case, reinforcing the sketch increases its visual presence for later consultation. This introduces a second kind of reinforcing lines.

Some lines were reinforced to bring them back at the forefront of perception (as if the lines were dissolving in time). This is a way of placing them as the latest perceptual event.

Some lines are reinforced for communicational reasons, either for the self, to have the sketch "read" stronger, or toward another (for example, in trial #3, the outline of the last plan is reinforced because it is the "answer").

Some occurrences of reinforcement were almost "mechanical"/automatic gestures, during the conversation with the experimenter or to oneself, to attract/locate one's attention while thinking.

This latter case seems to be close to the case where reinforcing a line seems to be a secondary gesture whose sole purpose is to keep 'into the game', to sustain the attention, to stay gesturally 'mobile'/active and ready. It is perhaps a contribution or a call from the body for the continuation of the action.

Silent traces /between superimposition and pointing

Invisible on the paper but extensively present while sketching are what I call the 'graphically silent traces', the multitude of traces/itineraries, paths that the designer takes/makes when the tip of the pencil travels raised above the paper.[22] The silent traces constitute a category of movements of the hand above the paper space different from the purposeful hand displacements from one point to another within the drawing-action. I observed two types.

One type is a sort of dynamic pointing: by following "itineraries" above the paper but in relation to the content of the sketches, the silent traces are a way of engaging the form or of re-visiting/reading the space. The other type of silent trace is inscribed into the direct preparation of an action in the drawing (for example tracing a line).

Trial #1 provides numerous instances of these preparatory movements that use the path created by the repeated movement of the tip of the pen above the paper to visually project its outcome onto the drawing below.

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[21] More tangibly, this effect is reinforced by the perception of different reflections of light in the ink as it dries.

In its first type, the silent traces show how drawing relies on the visual and gestural feedback provided by preparatory movements. In its second exploratory type, the silent traces suggest that perhaps a certain level of experience of the projected design is accessible through the traveling of the pen. In this view the pen is the mediator in the projection of oneself into the space. It provides a visuo/motor experience that stands for the real experience.

The previous sections of this thesis have investigated some rather particular features of the drawing: partial or total superimposition of drawings, line reinforcing and silent traces. They have shown through these rather accidental-looking examples –that are nonetheless inherently part of 'drawing-action'—that drawings are the fruit of complex processes involving both our body and our mind. At the articulation between the two part of this thesis, this section widens this point of view by considering the extent of the design sessions. It points at certain continuities and ruptures in the design process. It credits initial design ideas with a special power and draws upon the idea of the strong representational power/value of gestures to speculate why certain ideas live longer than others.

Persistence

[persist: (obsolete): "to remain unchanged or fixed in a specific character, condition or position"], the term has otherwise an active, positive sense.

In the unfolding of the design process, there are ruptures and discontinuities; there are also reappearances and 're-inventions'. In other words, the design process is not a linear process that unfolds in a step-by-step sequence.

Gestures as representations

In my view, this experiment has shown that a design option a designer had perceived and described -- verbally and gesturally-- as an ideal (answer to another closely related design problem) played an important role in the process. Additionally, this experiment has clearly shown that designers reinvestigate certain previously abandoned options. To cast light on thess two assertions, I will briefly present two key processes of the design process as I see them taking place in trial #3.[23]

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[22] An interesting study could be to superimpose a video recording of the silent traces on top of the real sketch/physical traces to compare and to understand how they relate to the drawings.

[23] See also Appendix.

Regarding the first assertion: the mention by subject 3, during the verbalization phase previous to the design phase --that if the design had been for fewer people, she would have explored a circular scheme--, is important. In my view, her gesture with her hands expressing the union of the circular shape and the elongation (consequence of the larger number of people) producing a shape strikingly resembling to her final scheme.

Fig.6 Gestures as representations. (During verbalization)

Regarding the second assertion: the reappearance of the lens-shaped tabletop later on in trial #3 is significant of a movement –also observable in the other trials-- of re-investigation of an early option.(I already described how this scheme which was 'victorious' over another scheme in a superimposition case.)

The subject's early gesture (with her hands placed to form a quasi ellipse) is a representation of the table-in-her head. The representation is really a representation: it operates/is based on the similitude of shape and leaves the difference of/in size/scale ('real table'/gesture) aside. Obviously, the gesture has a strong symbolic meaning because it embodies the sense of gathering of the group around the table in the gesture of grasping or 'rassembling'. The gesture here is representation: representation of the shape/form and representation of the unity of community. My interpretation is that the gesture was a powerful representation, which, although not inscribed on paper has a powerful enough 'internal life' to the point that the subject came across to capture this gestural-symbolic-internal representation into another representation, a graphic-overt one.

We have now the following interesting hypothesis: representations through gesture in design are very robust/persistent (modes of) representations that work in parallel with ideas. The hypothesis insists on two aspects: robustness/persistence and parallel.

On robustness/persistence

The notion of persistence can help us understand the nature of the processes in action here. Two types of persistence are postulated: a conceptual persistence and a gestural persistence.

Conceptual persistence means that abandoned design ideas/option survive and are often revisited.
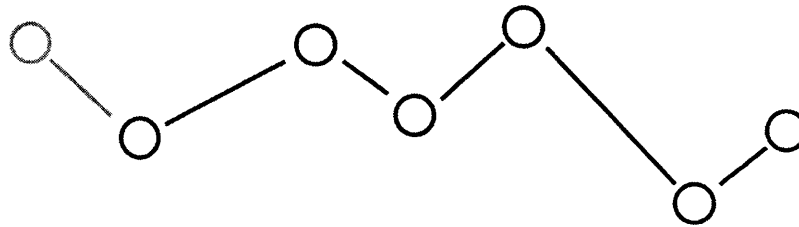
AN A POSTERIORI VIEW OF THE DESIGN PROCESS

n-2   n-1   n

| a | | a |

n-3   n-2   n-1   n
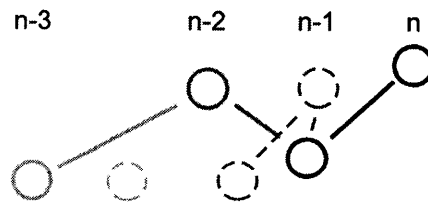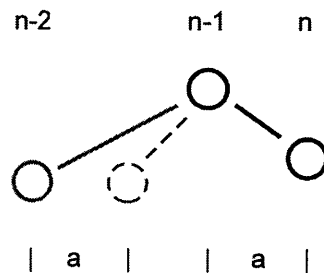
CONCEPTUAL PERSISTENCE: PERSISTENCE OF PREVIOUS MOVES

Fig. 7: These diagrams depict abstractly the general movement of the design process with anterior/previous design ideas/schemes/moves being pulled forward as to signify that, although abandoned, these options are still present. The overall pattern that develop is a kind of cloud of options around the current one, signifying that the knowledge of the design problem at a given moment is made of the knowledge gained through all these anterior attempts ("moves" are represented by one segment associated to one circle)

In the context of the example presented here, conceptual persistence means that an important design idea formulated early in the design, after being left aside, stayed present -in a latent existence-, and was revisited later on in the process.

26

The idea underlying this view of conceptual persistence is that the investigation of design ideas modifies the view of the design problem and that initial design ideas are often given consideration again in light of the new context (actually, the new understanding/perception of the context).

Gestural persistence is the associate phenomenon to conceptual persistence. Gestural persistence has two facets. On facet A, gestural persistence simply means that at a gestural level, in the act of sketching, there are forms that recur.[24] Facet A mostly accounts for the re-visitation of previous schemes/forms (the re-appearance of the lens shape) . On facet B, gestural persistence means that the representational power of gestures is strong, robust, persistent, and that it can outlast other forms of representation like ideas or drawings. Facet B accounts for the influence that the gesture-in-form-of-ellipse had throughout the process and its presence in the scheme.

Gestural representations might be low-level representations that are not perceived as representations by the subjects themselves. Nonetheless, they are so persistent and so deeply anchored in the subject's way of representing the problem to herself that at some point, the design 'path' of subject 3 crosses this gestural representation again and is decisively influenced by it. [In the example, it seems that the expression of both the ideal and the design idea as embodied in the subject's gesture with her hands corresponds to a gestural level of expression of the problem/situation.]

Question: is conceptual persistence to be explained by the limited amount of time offered to each designer in the experiment, which is 'forcing' them to 'stick' to one option (if they want to have a design by the end of the session)? Perhaps, although, conceptual persistence can more likely be explained by the designers' conviction of the validity of their previous idea/proposal.[25] Or simply by the fact that the designer is running out of ideas and is recycling old ones?

An alternative view of conceptual persistence could be that 'the first idea is the winner anyway'. Under such an account, one would have to read the process of design according to the following pattern: the designer does not immediately acknowledge the power of the first idea; therefore, all the subsequent work during the design process is actually made to help eliminate other options (and find argument in favor of the first option through the other options). One of the many difficulties with this view is how to actually identify the first idea: an 'a posteriori' look at the process will easily 'see' that similitude/"parenté"(='familyhood') between the final and early schemes. But this may be simply an after-the-fact construct. Noticeably, the designer-at-work does not of course have this 'clarity' of view and

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[24] Sometimes not as the result of a particular will, if one follows S3's opinion. A week after the trial, telling her informally about the 'striking re-apparition' of the lens-shape in E3 A5.1p (based on A4.2p), subject 3 indicated that, for her, it was the result of going too fast when copying from A4.2p and, consequently, was not significant. In contrast to her opinion, my interpretation tends to give more weight to this act of revisiting an already investigated form. S3's affirmation actually reinforces the statement of the existence of a gestural persistence: if unintended, the resultant shape still noticeably belongs to the 'catalogue' of shapes that have been already explored at this stage of the design!

[25] At least in the first phase! The development of the design in the three trials does not go beyond a formulation of ideas/ schematic design type of phase. That is not far enough to encounter problems that could trigger a complete reorientation of the design toward another scheme.

he/she has to undergo the entire process before he may verify that a certain early idea is still readable in his/her final scheme.[26]

On parallel

Until now, my observation of trial #3 has not enabled me to judge whether or not this "first is winner" hypothesis is valid. If one interprets the first sketches as purely oriented toward the grasp of the proportion of the table in relation to the number of seats and a functional study of elbowroom requirements, then one should see support of the "first is winner" hypothesis. After all, nothing forbids thinking that the 'first idea' receives a special status at a conceptual (or memory) level. This could be seen as not very different from the phenomenon of 'conservatism' of the visual system, which shows a tendency to lock-on to an early interpretation of what is perceived.[27]

But by hypothesizing so, we have not escaped the difficulties in our interpretation of trial #3. Interestingly, the protocol of the trial, with its division into a preliminary verbal session and a consecutive design session, seemed to have helped create 2 "first ideas": one in which the gesture is primary: the ellipse-shaped tabletop, and the other in which the gesture is secondary: the lens-shaped tabletop. In my view, part of the complexity of the design process in trial #3 can be approached from the angle of the competition between these two "first ideas."

Obviously, additional study would be necessary before any conclusion could be reached regarding the modalities of cooperation (or non-cooperation) of 'gestural persistence' and 'conceptual persistence'.

A possible way of investigating the notion of persistence more in depth could be to ask the subject/designers after the session to give their own account of the design process or by asking them directly if they see/perceive a correspondence between the two.[28]

Also, facet A of gestural persistence would have to be distinguished from gestural memory or simple gestural habit or routine. I will not elaborate on this, but simply mention that, as already described, designers rely on drawing routines. This is perhaps not any different from the sort of repetition observed here, where a shape that recurs over and over. This phenomenon might be the illustration of how the medium starts to act as "system", starts to work for itself or 'to spin on itself'. In such a context, perhaps, the designers' motivation to engage another activity, like starting a model for example[29], is to 'escape' this sort of 'gestural imprisonment' by approaching the idea/scheme from a different point of view (which corresponds to a change of the modalities engaged in the new task).

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[26] This question of readability is present in the section entitled "Stories."

[27] Studies by M. Potter in the 60's brought evidence of this phenomenon.

[28] In trial#2, when moving to her second concept, S2 claims this return to the "initial idea". In trial #3, the iteration of the movement (exploration-dissatisfied evaluation-restatement of goal/ideal) described earlier in this thesis might be seen as being of the same nature.

[29] Subject 1 sees "drawing a scale drawing and building a model" as his next activity (gathered verbally after trial) and subject 2 also considers building a model later on.

Finally, another aspect of the notion of persistence that should be reflected upon is why the gestures-representations of the verbal phase in trial #3 were not observable in the following phase. How did the engagement of another form of representation (graphic) impact the first categories of gestures? Are the gestures in the verbal session really different from the ones in the design session?[30]

This discussion of the notion of persistence was the occasion to hypothesize on the intertwining/ interworking of the two kinds of persistence based on the observation (and interpretation) of trial #3. The notion of persistence provides a framework for a model of how/why design ideas are revisited throughout the design process. One of the interests of this model is that it integrates the power of gestures as representation into of the design process.

The next part of this thesis will be less interested in the mechanisms underlying the activity of design and more concerned with the human multimodal experience taken both as a driving force of the design process and the reference to judge of its achievements.

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[30] Further study should incorporate [McNeill, 1992]'s categorization of gestures in narrative situations.

Part C: Grounded

> Grounded: having a base, being founded. The design process is deeply enrooted in the physicality of the human experience. Humans are bodies and not "points" or abstracts entities.
>
> What role does this bodily existence play in the process of design?

We have seen in the preceding part that the hand grounds the design activity in the bodily. In this part, I will first provide a general view of two other ways for the design process to be grounded. Both have to do with being --physically and perceptually-- and with engaging the world. One is in the instant, in the on-line perception, in the direct engagement with the environment. The other is in the past experience, the repertoire. In the second section of this part, I will describe examples of how the body is part of the thinking of size and dimension/measure. Finally, in the last section, I will provide an example in which language and gestural representations of the design problem complement each other in helping to grasp the problem at hand.

Experience and repertoire

In the trials, one could observe the relations the designers established between the real desk and the projected one in terms of the dimensions and physical impression of what it would be like sitting at that table. There were shortcuts in the difficult task of imagining what the experience was like in the design-to-be by engaging directly the trial's environment. Across trials, there were also observable differences in level at which the designers used the actual physical setting of the experiment to provide themselves with feedback on the projected artifact.

> For example, in trial #1,which took place in a somewhat less inviting setting than the other trials -no folded yardstick was provided and the desk used for the session was not a dinning table--, the information regarding the dimension of a table was obtained from the graphic standard book and not from the desk itself as observable in trial #2 and 3.[31]

Other aspects of the environment besides dimensional ones were interrogated too: formal, tactile,>>>>

Nonetheless, the reliance on the real space/environment was not constant, and when it took place, it was mostly "afterwards". Regarding dimensioning, for example, calling upon the environment was done for a verification purpose (see next section). In my observation, I have not noticed any case in which the design problem was immediately acknowledged to be related to the actual situation and therefore engaged directly in the real space. On the contrary, the three trials were all engaged through investigation in the paper space

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[31] This dimension taken from the graphic standard book was used as a first approximation by subject 1, whose later scheme was exploring a tabletop with different heights in the center and at the periphery.

and through reliance on the designer's knowledge of what a table is. Subject 3 clearly stated that her approach consisted of exploring and reconstructing the network of constraints associated with the design problem and did not consisted of copying the real desk.

An intermediary conclusion is that the two worlds are connected but do not map onto each other exactly. Design takes place both in the physical/experiential world and the mind/conceptual world of the designers.

This experiment also confirmed that designers draw upon a repertoire of experiences to engage and sustain design tasks. The designer's repertoire of experience compares to a store of perceptual states concerning events or configurations the designer has experienced in the past. The repertoire can be seen as a subset of the general category "memory", which calls upon mental (visual) imagery, tactile, olfactory and auditory "impression", kinesthetic memory. When a particular experience is recalled in a particular sensory mode, then other modalities are called too. Memories are interconnected into a wider multimodal "experience".

> *Most clearly was the verbal pre-design session in trial #3 the theater of this 'looking inside' one's store of experiences.*
>
> *But many equally valid examples/manifestations were also brought under less directed circumstances. For example, when evoking materials for the tabletop, both subject 2 and 3 made gestures with their hands as if they were revisiting the tactile contact with the material in parallel with other modalities.*
>
> *Plus, in trial #2, a construction detail was embodied in a gesture involving the two hands.*

Designing as foreseeing the perception-to-be

Remembering how a given material with a given surface treatment would 'feel' to the touch, how it would reflect light, how it would sound if knocked upon lightly with one's hand, or how a room clad with such a material would sound are all bits of the multimodal experience of a given material in itself or in a particular spatial arrangement. The knowledge of such information is interesting to the designer because this knowledge is at the base of the experience that the artifact being designed will afford to its user. Consequently, a designer interested in having mastership over the final result of his/her production in terms of the way a user will perceive it, will be interested in first understanding for himself how his/her design conveys a particular reading of itself. Thus, the designer will certainly be encouraged to pay attention to the experiences he/she encounters, and be called upon to memorize/store/organize them in his personal repertoire.

This interest is not only present/awakened regarding isolated material or forms to which are attached a 'bunch' of qualities as experienced through our sensory modalities: it is also present in the questioning and careful observing of what human actions are about (beyond there obvious goal). As an example, in relation to the design task in this particular experiment, a real important question is: what does it means to sit? What does the action of sitting entail in terms of bodily knowledge? What happens when I sit that does not happen when I am not sitting?

These questions extend to the following one: what do I know from sitting when I am imagining that I am sitting? These are some of the questions that a designer might be interested in asking. Certainly, the limited time allowed the designers for the trials was not favorable to such depth of inquiry, but in the longer term, a designer is certainly to be attracted by these essential questions.

If this interest in storing/encoding one's experience is a longer term question, then perhaps experienced designers should be able to rely on their store/repertoire without showing the overt behavior of reliance on the immediate environment as displayed by subjects in this experiment. It would therefore be interesting to study more mature/experienced designers in order to see whether or not –and under which conditions-- they enter this type of dialogue with the actual physical reality to support their design process. A reasonable guess is that this type of operation would be more internalized, less visible, in their behavior. But one could well argue that the direct call upon the real world/environment would not disappear, that even the most experienced designer would be careful to revisit (certainly in a less overt way, but no less deeply) the archetypical human action to try, again and again, to touch/capture its essence.

Because it would go beyond the scope of this thesis, I will not try here to explain why a more mature and experienced designers would show different pattern of behavior (internalized experience versus overt behavior).

The next section investigates measuring and dimensioning calls upon the designers' body.

DIMENSIONING and MEASURING

My concern in this thesis being to investigate the role of the body in the design process, I now turn to dimensioning and measuring which are operations of the design process that draw heavily on the body through numerous different ways, some of which, I will present/outline more in detail in this section.

First, we have to distinguish between measuring and dimensioning.
In the usual understanding, measuring primarily means acquiring a data regarding the length/size/magnitude of an object or a phenomenon while dimensioning means giving a dimension to an artifact. To simplify extremely, one is taking while the other is giving. Actually, their "opposition" is more appearance than reality in design: dimensioning and measuring do work together/rest on each other.

The operations of dimensioning in design are difficult because the designer tries to give dimension to an object that **does not exist yet**. Therefore, the relation the designer entertains with this object-to-come is not direct but rests on representations (internal or external). In the case of this experiment, this means that the designer does not have his/her design physically present in front of him: he/she is not sitting at the table for a dinner with friends and therefore cannot use his/her direct impression/perception of comfort or direct judgment of the qualities of the table. As a designer, he/she knows that he/she is not designing in the pure,

uninhabited, 'gravitationless' world of geometry: he/she must consider form and size/dimension in the full extent of their interaction.

But measuring is also not as easy as it might seem. The difficulty is: what is exactly measured? From what point of view is the measure taken? For example: acquiring the metric measure of an existing table does not provide a designer with a measure of the conviviality of it.

After having briefly acknowledged the depth/complexity of the operations of measuring and giving dimensions in design, I will turn to investigate how designers use their body while engaging the measuring and dimensioning operations./ what role does the body plays in measuring/dimensioning operations

Learning from the experiment

In trial #3, at least 11 phases of measuring and dimensioning operations of the tabletop were observable. [32] Chronologically, the phases were:

1. Variables Identification
2. Rapid graphic evaluation/estimation
3. Measuring/ Data acquisition for variables/ nominal dimensions: ("elbow room" as the noun that designate a particular dimension)
4. Maturation 1: relating interdependent dimensions among constraints
5. Calculation 1 (1st occurrence of a repeating pattern)
6. Verification 1/ Correction (type B). Using desk/table for comparison
7. Maturation 2, synthesis (larger drawing with circular/continuous edge)
8. Calculation 2 (2nd occurrence of the pattern)
9. Verification 2/ Correction (type B). Using the desk/table 1:1
10. Re-calculation and Correction (type A)
11. Final Correction (type B) with direct interaction with the desk/table and folded yardstick

Although very rough, this list gives an idea of the multiplicity of operations that takes place along the process of giving dimensions to the designed artifact.

Several intermediary conclusions can be drawn from these observations.

■ Although the size of an object, like the tabletop in this experiment, is finally expressed in a **metric** measure, for the designer-at-work, operations of dimensioning are rarely the result of a simple, direct arithmetic operation. On the contrary, before they come to a 'final' number/metric value, operations of dimensioning require **several iterations**. These iterations involve the body.

■ Operations of measuring and giving dimensions in design are difficult, complex and (intricately connected: boundaries?)

    o   Perceiving/grasping of numbers/quantities and dimensions is a difficult task; (see S3's grasping strategy which consists of apprehending the 10/12-people table graphically. S3's first two sketches are to provide her with a visual embodiment of the size and

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[32] see Appendix for details regarding the content of each phase.

elongation/proportion of the table, and with visual familiarity with the quantity as opposed to the non-vivid representation 10 or 12 as number)

o Counting can be confusing (until result is compared with real world)

o Relying on one's impression that this "bodily position is right" is efficient

These conclusions show that numbers do not provide an immediate vivid 'sense' of the actual size of what they represent: the world of numbers is **loosely connected** to the world of physical/perceptual experience. Obviously, one of the difficulties for the designer is to articulate two very different domains: the domain of his/her experiences, perceptions and interactions with his/her environment and the domain of the number and the metric. These two domains are very different. On one side, numbers are abstract entities, there is infinitely /continuously a number after another; operations among numbers are ruled, 'self-contained'. On the other side, the domain of experience/interaction with the world is complex, is non-homogeneous, has thresholds and plateaus (for example, the distance between two people conversing has an upper and a lower limit in any social situation)[33].

The presence of these difficulties suggests that perhaps several types of thinking are involved to answer these more or less different related tasks.

To overcome the difficulty of measuring and giving dimensions to their designs, besides drawings, designers rely on themselves (their perceptions), on tools, on the environment, on iterative estimates, on comparisons, on simulations and on imagination.

Use of tools and significant objects: the folded yardstick, the desk and the cup[34]

Among the objects used for operations of measurement and dimensioning during trials 2 and 3, one has to distinguish between the explicit measuring tool –the folded yardstick- and objects –the desk and the cup- that are not explicitly measuring tools but that are used as such part of the time. Under this view, the table is more than simply an object that is measured but also a measuring tool.

In the trials, the folded yardstick obviously encouraged/enabled reliance on the environment -the desk the designers were working on-. The folded yardstick played the role of 'connector' between graphic representation and real world. During these design sessions, the yardstick was more and more used and was ever-increasingly present on the desk.[35]

The desk at which the subjects worked was evidently used as a reference, as an element from which data was extracted (length, width, height, tactility of material,…), and as element of comparison.[36]

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[33] As described in E.T.Hall, <u>The hidden dimension</u>, Garden City, N.Y., Doubleday, 1966.

[34] For the sake of clarity, the table at which the subjects are sitting during the experiment is called "desk" in this text.

[35] For example in trial #2, one can observe a correlation between time and presence of yardstick: the more the time passed by, the more the yardstick was kept unfolded on the desk.

[36] From my observation, I was able not detect if the desk was considered as a whole, that is, including its memories of dinners, or only as a reference to compare isolated data (for example, the length, and later on, its horizontality, etc).

The desk, the chair and the cup were also the primary means by which the designers engaged simulations. By acting/simulating a situation like holding a cup while sitting at the desk, the designer called upon her bodily knowledge of that particular situation, which enabled her to confirm that a metric measure corresponded to a real situation.[37] Direct physical manipulation of objects was sometimes the way chosen to clarify/engage the problem: the world of abstract dimension vs. the world of concrete dimension, which does not only have a metric but other experiential qualities (tactile, kinesthetic, etc).

Use of self

In simulation cases, two measures are superimposed: the bodily measure of the 'rightness' of the bodily posture and the metric one. Measuring oneself is not always performed in order to provide a final measure. For example, subject's #3 stated ergonomic approach -measuring her elbow's extension- was a first evaluation meant to be a 'template, a dimension to play with afterwards."

Correction/adjustment processes

The experiment showed two types of correction. The first type (type A in trial #3) consisted of adjusting the result of the calculation by adding or subtracting +/- 30cm to it.[38] In my view, this correction shows that designers use a mechanism of estimate of what the dimension should be; the raw result from the calculation is compared to the estimate and is modified to follow its tendency (smaller or larger). One is a pure number while the other is a 'sense' of the right dimension.[39]

The second type of correction (type B in trial #3) consists of comparing the result of the calculation with the environment. In both cases, it is the designer's body, more than the arithmetic, that tells him/her if the proposed dimension is suitable.

From Material thinking to Dimension thinking (On a repeating sequence in trial #3)

In trial #3, a sequence during which instances of the above-described reliance on the physical desk,

(for confirmation of calculation result by comparison) (visual estimate and use of the folded yardstick),

was repeated twice under very similar conditions.
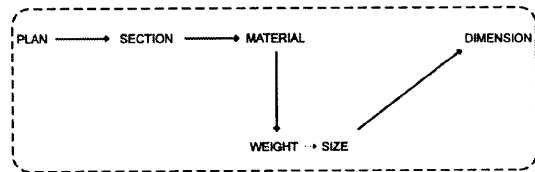
Fig. 8: The sequence in trial #3
(see also Appendix)

Figure 9 represents this repeating pattern/sequence during which visual thinking and bodily thinking come into play to supplement the calculation. The pattern took place when subject 3 was brought to calculate the

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[37] For example, by doing so, she did not have to question herself regarding how many inches was the gap between the table edge and her abdomen, she just had to act it which in turn enabled her to acquire a measure of the desk.

[38] This becomes visible after recalculation of the additions that subject 3 wrote on her overlays. Actually, the "think aloud" announcement of the result was delayed, until the correction was made in accordance with the estimate.

[39] Perhaps comparable to running two different computations in parallel: one precise and the other approximate. According to [Dehaene, 199?], each of these two computations call upon very distinct centers in the brain (precise versus approximate calculations involving language and visual centers respectively).

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dimension of the tabletop after having considered aspects of the plan, of the section, of material for the table legs and top and of the tabletop's weight as dependant on its size.
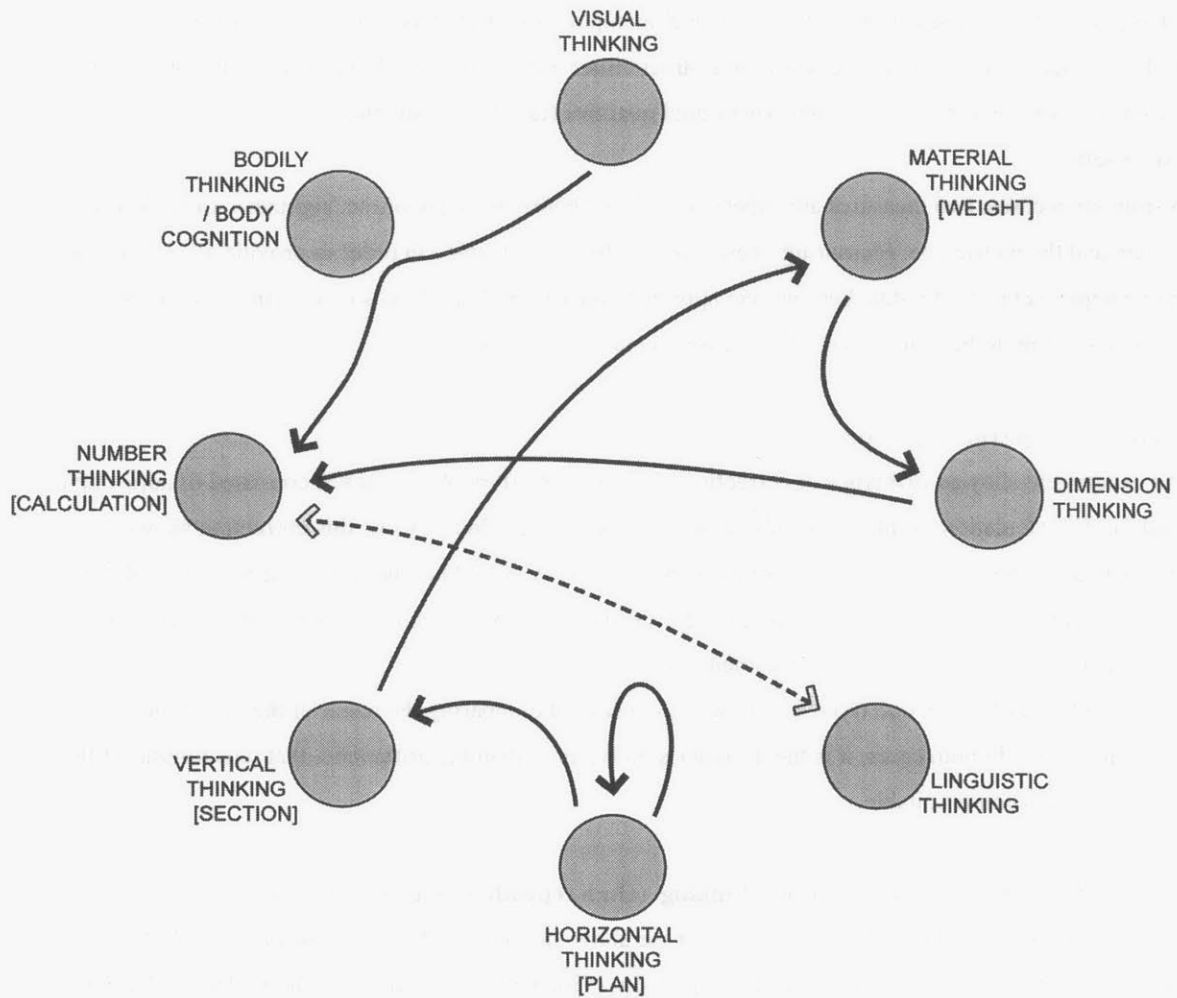
Fig. 9: Mapping of the thinking types shifts along a dimensioning operation in trial #3.

The figure assumes the existence of multiple types/instances of thinking involved in the design process and the calling upon one to the other according to the task at hand. Thinking in 'projection' is divided into two nodes: 'vertical thinking' and 'horizontal thinking', according to the postulate that thinking in section and thinking in plan are different in terms of bodily engagement of the designer in the each. Visual thinking and bodily thinking/body cognition 'close the loop' by correcting the raw outcome of the 'number thinking'. The 'linguistic thinking' node of the diagram should be accounted for being at the base of the 'number thinking (calculation)' node operation. (See note above).

A picture of how dimensions are integrated in a design?

BSD/DSB

Putting dimensions together is not simple aggregation.

What process underlies the reversal pointed at in "**the Body Shapes the Design/the Design Shapes the Body**" example in the forewords? What takes place between the two images is the integration of weakly-related dimensions (extracted from a direct measure of the designer's body in this case) into a global 'project'/design. The newly formed design does satisfy the individual requirements as embodied into the individual dimensions. But it satisfies them only partially: the design's internal coherence imposes a revision/adaptation/refinement of these dimensions so that they be satisfactory 'from within' (the design). The two images (Fig. 1 and Fig. 2) illustrate the different points of view (from which the measure is taken/the dimension given) and their postural manifestations underlying these two very different moments in the design process.

Stories

After having asserted that designers do not gesture/ct independently from thinking, talking and drawing while designing, I now turn more specifically to the interworking of language and bodily-based activities/behaviors in the design process. The idea behind the choice of this angle of observation is that 'events' in the verbalization reflect 'events' in the designer's grasp of the design, and therefore tell us something about the design process at large.

The first aspect of the interaction between language and body in this section relates to how designers call upon their bodily experience through language. The second aspect of the interaction between language and body examines how the verbal 'construction'/elaboration of the design evolves throughout the design process.

Verbal elaboration

Words carry meaning: a table is a... table. Words also carry mental images: here, the –visual, archetypical-- model of a able (rectangular with 4 legs and the top lightly cantilevering/sticking out). Finally, words carry a multimodal experiential model, very rich, interconnected and complex, that designers explore through verbalizations.

> *Trial #3 –because of its protocol including a preliminary verbal session-- provides an example of design process engaged/initialized by a phase of verbal elaboration during which variables relevant to the design problem are identified.*

What is important to notice in the context of this study, is that the verbal elaboration of the problem observable in trial #3 expresses through the mental re-visitation/invocation of the bodily experience of

being at a table with a group of people for a dinner. Of course, I assume that it is not possible for the designer to access/re-visit, extract and describe by language the entirety of his/her bodily experience, but what is important for my argument, is that there is parallel movement of physical recall of the experience and of 'representation/translation' into words.

> *Interestingly enough, in trial #3, the most significant gestures - regarding the table elongation and rounded shape- observable during the preliminary verbal session were not present anymore during the design session.*

"Threads"

Figure10 expresses the idea that the enunciation by the designer of the list of variables to pay attention to later, takes place by extraction from and decomposition of the recall of the actual experience. The designer's construct of the problem and the problem's requirements is grounded in the designer's bodily experience of a similar situation. The arrows signify that, in particular in this early stage of the design process, there are movements back and forth between the verbal-conceptualized and the experiential-bodily.

The underlying hypothesis of figure11 (on the opposite page) is that the articulation of different requirements together (like establishing that flexibility, number of seats, presence of a 'transition' between the ends and the middle parts of the table, and edge continuity are interdependent) corresponds to an articulation of the experiential dimensions associated to these requirements.

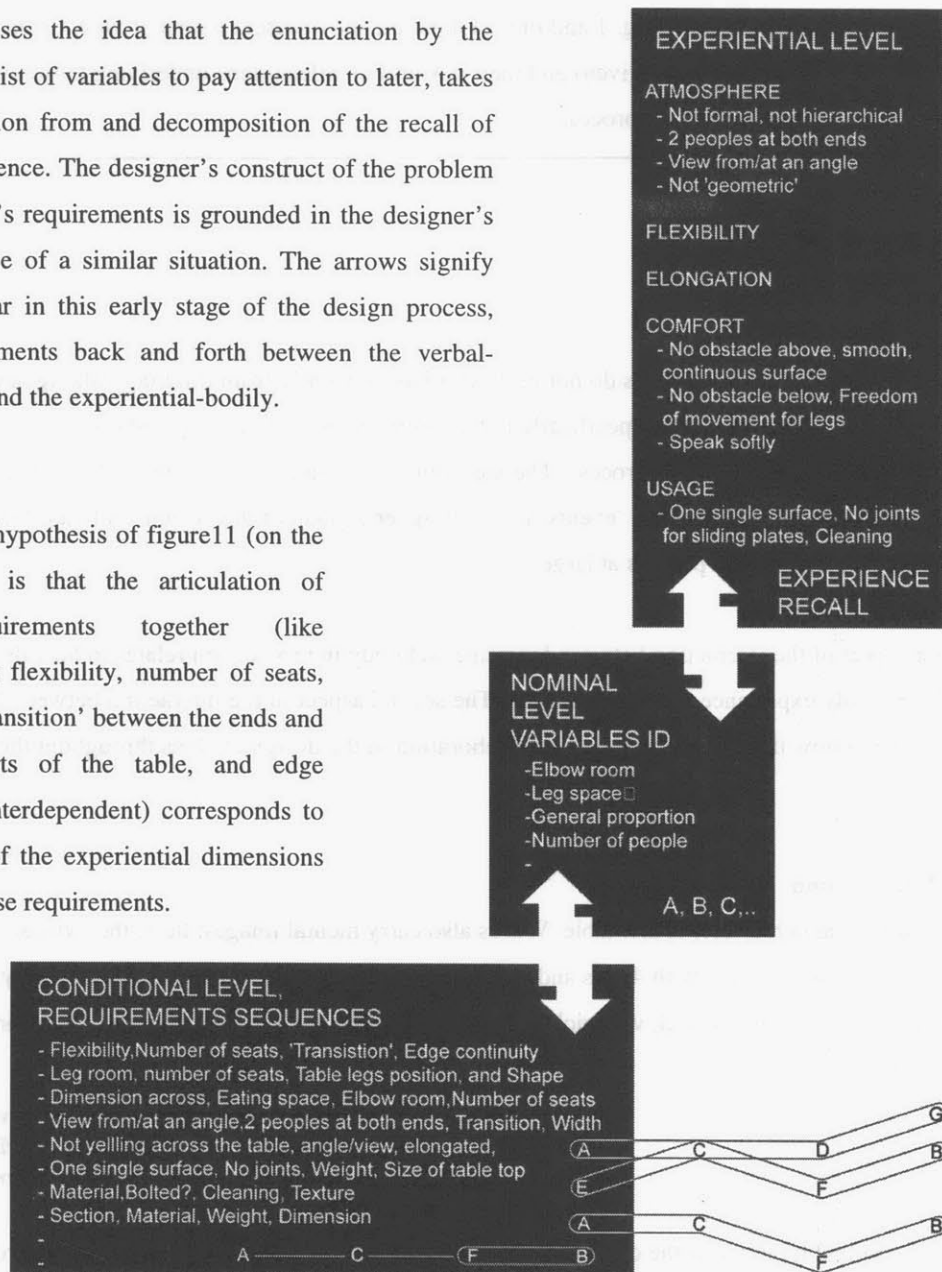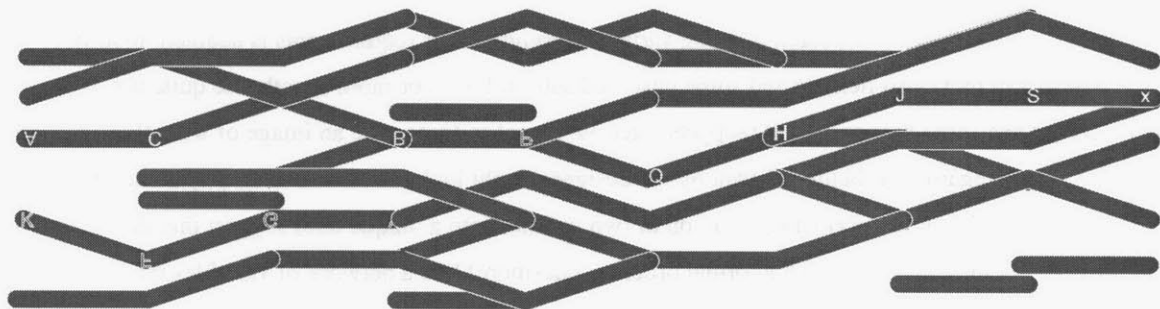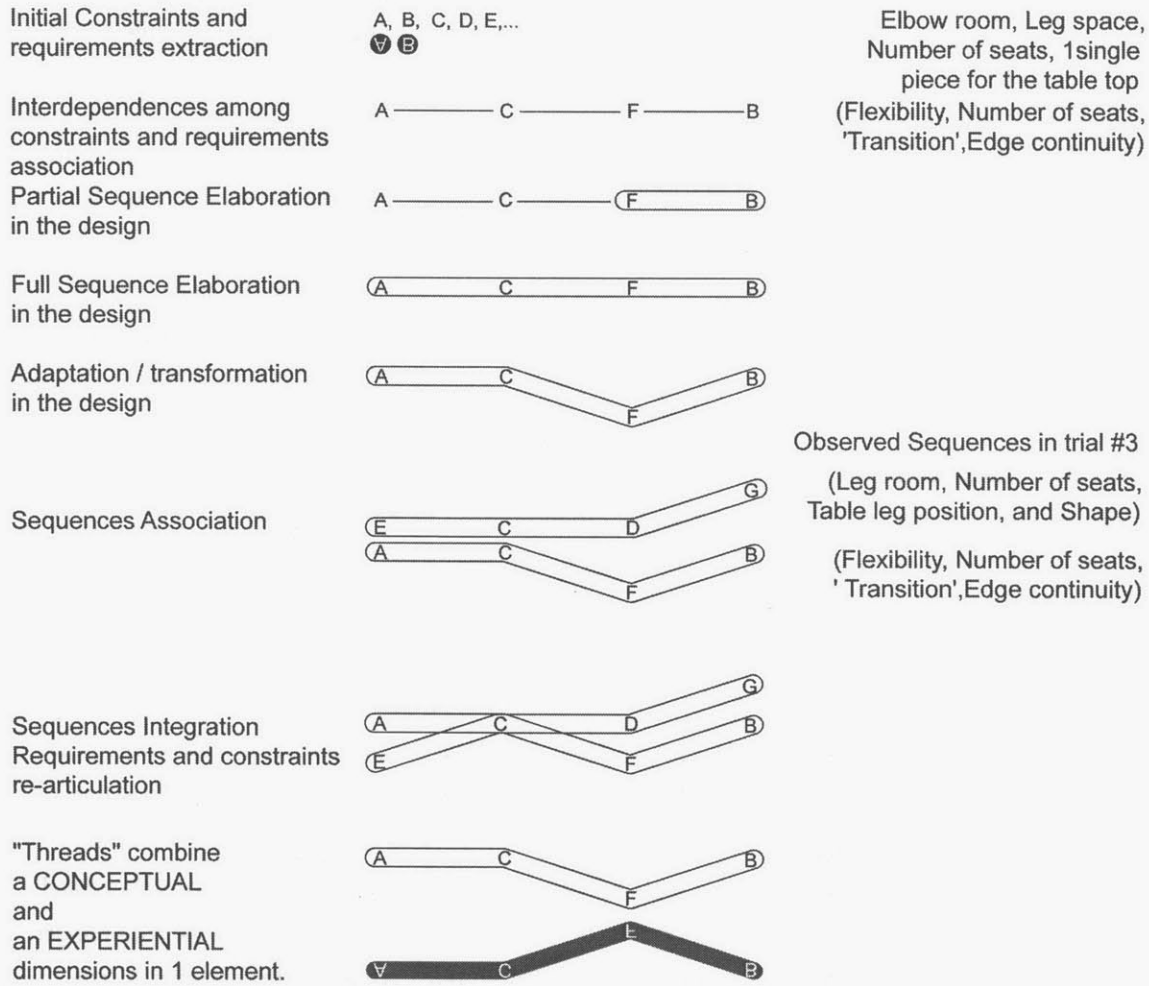Fig. 10: Design variables identification: verbalizations are grounded in experience.

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Fig.11: "Threads, A Model Of Requirements Sequences Integration" (the experiential and the conceptual dimensions of a variable are the two sides of a same coin.)

Description updating: a case of evolution/adaptation of language/denominations to new constraints in the design[40]

> *BSD/DSB shows two (crucial) moments of a larger continuum along which subject 3 constantly update the terms that she employs to designate the space to sit a person at the table. Throughout the trial, this space is successively named: "Elbow room" (90cm) becomes "dinner area" (75cm), later "zones" (NA) and finally "minimal dimension" (60cm).*

In my interpretation, on top of being dimensional adjustments, these successive denominations reflect the evolution of how subject 3 conceptually and bodily related to that space. Initially, the 'elbow-room' is approached egocentrically –in the way of measuring from oneself and also in the fact of naming a body part. It is also approached 'nominally' in the sense that a value is attached strongly at the name 'elbow-room' and that this value is meant to be followed.[41] Later on in the design the 'nominality' of this value will be reinterpreted

Requirements satisfaction and narrative adjustments

A model of design based on progressive requirement satisfaction?

Designers invent "contexts" or scenarios for themselves to supplement the original problem. They select certain aspects of the problem over others, and reformulate it; they give themselves self-imposed requirements in terms of what their design should achieve. They establish/generate a narrative that correspond to their interpretation of the important aspects of the problem. This narrative/set of argument constitutes the framework within which they appreciate/evaluate their design (the framework within which their design is a pertinent /attractive answer. Designers set a hierarchy among variables they identify as relevant for that problem.[They also choose among approaches according to how pertinent they seem to be]. But this hierarchy is not a rigid one: once a particular aspect of the problem has been investigated and is interpreted as facing a dead-end, 2 attitudes seem to be engaged by the designers. Either the requirement is restated and another angle of inquiry is investigated (another proposal is emitted, the designer takes a new guess on the base of what is known of the problem at that time) or the requirement is revisited, reformulated, adjusted and the hierarchy among variables, arguments or requirements is adapted, modified. But the new hierarchy is also flexible and some unsolved sub-problems or more exactly the quite not satisfyingly yet answered proposals will reappear later on. I want to try to give an image of what this package of issues regarded as being relevant by the designer might look like. The massive dynamic of re-interpretation and reformulation (including union of two variable into a unique one) suggest that this hierarchy does not look like a list with a formal ordering but (more) like a network of variables the

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[40] Another example is "elongated" which becomes "slender and slick", and is repeated twice again, before being "not so elongated" which indicates a revision of the original verbal requirement.
[41] 'According to plan, to prevision' says the dictionary at entry nominal.

interdependency of which is progressively experienced/made sense of/acknowledged /constructed throughout the unfolding of the process and the designer's engagement with new issues.

The designers in this study show signs of regularly –depending on the course of study—adapting the formulation of the "problem". The design takes place in an interpretative framework that is subject to multiple –if not constant- re-interpretation. Very clearly, this process is not about determining once for all a list of the relevant issues and to follow it rigidly. A part, at least, of that list "fluctuate" to accommodate the feedback of what is tried out. In this account, it is as if trying out 'solutions' at a more or less local level, The answers helps constructs a more coherent question. There seems to be to a certain level a parallel development/construction of the answer and the question.

Conclusion

The point of this thesis was to observe the design process through the filter of the role the body plays in it. In this section, I will first review the findings/observations or the hypotheses generated in this thesis, then I will reflect on the impact of these findings on design inquiry undertakings. Finally, I will succinctly state how notions investigated in this thesis can inform a model of the design process.

From my observations based on 3 trials of a design-task experiment involving graduate students in architecture, my conclusion is that the body plays an important role in the design process in several ways. I will attempt to synthesize this role by presenting three ways in which the body and design process relate to each other.

- The first way for the body to play an important role in the design process regards representation.
- The second regards the constraints that the body brings/imposes to the design process.
- The third regards body cognition, that is, how the design process is grounded in the designer's experience of the world and his/her bodily knowledge of it.

Representation/representing through the body

Designers use their body to think and to represent all sorts of abstract ideas and concrete objects. They use their body as a means of representation for communicating with others and with themselves.

We use gestures to represent that something is big or small, to think of/represent the tactile and visual qualities of an object, to represent the form of an object, etc. In certain cases, the representations through the body are just simple mimicking of the gesture/action they refer to. These representations are embedded in 'automatic' gestures that reflect gestural habits/routines of interaction with the world. We acquire these automatic gestures and they anchor us in the world.[42] Beyond, our body has an internal –beyond awareness- -representation of the room we are in.[43]

Because our body is at the interface between the world and our mental representations, representations through the body are at the articulation between our direct experience of the world and our mental representations.

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[42] For example, we know where the soap is when in the shower, or we know (our body knows) that the object our forearms are resting upon is a table. More generally, we have a bodily representation of the physical world.

[43] I refer here to the fascinating account by [Spelke, 1996] regarding how reorientation in infants relies on an encapsulated function that processes the geometry of the environment/room only, that is, regardless of any other orientating clues, although the infant has perceived these clues, as Spelke demonstrated it. This orientation process, observed in other adult mammals, is modulated in the human adult, which would integrate the other clues in his/her reorientation. For an architect, these findings raise the question of what is 'known' from our body of the space we are in that we are not consciously aware of.

Perhaps representations through the body are not as elaborate as graphic or verbal representations. But representations through the body are nonetheless constantly present and seem to be persistent and robust, as has been shown through examples in this thesis.[44] This study has pointed at their influences on the design process. An extension of this thesis is the assumption that studying the representations through the body can help us understand the notion of representation in a more comprehensive way.

The body constraints the design (process)

Designers use their body/hand to design and draw. One of the hypotheses developed in this thesis, based on observed consistencies in the size of drawings, is that the hand constrains the size of the drawings and by extension, the process of design. The idea here is that designers are not questioning each of their movements (what the hand is doing). The 'easy size' hypothesis states that there are drawings that are the size they are because the designer's hand feels comfortable with it, because this size provides the most seamless interaction between idea and hand, mind and body. But the hand is not always this silent/transparent extension of thought: reoccurring shapes that are sometimes more the product of gestural routines than the product of a clearly maintained orientation also populate sketches.

Thinking about how the body constrains the design process is thinking about how the continuities and the discontinuities observed throughout the trials -- options appearing, being adopted and developed, then disappearing, to sometimes reappear later on in a different light-- can be interpreted as having not only a conceptual dimension but also a gestural/bodily dimension.

Body cognition

Designers rely heavily on the knowledge acquired by their body through their actions and perceptions, both past and present. Designers rely on their past experiences –as isolated memories or a 'repertoire'. Designers also rely on their present engagement with the design problem, by means of tools or artifacts they produce to investigate the design problem or/and by means of their direct bodily engagement with their environment (to retrieve or project qualities upon it). It is then the hand that searches for data, that is the entry point for 'physical thought', the interface between the physicality of the world and the human mind.

The role played by the body in the design process provides an illustration of the fact that the human self is multimodal, that is, that perception involves the interworking of different/several/all the sensory and motor pathways of access to the world (which also includes ourselves and our mental representations).

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[44] For example, representation of form, representation of tactile qualities,...

About the research domain: design inquiry and the question of the body in the design process.

The question that this thesis starts to address is: what would be an analysis of the design process in terms of gesture and the role of the body in the design process?

Pointing at the silent traces

With the silent traces, the meandering of the designer's hand and pen above the drawing without actually leaving a tangible trace, we have an illustration of the complexity and richness of how the designer interacts with his/her drawing in the ideation process. The existence of these silent traces speaks in favor of a careful observation of the entire practice of sketching (including the gestures and verbalizations that come along with it), not only its tangible outcome, which might represent only the very tip of the (cognitive) iceberg. These 'graphically silent traces' raise the question of the integrity (in the sense of completeness, explicitness and self-sufficiency) of the sketch as the sole object of study for design inquiry. Are the sketches detachable from their other traces and accompanying gestures and verbalizations? They are not.

This study has provided us with a view of the great variety of sketches along the process of design, at least in terms of the context in which they take place perhaps more than in terms of their final appearance. One could conceive that in the movement of design, some sketches exist as in-between (that is, just for the movement they accompany in the thinking) while others perhaps exist as landmarks displaying a local/temporal solidification of the design idea/scheme.

This view that the sketches are sometimes pure "in-between" objects seems to be perfectly in accordance with the assumption that optimization/minimization of cognitive loads is the overarching principle of human natural computation. (Put more simply: since we usually just do the necessary minimum, sketches may be that kind of very 'light' tool for thinking about objects-to-be and spaces-to-be!). Although attractive, this argument nonetheless needs to be counterbalanced by the acknowledgement that each system of representation tends to be a closed system that makes one blind to other aspects of the problem at hand. For example, these trials have provided illustrations of how representation of physical dimensions with numbers could be self-contained and not in a vivid relation to the actual perception of the dimension.

What sort of model of the design process is provided with this thesis?

Although still 'multidimensional'/disparate, this study possibly provides elements of foundations on which a more comprehensive model of the design process can be constructed. A model in which:

o   The process of design is influenced by our multimodal perceptual and physical being,

o   The process of design is based on the interworking of different representations, which are not always seamlessly interconnected,

o   The notion of persistence complements/balances the notion of move to provide a framework for thinking of the dynamic dualities at work in the design process (to think about notions of anchoring, exploration, repetition, revisiting, etc).

o   The major role played by representation through language is articulated to the rest of the construction.

The beginning of an approach?

Rather than a clear-cut definitive approach, this exploratory study provides an increased sensitivity to the question of the role of the body in the design process, as well as a reinforced conviction of the validity of its questioning. If, on the one hand, a method for a comprehensive observation of the role of the body in the design process still needs to be invented, on the other hand, the approach consisting of observing the process of design-at-work is nonetheless valuable, and therefore, although "processing-costly", deserves to be maintained. After this preliminary investigation of the role of the body in the design process in several directions –but leaving aside many others-- my conclusion is that design inquiry undertakings should take the aspects of the 'design-making' described here more into account.

In potential developments of this work, further effort should be invested in trying to distinguish between gestures that belong to narrative and gestures that belong to design among all the gestures that support the thought process. [45] Effort should also be made to more deeply understand representation through action.[46] Certainly, this next generation of undertaking will need to think of computational methods of sorting the wealth of data produced in this type of approaching-real-life design-task experiments.

By providing perspectives on the role of the body in the design process, this thesis opens a path toward a reflection on the modalities of design thinking (and their interworking) that includes as one of its major components body cognition/bodily thinking.

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[45] In relation to [McNeill, 1992] 's study on gestures in verbalizations.
[46] In relation to Bruner's enactive mode in the trilogy enactive, iconic, symbolic.

Appendix

Presentation of the three trials of the experiment.

An experiment: (behavioral) observation of designers/students at work :

This section presents three iterations of a design experiment in which three subjects, current or former MIT graduate students in architecture, took part.

Assumptions

The following assumptions underlie this experiment:

o   Knowledge of design processes and design thinking is achievable through experimental methods.

o   An experiment close enough to real design condition –both in terms of task and setting— is an acceptable substitute for real design.

o   There is "bodily thinking'"/"body cognition" in design thinking (but how does that looks like?)

o   Observing how the design session unfolds and observing what the designer is doing (behavior, gestures, etc), sketching and saying can provide insights into the process of design, and the role of the body into it.

o   There is a reason why certain things take place when they take place and the way they take place. This idea extends to the idea that reflecting on why things have occurred this way will enable a better understanding of the design thinking process.

o   Shifts in the activity/behavior of the subjects/designers will be observable which corresponds to shifts between several levels of design thinking.

o   Because the body is what is common to all of us, beyond effects of culture that impact on conceptualization and perception, there might be a certain degree of commonality across designers in the way they engage their body, sensory and perceptual apparatus when/while dealing with design tasks.

The design of the experiment

The questions: How/what to observe? What I am trying to observe is a phase of ideation at the beginning of the design and the design process at large in an attempt to cast light on the role of the body in the design process.

1) A real design task –based experiment.

To increase the chances of successfully showing evidence of the "the presence of the hand and the body in the design process", the experiment is designed to invite these manifestations, both in its content and its context/setting.

Although the design of the experiment attempts to reproduce a normal design situation, there are nonetheless differences with a normal/real design situation:

o   the experiment consists of a design exercise leading to a design proposal that has no extension beyond it. It therefore focuses on the earliest ideation phases of the design process.

o   the experiment imposes to deliver a proposal within a given (very limited) time constraint.

o   subjects are asked to 'perform' in experiment-set work environment over which they have no full-control, and an experimenter is present and intervening verbally to a variable extend with each of them.

2) The subjects

Three trials of the experiment were run. Each trial involves one subject. Subjects are all designers

From the 3 subjects, 2 are current MIT architecture **students** and 1 is a very recent graduate.[1] The concern of this thesis is not about the dexterity or artistry that a particular designer might display, but more generally about the simple fact that designers in general are in the world and use it or engage it in various ways, directly or through representations or tools, when working on design problems. One of the underlying assumptions of this experiment is that students will rely more overtly on their environment than a mature designer might do, therefore providing us with more visible manifestation of that reliance on the world and of the use of their body in the design process.

3) Observing from different points of view

There are three types of data collected throughout the design sessions and analyzed later on:

o   the sketches and notes inscribed on the paper or tracing paper,

o   the verbalizations (transcripts of the "think aloud" or of the verbal exchange between subject and experimenter)

o   the video recordings of the sessions (images and words) showing the postures/gestures of each subject during the design session and enabling me to observe the 'movements' from one sketch to another, the

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[1] One male, two female (one is left handed).

use of tools, the ways of engaging the desk on which the subjects were working, the moment of reflection while drawing, etc.
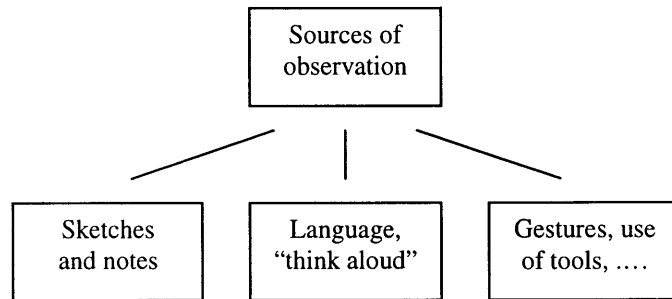
Fig. 12: Three sources of observation.

This method enables me to observe what the designers do while designing in both real time and in playback.

The chosen approach is first to follow and observe the design process in its entirety, heterogeneity and complexity, and then, to see what happen at various levels (in the sketches, verbalizations and gestures) and to try to relate certain observable "events" or "episodes" to others on the basis of their simultaneity or their "successivity" or relation across longer periods of time.

Evolution of the experiment across trials

A pragmatic approach was chosen regarding how the trials took place. The approach was aimed at fine-tuning the protocol of the experiment in order to obtain better results. The strategy was to run a first pilot trial under predefined conditions. The global outcome of the trial was then analyzed in order to determine what changes/improvements should be implemented in the following/next one. Accordingly, minor variations were introduced after the second trial in order to focus better on a particular aspect of the design process or to observe the impact of absence or presence of a parameter in the design task or in the context of design.

Description of the experiment: task, settings, timing, requirements.

The 3 trials have the following points in common:
o   The design **task**[2] is to design a table for dining seating 10 to 12 people and allowing a good communication between people while dining. The subjects have to decide on the size and shape of the table, and also have to indicate where the people are sitting or where the plates are placed on the tabletop.
o   **Requirement**: production of a sketch (the brief/task description use the generic term "document") of the table with dimensions. The brief also specifies that the **document** should provide enough

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[2] See at the end of the appendix for the complete design task description in each trial.

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information for someone else to be able to cut the tabletop and set the table.[3] At the end of the design session, all sketches are collected.

o **Media**: White letter paper 8 1/2x11 inches sheets or tracing paper roll 12 inches wide. Pen (Sign pen), fine felt tip or 6B pencil.

o **Time**: 45minutes +/- 15minutes depending on protocol of each trial (see trials description)

o No other **person** present during the session besides subject and experimenter.

o The **working space** during the experiment is a large table in all cases (large rectangular meeting table in trial # 1, a 183 x 76cm table used as dinning table covered with paper cloth (on which telephone numbers or to do lists are usually scribbled down) in trials # 2 and 3. Arrangement of working space during session: Experimenter sitting at the short side of the table/desk, circa 1.5meter away from the subject who is sitting at the long side of the table/desk. See photos in the transcripts at the end of this appendix

o Method: direct **observation** of behavior of the subject designer by experimenter and **Video** recording of the session. Static video camera placed over the table approximately 2.5meter above ground, inclined at approximately 45 degrees downward to focus on the working space and the subject. Recording starts when subject reads the brief/assignment.

o Involuntary commonality: each session was interrupted briefly (by a visitor, a telephone call or a doorbell ringing)

Interest:

As an introduction to the following section on predictions of the outcome of the trials, I will here review some reasons why this experiment seems to be an appropriate tool for the study of the role of the body in the design process.

Apparently the task is a simple exercise in '2D' (shape and dimension of the tabletop). It calls upon the archetypical table that is made of a tabletop and four legs only[4]! Adopting that archetypical image, the degree zero of the design for a table accommodating half a dozen people would be a rectangular table whose dimensions are based on the dimension of the individual space for eating and taking care of the particular situation of the angles (the length of the sides are expressed in units of nominal[5] dimension plus 'something' for the angles). At this degree zero of design, one could create an algorithm based on the 2 above variables that would generate a rectangular table only by considering its perimeters.

But the task also requires considering the section or the side view (which represents a shift between thinking 'horizontally' and thinking 'vertically'), which makes it a complete/veritable spatial design task. The task is a real design task and it connects with reality.

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[3] These latter requirements were not satisfied in all three trials.

[4] At this point I understand that it would have been interesting to have asked the 3 subjects to represent what they "see" when they are told "table" (and to sketch it).

[5] A definition for nominal in that sense is :of, being, or relating to a designated or theoretical size that may vary from the actual" and "being according to plan"

A 10 or 12-person table is not a familiar object, but subjects will certainly be able to draw upon personal experiences (family gathering, dinner with friends): it is interesting that the design problem is 'real' and not entirely new. One has to investigate (remember) actions/gestures/bodily postures that one has performed often without necessarily paying attention to. A difficulty is to appreciate the "right" distance between people (the measure of which is not necessarily given by a norm), neighbors and others, in accordance with the conditions of the dinner, e.g. formal versus informal. There is a dimension embedded in the 'dinner' that is to be investigated. The dinner experience comes from the people around the table, from what the table affords in terms of interaction between these people and from what is placed at the center of the table (that participates in the setting of a particular atmosphere). Subjects are obliged/likely to think in terms of body placement: it seems necessary to imagine one's neighbor and to project the experience of how close one sits to another. An extreme case, or another degree zero[6] could be a "firing squad" arrangement. In this linear configuration, the algorithm would be even more simple, not having to take into account any angles: the length of the table being the number of eaters multiplied by the 'eating space' nominal dimensions. Obviously, this arrangement would not be favorable to the good communication among all eaters. The experience/atmosphere would be very different from the one of a circular table, where no hierarchy exists, and where every person sits in the identical spatial relationship to the others. One of the major interests of this design experiment is to observe how designers raise and address these issues of individual and global, how they rely on their own perception to go about 'solving' that problem. Overall, it is interesting to observe how the 'shape of the table' part of the design problem will be considered together with the "size/dimension of the table' part and the "material" part of the design problem.

Predictions: use of various representations, manifestation of different bodily engagements.
Because the design task is very open-ended, because the program is minimal and requires an interpretation, a great variety of designs are expected based on various graphic representations along with involvement of the designer's perceptual and sensorimotor capabilities to investigate the design problem.

Simulating and engaging reality:
Because the experiment will certainly not be perceived by the subjects as an abstract problem but as a very **tangible** one, I expect to observe real life behaviors like acting as if dinning at the table. Although this experiment is based on a very common/'everyday' experience, student designers are not expected to have a pre-set answer about the size and the shape of the table. Therefore some people might be interested in exploring the design task by arranging real tables, plates and people. Certain designers might be interested in solving the problem in a **direct** manner, for (extreme) example, by taking a table, placing 12 people around it, and evaluating how satisfactory the arrangement is. They might perceive that such a way of

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[6] because it only look at one requirement concerning the individual space/width.

engaging the problem would allow them to directly access to certain aspects of the final/intended experience. Perhaps a designer will take a particular case from his/her own repertoire of experience as model/reference and might want measure from that (for example go back to a place/restaurant that has such a good table).

Measuring and 'using/calling upon reality'

At the least, it is expected that designers will have to measure themselves and a table in order to place a value on the 'feel' of what the dimensions correspond to in terms of distance of interaction/communication. The experimenter might be invited to take part in the experiment in the role of a neighbor, to enact the situation of sitting next to one another. The exercise requires the designer to explicitly acquire a (formerly implicit) bodily knowledge in order to obtain a set of relevant dimensions to help design the table top and decide its dimension.

There will be a 'dialogue' between the projected/represented table and the table used as a desk; that is the subjects will gauge their design by means of the table they are sitting at. There will be a clear moment when the designer is "in his/her design" and other moments where he/she is back in the real world, engaging the table in front of him/her.

Method of data analysis

Beyond the collection of "raw data" --sketches, transcripts, video recording--, documents of interpretative nature have been prepared for the 3 trials in order to help "read" the design process. Their purpose is to bring a certain level of understanding of the principal phases of the process of design in each trial, which in turn allows situating the manifestations of the body in the design process in their context.

The aim of these documents is to try to answer the questions: How to decode the type of observations I am looking for? How to filter them? How to subtract what is not necessary in order to reveal/focus on what is significant?

The need for selection/the problem of selection

This thesis simply cannot pretend to point at every aspect or detail of the design process and at how the body then relates to them. The natural tendency of this sort of undertaking/analysis is to unfold infinitely and to grow in detail, then face the risk of loosing the global 'picture'. Consequently, the challenge is to generate different "views" varying from the general/global to the more detailed/fine-grained.

Three levels of analysis/observation.

Because there are too few trials and because there was an evolution of the protocols across trials, this study cannot pretend to claim any generality. In terms of my observation, the trials complement themselves more than they compare to each other.

The problem in this thesis is how to bring to light these different manifestations of the 'body/hand in the design'. The approach chosen here is to reflect on the manner of observing/capturing and representing/thinking of the role of the body in the design thinking. Therefore, different representations have been explored throughout this thesis under the guiding principle of letting oneself be penetrated by the outcome of the trials.

Because of the exploratory nature of this undertaking and the absence of unique fixed, ready-to-be-used representations of the phenomena, redundancies or co-existence of parallel accounts of the same trial have been considered a necessary step.

Regarding the analysis of the data, certain general documents have been produced for each trial, while other documents/representations/accounts are only present for one particular trial.

The following general documents presenting the entirety of the trial/design session are provided for each trial. These documents provide a "**large scale**" vision/'reading' of the trials.

- o A brief synthetic description/narrative of the design process, its different directions of inquiry, its dead-ends situations, its salient characteristics in terms of when the designer engages certain particular problems (for example: dimensions...),

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o   A one-page document called "collection" in which all the drawings of a design session are presented in chronological order of creation of the overlays.

o   A synopsis decomposing the trial into "segments", each of which describes:

   o   when a new segment starts and what it corresponds to in terms of the task the designer is involved in (for example: a new sketch is started,)

   o   what kind of representation they are (for example, plan or side view),

   o   what problem is studied through them,

   o   other significant events (verbalization, gesture) occurring at the same time,

   o   at a higher level of abstraction, how several segments aggregate to form a **sequence** or a **phase;** that is, in my interpretation, a significant and identifiable/isolable 'chunk' of the design process (which enables to visually represent re-occurring patterns of design activity/thinking.)

In addition, for trial #2, I present a document/table in which bodily postures, design moves and verbalizations are put in relation. For trial #3, I present a chart/diagrammatic representation of the design session respecting the chronological order of occurrence of significant moments or chunks of the design.

At the **medium scale of observation**/mapping/representation, events spanning a shorter period of time are presented, through text and diagrams more specific to the particular situation they describe. At this level of scale are presented and studied reoccurring **patterns** of the design process, for example, in the main body of text, the sequence described in "dimensioning". (For example holding the cup)

The **small scale of observation** looks at how a designer engages the process of giving dimensions to his project by calling upon input from the physical world to feed his "dimensioning thinking". (description from trial #3)

These medium and small-scale levels of observation are reflected in the main body of text of this thesis, whereas the large-scale observation/interpretation/understanding of the design process in the sessions is presented in the next sections.

Running the trials

In this section, the specificities of each trial in terms of protocol and 'context' are mentioned. Then several accounts (narrative and graphic) of the process of design are given that reflect my current understanding/analysis of the process of design as it occurs during the trial. These parallel different forms of account of the process imply, of course, many redundancies.

Comparative Table across subjects/trials: Protocol/setting/task.

Criterion of comparison:	SUBJECT 1	SUBJECT 2	SUBJECT 3
Sex/ Student	Male / Graduate	Female/ Former	Female/Graduate
Total trial duration	34 min. 05s.	44min.50s.	61 min.35s.
Decomposed : Reading & question	9min. 55s.	2min.	1min. 40s.
Preliminary verbalization	0	0	6min. 40s.
Design session	24min. 10s.	32min. 15s	45min. 20s.
Design as wrap-up	0	10min. 35s	8min.
Trial based on Design Task number	Task # 1	Task # 1	Task # 3
Type of protocol (design session)	Silent	Discussion	"Think Aloud"
Intervention of experimenter	None	Yes, many	Yes, some
Where does the trial takes place	MIT, studio 5	Apartment of subject	
On what type of desk/table	Large meeting table, wood	Large eating table covered with paper cloth	
Tableware/objects on the desk?	None	Cup and teapot	None
Use of an instrument of measure/ oneself to measure 'comfort space'?	No (used graphic standard book)	Yes, 2 meter long folded yardstick	

Table #1
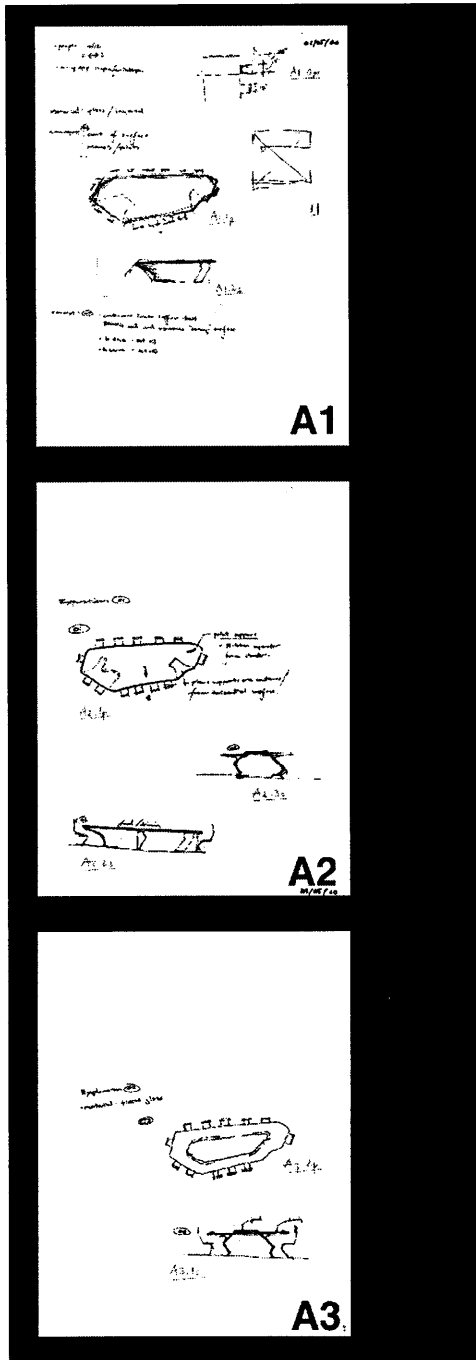
Fig. 13: Collection of the sketches of trial #1.
Scale 1:5

Trial #1

Context/protocol

In trial #1, the design session started with an introductory period lasting almost 10 minutes during which subject 1 read the brief/task and the experimenter gave additional information on what was expected. For example, subject 1 asked if "multiple ideas" were demanded, and emphasized that it would be a different situation if the table were for himself or for other people.[7] The experimenter presented the design task as very open-ended. The maximum duration for the trial was fixed at 45 minutes (30/35 minutes being the goal). Finally, in this trial, the subject was not asked but only encouraged to talk during that design session. Because no verbalization took place during the design period itself and because the nature of the verbal exchange in the reading/questions and explanations was mostly about what was expected and little about the design itself, trial #1 has not been transcribed. In this introductory question/answer session, though, S1 noticeably underlined the importance he placed on the relation of that table to the space in which it is installed. Important point: in the 2 minutes that precede the beginning of the session, I told subject 2 that the design task concerned a table. S1 checked immediately the graphic standard book for reference regarding the height of the table. This clearly defeated a considerable part of the purpose of the trial, which was indeed aimed at observing how (and when) the subject-designer would proceed to acquire the knowledge of these dimensions. At the end of the introductory session, early in the beginning of the design period, subject 1sketched a section with these nominal dimensions read from the book (drawing #A1.0ps).

Narrative

S1 started by investigating the shape of the tabletop with the idea that the tabletop is a large glass polygonal surface supported by "plane supports (...) continuous from (the) horizontal surface". (the glass is folded). This first formal/constructive exploration phase was followed by confirmation of that geometry in a cleaner single line reproduction of the precedent shape. At this stage, S1 also dealt with issues of stability and of reduction of the number of seat (from 14 to 13). Then, Subject 1 explored another section/side elevation of the table with a raised central area for placing plates, while maintaining the original size and shape in plan (adjusting the number of seats to 12). Again a second "final", clean sketch was drawn of this alternative. Subject 1 presents these two options as equally valuable.

Synthesis. In the very short design session (25 minutes), the plan was used as a (for the moment unquestioned) reference point around which two alternative sections were developed. There was a variation of point of view in the successive sections, from material and form, to stability, and finally, to aspects of the experience of dining (differentiation of spaces on the table). In my interpretation, the session

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[7] Subject later choose to be his own client.

corresponds to a phase of initialization in which the design problem starts to be grasped, by the designer proposing a solution and playing with a limited numbers of parameters only one at a time.

Synopsis trial #1:
Accessories: paper, tracing paper, 2 different felt tip pens (larger one is here called Pen2)
Experiment takes places on a large meeting table (here called 'desk') in studio 5 at MIT
Subject 1: S1, Experimenter: R

TIME	EVENT	NATURE OF TASK IN THE DRAWING	REMARKS/ OUT OF THE DRAWING	SEQUENCE CHARACTETRIZATION
3 min. before start			R presents context " ..to design a table", S1 checks graphic standards book for table and chair dimensions	
0: 00	Start video recording	Reading task and questions/explanations	S1 takes notes S1 puts his paper in order several time S1 "is his own client" R "No need to design the space 'around' table"	Requirements discussion
9: 55	Start	S1 writes down some indications regarding program: 10-12 seats	S1 puts his paper in order	Exploration polygonal shape plane legs folded from the tabletop surface
11: 30	**Start Design Phase** A1, paper	Plan tabletop A1.1p, on white paper, polygonal elongated shape	Light lines retraced over several time, some sides are more reinforced than others	
12: 40	A1	A1.2s, longit. section explanatory the concept of folded plane	Not exactly to scale with A1.1p	
12: 45			Short interruption by alien to experiment	
13: 50	A1	Reinforces line in A1.2s Place chairs in plan A1.1p (14seats)	with pen 2	
16: 05	A2, tracing paper	New overlay plan A2.1p based on A1.1p, traces ext. shape, copies chairs at the table ends	Cuts precise format of trace Table contour with pen 2	Elaboration of exploration
17: 05			Change pen (2x)	
17: 45	A1	Writes on A1	"-concept: cont. of surface, -Planes/points"	
17: 55		Studies the footing in A2.1p		
18: 55	A2	Partial overlay on A2.1p to prepare a new longitudinal section (A2.2s). Draws tabletop first, then study legs	Uses dotted lines	
20: 50	Overlay A2/A1	Adds missing chairs in A2.1p, (13 seats), adds a leg.	modification: less chairs on the long side	
22: 10	A1	Writes on A1	"material: glass/ layered"	
	A2	Studies table legs in A2.2s		
23: 50	A2	Back and forth between section and plan, Adds another foot in A2.1p Refines A2.2s (legs)	Indications regarding legs in A2.1p	

Time	Actor	Description	Notes	Phase
25: 15	A2		Folds tracing to adjust format to format of white paper	
	A2	gives additional indications in A2.1p		
	A2		"silent traces" /preparatory movements	Exploration #2
25: 50	A2	New sketch: A2.3s transversal section (modifications of table legs and connection to tabletop.	new concept	
26: 35		Reinforces in A2.3s, observation	Using pen 2	
27: 15	A3	New overlay section: A3.1s based on A2.3s Continuity of footage, clarifies connection to top.	Immediate, 1 clean line, Leaves the new drawing aside	Redraw of exploration #2 (with raised central part)
	A2	Organize give drawings a number by order of creation. (for A2.2s)	Distinguishes betwS1n the 2 concepts	
29: 00	Overlay A3	New plan: A3.2p based on A2.1p -copies exterior outline/contour -offsets contour inside (footage) -copies chairs (subtract one) -adds indication regarding footage	(12 seats) numbers all drawings	
30:10			Relaxes, stretches, folds tracing paper to adjust format	Communication purpose
30: 45	A1	Writes comments	"concept 02"	
30: 08	A3	adds text in A3.1s	"food, dining" indicating zones	
31: 25		adds chairs and plates		
	A2	Adds chairs in A2.2s (longitudinal)		
32: 55			Puts all drawings aside	
	A1	Adds text regarding concept 02		
		Adds titles tracing with date		
34: 05	Finish			
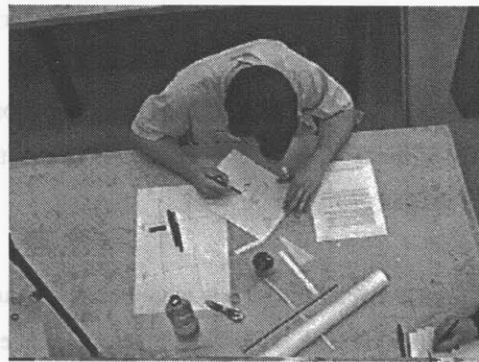
Fig. 14: The settings in trial #1

(view at 13min. 30s.)

In the post-trial discussion subject 1, while explaining his design, mentioned that:

- o The table was to be installed in an elongated rectangular room fully windowed on one long side with a view to the outside, the main axis of table placed parallel to the longer side of the room.[8]
- o The next phase would be to make a scale drawing and see if the spirit of concept 2 is preserved, followed by a model. S1 "sees his proposal very likely to be modified after verification."
- o He would like to explore possibilities of playing with height of table (idea of "a lower table top like in Asia".)
- o He was mostly interested in the horizontality of the table as provided by its size.

Observations

Regarding the role of the body in the design process:

There are "silent traces"/preparatory movements before tracing new lines, in particular while drawing the plan at the beginning.

There are a lot of gestures related to organizing oneself (restacking the paper, cutting tracing paper to the exact format, noting consistently written indications both in each 'final/clean' sketches and on the first page (more general about the two concepts)

There are a lot of movements observable between sketches

Different qualities of lines and use of two different pens corresponding to different moments in the design (exploration versus consolidation).

In this phase of ideation, S1 made no use of dimensions, but relied on proportions of tables and chairs. Because of the use of overlay, the size of the table was kept constant, although the number of people sitting at the table diminished from 14 to 13 to12 in the different plans.

The striking aspect in this design session was how the plan is maintained unchanged and how the design was investigated in the sections. Overall in this trial, the subject placed a great emphasis on the formal aspects of the tabletop, leaving aside the dimensional ones (that are part of the dinning experience).

The fact that subject 1checked immediately in the graphic standards book show that he considered this information to be a prerequisite to start designing (in absence of book, this could have been substituted by measuring from a real case of a person seating at a table).

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[8] See sketch below A1.0ps, draw after the design session.

Trial #1 was an interesting case that challenged my expectation that the designer would use the physical world to "get into" the problem because it is so close to one's. A question worth of additional study is how was the information acquired in the book re-invested bodily later on?

Regarding the protocol:

Trial #1 was a test, a "pilot" trial. It was clearly too short. It was not enough about the dinning experience, in other words, the limited time did not enable enough development. Finally, it was also too silent: the absence of verbalization during the session did not encourage/generate the type of gestures that are usually observable during conversation. In the next trials, the goal was to increase the density of richness of the observation in particular, by encouraging the 'talk-out-loud-what–you-think' in order to have more indications about what the designer is thinking.
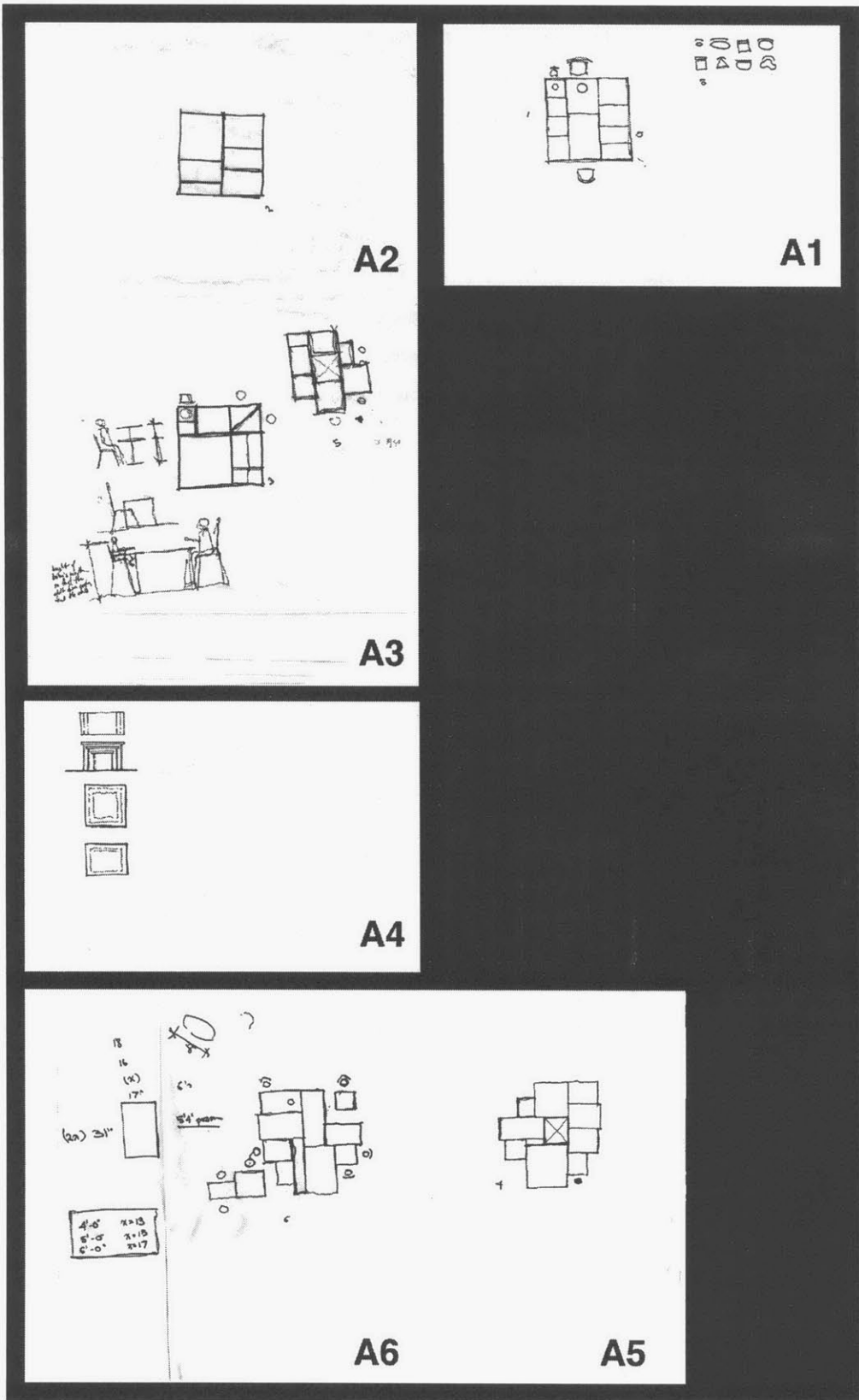
Fig.15: Collection of the sketches of trial #2. Scale 1:5.

Trial #2

Context/protocol/brief

The start of trial #2 was delayed for 3hours for technical reasons. Subject 2 was informed of the design task to be a table but she reported not having prepared for the design session or not even having thought about it. Therefore, one can consider that the trial veritably started by the reading of the task. Compared to the previous one in trial #1, the design task requested emphasized more on the dining experience.

A characteristic point of trial #2 was the high level of verbal interaction/dialogue between Subject 2 and experimenter (R), which made it sound like a conversation[9]. Under these conditions, I am tempted to say that the design process in which S2 was involved took place (sometimes) in spite of many 'contributions' and interruptions by the R. As a consequence, certain gestures observed during the design session might have more a communicational purpose rather than a purpose in relation to the design thinking process. Nonetheless, one can assume that by serving this communicational purpose, these gestures also served the purpose of helping S3 better understand her design.

Accessories. Another major difference between trial #1 and trial #2 was the introduction of a folded yardstick of wood, 2 meters long when unfolded, with graduation in both centimeters and inches. Another important element of the setting was the presence of a teapot and a cup on the table. The cup was used not only to drink throughout the session but also more importantly as an object to engage the design problem (to acquire measures, to simulate situations).

Narrative of the design process and design issues:

To support her design thinking subject 2 developed a scenario in which the involvement of the dinner's guests was implied. The guests had first to choose the chair they would sit on from a collection of chairs present on the spot and second to adjust a table according to their own comfort, depending on their personal bodily height. Her design followed two paths successively. On the first path of exploration, a large square tabletop was divided into 10 panels of various sizes and adjustable in height. This arrangement was abandoned after further study of different options of dividing of the large square into smaller elements. In my understanding, subject 2 considered unacceptable a contradiction between the original concept of everyone choosing his/her own chair and table and the resulting situation at the table's angles, where two persons had to share the same corner. Subject's 2 second path of exploration reinvests the initial idea that had been "dissolved" into the square concept (At the very beginning, the large square was not drawn first and then subdivided but it started by placing tables next to each other). In this new scenario, different tables picked by the guests were aggregated together to create larger table, whose overall shapes were to vary at each dinner. Only after this conceptual phase did subject 2 investigated aspects of dimension in a final phase.

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[9] Certainly, the correction operated after the silence of trial #1 was a little too far in the opposite direction!
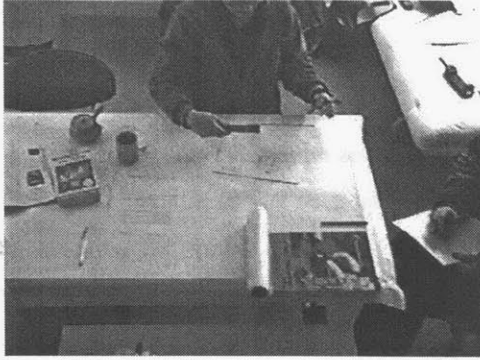
a) at 7min.20s.
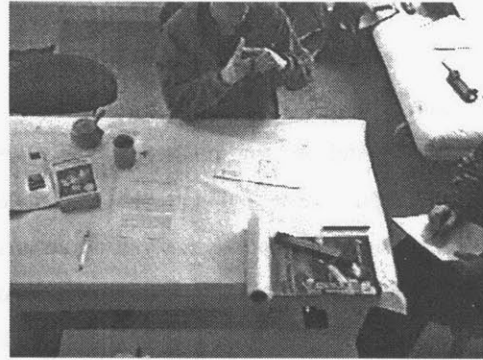
b) at 9min.00s.
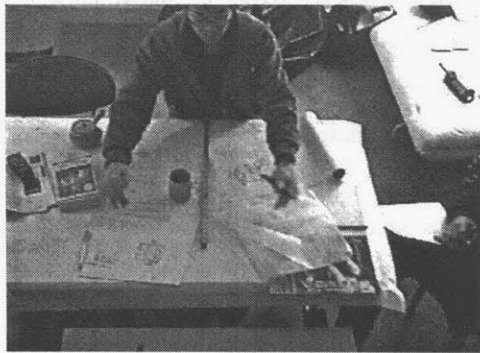
c) at 34min.50s.
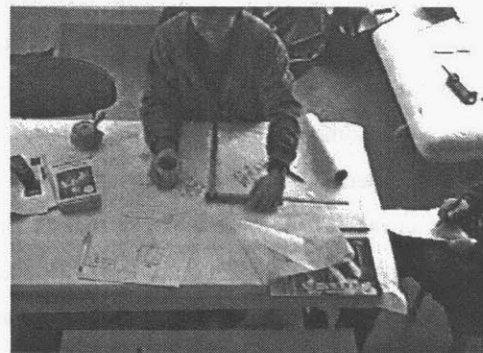
d) at 36min.30s.
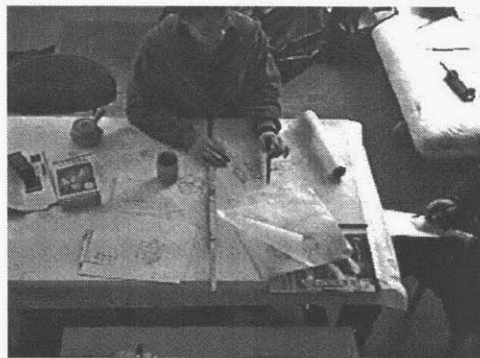
e) at 40min.10s.

Fig.16 (a,b,c,d,e): Images from trial #2, showing the use of the folded yardstick and the cup as instrument to support, complement and mediate between the experience and the operations of measuring and dimensioning.

Synopsis trial #2				SEQUENCE CHARACTERIZATION
Task: Table 10-12 (see appendix n), Accessories: paper, tracing paper, cardboard, foldable yardstick two meters long (called 2xmeter). Use one single type of felt tip pen. Experiment takes places on a six-seats table with paper cloth allowing to draw on it.				

TIME	EVENT	NATURE OF TASK IN THE DRAWING	REMARKS/ OUT OF THE DRAWING	SEQUENCE CHARACTERIZATION
-3H	information		R presents context: "..to design a table for 10-12"	
0: 00	Start video recording	Reading task and questions/explanations	S2 1 pen type.	
2: 00 / 4: 10	**Start Design phase 1** sketching A1	Starts on white paper plan A1.1p by first drawing 2 tables and 2 chairs places next to each other. Then draw a larger square made of 10 tables with different formats (3rows)	R stands back and go to observation location S2 ask "can you see..." R move to end table position	Initial idea, setting up scenario number 1
4: 30	A1	Explains and draws additional chairs placed remotely from the table	S2 "will be her own client"	
6: 15			S2 explains " chairs and tables from different size and height in a vast loft' 'everyone would pick a chair and a table' then assembled to form the larger square. Tables adjustable in height	
7: 20 photo			S2 first reach to the 2xmeter S2 mentions elbow room	
9: 00 photo			S2 explains detail between vertical and horizontal elements in table with hands	
9: 20	Overlay A2/A1	New plan A2.1p based on outline of A1.1p to study "system of dividing" Study of flexibility. (6 larger tables in 2 rows)	Designing and talking	Testing scenario with different arrangements
10: 35	Overlay A3/A2	New plan A3.1p based on A2.1p, square arrangement of tables with stronger contrast of size, sketch different divisions	By folding tracing paper R: dimension, height?	
11: 55	A3	New side view A3.2s presenting a child, discussion height,	S2 "child five/ ten years old" Line weight light	Testing in height/section
12: 55	A3	New side view A3.3s, child high-chair and an adult at a table.	R and S2 discuss. Line weight light	
15: 40 / 16: 40			Uses 2xmeter for evaluation of child head-height in high-chair (=36") in accordance with a feeding movement	
17: 35	A3	High-chair/table situation in corner of large square in A3.1p (add a few lines)	S2 " usable as starting point for serving, or flower" [pb /small-sized table to fit with other tables in large square scheme]	

19: 15	**Strart design phase 2**	Starts A3.4p plan, Line weight light, respecting overall square only partly " I have set my limitation at a square"	"my original idea" [see 20]	Rediscovering the 'original'
20: 05	interruption	Keeps drawing A3.4p	Interruption by telephone call 2min.	
21: 25	A3	Discussing Assembling	"all tables have 4 legs" R "possibly a hole in the center" ; ask "Dimension?"	Setting up new scenario, synthesis between plan and section, clarification of a system.
22: 35 23: 55	New sketch A4 paper	Side view and plan A4.1ps (white) Study 3 groups of 3 tables, (9 tables) with different proportions	S2 "table top light color all the same, birch veneer" Tables are stored by group of three, one underneath the other.	
26: 10	A4	Keeps drawing A4.1ps steady	S2:"exercise in being very systematic". Overall square completely abandoned	
26: 30	New overlay A5 tracing	New plan A5.1p based on A4.1ps, created by randomly aggregating tables picked from the collections of 9 tables represented in A4.1ps (no regular overall shape). Base of a new concept	S2 "arrange and work with the dimension" "Little notch here"	
28: 54 29: 00	A5	Reinforces center square in A5.1p	R question S2 regarding corner situation, S2 "not nice situation" R individuality vs. community	
30: 35	A5		S2 compares the two 'tables' "trial and error" "The elbow room dimension"	Discussing the limitation of the system
31: 20 33: 10	New overlay A6	New plan A6.1p (contour) with 'satellite tables' and a few chairs (identical sizes)	S2: "allows different type of conversations" "problem with screaming across the table"	
34: 10 34: 25 34: 50 photo	A6 OnTable		R "dimensions?" S2 "go by me" → measures the width of comfort room, trace on the table, measure with double-meter (31"), use the cup place it on the table, depth= 18" Several tries with cup (R ?)	Investigating bodily measures and the desk's measures to generate the tables' dimensions
	A6	Draws rectangle approximate proportion 17 x 31 (plan A6.2p)	The 2xmeter remains unfolded.	
35: 50	A6	Sketch A6.3p with dimension 8"	S2 "in a Chinese restaurant=8"	
36: 15			Measures " the table here is 30" ", correct 17"above to 16"	

36: 30 photo	A6	Adds x and 2x to A6.2p,	S2 Establishes rule of progression for height of the table top according to the person height	Systematizing the dimensions
39: 10 40:10 photo	A6	Writes 2 columns indicating the correspondence between the height of a person and the height of a table.	S2 Measures height of the table on which the experiment is taking place. (38"20) [use table for comparison]	
40: 50			S2 explains: "try out with the chair you pick" table are not adjustable in height, 'too complex' , on caster roll, "design still need work in the Z direction"	Adjusting initial requirements
		Adds numbering to the drawings	The double-meter is remained unfolded on the table.	
44: 50	Finish			

In a post design session conversation, S2 reported that one of the next steps would be to build a model.

Observations

Regarding the role of the body in the design process:

- There was a lot of interaction with the folded yardstick. The folded yardstick was convenient/used to measure larger/real dimension. Trial 2 could almost be entitled "conversation with a folded yardstick"! Its use evolved both in frequency and nature. It was used more and more often and was more and more present on the table. In the beginning, it was folded up after use. Later on, one or two segments stayed unfolded; at the end, the folded yardstick was unfolded to correspond to the width of the table. It remained like this (unfolded on the table) until the end of the experiment. My interpretation is that the folded yardstick 'embodies' a relation to reality/physical space.

- Sometimes subject 2 drew upon comparison with her personal repertoire of experiences (for example: episode of/reference to Chinese restaurant, and comparison with the actual dimensions of the table used during the experiment (30'').

- From bodily to quantitative/formal knowledge of the simulated situation. Subject 2 used objects like a cup and a teapot to evaluate the comfort space for one person.(and used the folded yardstick to quantify it). In the final design phase dedicated to giving dimensions to the 3 groups of 3 tables in relation to their variable height, subject 2 simulated situations like holding one cup while sitting to measure the space she was occupying. Instead of imagining it or constructing/drawing it, S2 just did it, it was faster. Gesturing or simulating/mimicking demonstrates that certain dimensions are given according to the body size. Freezing the gesture/posture to measure it is a technique to bridge/connect bodily knowledge of the action to the dimension. S2 drew her width/elbow room on the desk's paper

cloth, another way of engaging the desk/environment on a full-scale and of visiting the actual experience of sitting at the table.

- During this phase of ideation, S2 made no use of dimensions, but relied only on proportions of tables and chairs. (Because of the use of overlays, all drawings are the same scale across the session except for sections with high chair, which were the first of the kind)

- Quality of material was represented/experienced by gestures "light veneer" (at 22min. 35s.)

- Subject 2 talked a lot and created scenarios that provided a context and a framework within which the design made sense. There was a strong level of interaction between the verbalization and the design. Sometimes the verbal replaced the drawings (for example in the first design, the idea of the 10 elements adjustable in height was only verbalized but not investigated in drawing)

- S2 moved from the original concept to the new one by 'exchanging' requirements, by trading the overall square shape for the 'systematic' storage of the tables (also solves a structural problem). This movement was accompanied by a verbal reformulation of the design problem.

- In the drawings, different qualities of traces are noticeable, for which there seems to be a direct correlation between how sure the subject is of her idea and the line weight in the sketches.

- Subject 2 arranged the drawings on the tabletop in order to have them ready for visual consultation at any moment.
  - Subject's 2 first idea[10] --of adding different-sized tables which expanded into the idea of forming by aggregation an overall square-shaped table in plan (the section being dependant on different height)—was 'revisited' after 19 minutes.

Regarding the protocol:

The critique after trial #2 was essentially to reduce the level of verbal interaction between experimenter and subject, and to "try on" a different protocol involving a preliminary section/phase dedicated to verbalization on the design problem.

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[10] This idea was not expressed because it was during the beginning period of the trial when the placement of the experimenter was discussed.

| DESIGN CONCEPT 01 2:50 | EXPLANATION CONSIDERATION 2:45 | EXPLANATION HEIGHT AND MECHANISM 1:20 | STUDY ALTERN. DIVISION (2) 1:25 | STUDY ALTERN. DIVISION (3) 0:40 | STUDY HEIGHT HIGHCHAIR/KIDS 4:20 | CONSIDERING USE /CONSTRAINTS 3:05 | BACK TO ORIGINAL CONCEPT (02) 3:20 | IN SECTION CATALOGUE 3:55 | USING THE CATALOGUE 3:50 | "SATELLIT 2:45 |

early in the analysis of the session as an attempt to relate the postures to certain phases of the design and to the verbalizations that accompanied i
re. This representation that observe postures that are maintained for a certain period of time contrasts with the "instantaneous" images in figure
the very original idea by showing the construction of the first drawing and linking it to the second scheme, 2) indicates when tools (cup and fold

Trial #3:

The protocol, the context and the brief

Trial #3 was a 3-step[11] trial (verbalization, design, revisit the design) using a "think aloud" protocol[12]. It took place in the same space as trial #2, on the same large table with a paper clothe on it which was used to write things down. As in trial #2, the folded 2-meter long yardstick with graduation in both centimeters and inches was provided, as well as large sheets of both corrugated and non-corrugated cardboard. In contrast to trial #2, there was no tableware present on the table.

In the five minutes before the beginning of the trial, the experimenter presented succinctly the context of this study: "how designers engage their body in the design thinking".[13] The unique example given to the subject was that a subject's perfectly acceptable reply could be "let's go see and measure that table I had a wonderful dinner at with a dozen of friends yesterday".

The trial followed the protocol:

1. First, subject 3 read the brief and expressed verbally in approximately 10 minutes how she perceived the task/problem and planned to address it.[14]

2. Then, subject 3 designed (overlay A1 trough A4) using almost only sketches at no particular scale. Throughout the approximately 45 minutes of the design, the experimenter invited the subject to maintain her 'thinking aloud' and to tell the questions she was facing.

3. Finally, subject 3 was asked to "wrap-up" and to review her design in approximately 10 minutes, evaluating how far her proposal was fulfilling the requirements of the brief in terms of quality of the dinner experience. Subject 3 took advantage of the opportunity open to her to work more at the design to finalize it.

Narrative, synopsis, diagram (global)

Narrative of the design process and design issues in trial #3

The process of design shows the influence of the preliminary verbalization section as set in the protocol of the trial[15]. The preliminary verbal phase raises several points that have either

- the status of variables (issues whose reality has been acknowledged but for which no preferences have been expressed) or

- the status of requirement based on the subject's preferences.

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[11] Initially, a fourth part was meant to take place: a rehearsal of the video recording directly after the experiment together with experimenter in order to provide more information on how the subject perceives the problems that are faced, what actions are thought of to solve these problems, etc). For time reasons, this fourth part could not be carried out.

[12] see Task #3 at the end of this Appendix

[13] After the trial, when asked if having been informed that the study was about how designers engage their body into design thinking had influenced her way of proceeding through the design, subject 3 was affirmative that this had no influence and that she had proceeded in a way that was familiar and natural to her.

[14] For a list of the points see the transcript of the trial.

[15] I'm not entering a discussion about where the design actually starts (with sketching or with formulating requirement for one's proposal?)
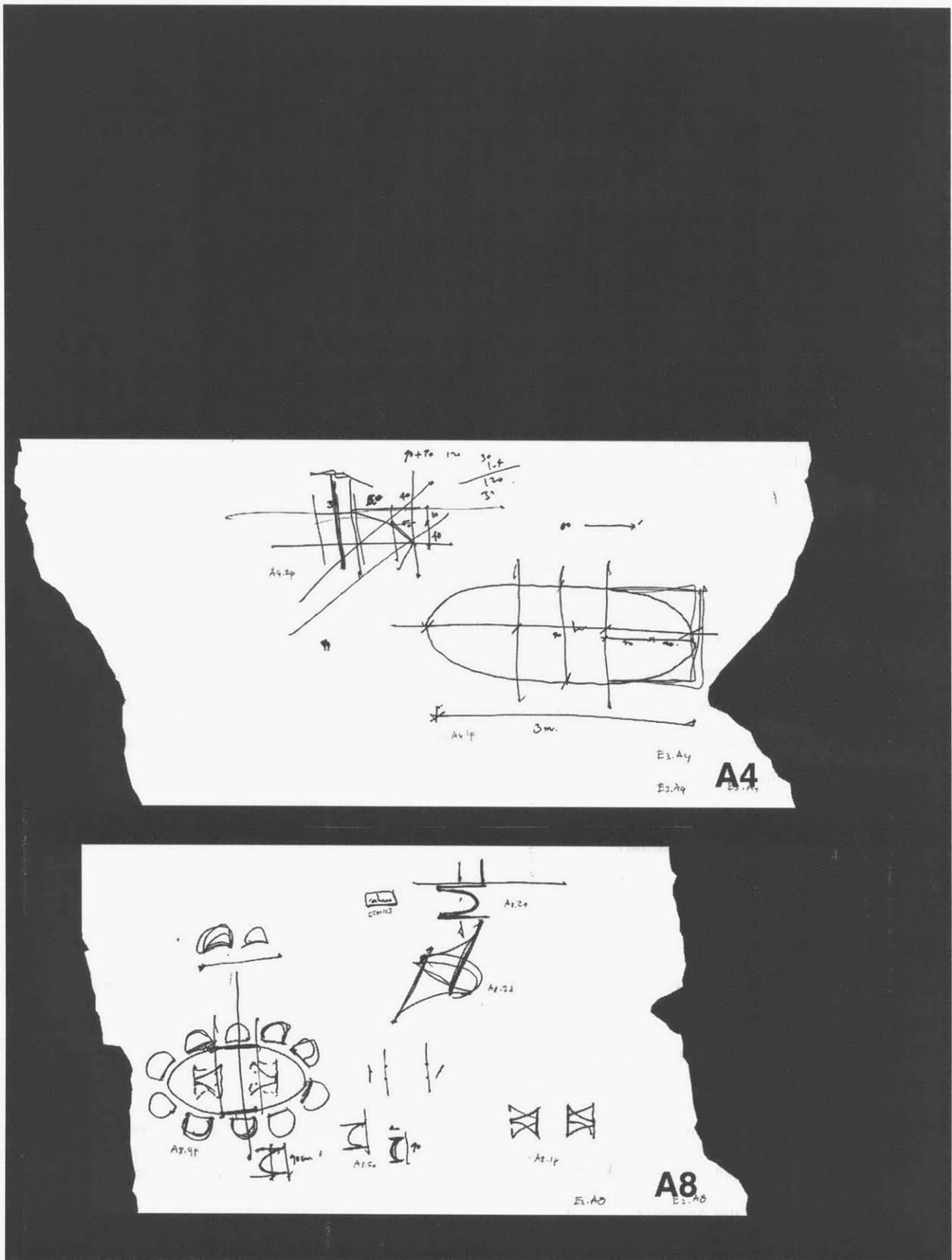
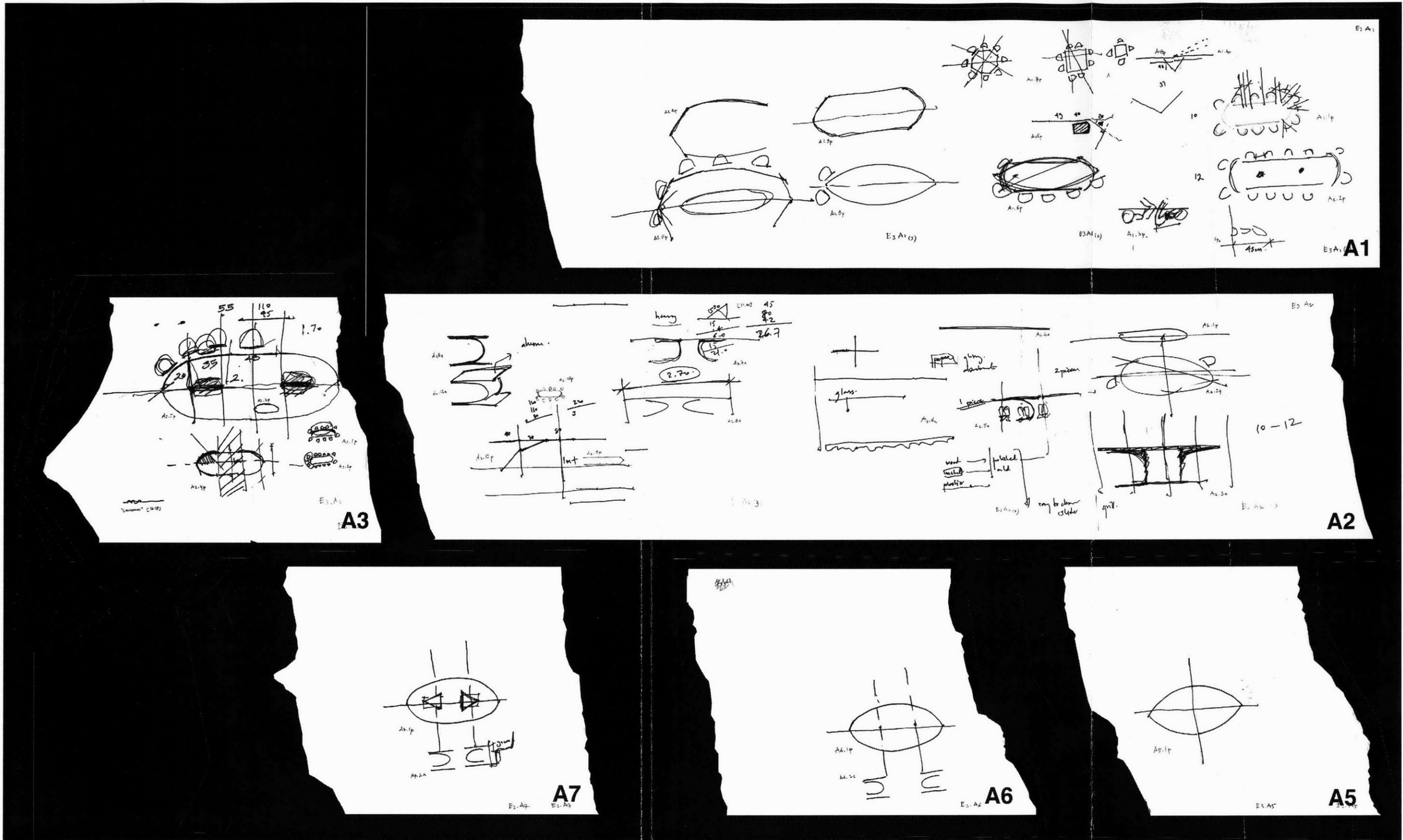Fig. 18a: collections of sketches of trial #3. Scale 1:5.

Fig. 18b: collections of sketches of trial #3. Scale 1:5. Reading direction from right to left.

In this personal account of this design, I think that the point raised during the verbal phase regarding the subject's preference for a "round scheme" --if there were fewer people to seat-- is important because it reappears, modified, in the final scheme, as we will see later on. (see chapter "Persistence")

After the preliminary verbal phase, the first part of the design phase consisted in investigating successively (in very much the same order) by means of sketches the different variables/self-imposed requirements identified in the verbal phase. In my interpretation, there are 4 sub-parts in the first design phase. Three at least (the two plan versions in overlay A1 and the study of the section in overlay A2) present quite similar patterns in the way they unfold.

- They start with an idea expressed in a sketch (A1.1p, A1.6p's lens-shaped part, A2.3s respectively),
- which is then developed into another or more sketches,
- which turns out to be unsatisfying to subject 3
- who consequently consistently concludes the direction of inquiry by restating –both verbally and in a sketch-- the original requirement ("elongated" in plan or " 1 piece" for the tabletop in section) or by calling upon an 'ideal'/reference case/model ("square" tables for 8 or 4 people in A1.7p)[16]

Before engaging the phase of synthesis D2 (overlays A3 & A4), subject 3 completes the review of the list of variables/requirements by investigating possible materials and calculating the length of the tabletop. Because she experienced difficulties with this latter calculation, subject 3 verified its validity graphically by means of a scale drawing. The drawing is, for the purpose of simplifying its construction, first drawn with the table ends at a 45-degree angle. This unsatisfying configuration in terms of flexibility of fitting 10 or 12 people at the same table leads S3 to (re?)-introduce a rounded 'transition' between the ends of the table and the central part, --which, in turn, generates the idea of a new form. S3 then puts all these different aspects together, but finds herself still unsatisfied by the form of the tabletop. Here, another repeating pattern of design activity is observable[17]. It was already present in the first design phase, in the articulation of D1b,c and following. It consisted of the movement originated by dissatisfaction with the plan, calling on S3 to study the section, which triggers thoughts about material, weight, size, which in turn, triggers an operation of re-dimensioning the tabletop.[18] In this synthesis phase, S3 also revisited the requirement of flexibility in accommodating 10 or 12 people in parallel with the placement of the table legs, and she decided to design for 10 only[19].

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[16] Interesting to notice is also the consistency with which these re-statement/ideal cases are 1) drawn 2) located in the upper part of the format in use.

[17] Actually, not from the resulting sketches in which the timely construct dimension has disappeared, but from the diagram presenting the chronology of the design phases (see fig.20)

[18] this repeating pattern is given more attention in section "Dimensioning"

[19] My interpretation is that S3 is more interested in 10 because it enables her to place 2 persons on the central axis of the table, creating a more contrasted hierarchy among seats. (this could be seen as an interesting reinterpretation of the type of hierarchy embedded in the elongated table with 1 person at each end (option rejected by S3 at the beginning).

The last section of the trial -the "wrap up" section—provides S3 with the opportunity to revisit her scheme (overlay A5 to A8). Interestingly, the previously investigated and abandoned lens-shaped form of the tabletop re-appears and is evolved by successive rounding of the two ends. A possible reading of the final scheme is that it is the one that most closely approaches the round scheme that subject 3 mentioned (and gestured, see fig. 6) in the verbal phase as her would-be favorite scheme for a table for fewer people[20]. In this section, additional study time is dedicated to the table legs, and an indication of height is given after solicitation by the experimenter.

The design process could be synthesized in 4 main phases:
- **Verbal: set variables and requirements**
- **Design Phase 1: successive "independent" study of variables and requirements + consideration of material and calculation of the length of tabletop**
- **Design Phase 2: First synthesis of variables and requirement in a single comprehensive scheme, dimensioning revisited**
- **Wrap-up, Design phase 3: Revisiting, second synthesis, form refinemen.**

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[20] At least, this reading presents some "literary" interest! A possible interpretation for justifying subject's 3 choice in favor of a 10 people table could be that within the required range [10-12], 10 is the lower bound, the closest to a smaller number of seats. Again, more likely, the clear presence of a central axis on which 2 persons sit seems to be the best candidate for explaining why 10 versus 12.
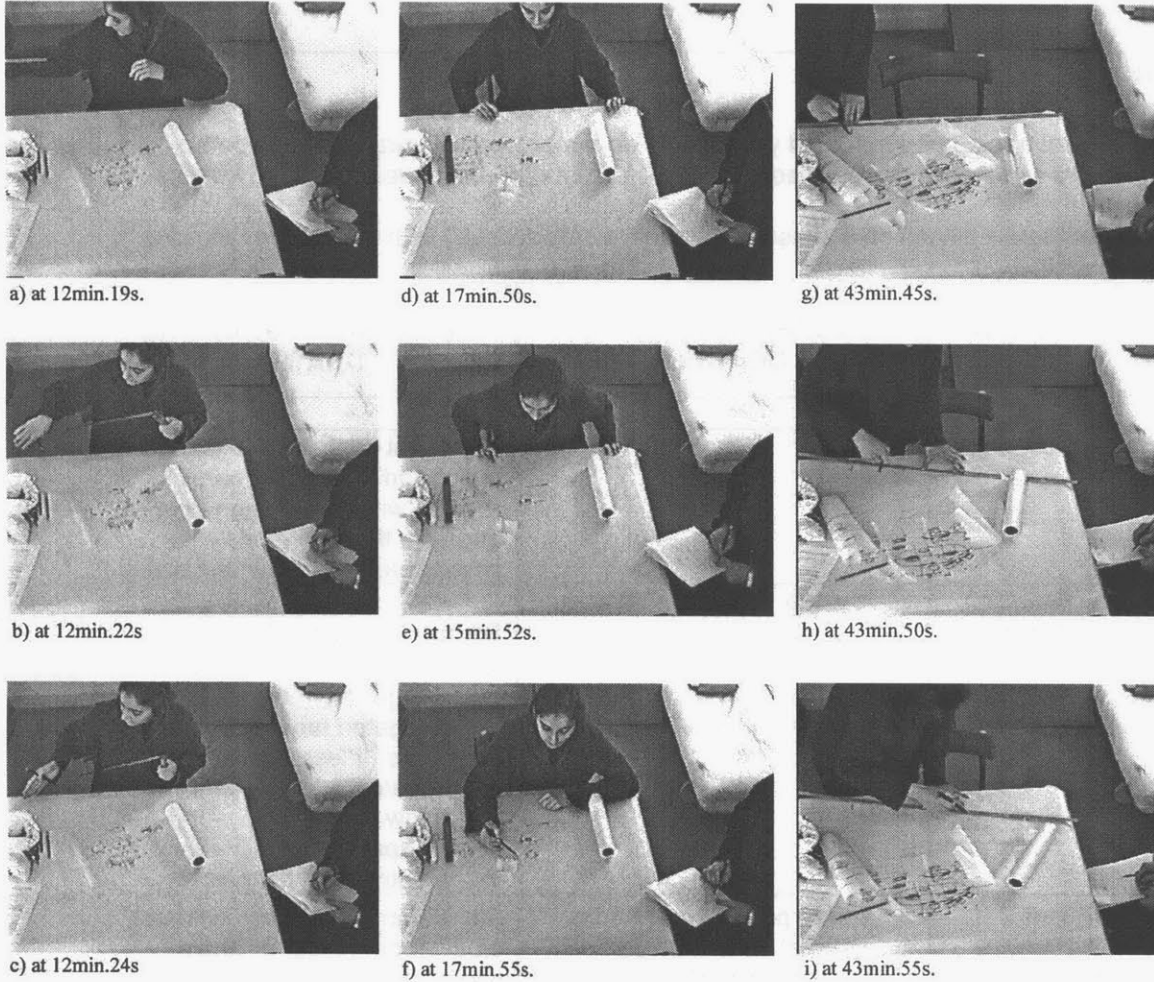
Fig.19 (a-i): Images from trial #3, showing the designer's use the actual table/desk/environment as reference for her design thinking.

In (a,b,c), gestures with the hand (superimposed to the actual environment/desk) are there to help the designer imagine how her design could be like in 'reality.' (A,b,c) show gestures of simulation/projection, when the designer tries to engage the reality-to-be of the projected design by simulating more or less interiorly or overtly what it would be like (in particular, in (a), in trying to feel the distance from /presence of a neighbor. This is also the case in (b and c) of trying to support the imagination of the size and shape of the projected table.)

In (d-f), the designer revisits/'replays' her perception of the table edge in order to support her grasping of that aspect of 'sitting at a table.'

In (g-i), the actual table is used to proof the calculated measure.

Synopsis trial #3:

Accessories: tracing paper, folded yardstick (Two meter long with graduation in both centimeters and inches, here called '2xmeter',) paper, cardboard were provided but not used.
Experiment takes places on a six-seat table (here called 'desk') with paper cloth allowing drawing on it.

TIME	EVENT	NATURE OF TASK IN THE DRAWING	REMARKS/ OUT OF THE DRAWING	SEQUENCE CHARACTETRIZATION
-5'00	Information		R present context "...to design a table" and situate the study in relation with how design thinking engages the designer's perceptual and bodily apparatus	
	Recording	Start video		
0' 00	Reading		S3: reading "task 3"	
01: 39 photo see fig6	Preliminary verbal session		S3:" images from the past" V1: elongated table, 2 persons at both ends (if less than 10 persons → choice/rounded scheme) V2: elbow room V3: leg space V4: tabletop as 1 flat piece	Identifying variables and requirements
08:17	Start sketching Trace A1 [START DESIGN PHASE 1a]	A1.1p (10 people) and A1.2p (12 people) as archetypal tables, satisfying V1	S3: -comments on two different elbow room (linear or angle situation) -identifies constraint with 2 people at the ends/proportion elongation -identifies relation location table legs/position people (according to point V3)	Test size and proportion of tables for 10/ 12
10:44	A1	A1.3p a and b, study elbowroom as determinant unit. (Evaluate it as 90 cm)	S3 measures self, use folded yardstick,	Investigate variable elbow room in linear and angular/end configuration
photo 12:56	A1	A1.4p: diagram to study angle variation at table ends	S3 detaches piece of drawing A1.4p to "play with the angle"	
16:29			S3: "setting standard, template, will be modified later on" "Sitting at the table"	
17:27 photo	A1	A1.5p: makes clear the constraint provided by the angle Start A1.6p (one line only)	S3: expresses doubts about form of table with angles at the end. (compared to a continuous edge)	
18:25	A1 [END DESIGN PHASE 1a]	A1.7p: recalls and inscription/drawing of past experience	S3: "the most ideal table I have eaten were for 8 people square tables".	Calls upon repertoire

Time	Code	Description	Notes/Quotes	Annotation
19:38 20:38	A1 [START DESIGN PHASE 1b]	A1.6p: plan made of two superimposed alternatives: archetypical (same as A1.1p) on top of which a lens-shaped form is added (immediately investigated in A1.8p) Create a sharp angle at both ends	"not sure this is an angle that I want, because… but that's an option!" symmetric: Yes, not satisfying, (room for eating) need "to invent a shape"	Tests different plans/angles [problem with flexibility]
20:57 21:55	A1 cuts trace	Pursue investigation of different angles A1.9p, A1.10p, A1.11p	A1.11p is judged "Bulky" clear desk, put overlay A1 on the floor	
22:05	A2 [END DESIGN PHASE 1b]	Sketch very fast A2.1p (slim) and A2.2p (fat) diagrams as goal and not-goal. [the two are **elliptic** shapes]	Restates "slick and slender" regarding elongation and proportion	Restates **ideal** again
22:40	A2 [START DESIGN PHASE 1c]	Starts section A2.3s with axis indicating where people sit	"dead-end here, but I think I (.) know (.) in section"	Studies table legs and top in **section** Regarding peoples' placement
23:21	A2	starts A2.4s, 1 horizontal line then interrupt:	"I'm still not thinking about the material"	
23:37			R: regarding section? "space for peoples' legs" "question about deciding between 10 or 12 people!"	
24:00?	A2	A2.5s section, proposal with tabletop in two parts	Unsatisfied with proposal for tabletop made of two pieces, Reaffirm necessity for one part only (P4)	
24:45 29:53	A2	Takes notes [A2.6n] while discussing materials, quality of finish for tabletop and… A2.7s, A2.8s detail attachment legs "punched through? bolted"	Wood? polished. No metal, no plastic. Paper? Want glossy surface, decide for glass with 3D/print on reverse side Want heavy legs ("molded steel?") Problem with "two different…"	Discusses **materials** for tabletop and legs
31:00 32:25	A2 [END DESIGN PHASE 1c]	A2.9p, A2.10p,	Considers weight and dimension, calculation (after correcting mistake: length= 2.70m) Uses double meter to compare with experiment's desk-table. And use scale drawings	Considers weight and **dimensions**

Time	Phase	Action	Description	
35:10	passage A2 to A3 **[START DESIGN PHASE 2]**	Overlay A3.1p on A2.10p addressing the problem of the angle re-appearing in the latter. A3.2p, A3.3p	"to satisfy 12 people sitting at this table" researches "comfortable transition" introduces rounding of angles	Putting the plan together 1 (synthesis)
37:00	A3	A3.4p	"working in zones" for leg space	
38:50	A3	A3.5p (draws the table by quarters by folding the tracing paper and using its transparency) (includes legs in plan)	"Here is my uninteresting shape" → moves on to the section on overlay A2 [clear desk space]	
40:10

41:30 | Back to A2 | A2.11s and A2.12s, studies footage table | Considers alternative material. Aluminum, → Question regarding weight of glass → Reconsider dimensions tabletop | Considers material |
| 42:00
43:00

43:30 | A3 | Adds to A3.5p

Draws on the desk's paper cloth | Calculates dimension table top, abandon the 12 people option Notices a mistake, uses desk as reference, stand up, uses double meter, draws lines on the desk's paper cloth. | Calculates, corrects mistakes by using 2xm and evaluation outside of the calculation. Maintains overall agenda regarding proportion of table top. |
45:05	A3	Adds dimension to A3.4p	Determines the width across the table :1meter	
46:30	Back to A2	A2.13p	Re-calculates	
47:05	A4	New overlay A4.1p based on A3.5p Studies distance across	Clears partially the desk (overlay A2 is placed on the floor) Tabletop dimension: "let's say 3m x 1m!" "proportionately, it could be less than 3m"	
48:40	A4 and desk	Uses folded yardstick on desk.	Uses 2xmeter, "to imagine without drawing" Calls upon "the most comfortable dimension, minimum dimension I could dine in": 60cm	
49:30	A4	A4.2p (geometry) to calculate the projected dimension of the 60cm eating spaces along the "3 stages" of the curve. (this plan is more lens-shaped than A4.1p)	Calculates 50+40+30=120cm Multiply by 2 and round the result up to 2.5m	

53:36	[START DESIGN PHASE 3]		R calls for **wrap up**. S3 clears all overlays away from the desk.	
52:40? 53:00	A5	new overlay, A5.1p based on A4.2p but curved, ¼ shape, cuts overlay and fold it to complete drawing	Regarding top being 1meter across: "although, I remember at the beginning, I do wanted a slick and slender table!"	Revisit lens-shaped top as explored in A1
53:40	A6	New overlay, A6.1p based on A5.1p, (less lens-shaped) A6.2s	"here are where the legs come, (.) more or less centered" section associated with plan	
54:20	A7	New overlay, A7.1p based on A6.1p, corrects the legs location and is more precise regarding the shape of legs, same top than in A6.1p	"[55:00] I never considered the legs in plan, so I'll just conclude about those!"	Decides in favor of an 'elliptic' top and study footage
55:55	A8	New overlay, A8.1p plan of the legs only based on A7.1p. Section A8.2s and perspective sketch A8.3d	Studies table footage (two opposed triangular aluminum plates connected by a 'spring') "some plate that's folded and sits like a spring, and supports the two pieces"	
57:45	A8	New plan A8.4p based on A7.1p including footage.	"(.) community gathering around the table (.)"	
59:05		Studies footage in side view A8.5s, (which appear to be more vertical than previously thought)	R question regarding height. S3 uses 2xmeter to measure desk. (does not verbalize)	Studies footage in section and 3D, and height of tabletop relative to seats.
1:01:00	A7	Add a chair in the side view A7.2s	"The height of the table really depends on the height of the chairs". Measures height between seat and desk surface (do not indicate result of measure) Gestures with hands as to figure out what a higher tabletop would be like. Verbalize: "Approximately 30cm, a little higher than this"	
1:01:36	Finish			

Highlights in chronological order of different stages of measuring and dimensioning operations of the tabletop along trial #3. (See chapter dimensioning)

1. Variables Identification: [02min05s-08min00s]

In the verbal session before the beginning of the design session, subject 3 identified variables in regard to comfort at the table. (Elbow room and leg space, along with requirements like sitting two persons at the two ends of the table that implied consequences for the proportions of the table). At this stage, S3 had only a notion that the table is elongated.

2. Rapid graphic evaluation/estimation: [08min00s-10min30s]

To obtain a rough grasp of the actual elongation of the table, S3sketched two similar/identical plans depicting tables for 10 and 12 persons. While drawing the first table [A1.1p], there was a moment during which S3 thought that the table she was sketching accommodated 12 persons when it was actually drawn with 10 places only. Interestingly, after she noticed the confusion, the following sketch, a plan for a 12-seat table, was drawn with slightly 'over-sized' dimensions (with people very far apart from each other). This was the first illustration that numbers are confusing and weakly connected to reality.

3. Measuring/ Data acquisition for variables/ nominal dimensions: ("elbow room" as the term that designates a particular dimension) [10min30s-12min30s]

S3, using the folded yardstick, measured in an egocentric framework the nominal "elbow room" dimension. ("setting a standard") (See photo in 'BodyShapesDesign/DesignShapesBody' in Forewords)

4. Maturation 1: relating interdependent dimensions among constraints [12min30s-30min00s]

S3 (discovered and) investigated through multiple drawings the interdependency between angles at the end of the table and dimensions along the table edges. This included an interesting drawing-turned-tool [A1.4p] to study angle variations at the transition between the parallel section of the tabletop and the end parts. The use of drawing implied a manipulation of the detached part of the drawing on top of the remaining one.

5. Calculation 1 (1st occurrence of a repeating pattern) [30min00s-32min00s]

After having left the plan unsettled, investigated the section, thought of materials for the top and the legs, S3's calculation was triggered by consideration of the weight and size of the top. The computation of the length of the tabletop was complicated by the fact that the shape of the table was still imprecise, that S3 mistakenly used half dimensions instead of full ones and by the fact that the her concerns at the moment was the position of the table legs (she was studying in section). This is another illustration of the weak connection of numbers with reality.

"Correction" (type A)

Between the actual result of the calculation of a dimension and the announced result, S3 always introduced a 'correction' of plus or minus 25 cm to the calculated dimension.[21] This correction reflects a mechanism of appraisal of what the dimension should be compared to the raw result from the calculation (which is blind to the real physical size of the table). One is a pure number, while the other is a 'sense' of the right dimension. Throughout the design process, there is a constant interplay between the two: one is re-

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[21] This becomes visible after recalculation of the additions that subject 3 wrote on her overlays.

evaluated by means of the other: the nominal dimension is first acquired, and later on is manipulated and processed in various ways.

6. Verification 1/ Correction (type B). Using the environment (desk) for comparison/ [32min00s-36min40s]

After the calculation, S3 engaged a second operation of verification: one consisted of comparing the computed dimension with the actual length of the table she was working at, another consisted of drawing a scale drawing of the table top. My interpretation of these actions is that the scale drawing was started because the measure of the table with the folded yardstick was 'surprising' to S3 (similitude 1.7M/2.7M). It is important here to observe her reliance on a direct experience of the environment to confirm/correct her calculation.

7. Maturation 2, synthesis (S3 draw a larger drawing with more circular/continuous edge. [36min40s-41min30s]

8. Calculation 2 (2nd occurrence of the pattern) [41min30s-42min30s]

The same pattern as before (plan-section-material/weight/size) triggered a calculation dimensions of the tabletop. (In that case S3 is interested to reduce the length of the table). Here again, the delivery of the raw result of the calculation was followed by an evaluation in the real world of how the result holds. In this second occurrence, the reconnection of the result of the calculation with an actual representation of what this results corresponds to in the real world happened faster, as if the benefit of relying on a real-world experience/ comparison had been learned from the process of correcting the first mistake.

9. Verification 2/ Correction (type B). using the table 1:1 [42min30s-45min50s]

This phase of engagement with the direct environment (desk) included measuring from the desk for comparison and placing the folded yardstick so as to make the computed dimension visible. Subject 3 also stood up and traced lines on the desk paper cloth meant to represent the angles at the table end (scale 1:1).

10. Re-calculation and Correction (type A) [45min50s-48min35s]

11. Final Correction (type B) with direct interaction with the desk/table and folded yardstick

Observations in Trial #3

Verbalization:

In addition to the advantages provided by the documentation (sketches, transcript and video recording), the protocol used in trial #3 offered the possibility of comparing what was said during the initial verbal-only 8 minute-phase and what was designed during the rest of the session.

Overall, the initial **requirements** that S3 had set verbally for her design were held to (two people seating at both ends, to view other people from an angle). Subject 3 was careful to hold her original requirements or to **reformulate** them, or to justify the shift away from them if it was the case. (see "elongated")

- Continuities/discontinuities between the verbal and the drawn: when thinking aloud, S3 described her activity with a lot of verbs of action (example: "to jump" and "to go back").[22]

- S3 very systematically wrote/noted on the tracing paper the indications that she gave verbally, for example, regarding materials (paper, glass, aluminum...) or qualities (heavy, polished...).

- The gestures observable during the verbalization phase were not observable anymore in the design phase.

- Representation by numbers and calculations with numbers did not seem to have direct connection to the experienced dimensions of the desk. At least the subject showed a shift from thinking with numbers to paying attention to her impression/perception of the good result/dimension.

Regarding the role of the body in the design process:

In Trial #3, there were different sorts/qualities/kinds of moments when the "bodily" came into play: as imagination of being there, as gesturing-simulating, in measuring operations, etc.

- S3 expressed clearly the desire to ground her design in an 'ergonomical' approach, as opposed to "measuring from this (table)" (used for the experiment). In accordance with this approach, S3 measured herself --or the space required for comfortable eating—repeatedly; S3 also engaged in thinking how it would "feel like" with a person sitting next to her. The distance between people was considered (through the nominal 'elbow room' dimension) and the distance across the table ('hate yelling across the table', therefore limiting the dimension across: "1meter across is plenty").[23]

- S3 engaged the 'future' experience of the table at several levels:

  - Individual/egocentric: space for eating and resting one's elbows, leg space under the table

  - Collective: placement of people, views from an angle instead of a rigid perpendicular scheme

    - Action: passing a plate, cleaning the surface, looking at other people across the table, touching the material

---

[22] An interesting study of the transcript in terms of the "I want..." versus " the table wants...", "it..." could be undertaken.

[23] And S3 rejected an exclusively geometry-based arrangement (decagon or dodecagon) because of its concentration toward the center while the quality S3 was searching for is the accentuation/engagement of the periphery, the definition of overall enclosing perimeter defined by the people around the table.

VARIABLES IDENTIFICATION AND STUDY

FIRST SYNTHESIS

SECOND SYNTHESIS

ASSOCIATIONS

ÉLONGATED
10-12

ANGLES

REPEATING
8 4

"GRASPING"

A1-A2

TACTILE
QUALITIES
- PAPER MATTE/GLOSS
- POLISHED WOOD

"PUTTING UP TOGETHER"

(A2), A3, A4

"REVISITING"

A5-A8

PERSONAL REQUIREMENTS

WITH TWO P & ENDS
(NO)

VIEW @
AN ANGLE

LEG SPACE
FOR PEOPLE

SECTION

FIT BOTH
10 or 12

ABANDON
10 & 12

PICK 10

MINIMAL DIMENSION
"60"

"SLIM & SLENDER"
(REVISED?)

EXPLORATION USING DRAWING

INVESTIGATING COMPONENTS/ASPECTS OF THE DESIGN PROBLEM.

A
B

NOMINAL DIMENSION

FORM.

"RIGHT" USE vs. "BULKY" FORM

MATERIALS   DIMENSION I

FLEXIBILITY

INDICATE TABLE LEGS

MANUFACTURING MATERIAL & (LEG)
CAN'T

STEEL

FOLDED   ALUMINUM

DIMENSION II

DIMENSION III

FORM + STRUCTURE LEGS

PROBLEM ENCOUNTERED

• [DISTANCE ACROSS "BULKY"]

• HOW MUCH ELONGATED
EVALUATION

"NO"

WHERE THE PEOPLE SIT / TABLE LEGS

(ACCOMODATE)

MATERIAL FOR TABLE TOP

SIZE & WEIGHT

1 or 2 PIECES

"GLASS"

NOT MOVABLE

A

"COMFORTABLE TRANSITIONS"

"UNINTERESTING SHAPE"

"HOW IT STANDS"

MATERIAL FOR LEGS

GLASS
WEIGHT
SIZE

Fig.: 27b: Form/Dimension/Usage and Material
concerns notation in trial #3

Fig.: 27: Chronol ogic notation of design moves and phases in trial #3.
The representation of the design process in trial #3 as embodied in this
document: Emphasizes the relative "isolation" of the different variables
explored in the first phase. Identifies the repeating pattern linking plan-
section-material-weight and size-dimension. ")
Shows how different forms/themes reoccur and are refined/transformed.

- Material, qualities, boundaries, directions, etc are represented by gestures in the "think aloud". And S3 used gestures to retrieve an information from the world (example: texture paper cloth, vertical (continuous) edge, " I thought about shiny surfaces…" E3[25:24],

- Posture of being at the table, simulation and projection:
  S3 called upon past experience and knowledge of dining situation. S3 used the desk as a means of comparison to detect and correct calculation mistakes (computing the size of the table with the difficulty of measuring along a curve).
- S3's gestures showed how the engagement in the design task called on:
    - projection into the past (experiences, memories, recall of ideal examples)
    - presence in the present (for acquisition of necessary information and for comparison)
    - projection into the future of the table (imagination).

- Repeated use of the folded yardstick, and evolution of the use of it in accordance to the moment in the design process(see "Body Shapes Design/Design Shapes body example" in forewords)

- To study the elbowroom dimension in relation to variable angles between people at the ends of the table, S3 first drew/prepared a diagram along the upper strip of overlay A1. Then she cut half the diagram and placed the now detached part over the remaining part, by varying the angle between the two. No verbal explanation was given by S3 regarding this drawing that is turned into a tool besides the desire to produce a diagrammatical representation enabling an investigation of this varying angle situation.

- On the use of the paper space and working space:
    - In the first study phase S3, who produced more overlays than the other subjects, cleared her desk from the overlay she had just drawn, then in the last phase, she kept the overlays on the desk.
        - In the first synthesis (overlay A3), plan and section were still "non-connected" but later on, in second synthesis (A6,7,8) section and plan were related directly.

- Complementary strategies were observable:
    - for example, subject 3's use of segmented curves to ensure that the developed perimeter provided the required individual/nominal spaces.
    - Similarly, the use of the plan of the table top with the 45-degree rotated ends in place of a rounded end (for facility of measurement purpose)
    - Other example: to clarify the confusion/mistake with the addition, S3 drew 3 colinear segments that helped her order her thoughts and make sure that she was not 'missing' something this time (trace left of A2.7s).

- Folding paper to help draw a shape with symmetries. (The affordances of the material 'tracing paper' were exploited to facilitate the task at hand).

- Silent traces were observable of a different type than in trial #1 (where silent traces were mostly preparatory movements). These consisted of pointing at a drawing ("not like this"), or pointing at a drawing to focus on it while performing another operation.

Comparative Table across subjects/trials

Criterion of comparison:	SUBJECT 1	SUBJECT 2	SUBJECT 3
Design			
Is the requirement regarding providing dimensions fulfilled?	No, (no intervention by R	Yes, on R's demand at the end of session	Yes, throughout the session
Does the subject mention the space in which the table is to be installed?	Yes	Yes	No
Is the designer/subject his/her own client?	Yes	Yes	Yes[24]
The need for knowing relevant informations about one's body and a table. Does it happen early?	Yes, (right before the trial actually started)	No, at ¾ of the experi. duration	Early and throughout the trial.
Do subjects start to sketch immediately?	yes	Yes	No (protocol)
Do subjects call explicitly upon a past experience	No (but mentioned interest in designing furniture)	Yes (related to her collecting chairs)	Yes (square tables for 4or 8, "images from the past"
Were the sketches drawn at a particular scale?	No	No	No except as verification, A2.13p
Were the size of the drawings varying	No, use 1 scale only	No, use 1 scale only	Yes, varying in proportion 1:6
Is the paper space distinctively organized?	Yes, first page to receive notes	No, mostly consequence of the overlay copying.	Yes, upper strip for calculations and ideals, lower strip free
Model?	"Next phase"	"Next phase"	Expressed no need during the trial.
Did the subject moved, stood up?	No	No	Yes
...			

Succinctly...

Different designers acting under slightly different protocols generated different designs, and engaged the task with different approaches. The trials also show variable degrees of the designers' reliance on the physical space/environment to solve the task.

Subject #2 and #3 engaged in this particular design task show evidence of engagement of their body in the design thinking process at –at least- two levels:

At a motor level, in relation with a data acquisition task, for example, when using their body to obtain a measure of some relevant dimension for the design.

At a perceptual level, in relation with an evaluation task, for example, when trying to place themselves in the projected artifact and appreciate/evaluate one or many of its dimensions.

Observed bodily postures seem to correlate certain mental states of the subject. For example, showing surprise at the result of a calculation, being contemplative (versus being productive) of the design...

The table design is never only a problem of size, form and material: not surprisingly, the table is tied into a rich/dense 'network' of usages, memories, relations among people, gestures while sitting or serving, etc. Some of this life, some of this anchoring in one's experience appears –more or less clearly- in every trial. But, for the designer-at-work, to consider this 'network' of infinite interrelations is not what provides him/her with a 'solution", a design. Nonetheless, along the process of design, numerous 'connections' to this 'network' take place.

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[24] "I am definitely sitting at the table"

Trial #1: TASK

Subject 1 and subject 2 received the same task, but in the oral presentation complementary to the reading of the task, subject 2 was ask to talk while with subject 1 talking was not mandatory.

Task: You are asked to design a table seating 10/12 persons for a dinner or a lunch. These people know each other to a degree you will determine and make explicit verbally at the end of the design[1].
Your design should promote a good and friendly communication among these people while eating together. The scenario for this design task is that another person will construct the tabletop and set the table according to your instructions. (if you feel you need to talk to that person, I/the experimenter will play this role) By setting the table, I mean seating the people and a plate (at least) in front of them.
You have to provide a 'document' (sketch, drawing, model, whatever you feel appropriate) with general dimensions of the table and dimensions for people's placement in order for the other person an to be able to make the table top and set the table (put the plates on it).

You can request from me modeling and drawing materials if you feel you need to help you develop your design. Provide a table that is adaptable in height to test different height

You can "think aloud" while you're designing.

Time: 'maxi' 45 min. but flexible in case more time is needed, for example if you start looking at the construction of the table (which is not the focus here, but which would be perfectly acceptable to be concerned about)

At the end of the design session there will be a 5-10 minutes presentation of the design by the design followed by wrap up a 5-10 minutes discussion.

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[1] You may feel the need to provide verbally or by any other means some indications regarding the context under which your design makes particularl sense. (what kind of people are gathered, on what occasion or non-occasion, etc)

Trial #2. Transcript of verbal exchanges:

(45 minutes design session, including a wrap up/consideration of fulfillment of requirements period at the end)

R is experimenter   **S2** is subject 2

00:00 [Start video tape]
[S2 reads task #3]   **S2:** Ok, ok, so.. what do I do? Do I have to write on paper? OK!
01;15 R: There is some paper, There is some tracing if you want and...There's cardboard, a brand new pen, and ...I think, if I just point out what you have to figure out, shape, where you organize the people
What I call document very generally, something that explains dimensions, placement of people...You can measure [pointing at the folded yardstick]. All right!
02;32   **S2:** And I can go through different variations and pick one at the end?
R: Absolutely   **S2:** Is that the idea of me doing this?
R: Yes, to give you a hint, I think what I'm interested in observing is more how you proceed, how do you do through that thinking...
02;55   **S2:** OK, so I should talk
R: Yes, we can talk!   **S2:** OK, I just explain my ideas
R: Yes, I would like you say what you are discovering, when you say 'ok ,here, I Should understand this better,....More than actually the final result, but , of course, there is a relation between how you do and ... all right!
[start drawing]
03;25   **S2:** Can you see what I am drawing?
R: Yes   **S2:** Really?
R: Yes!
03;50 R: But If you want I can sit over there!
                           S2: You might want to get closer!
R: Allez!
...
R: What I am going to write down, is the time and other type of indications, like when you move from one drawing to another, when you switch from paper to tracing,
                           S2: Are you timing this?
R: Yes, it's more for me to have a reference, If I am looking at the video, I can check the time and I'll know where to find what.
[counting by pointing in A1.1p]
05;22   **S2:** Somewhere in the room, there would be chairs of all different sizes and shapes,
R: Like here!   **S2:** Yeah!
R: do you think this is a table for you? You could say this is my table, you could be your client!
05;50   **S2:** Oh yeah! This is totally my ideal! This is my ideal table, and the table would be square, and that's jus because I like... squares,
[laughter]   And,... and...
R: You said, there are chairs of different sizes and shapes
06;12   **S2:** Yes on the side,... And in fact, if there is ten or twelve people, I mean, there might be 20 chairs in the room of all different size and shapes and... and when the guests come in, they just have to... pick the chair that they like and the chairs that I am drawing are not necessarily the actual plans of the chairs , I'm just kind of ..trying, ... just to represent different chairs of different sizes....
06:53   so everyone would pick... a chair from the side of the room and they would pick up their chair and come to this square table,... for which... there would be ...these horizontal and vertical marks on the

table that are actually adjustable,..., I haven't really figured out how they would adjust.. it might be simply chopsticks, or a mechanism like this, where..

[pick 2xm]
photo
07:37

...the vertical and horizontal can expend and contract accordingly... and I would encourage everyone who come into the room to...mark out the space that is proportionate to their elbow room so...

07:55

R: *So your going to have 1,2,3,4,5,6,7,8,9,10*

S2: But I mean, given the actual dimension of the square table, it would be ...you know

R: And here you adjust also the height?

S2: yeah, there a little... but you're allowed to adjust the height, and this would be a very difficult mechanism to create, but just...

R: *I don't' think it's the point to look at it now, but if you feel you have to investigate that, hm,, because it could be modeled very simply , you don't have to built the complicated mechanism to try that first, you might say...*

08:48

S2: I mean, It might be as simple as my 'metro' shelving system. The metro shelving system is of course very ??? to put together, but it has the idea that you can Create different level and attach different shelves to the same pole but at different angles...

09:10, [gesture detail] photo

R: *So, every body adjust the height that is most convenient!*

S2: Yes!....So ...I think the limitation with.... this kind of ....grid pattern is .. is that the people who are.. for example... facing each other, they would have to be comfortable with the same elbow room size!

R: *So that's a limitation, but if it's a comfortable dimension, then it should be ok, . there could be a problem if where narrow, but here there..*

10:05

S2: But then Maybe ...what the design process should be asking.. if there is a better way to use a system of dividing, and maybe the system is not so rigid,... but actually you're allowed to step... and stagger away....

10:38

Ooooh...

R: *If 2 people... Like perhaps if you have two people seating here...*

S2: What 2 people?

...and so there's less partitioning but maybe, maybe there is more flexibility somehow

R: *because you feel that with the first solution, there might be not enough flexibility?...*

S2: hu hu, It's just in how... this division occurs. I mean, you could take it another way...

11:22

I mean, it seems as if maybe ....these partitions ....are kind of restricting, I mean... I don't know..........

11:49

Is there any advantage to ...letting ...someone.. cut a table ..like... this?

R: *You put people in the corner, it does make sense to keep the concept of choosing the height for one's own table, but how do you think?.. maybe you could say more about the height you're thinking of? Sort of... What's the range that one can adjust the height?*
For example, is one going to eat like Japanese height, or...?

12:33

S2: No, everyone would have a chair but... you would have...I mean... there are certain conventions eating with chopsticks or with a fork I guess, even... a child... the dimension would have to be a table height for a child to a table height for an adult, so, Whatever that dimension is, who knows!

13:10

Do you want me to actually figure out what these dimensions are?

R: *I think that in your concept, it's sort of important! Just about the range, it's not about necessarily*

understanding the technical solution, how it would be built!

13:27   **S2:** Well The requirement would have to be ... it would have to be a child who can actually sit by the /chair, so two/ three years old...
Oh , but then I guess the question would have to be at your table , then, it's actually the high chairs that actually makes up for that dimension.

13:53   But There does come a point when in any child's life, they are half way between a high chair and a regular chair, and they are always ultimately with the table at their chest! that, that,.. Those poor kids from 5 to 10, those are the kids I'm thinking about!

[laughter]

R: In a sense, the crowd that you're imagining here is a mix crowd of adults and children and or children of different ages, from teenager that are already two meters tall to or younger kids.

14:38   **S2:** Yeah! But like if they are not much higher that the table, then they can just can be a high chair, it's ok
So...If That's the high chair; then they are not really eating on the table, they are ???? But it has to be ...

R: You could, you could incorporate...I think the high chair is to be putting the kid at the same level,
            S2: Yeah

R: His face is at the same level than the parent's face?
            S2: hmmm? No, Not a the same level, I think it's ok for a person to sort of bend down, but it would have to be...actually the height of the baby's head would have to be somewhere Close to the range of a human...an adult... with a spoon, the height of a spoon going to...

15:45
R: So how much is that? Is that 3 feet, 3 ½ feet?

[use 2xm]   **S2:** We can measure, well, I'm different too, me feeding a baby is different from a person 6-foot tall

16:04   So 36, it says...So... I mean, for me that's very comfortable, so... Ok, 36...Yes,

R: That's where the baby...
16:21   **S2:**That's where the baby's mouth is! 3 feet
R: But it must seem a little bit higher than he actually is
            S2: So, there is my adult ...and there is my baby, but this adult is not being actually a baby, hahaha! ,
Cause the adult would have to feed this baby, In terms of height, I would, ... for me, right, you could say that it's three feet Or you could designate it as height of Baby 's mouth hmmm...so that hmm... the adult ... hmm can easily feed the child, So that's the dimension, whatever that dimension is!

17:16
R: This is sort of... but you think that the high chair has its own 'plate'? Or is that one of those that can potentially... one of the division of the table you have already drawn that sort of sticks out and becomes... Because it's not that incredibly high! You said the baby's mouth is there... it's just like half a foot

17:50   **S2:** The problem is that they don't make high chair without them, or you can just not put in on! You can keep on the high chair after...

[laughter]
18:04   **S2:** So, I mean, the good thing about actually... doing that, with your suggestion, is that if the baby is not there, then... that... table, that piece,... because its... its small dimension

[gesture with hands]   might be able to be used as a place where you put something a center piece, where you put flowers where you start the butter, or where the person that is serving starts all the food and then it gets passed away.[18;38]

R: Ok, So we have a very strong determination through the fact that the baby is potentially... what happens if there is two babies? Because that happens sometime! Is this detail going to occur every corner?

19:00   **S2:** Well, that's what I am trying to deal with now, I'm am trying to figure out what is the best system of dividing this... because I set my limitation at a square, and by setting my limitation at a square there's only specific ways I can divide it!

[switch, start A3? New concept] My other idea at the beginning when I first started to draw, if you noticed, was I was actually giving every body a separate table that was different size, and then they would all come together, so every one would pick their...

19:40

R: Hmm, hmm so, the table share some dimension, regarding the table that you pick, you might assemble them, or ...you might accept to have like an empty space in the middle,?

         S2: Yeah,

R: But in the case when you have someone sitting there...

20:00 [Telephone ringing]---   **S2:** allo! [...]

(keep sketching retracing/reinforcing line on drawing S2.A3.4p)

[[short interruption in the video recording]]

20;33 [start again]   **S2:** sorry!

R: So, this option is about assembling individual elements

         S2: What I was about to say: that the guy that is going to sit there will be almost turning his back to the guy that is sitting there...

R: what if the person is sitting there? Then this person is behind here, right...the thing is that they would... you have to arrange the all thing. But that means that if that is empty the table is suddenly,...you have to distribute the food by turning, you cannot like, say...

20:16   **S2:** well it doesn't have to be empty, it could be actually another table! I mean, the good thing about this is that...hmmm... it'll be easier to construct [laughter] Because all the tables would have four legs and it's just a matter of putting them together!
So Everybody would have a chair to pick and a table to pick

[concept is maintained although solution is different]

R: But in that case, you think that the table would be still adjustable? Or It's a given height?

21:51   **S2:** No! At that point, I am in a big big big loft space, a lot of room so...There's a lot of rooms for a lot of tables!
So maybe I should start collecting table now too!

R: Ok, So ok, if we want to fulfill the requirement that I have on this piece of paper, should we dimension that? And give... say, I don't know, you think that every table is different?

         S2: Yeah!

R: There are not exactly like different, because they have certain dimensions in common? Hmm,hmm If you say I have to create all these different type of table, If you say it's not about collecting tables, about recycling them...

         S2: I would design them, I would design them definitely!

[roll A2, Place A1 and A2 in front of herself]

R: So, You would go for three different kinds of table, where each are different but at the same time that have things in common to facilitate the 'putting together'...

23:10   **S2:** OK, I am drawing a section now, this is what I would do! It might be a top, and they would all have four legs... and the top would probably be a light color... beech veneer, very light!

[gesture to accompany the description of the material]

R: The tabletop is always the same throughout the collection!

         S2: Yes and all the legs are the same too! Only the size change of the tabletop differs,
Hmm! Hmm! Yeah!

23:56   This is a very systematic way of committing yourself, but, let's try it out! it would be nice if all the table could be stored one underneath the other, and ..

R: Those Dimensions are smaller than the other one

24:22   **S2:** But this is... and then you...in plan view, this one would probably... something like that ... those with those proportions, and then, I would also have probably...one that is more square,...more

elongated... and I would have it with exactly the same section drawing but with the table top that is ,... hoops, that's not square, And ...

R: You 'd like to have three different sets of those tables, some are 'hiding'. Do you only have at the end those three tables instead of those nine or ten. Because the table are hidden underneath each other!

25:08   **S2:** Well, I mean, ...you just pick one, so...like
               Let me just draw it, .. and say, the last one just
               So Actually I have a total of nine tables, ... right, I'm accounting for nine tables, there is one underneath here, so there is three underneath here, two underneath there.

R: Ok.

25:56   **S2:** Now... I'm not really sure what this accomplishes! Right...Oh! Actually you know what! Maybe the table should.. they don't necessarily gets smaller, but maybe they are the same width, you know! So... Then what happens is... hmm, interesting... so this is more of an exercise in being very systematic. in order to see whether this works, you would have actually to start to play them out!

26:35 [cut new overlay A5]
R: you have sort of a general concept, I don't think we have enough time to develop it,   in all the combination, but I think I understood the concept of assembling a set Of of tables of different sizes

               S2: hmm, hmm!

27:09   I think this is actually where the design has to come in though! You have to,...You actually have to come in and work with the dimensions, because for example I have the little notch here, now I have to decide if I want it or not, which is , you know, few inches, whether that is something that I desire from a design standpoint, because I could create these... I could work out the dimensions so that, the only overlap that would occur is something that's more closer to six inches, right, like that, right?

27:42   And so.. depending on the dimensions of my ..of my pieces, I want... I need to figure what my least desirable dimension is and what it accomplishes, so...One thing we didn't account for... is little baby...[laughter]

28:18   Now I have to I have to ask myself, if I am happy with my table situation!

R: I have the feeling that perhaps the center can stay empty, ... because there is a sort of a growth, like where the center (?)... different edges are creating the table! Which might mean that everybody receives a pretty small table! You don't want the people to be too far away from each other

29:00   **S2:** Yes, hmmm...It doesn't have to be, I mean it could be solid or void, the problem is... is these other pieces, because this situation right here is not nice! I mean, this I don't mind so much, you know, a little kid will poke his eye out!

29:27
R: But don't you think that in your proposal, you're putting a stronger bet on the individuality of each of thee table situation   versus the feeling of the community   which in the case of this, was much stronger because you had this clear shape of this element that says .. ok, It's a variation between the individuality to community

30:03   **S2:** Well
[reorganizing working space]
R: For the moment there are sort of two options you have, here The individuality was given by the height, while here, Height is maybe less an issue...Hmmm, I think It's still there, It's still there!
But you already picked the individuality because of the individual details that are revealing the individuality...

30:33   **S2:** Yeah, so I think I...I think it just depends,,,, It might have to be trial and error , but yeah, what I am definitely.. (...) What I am definitely set on, is that... I am definitely leaning toward this one because there is a... the elbow room dimension is actually freer in this one, just the way I have drawn it, because ...here...

[pointing at A??p]	at a certain point, your get to the point when someone is going to... get tight, where in this one , if you don't like where you're sitting, if you picked the table that you really, really like but your knocking elbows with the person sitting next to you, what you could actually do is... given the overall
[fold trace, start A6.1p?]	form of it,...right...
31:40	And here is this person that you're 'supercramped', I mean, You could pull yourself out, and granted that your table is not touching anything else...One has to wonder if that actually prohibit or... yeah...I mean, One person doing might be a problem, but I mean...

R: So, It might be organized as a set... of Micro rules within this bigger rule,

32:22 [laughter]	S2: Yeah, and maybe, you just hmm... I don't know if a person is allowed to have two tables, but if a person is allowed to have two tables [laughter].... then this person can move from there to there and have different conversations, or maybe two people would like to share the same table! ...If there are two kids that want to share those two tables

R: So , that's the satellite tables!

	S2: Yeah, that's probably.. a good way...to.. to solve... the problem of everybody who is smooched, because there is no way that in a group of ten-twenty people that you would actually have a intimate conversation with the person on the other side of the table,
33:19	If...You would have to yell over multiple conversations to actually talk to the person, so maybe that situation is maybe relieved where it's kind of Musical chairs - musical table situation [laughter], where everybody...sits next to the person that they want to have a conversation with at the beginning of the dinner and say it's a five course meal and over each course you have to switch tables!

[laughters]
R: In you case, It's a little bit like a buffet where you go pick your stuff and then you sit at the table where there is room

33:53	S2: I don't like buffets though, so it would have to be a multiple course dinner!

R: Then you need to move everything!

	S2: Oh, but with ten people it's ok, if it get to 50 people, then you start to have a problem!
34:15	

R: Can we try to give dimension to that object?

34:28	S2: Oooohooohooho ahhaaahhaahh! Well, it will have to go by me! I'm here and I' am comfortable with...that , good thing that I can draw on the table,
[using 2xm, laugh]	that's 31 inches, so 31 inches and I should give this dimension too because there is a comfort dimension in that dimension as well! And
[use cup]	...I would fell comfortable there and I should certainly give enough room so that it doesn't fall off, so 18. So 31 and 18...
photo	18 is small, I'm a small person, I'm not going to put my cup there!

[use cup to evaluate eating space in front of her again]
R: Yes, but if you have several glasses?

	S2: Oh yes! there is one for red, one for white, one for water...yes No, because...

R: I'm also saying that because when you receive a plate that is turning around, you need some room to serve yourself, except if the person before you is holding the plate for you.

35:44	S2: Or, The plates wouldn't be that big, because if you go to a Chinese restaurant, the plates... you know.. are not more that 8 inches
[draw and check yardstick]	If you go in one direction, 18

| 36:01 | Because if you go 18, 18 has to be max, because I think if you're talking with somebody across from you and they're already 36 inches away from you, this already too much! This… this table here is already 30, |
| 36:19 | so I wouldn't even try to take it bring it down. See…15. No 15 is too.. |

[use the cup to determine dimension]

photo ….O.k. 17!

36:45

R: Perhaps, maybe, in terms of combination, like if it's a double square, like 17 by 34, that might help you in the future, 32 by 16…Sort of the refinement!

| 37:12 | **S2:** so this is x and this is 2x, yeah, that's good, and this is (a-b) square |

[laughter, referring to a previous conversation]

| *R: I remember!* | **S2:** So.. anyway…Is that ? yes, basically we could measure that table x or two x…but… |
| *R: What is that?* | That's for me , I'm a 5-foot 4 person! |

R: Ok, …in a sense this has to adapt to another table that is going to be next to it, which someone else will have brought from your all set of tables!

S2: No! why..

R: Your tables are different, in size, but not in color,

| 38:00 | **S2:** No, but I am going to make them! Right! |

[shift in the concept, no more collection]

So, this x, 2x, maybe, maybe this x is 16 for me but for a six foot person, maybe that dimension is18 , Ok

R: Which means, there are going to be very small differences here!

| 38:17 | **S2:** Yes, it will, but maybe it will still be nice, hmm hmm, Maybe the range of x would be, maybe for a little child, for a kid…, |
| 38:40 | maybe , maybe 13? 13? X equals 13, right and for a 5 foot person x equals.. I'm at 16/17, so let's say 15, … 6 foot person, x equals 17, yeah, Because 18 is already too far, you get two 6-feet person next to each other and…But I mean, these dimension you'll have to actually, you know… draw six-foot person and their range they fell comfortable… because obviously two six-foot people at this table may be too big, but At this table right now, Mine sat right there, I'm fine because we're both five –foot something… you know, something like that and then, the other dimension is always 2x. |

39:40

R: So we have,…yeah, Since we don't know the final arrangement which depends on the people on a day to day base!

photo **S2:** It's depends on how many people are what height!

R: And You go for saying the smaller table for kids are going to be lower and the tables for tall adults are going to be higher.. but If I want to take a big table because I have a big ego?

S2: Oh, you're not allowed!…it's OK. The all idea is that you are as comfortable as you can be while you're eating, so…

R: but what happens if I understand I choose the wrong table, it's actually too high, I have to change

| 40:40 | **S2:** there will be enough table to go around, there will be enough table, certainly, I will make enough tables, |

R: so I have to bring it back, and bring another table.

S2: but you have to tried it out with the chair before you come in to the center

R: But, I will have tried it out with my chair, but not with my plate, while eating, so, it's a different situation that I discover actually only when I start eating!, well, I just follow the..

| 41:20 | **S2:** you can go and exchange! |
| *R: all right!* | **S2:** No problem! |

R: ok so we have the design, we have the dimension

S2: yeah…so…

| 41:38 | at least , I mean…, there is rudimentary…for the z dimension…you need… there still needs some work |

R: But With this idea that small size tabletop are also going to be the lower, but are they going to be adjustable or is it set?

                                     S2: I think it's set!

R: because I the section you've drawn, they were not, but they could be adjustable!

42:12   **S2:** Adjustable, no, those are the actual heights, those are fixed heights, dependent on this height

R: the idea of the adjustability like in the beginning doesn't apply to this concept.

42:30   **S2:** no, but the system is still up the ground…but I haven't figured out how it would be… build!

R: That's ok, That's another part of design!

42:51   **S2:** At least, that's the idea that I would want, that all are on casters, and you can rolled them right underneath each other, to store them! Ok! yes , they're definitely stored like that, and they are not adjustable!…Cause At this point…I hope I can account for [laughter]

R: you could have them adjustable

43:31   **S2:** No, people will already have to Step on the brake to stop the casters, so I don't want them have to fool with adjusting everything!

43:50

R: I think that's it because we have the dimensions, and since you have been giving a lot of information, I don't think we need more than that!

44:07   **S2:** So, this is my final , this is one, this is two, this is three, [providing number to sheets of paper]

44:58 [end of video taping]Trial # 3,Transcript of exchange:

Trial #3: TASK

In the case of experiment #3, the experimenter has explained the context and hypothesis of this study to the subject participating to the session. The experimenter explained the assumption that design involves bodily thinking, and that a designer could decide to address the design task by direct manipulation of real objects (versus sketches).

Subject 3 received the following brief:

Task: You are asked to design a table seating 10/12 persons for a dinner. These people know each other to a degree you will determine and make explicit verbally at the end of the design[2]. You should think about what really makes a dinner situation, the relation among the people as set by the object 'table'.
Your design should promote a good and friendly communication among these people while eating together.
Your design should pay attention to how people might engage the material used for the table.
The scenario for this design task is that another person will construct the tabletop and set the table according to your instructions. (if you feel you need to talk to that person, I/the experimenter will play this role) By setting the table, I mean seating the people and a plate (at least) in front of them.
You have to provide a 'document' (sketch, drawing, model, whatever you feel appropriate) with general dimensions of the table and dimensions for people's placement in order for the other person an to be able to make the table top and set the table (put the plates on it).

You can request from me modeling and drawing materials if you feel you need to help you develop your design. Provide a table that is adaptable in height to test different height

You are asked to "think aloud" while you're designing, that is to try to express verbally the ideas that you have, the problems that you face and how do you think you mighht attempt to solve them...

Timing: The session starts by 5-10 minutes during when you are asked to verbalize what the design problem suggests to you and how you want to approach it.

This is immediately followed by a 45 min. session for the actual design (time is flexible in case more time is needed, for example if you start looking at the construction of the table (which is not the focus here, but which would be perfectly acceptable to be concerned about))
The experiment is concluded by a 5-10 min. period for wrap up where you are asked to reflect on how your design fulfills the requirements (and eventually produce
a synthesis or improved final version).

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[2] You may feel the need to provide verbally or by any other means some indications regarding the context under which your design makes particularl sense. (what kind of people are gathered, on what occasion or non-occasion, etc)

Trial #3. Transcript of verbal exchanges:

Trial # 3 starts by 8 minutes of verbalization with no designing, then followed by 45 minutes design, concluded by 8 minutes wrap up/ consideration of fulfillment of requirements.

R is experimenter   **S3** is subject 3

00:00 [Start video tape]
[S3 reads task #3]   **S3:** OK!
01:39
R: So we start by a 10 min discussion, you explain what you think, how do you think you are going to solve the problem?

02:05	**S3:** The initial ideas that come to my mind are images from the past. 12 is an interesting number because it elongates the table! 10 is interesting as well, 10 might be an option I might switch to later just for the sake of designing the legs and how the legs are positioned, according to the people seating
02:45	I might be more comfortable working with ten... So, in general organization... I see it elongated and I divide it symmetrically. There are groups of people who are sitting linearly, next to each other, and there are people sitting at the ends. But... I always... thought about it, in a way, although I never designed a table before, but putting one at each end never works in my head, I like two people at two ends, and not necessarily everybody perpendicular to each other, I mean, if there were less number of people, I would have liked round schemes. So I think, the edges are a little... there are angles somehow, there're angled that would allow the people looking at each other from an angle, not necessarily perpendicular to each other
04:10	Another initial idea that comes to my mind is elbow space. Yes, so, elbow space determines how far the people sit from each other actually, I don't want to give it to much space, so that they eat perfectly comfortably, but at least you don't want your elbow to be in the next person's face, so... and there's a little... or you could be sitting close to the person, but not necessarily putting your elbow into the face...In a perpendicular arrangement, for example, even if you're sitting at an angle, you might actually be more comfortable, although your plates are only 10 centimeters apart, So , that's a benefit of a round table where everyone's elbows are free... So, and then,
05:15	a quick thought ...about sort of the vertical scheme... the most important would be leg space, that I can think of, I mean, before thinking of the height of the table, leg space is kind of important, I mean, we do things with our legs while eating, they are not just let loose. It depends also on who's eating, because if there're kids, their legs are not long enough maybe, but that's not the reason, some people and also a lot of kids like to rest their legs at a height and sometimes, it's really disturbing when you have this one big chunk of table leg in front of you and you can't really move right or left....
06:15	And another thing is, now that I remember, before the ten minutes are over, this is the last one that I am saying, the surface should be more or less one piece, because...yeah, it has to be one piece, it should accommodate different arrangement of seating and it should

also accommodate certain aspects of dinning, like, you know, you want to be able to slide plates and you want to be able to set every thing on level, you don't want... crocked place, or ... also you don't want things spilling, bread crumbs going into little streets, so flat surface!

07:11

R: in terms of materials?   **S3:** In terms of materials? No, I haven't thought about the material yet!

07:20

R: in terms of dimensions, you make a remark on how elbows move, you made a comment on how it's interesting to sit at an angle, or a rounded situation, how do you think you would determine these dimensions? To what operation will you call on to understand what's the right dimension for this elbowroom?

08:02   **S3:** I'll start drawing, because.. it really gets determined by what kind of form I start thinking about!

08:17 [start A1.1p]   ...Let's say there are two parallel lines...

08:57   It's not a six-B!

[Change to pen]   So there are two different elbow spaces, oh, actually, no, this could be the same as this!...

And then, there is this... so I think the dimension in between those two elbows here, is going to be different...

09:20   So, that's how I start determining,

[start A1.2p]   Let's see on it works with 10 people!

09:31, *R: Can I ask you to think aloud?*

S3: Yes, if I think, I will think aloud [Laughter]
Ok...

R: What do you think of when you say it's about 10 people? Is it about reorganizing?

S3: it's just about... stretching the...Actually, this was for ten people, I'm thinking now, if there are twelve people, what would happen in terms of... I jump into another thing about... this is not about elbow space now!

10:13, *R: yes?!*   **S3:** The other thing is the proportion of the table actually...Ok, maybe it won't matter that much, I can stick with ten people, ... for

[A1.2p, draw 2 dots for footage] now ...

10:31   and ...when I'm thinking how the table is actually elevated from the floor, and can then switch to the general.....I mean the overall dimension,

10:44   So, let's think about the elbow space...

11:07 [start A1.3p]   I am thinking about... about my ... my own elbow and...

11:26   Let's see how much!

[reach 2xm, start measure, hold]   Hmm, this is in centimeters! That's good!

R: both, Inches and centimeters

11:42   **S3:** I' am taking my axis, my central axis... I think 45 is ...like... I am not the fattest person, so... I don't think I am wide, but... if we're thinking a little bit more... this is like 45 centimeters for me, ...but it's generous...

[folds the 2xm back] photo   and....

12:22 [unfolds the 2xm again] get

to me, and in an extra parallel table edge or if there's an angle between us,

[end 2xm]   if it's slightly curving,...

12:48   there should be a way for me to draw this diagrammatically so

12:56 [starts A1.4p]   ... this is a line, let's say this is like the border between us, and I am playing with different angles... this is 45, ...

13:14 [gesture]	because I am extending my elbow towards the back, he or she can get really close to me… because our elbows could be almost parallel, I mean, my elbow goes around like a 45 degree angle…
13:40	and …

13:52 [cuts a piece out of A1.4p and use it to play with the angle…]

R: what do you want to check?

> S3: I want to check the angle, I want to play with different angle, how it looks, how it get take away from the dimension…So If I go up to 45 degrees, we can be sitting really close, actually! It seems!…

14:18, *R: that's what determines what happen at the end of the table*

> S3: yes, because this is pretty much set when I say 45, so this is interesting, because it takes a lot from the end spaces!

14.39 [starts A1.5p]   Let's make 45 cm and then another 45, another 45 ,.. hmm, see…

[grasps and then release the 2xm, keeps 'playing' with A1.4p]

> let me proportion this and…

15: 06   speculate another dimension …. I think it can go down to 37,
And , if Both of them, oh yeah, if these meet at right angle, meaning I placed them at 45 degrees, they should be more free… it could come

15:39   down to… as low as the… the dinner area, I mean, …The dimension that determines, the thing that determines that dimension is how much space ??? on the table, so yeah, that's another criteria!

[…ends back and forth play between A1.4p and A1.5p]

16:05, [listening] *R: I have a remark! The fact that the people are happy to dine together as a group, versus the dimension you are measuring considers the comfort zone for one person only. How do you imagine that they like each other? It might be a little bit more compressed, [tighter space between people]*

16:29   S3: Yes! But I think I'm not there yet! I think I'm just setting standard now!

16:36, *R: I have another question: do you think this table is for you? Are you your own client? Or is it a table for everybody?*

[explaining]   S3: I think I'm definitely sitting at the table!

16:50, *R: ok [add dimensions to A1.5p], so, what problem are you going to address next?*

> S3: Well, I'm still continuing setting up a template for me that I can play with, you know, dimensions, because I have never designed a table before, either I take a standard table, either I take dimensions from this or I develop them according to ergonomics! But, of course I have to speculate when I am doing this, and then, when I am working with the form or, you know, trying to introduce more realistic things into it, then it will change!

17:27   Hm… So,

[go back to A1.5p]   hm…What was I doing?.. I was thinking of this being

17;37 [start using 2xm]   very short, let's say 30, that might be

17:48 [end 2xm]   enough for me sitting at a corner at 90 degree table, yeah I'll do that! One thing I don't want though   I mean, although it's good to have

[start A1.6p= 1line]   … now I start to have kind of starting to design like interface, you know,   I think with ??? numbers more or less…

18:14 photo   it's good to have a flat surface to lean against while you're eating! It doesn't look like I have a nice form, I mean, the most ideal table I have eaten

[start A1.7p]   were for 8 people square tables … or for 4 people,

18:34   again square… but if I have like, you know, eight people, I don't make it an octogonal shape! I don't know why! Because it's not congregation about a center, I think it just kills the all esthetic, whatever, I don't like too literal…

R: Do you think this one is too much convergent toward the center while this one is…

19.13   S3: Yeah , definitely…So,

[A1.6p continued]	I want my table to be a little more flexible in terms of arrangement, not like this!
[points at octagonal table in A1.7p, superimpose 2 designs in A1.6p]	That's why I have been drawing round edges, but it could also be something like this
19:38	... I not sure this is an angle that I want, because... but that's an option!
[starts A1.8p]	But, it always has to be symmetric, I think, somehow! I was thinking of symmetric because
20:05	...Hmm... yeah... no question about that!

R: *so, here, you're trying to see if this sort of elongated boat shape is working at the end?*

S3: It's not satisfying at all! I'm just trying to... start from something else, you know, how would I invent a shape for myself? ...

20:38 [A1.9p]	...
[starts A1.10p, 2 s. appraisal]	So, what I am doing, actually without thinking, so I don't think I have
20:57	to talk out loud here
[laughter]	I'm just looking at things! ...Well, I can tell what I am looking at!
[starts A1.11p] R: *yes*	S3: ok, at the ends, my people are almost sitting at right angle,
21:28	a little wider maybe , would also be fine ... but.... I want them to connect... Ok, this table is getting a little bulky,
21:48	but it's fine still, because we need
21:55 [end A1.11p,	
cuts tracing and clears desk!]	.... We need... space in the center as well... but one thing I don't
[starts A2.1p]	want is, because this is an elongated table,
22:15	I want it to be slender, I want it to be slick, I don't want it to be fat,
[starts A2.2p]	because then these distances are more and more,... yeah, it doesn't bring the people together I think, I hate yell the table across!
22:33 [ends A2.2p]	Ok, I might be putting myself into a dead-end here, but I think I
[start A2.3s]	already know what I am doing in the section, that's why I am loosing too much time in the plan....
22:50	And just to make sure that I know what I am doing in section, I'm doing a section here!
23:13 [ends A2.3s] ...	

23:21 [starts A2.4s, 1 line!] Hmm, I'm still not thinking about the material!

R: *what is the idea in the section?*

[back to A2.3s]	S3: oh, the idea in the section, there are certain axes between people where I want the legs to go in. This was the question about deciding between 10 or 12 people!

23:37, R: *cause that's a stronger construction!*

S3: yes,

[add another longitudinal axis to A2.2p]	and the table is consisting of two parts that are each carried by a cantilever, or like a C-like section.
[start A2.5s]	And then they meet...So, one would sit here, these would be one and this would be the next person sitting next to him,
[end A2.5s]	... sitting at an angle, hm...and the person in the middle.
24:22	Ok now, this... although I described it in terms of two pieces, I want my board to be one piece !
[writing comment in A2.5s]	So that's still a consideration, ... at least, not one piece, but maybe finished together! Hmm...
24:46	So, if it's wood, actually, it can be...
[start writing A2.6n]	let say, if it's wood, it's going to be polished...extremely well!

and discussing	Because, this is such a big surface, I don't think this could be anything like metal, because I think that's cold, in terms of temperature, not in terms of materials!
25:14	Plastic wouldn't work! I am just thinking in terms of general materials, hm... ok ,
25:24	let me think about another option of... I thought about shiny surfaces because there are easy to clean, easy to slide things across, but also, if you spill something... because they are not absorbent, they just spill things all over you, right?
25:55	I don't know if that's important because you might actually know how to eat without spilling anything! ...hm... But,
26:11	paper... is a nice material, I think, on table tops, not glossy paper... like... absorbent paper.... So I'm thinking,
26:29	if there is a way of making it both glossy and paper !...
[writing]	Ok, I think I just have to compromise from certain things! Hm... paper might come in the section when somebody is setting the table up! hm... I'm thinking, I'm thinking, how I can visualize the table sets? I'm thinking at the glossy surface...
27:09 [reflecting]	
R: what do you see?	**S3:** well, I see glass, but I don't see paper still
27:27	And I don't like those little things that are put under your plate that sort of specify your territory itself ...I guess, it must have to do with napkins, like you spill something, be quick to just
[gesture to indicate wiping action]	.... Yeah, that would have been the major concern, so I'm
27:46	compromising ...That nice texture paper surface that I would like to have, but it might come in another part of our lives!
[laughter]	So, and, in the meantime, I switched, I mean, I didn't switch, but I started considering glass!
28:07 [1 line]	...Then maybe with glass, transparent, maybe semi, you know, sometimes, perfectly transparent glass tables are very delusional, you don't know your depth
28:22	and it's kind of dark, maybe it's good to have the glass on the bottom surface to be a little ragged here, you know, they beat the glass,
R: sanded?	**S3:** maybe not sanded, but a little rough, so that it's actually three-dimensional, you know, more wild! Another point, I don't know how the leg would punch into the table...
R: you are interested in the transparent surface!	
	S3: yes, I'm also interested in semi, the semi-transparent, semi-opaque thing, also I'm interested with the shadows of the heterogeneity of the surface... the color of the surface.. hmm.. so the legs then, I'd like heavy legs
[starts A2.7s]	for the table , so they could be molded steel and no one would be able to move this table ever! One other problem is, do I want the glass to be bolted on this or not? And how many points
[ends A2.7s]	do I want my pieces to punch the table surface? But clearly there are two different,... so whoever,
29:53	you I guess, is going to do this table for me... has to produce it , you know,
30:03 [starts A2.8s]	... in two... two different...
[ends A2.8s]	
R: what's the problem?	
	S3: It's not a problem, but it's the question of the legs again!... The surface is big, the glass surface is pretty big, so... I am not sure if it's possible at all to produce this surface of glass first of all, that big!...
R: I think it is!	I'm sure, I mean, you're going to do it anyway!

[adds to A2.8s]   It's just, I guess, not the easiest thing to transport this as well, but once it comes, then it comes! and the dimension would be, I mean, from one tip to another, it's something like, hmm...

31:00 [calculations]   I'm just ... trying to see how long [laughter] my table ... is ! It is 16, 5 meters! No! How can it be? ... I meant 170

31:40 [laughter and gestures with two arms extended to indicate a very, very long table!],
R: centimeters?

S3: yeah, wait a minute, I'm confused about the decimals here... 45, 80,... oh, it's actually close to 3 meters,

32:00
[adds dimension to A2.8s]   so that's not too bad actually, it's quite small! 270!
R: You think it fits in 3m?

[compares visually with table]   **S3:** Hmm?

32:17   Yeah, it definitely fits ...It's as long as this table maybe!

32:24 [uses 2xm]   let's see... but make sure that the angle... you remember that the ends are a little slanted?

32:35   Slanted that's why, I am gaining, exactly!
32:56 [ends using 2xm]

33:02 [grasps ruler]   Actually let's draw this,...1/50
[actually drawn at 1/100]   ... let's draw a little table here!
[starts A2.9p, small scale drawing]
R: What are you doing now?

S3: I'm drawing my table!
R: You are trying to catch it with more precision?

S3: Yes, just to make sure that I am not fooling myself with my sketches! But I'm not very good at scaling things!...hmm....I think I haven't been drawing for so long!

[A2.10p]   ...Yes, this is more like it! ...OK,...
[ends using ruler, ends A2.9p] A little problem is,... it can't fit more people on the side, but...

35:08 [cut paper, starts A3.1p] let's go back to the pen,... having jumped to thinking of material to fast, I forgot about my

35:27   ... my process of fitting people around,... so, my idea about keeping dimensions ... to be ... also to satisfy 12 people sitting at this table, I think it would fit, it could be more cozy!

R: the same table could be fitting ten or twelve?

36:00 [A3.2p]   **S3:** Yeah, except ... still the people at the ends still have the same comfort level, just these three people squishing in, which is a little weird, if there was a little, little more, you know, comfortable transition in between.... It would accommodate easily... so, that's why it was good to go to a rounding ...

36:40 [starts A3.3p]   but I'm not sure how this is going to work, again, let's go back to what I was doing

[starts A3.4p]   ... so 'I'm still working in zones... I have zones for every person... and on zone that stays put in the mid-center and ...

37:17   it needs to be bulky enough so that there's space to eat comfortably
[end A3.4p]   ... I wish there was a way
37:41   to check dimensions that are curved here....
[starts A3.5p by drawing a quarter of the shape of the tabletop]
[Inaudible R proposing to make a cardboard 1:1 'model' of the angle]
37:58 [draws small A3.6p regarding section of corrugated cardboard]

S3: The problem with the cardboard now, this is not going to help me now, because the problem is planar, I really don't have to model it! I can draw it,

R: You could have an idea of how it is real size!

S3: Oh one to one?
[adds chairs to A3.5p]   I don't think so!
R: and here, you're trying...   **S3:** Yes, I divided the table in four now actually...

38:50 [cuts paper A3 without using the angle of the table, continues A3.5p by folding drawing in four quarters to copy the ¼ shape] ...

39:20 — Here is my uninteresting shape! ...Here are where legs, more or less are going to be vertical elements to support in the center,.. hmm... yes.. In a little surface of course, ... Ok,

40:01 [clears space] — I think I leave the shape like this because I feel I have to work on the problem of how it stands.

R: You mean the structure? **S3:** yes

[back to A2, A2.11s] — ... So there are two surfaces, one on the floor, one above,

40:22 [and A2.12s] — and I want an arc in between, ...so it's like this...The question is: how am I going to mold this in steel?

R: Why is that a problem? **S3:** 'Cause I'm trying to think of it in terms of 3D

41:09 — ... is this a plate that I fold, maybe? because this is the way I think of it, maybe this is... some thickness of,...

41:24 — I'm not sure if aluminum is a good material to support glass! How much would this glass weight?

41:30 [adds dim. to A3.5p] — Actually, it's getting smaller now! This was 45 now and that was even big for me, this is 35 now and this is 20!

41:53 [mistaking full length with half length!]

R: are you thinking of reducing the size?

S3: No, It's already reduced! I'm just adapting to the new size, 35... 110 and 45... See, it's getting very small! ... If I am going to accommodate 12 people... no, let's forget about 12 people, because I am only designing the legs with axis!

42:20 — I think 12 people can squish but I am not going to design for that, so it's actually getting as small as 1.70.

R: the entire table will be less than this one?

42:45 [2xmeter, measure and draw on table]

S3: yes,

42:45 [grasps 2xm] — ..... maybe I'm thinking of,.... wait, wait...

[adds to A3.5p] — I think I'm missing another person! ... No,

[unfolds the 2xmeter] — It works like this !, If this is the length of the table, I understand I'm sitting here,

[stands up] — right? So let's start from there,

[stands up and draws on the table paper cloth]

— .... I am sitting here...and then the next person is sitting around

43:43 — ...

R: So, you are the central person in this case?

43:48 photo — **S3:** Here.... Let's see if I have space for myself!? ... Yes, because the other person is sitting at an angle...so

44:27 — ... ...42, 75, wait, wait, that was my work ??? ...It's going at an angle,... and I think this will come up to 15, more or less or 20...so the width of the table is changing at the same time! so this is

45:05 [add to A3.5p] — 40 plus 15, 30 ,70 ... it's like.. It's like 1 meter across at the fattest!

[add dimension to A3.4p]

R: what's the question now? **S3:** I'm still measuring, I'm not thinking too much! ...Oh,

45:53 [end 2xmeter] — one thing, I jumped too much ahead, now I have to adjust my dimensions!

[starts A2.13p] — ... I need ... approximately....

46:10 — Don't interrupt me in this! ... This is like 80 cm and ...

[inaudible calculating] — this is like... this is like...

— ...

[A2.13p continued] — ...

— Ok,

47:01 [new overlay A4, — ...

puts A2 on the floor] — so!, my new table:

47:07   ...

[starts A4.1p based on A3.5p]   ...yes!..

47:25   So its... precise dimensions would be... let's say 3 meters!...and... across... it's 1!

47;56   ..., so, proportionately I say, it could be less than 3, and the way to figure it out is either precisely drawing this, which I'm not always too interested in doing!

48:15   ...hmm...but roughly

[adds to A4.1p]   ...yes

48:38 [starts using 2x meter]   ... one meter in plenty! ... I'm trying to imagine without drawing

49:00   ... the most comfortable dimension, minimum dimension I could dine in... let me see

49:28 [ends using 2xm]   ... would be 60, hmm... so my table would range in between, ... hmm! ...

[starts A4.2p]   I have 3 stages...

R: so, here you're trying to find a method to exactly define what angles and dimensions,

        S3: no, I think I have, I have more or less an idea of the angles! Because I have been sticking with this... hmm... so

50:27   ... if this is 60 and this is 60...I 'm trying to speculate on the dimension across

50:38   !... this would be 40, this would be 50, just in between! 90 plus 30

[ends A4.2p, close pen]   ... we are going back to our small table,[51:03] **2.5!**

[listening]

R: Ok, it seems that you have a rather definitive choice! Can we say that we sort of wrap up? And see how you fulfill the requirement?

53:36 [cuts paper, clears all overlays from the tabletop, plays with the roll of tracing paper]

R: Your own evaluation, how do you think you're answering the sense of community at the table with the shape, and dimension you have given and how efficiently and nicely the environment is set for a good dinner? Can you redraw a final I can take home and build?

52:20 [takes drawing overlay A4 from the floor]

        S3: Well one meter across is only for the sake of allowing those

[adds dimensions in A4.2p]   angles , right!?

R: You have two people at the end!

        S3: Yes, although, I remember at the beginning, I do wanted a slick and slender table!...

[starts A5.1p based on A4.2p but curved, ¼ shape]

        again, let's...

53:00 [cuts paper and folds it to draw the entire tabletop shape in A5.1p]...

        ...

        ...

53:29 [telephone/door bell ringing, "keep talking", experimenter leaving the room, but no interruption]

53:38 [starts A6.1p]   ... hmm...

57:17 [starts A6.2s]   here are where the legs come, I think more or less centered!

54:22 [cuts overlay A7, starts A7.1p based on A6.1p]

        ... I'm going to draw them along the axis [54:38]...

[starts A6.2s]   I'm drawing this... with the legs!

55:00   I never considered the legs in plan, so I'll just conclude about those! Kind of!

R: evidently, the structural system would require more study, but you have been very clear saying, you want leg room, you have design something that allows a very high level of comfort [55:23,cuts paper overlay 8] *for the people in terms of legroom.*

[A8.1p footage based on A7.1p]

        S3: Yes...

55:35 [adds to A7.1p]   no, but I would like also to have a final word on the structure

55:40   Ok, so...

55:58 [starts A8.2s]	so that, in section, it looks, like this: some plate that's folded and sits like a spring, and supports the two pieces..., there are more or less like this,
56:15	they open up at the end, this is like the top piece,
[starts A8.3d]	this goes down and this goes up at the end again, right! ... but this doesn't have to be the shape, it's just, it's wider on this end here and it's wider on this end here, and... it's springs, and.. I think it could be
56:48	bolted... I'm not sure...

R: the table rests on it?

S3: yeah, I think it could be bolted! But again, it has to be investigated because, it's going to be metal you know, either... I'm not sure about aluminum, I'm not sure about how supportive it is,

57:10	but I think of aluminum, thick though, I mean a plate that is thick...
[ends A8.2s]	So, to wrap up! I mean, I could go on forever if you don't stop me!

R: I sort of stop you then! Well, we have the dimensions..

57:44	**S3:** We talked about the community gathering around the table too
[A8.4p, based on A7.1p]	...when I was talking of the glass, etc.

R: but perhaps, in order for me to cut the table an set it, can you indicate the chairs, please?

S3: all right...

58:08 [add, chairs to A8.1p]...	
58:31	It's really hard to... symmetrically draw this!

R: OK, in terms of material, this is this semi-transparent glass, and in terms of height? [stops reflecting on footage, 59:03, reaches for the 2xm and measures how high the top of the desk is above the floor] How high is the tabletop above ground? Is this average, or above average, or below average?

59.13 [ends using 2xmeter, folds it back]

S3: Hmm...

59;35 [A8.5s]	I considering how wide the legs are, because I am considering how the structural section depends on the height of the table, so hmm
[sketches footage in A8.5s]	...
1:00:03	I am going to....

R: it opens the spring more!

1:00:14	**S3:** So, it has to be thicker in terms of section, because it has more vertical ??? More in the vertical axis, but, I mean the height of the table really depends on the height of the chairs too! We haven't talked about chairs but
1:00:37 [cuts paper]	... let's say,
[looks at the table for comparison]	
	between sitting

[stands up and use 2xm to measure height between chair's seat and table top]

... let's give the dimension... between sitting and... table surface,

1:00:52 [ends using 2xm, hand gesture to evaluate the height of tabletop, placing hands approximately 5cm above the desk's surface]

.... Ok, approximately thirty,

[adds to A7.2s]	a little higher than this, hmm...
1:01:00 [adds chair in A7.2s]	

R: you said, approximately 30, will 30cm be the maximum?

S3: Hmm! Not necessarily! Approximately 30, it could be higher but, I think 30 is reasonable

R: all right, thank you very much!

S3: thank you!

1:01:36

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All illustrations by the author, except otherwise mentioned.
Fig.5 M.C. Escher, "Drawing hands", coll. Haags Gemeentemuseum, Den Haag,
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