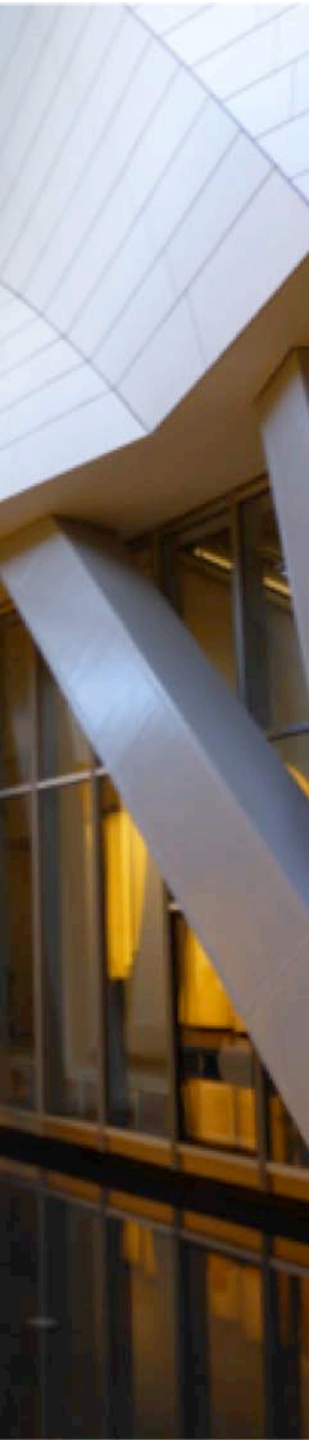

design theory and methods for innovation

SIG Design theory

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MINES ParisTech

Centre de Gestion Scientifique

ANALYZING THE GENERATIVE EFFECTS OF SKETCHES WITH DESIGN THEORY: SKETCHING TO FOSTER KNOWLEDGE REORDERING

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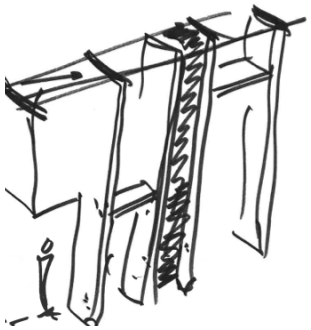
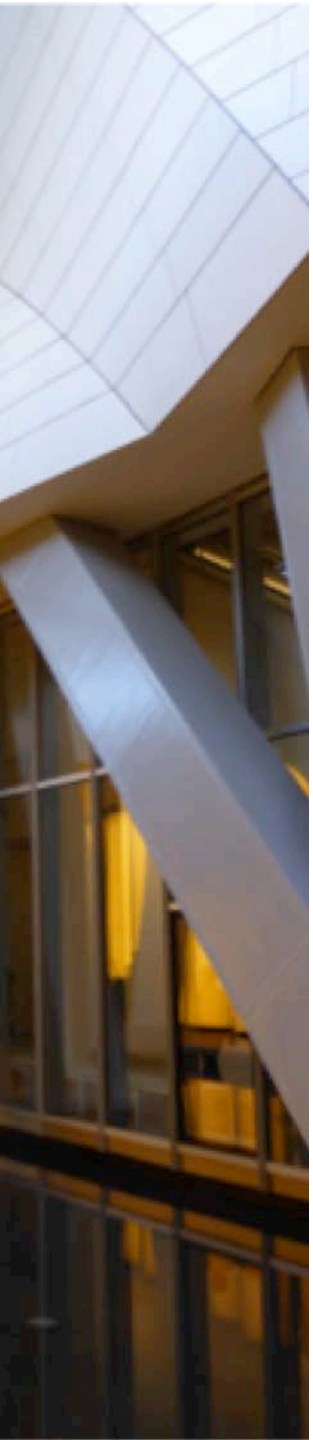


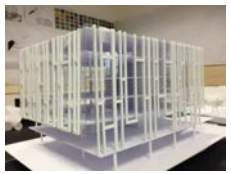
Juliette Brun
Benoît Weil
Pascal Le Masson

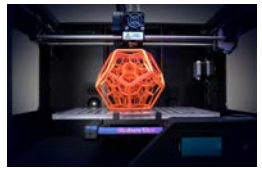


1. Introduction and research question

- **Non-verbal tools**

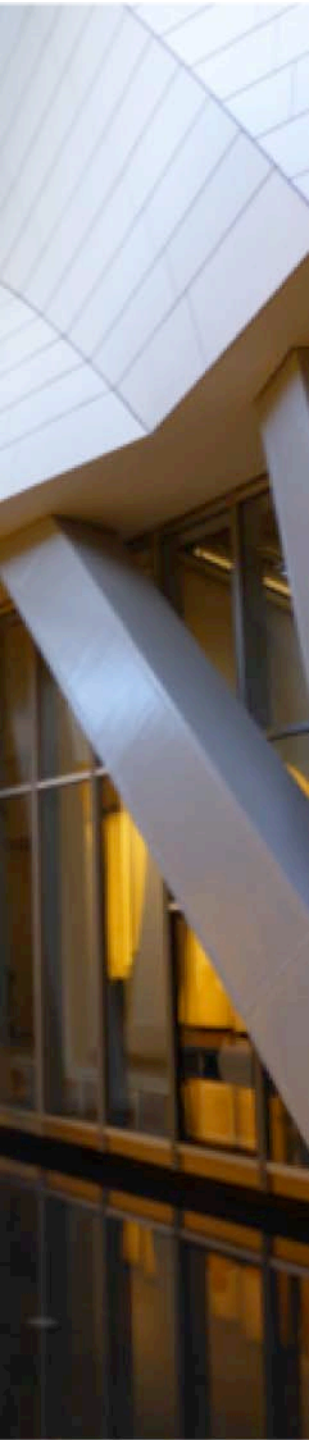
A **very particular language**, used by several designers (architects, graphic designers, but also scientists and engineers), in different stages of design and in different contexts

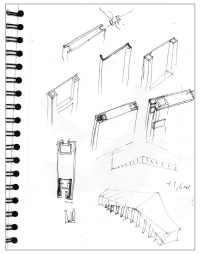



- **Effects ?**
  - Enhances creativity? Or fixation effects ? → **effects not always controlled**
  - Strongly operator-dependent (experienced architect or occasional sketcher)

- **Focus on architect's drawings** in order to study the **generative effects** of a very particular language
  - How architects do use sketches to reach generative effects i.e. to enhance the variety and originality of their explorations ?
  - How sketches do help architects to produce completely new things ?



2. Literature review



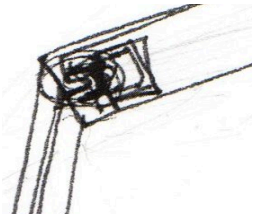
2.1. Sketching: an essential worktool for designers

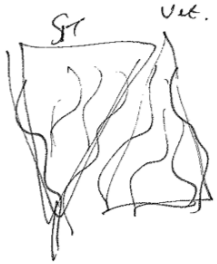
- **Sketches at various stages of the design process**

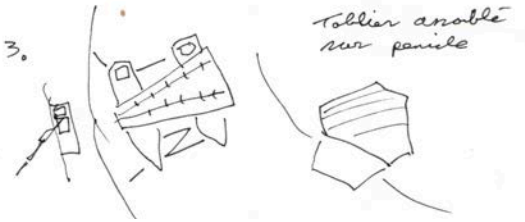
Fergusson *(1992)* emphasizes the generative effects of sketches.

3 categories of sketches:

- **Thinking** sketches: an engineer looking for new ideas
- **Talking** sketches: two engineers communicating
- **Prescriptive** sketches: meant to convince external people

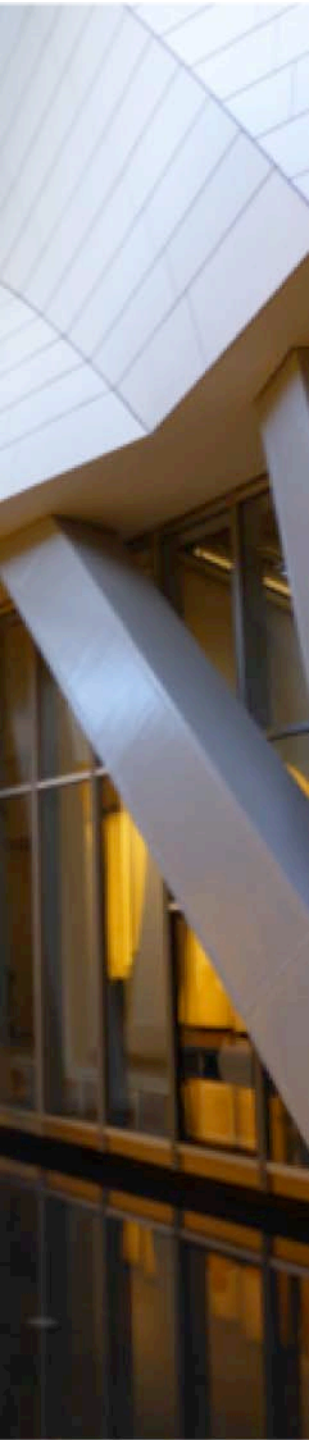






=> Involved at various stages

=> Nature and reasons of their **generative power** ?



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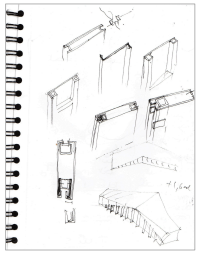
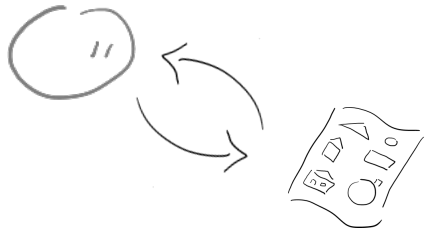


2.1. Sketching: an essential worktool for designers

- **Quick information processing**

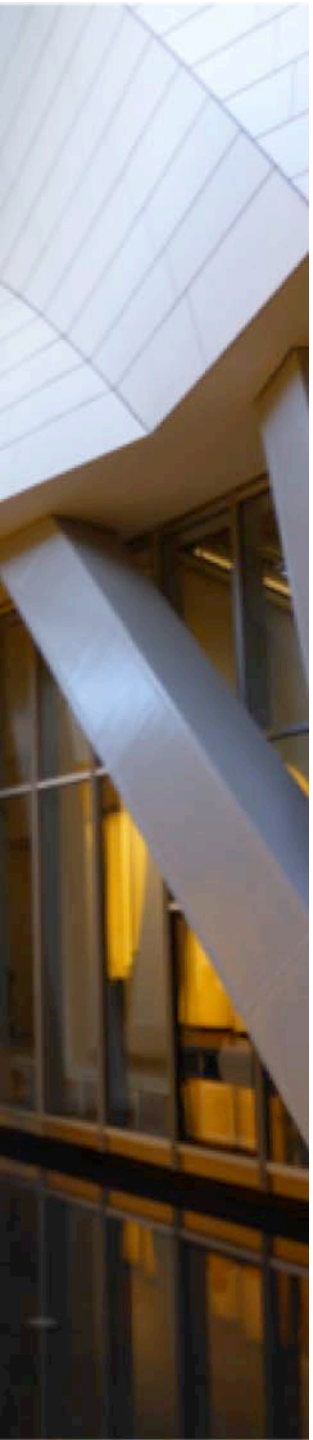
Sketches can be seen as **cognitive crutches** supporting the design reasoning:

- Externalization of the designer's ideas *(Tversky, 1999)*
- Instant feedback, economic cognitively *(Schön & Wiggins, 1992)*



⇒ **increase exploration speed**…
… But does not involve higher originality

=> Stronger generative effects should be involved



2. Literature review

2.2. Towards generative effects increasing originality

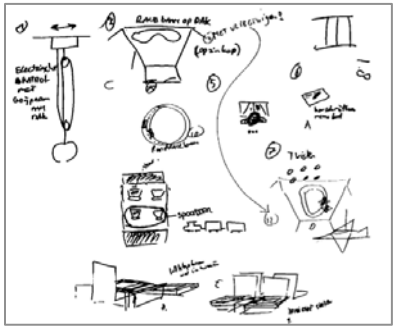
- **Sketching enhances reinterpretation**

Van der Lugt *(2002, 2005)* studies the roles of sketches during idea generation:

Brainstorming

vs.

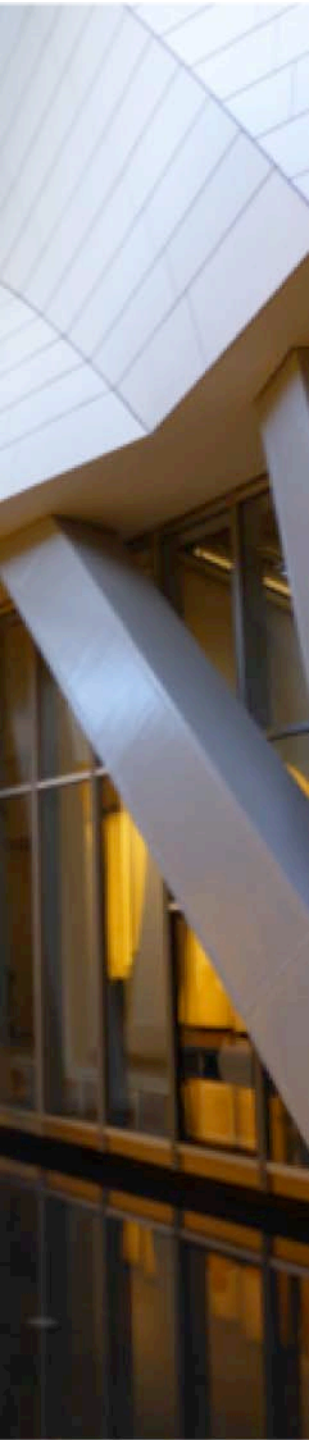
Brainsketching



Sketching provides support for **individual reinterpretation**

⇒ Helps reinterpretation = new ways of seeing a drawn representation *(Purcell & Gero, 1998)*

⇒ How sketching does allow this reinterpretation?

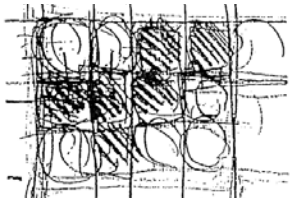


2.2. Towards generative effects increasing originality

- **Bringing new insights to the designer**

Sketching bring **new information** to the designer
(Schön, 1983; Suwa, Tversky, Gero & Purcell, 2001)

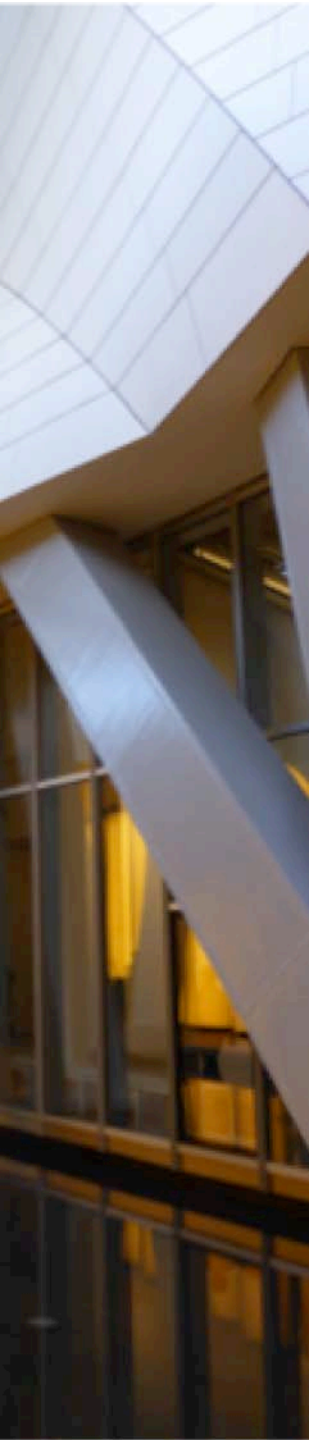
- Freehand sketches are often dense and ambiguous *(Goel, 1995)*



- A dialogue between the architect and his sketches *(Goldschmidt, 2003)*
- Depiction to extract original descriptive information *(Fish & Scrivener, 1990)*

⇒ Sketching can enhance the design process by bringing **new information** to the designer

⇒ However, these generative effects are **not systematic**, not even of the same nature



2.3. Modeling the design strategy to identify generative effects of sketching

- **The designer strategy impacts design quality**

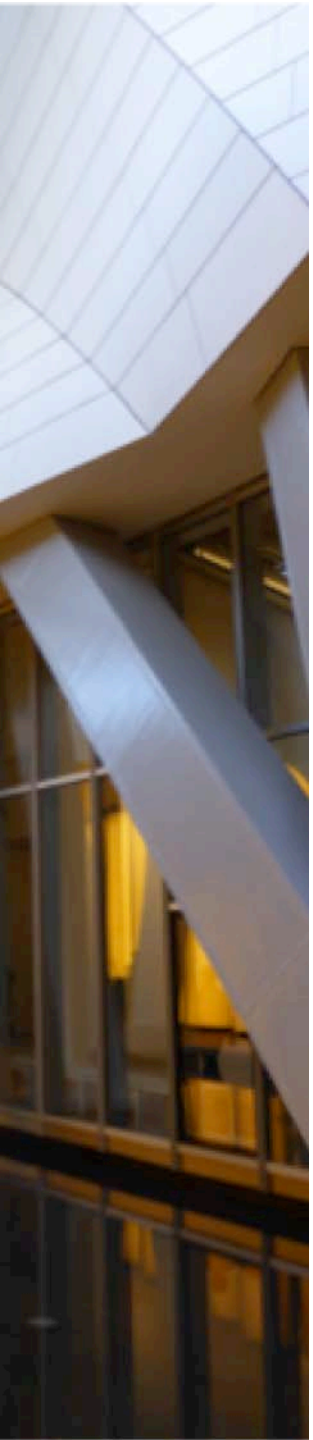
McGown, Green and Rogers *(1998, 2000)* studied the relation between the designer's strategy to reach novelty and the quality of his exploration

- Lateral and vertical transformations *(Goel, 1995)*

- Good design = balance between lateral and vertical transformations

⇒ not every sketched exploration led to generative effects

⇒ design strategies may be **less or more** efficient/controlled



2. Literature review

2.3. Modeling the design strategy to identify generative effects of sketching

- **Several ways to identify design strategies**

  - Lateral vs. vertical transformations
  - Divergent thinking vs. convergent thinking *(Guilford, 1950, 1967; Torrance 1962, 1966)*

  ⇒ **Creativity-based methods of analysis**

  ⇒ **Exploration of concepts**

Exploring knowledge with convergent thinking is necessary to produce new objects *(Cropley, 2006)* : important amount of knowledge in architecture

- **Research question – an approach with C-K theory**

An object with strong generative effects, a very complex process
+
Limits of creativity-based methods

To understand the **interaction between concepts and knowledge**
=> C-K design theory

3. Methodology: analyzing sketches with CK theory

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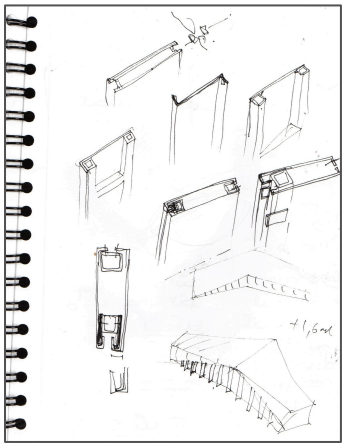
3.1. Selected sketches

- **Sketches made by experienced architects**
  - Breakthrough solutions in façades design
  - Involved in the design of the new Fondation Louis Vuitton

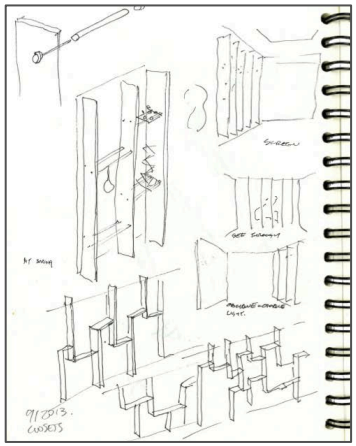
- **Three sequences of sketches**

The sequences had:

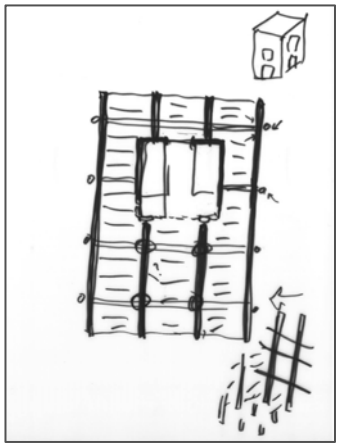
- To present original ideas
- To be of different types



1. Sun-breaker solution



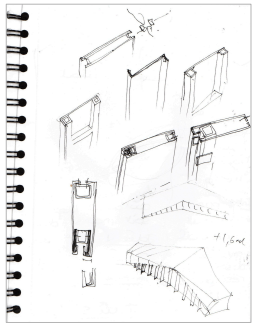
2. Bookcases



3. Police station

3. Methodology: analyzing sketches with CK theory

3.2. CK theory to understand generative effects of sketches



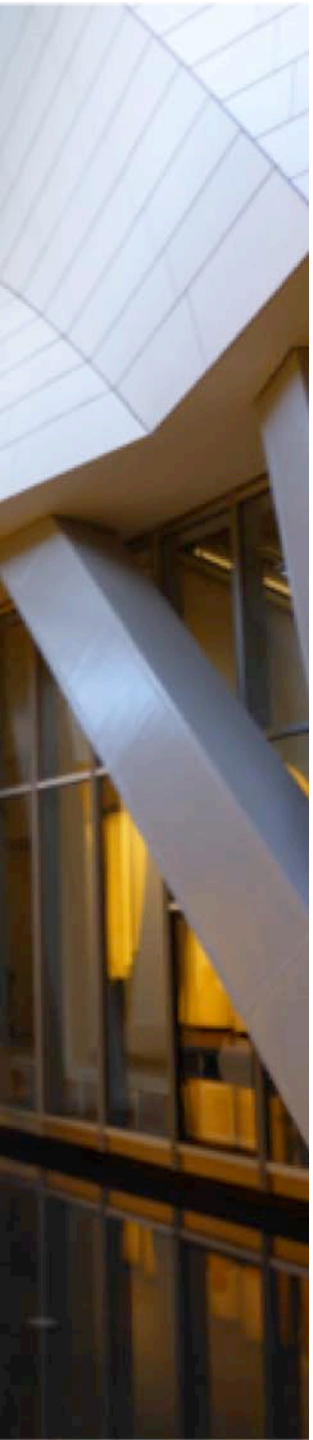
- **Sketches are not propositions**
  - Sketches = Not Concepts or Knowledge
  - Propositions from the design reasoning of the architect

- **Four new operators**
  - C->D
  - D->C
  - K->D
  - D->K

- **K and K***

Knowledge related or unrelated to the initial topic (C0)

	"The H structure is stable."	K: architect's experience	K->D
	"The plate-structure junction can be done from the inside, like this."	K: architect's experience	K->D
	"The final appearance would be this one."	K: final appearance	K->D
	"Something happens at the side."	K*: focus on the sides	D->K*
	"How to fix the plates to the structure by the sides?"	C: a junction system to fix plates and structure by the sides	K*->C
	"Fixation by screwing is not aesthetically pleasing."	K: screwing, aesthetic expectations	K->K
	"The plate-structure junction can be done with a clipping system."	K*: a clipping system	C->D and D->K* (conjunction)



4. Results: new knowledge and K-reordering to support the design strategy

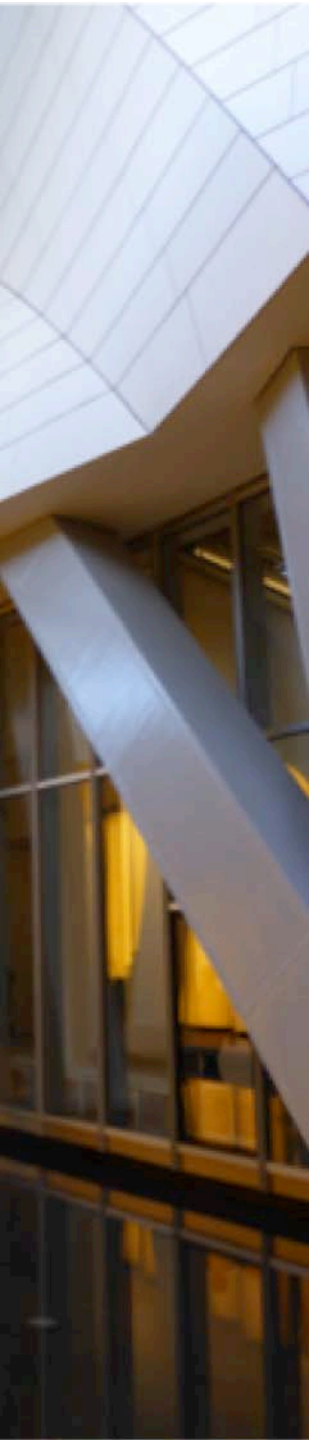
4.1. Succession and occurrence of the different operators

Sequence	Operators' succession	Operators occurrence	
1	K->D; D->K; K->C // K->D and D->K; D->K; D->C // K->D // K->D // K->D; D->K*; K*->C // K->K; C->D and D->K*	K->D	5
		C->D	1
		D->K	5 (2 D->K*)
		D->C	1
2	K->D; K->D; K->C // K->K; K->D; D->K; D->K*; K*->C // K*->D; D->K*; K*->K; K*->C //K->D // K*->D // K->D // K->D // K->D; D->K*// K->D; D->K // K->D; D->K*; K*->C // K*->D //K->D // K->D // K->D // K->D; D->K; K->C // K*->D; D->K; K->C // K->D; D->K*; K*->C // K*->D; D->K; D->K; K->C// K*->D; D->K* and K*->D; D->K	K->D	21
		C->D	0
		D->K	13 (6 D->K*)
		D->C	0

4.2. Results analysis

- **Sketches refer to both C and K**

  => The same sketch can refer to **both concept and knowledge** propositions



4. Results: new knowledge and K-reordering to support the design strategy

4.2. Results analysis

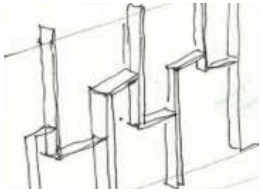
- **How sketches bring new insights to the architect**

The architects puts knowledge and concepts in his sketch : C->D and K->D operations

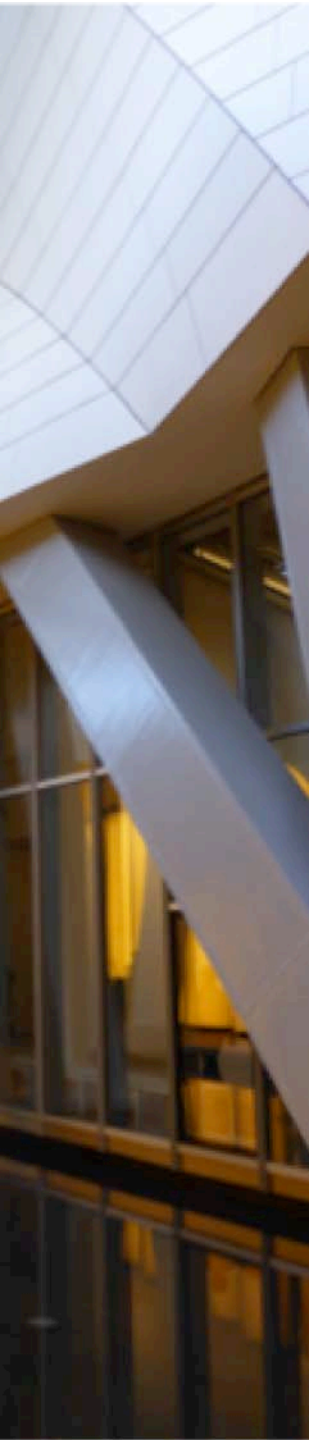
The architects also **receive a lot of insights** from his sketches : D->C and D->K operations

- Previous knowledge and concepts / **New knowledge and concepts**

- Several D->K corresponds to **evaluation operations**
  (K in K0: regulations, aesthetic requirements, expectations)
  Sometimes, the architect can read an **original knowledge** that appears unrelated to the initial topic K0 : D->K*



- The architect can also directly read **new Cs** in his sketches



4. Results: new knowledge and K-reordering to support the design strategy

4.2. Results analysis

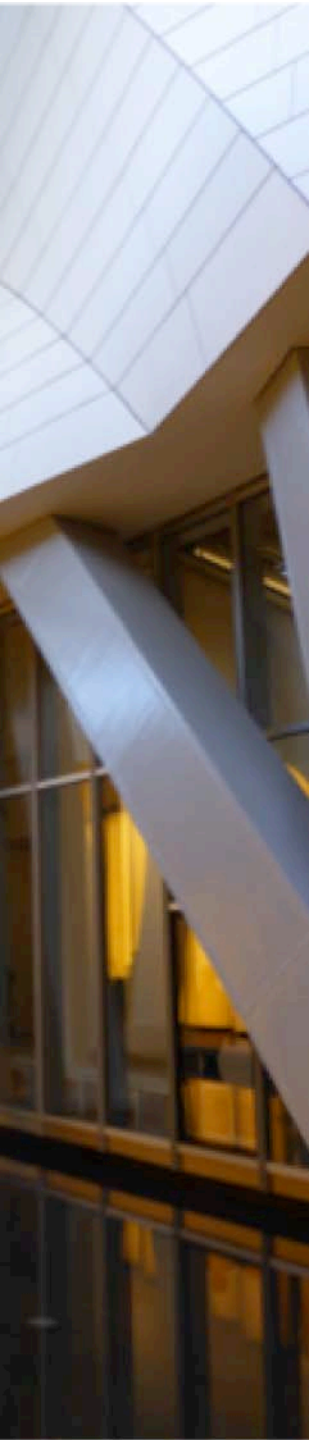
- **How sketches bring new insights to the architect**

Sequence	Operators' succession	Operators occurrence	
1	K->D; D->K; K->C // K->D and D->K; D->K; D->C // K->D // K->D // K->D; D->K*; K*->C // K->K; C->D and D->K*	K->D	5
		C->D	1
		D->K	5 (2 D->K*)
		D->C	1
2	K->D; K->D; K->C // K->K; K->D; D->K; D->K*; K*->C // K*->D; D->K*; K*->K; K*->C //K->D // K*->D // K->D // K->D // K->D; D->K*// K->D; D->K // K->D; D->K*; K*->C // K*->D //K->D // K->D // K->D // K->D; D->K; K->C // K*->D; D->K; K->C // K->D; D->K*; K*->C // K*->D; D->K; D->K; K->C// K*->D; D->K* and K*->D; D->K	K->D	21
		C->D	0
		D->K	13 (6 D->K*)
		D->C	0

Number of K->D and D->K operators vs. number of C->D and D->C operators:

⇒ The architect **plays mostly with knowledge**

⇒ He follows **a K-oriented design strategy**

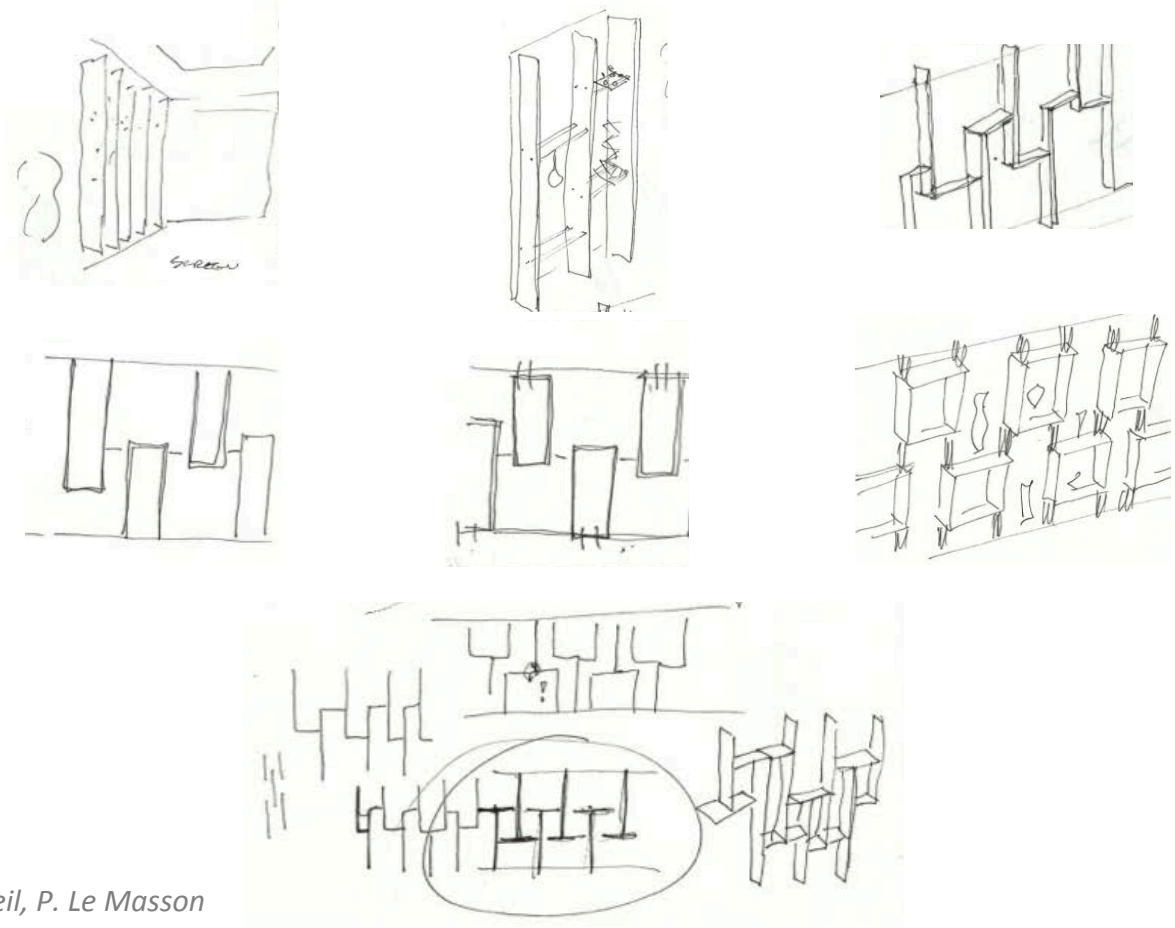


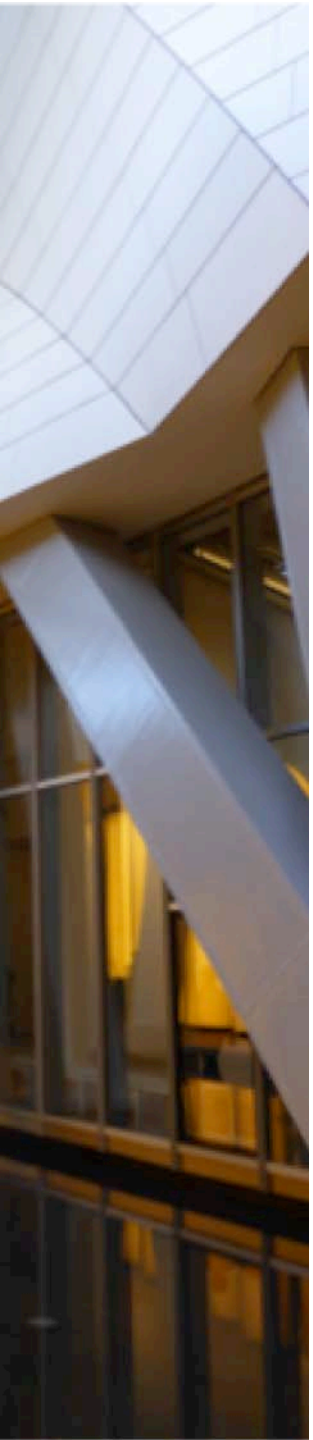
4. Results: new knowledge and K-reordering to support the design strategy

4.2. Results analysis

- **Sketches are not ready-made solutions, not even intermediary solutions**

  => The impact on the K-space has to be analyzed



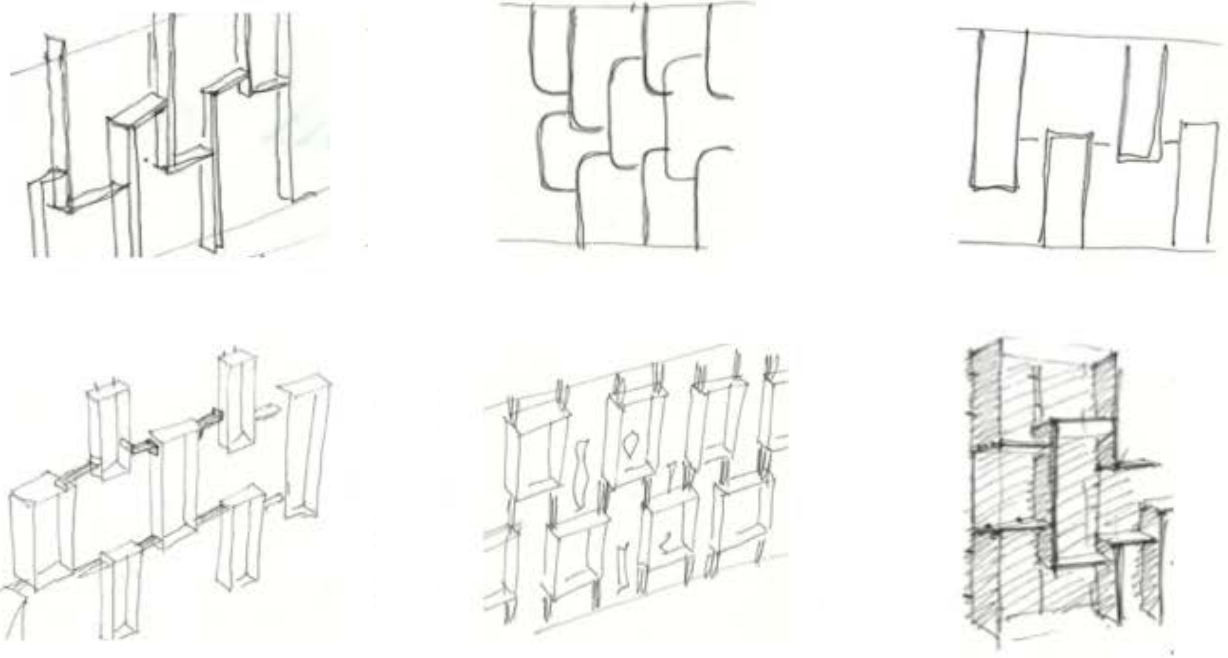


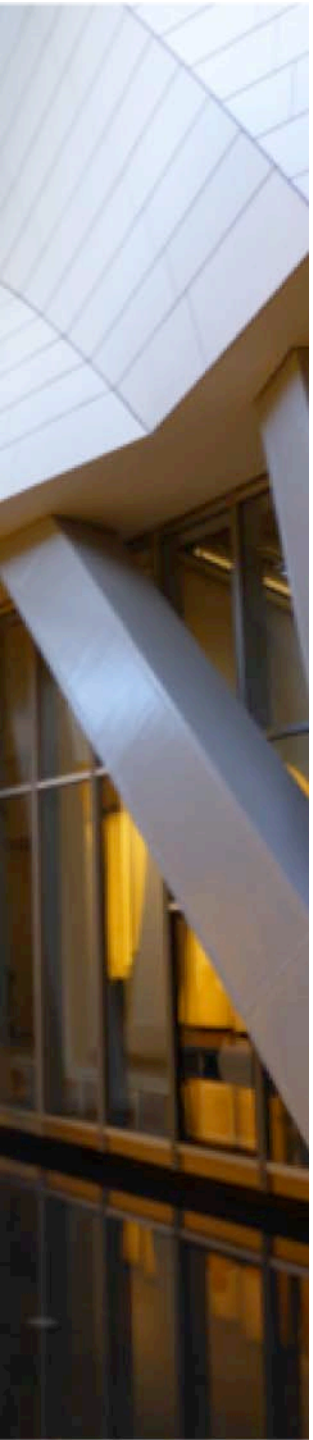
4. Results: new knowledge and K-reordering to support the design strategy

4.2. Results analysis

- **An important work of K-reordering**

  - The architect can test pieces of K through his sketches
  - He constitutes a **strategically built K-basis** (where each K is carefully selected)





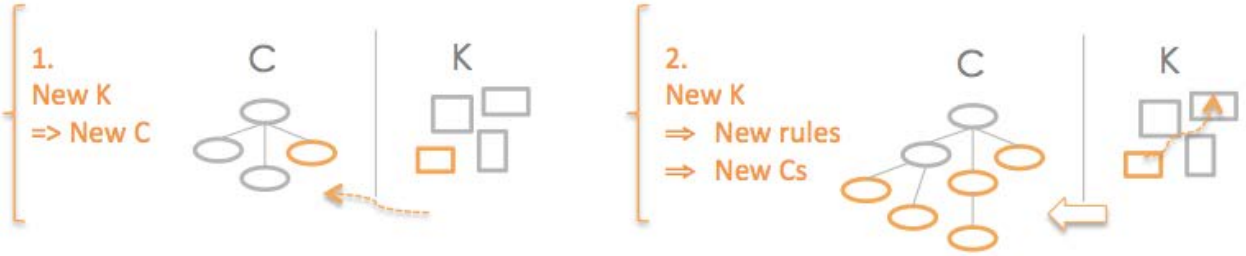
4. Results: new knowledge and K-reordering to support the design strategy

4.2. Results analysis

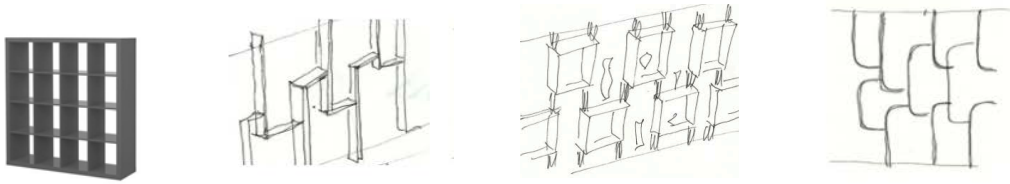
- **Nature of new K**

High number of D->K* : sketches allow **mobilizing knowledge not directly related to the C0**

- K*-elements allow introducing originality in the Cs
- But they have also an effect on the K-space itself

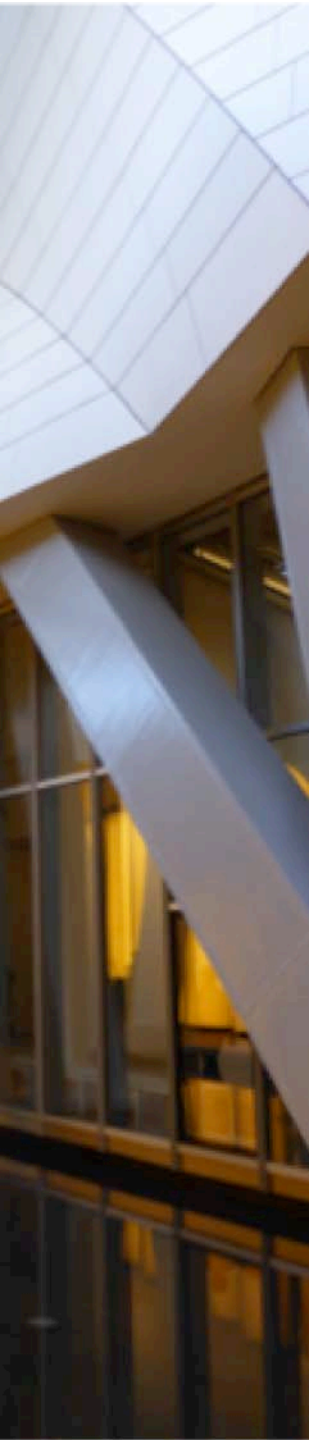


⇒ They allow creating interdependence (no modularity) in the K-basis without involving determinism



⇒ Knowledge basis with **"splitting"** structure (no modularity, no determinism)

Generative structure : enhances the production of new objects

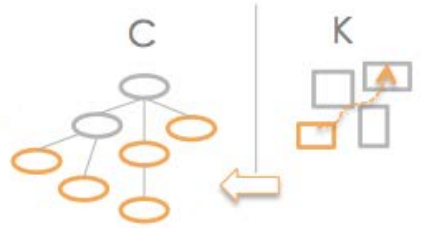


5. Conclusion

- **Understanding the generative effects of sketches with design theory**

This study allows to better understand the generative effects of sketching by clarifying:

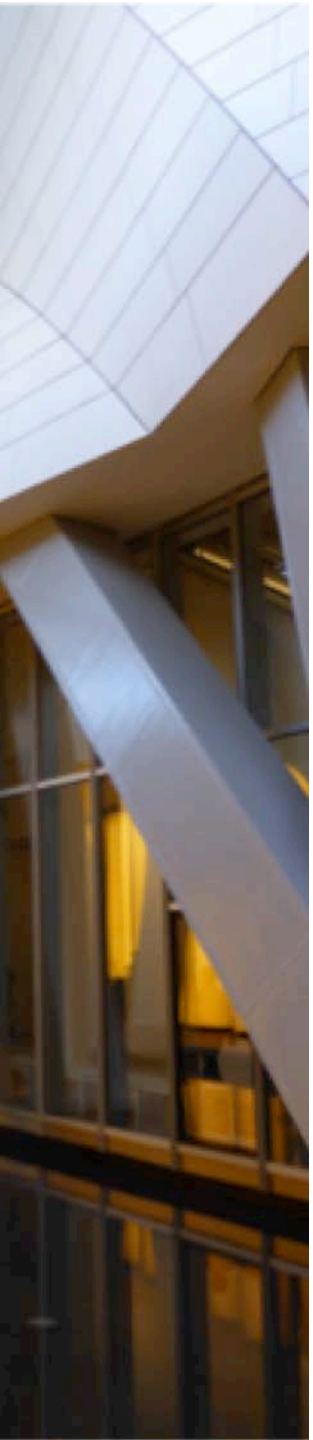
- The **new insights** brought by sketches
- The **strategy followed** and **how sketching supports this strategy**
- The **generative effects of knowledge** brought by sketches



- **Implications for design practice**

New dimensions in understanding the **nature of sketching**
The way **non-verbal devices impact the design process**

And the way **non-verbal devices impact idea generation during creativity sessions**



5. Conclusion

- **Implications for design practice**

Analyzing creativity with different rules … through knowledge structuration

- New rules for **evaluation**:
  ⇒ look at knowledge structure instead of quantity of ideas

- New rules for **management**:
  ⇒ be careful of saturation effects
  ⇒ target knowledge with splitting effects !