GIS Relance Agronomique

CASDAR

Innovation et partenariat

Résultats de l'appel à projet 2007

4 décembre 2012

Les défis de l'innovation : introduction à la conception innovante

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Pascal LE MASSON

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Mines ParisTech

Chaire Théorie et Méthodes de la Conception Innovante

The Chair for Design Theory and Methods for Innovation

Design Theory and Methods for Innovation

Academic chair for research and teaching

www.cgs.ensmp.fr/design/

DASSAULT SYSTEMES

RATP

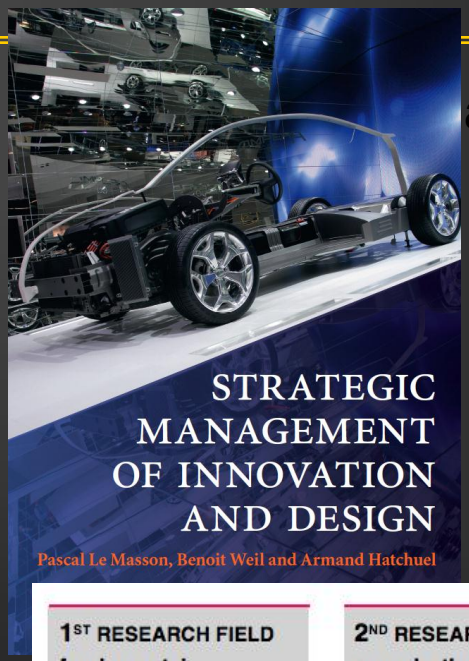
RENAULT

SNCF

ST

THALES

vallourec



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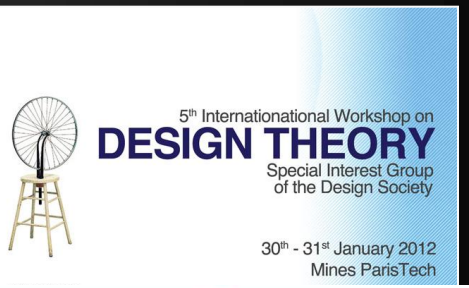
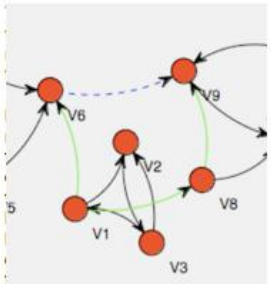


1ST RESEARCH FIELD
fundamental underpinnings of design theories and of reasoning in the unknown

2ND RESEARCH FIELD
organization and tools for innovative design

3RD RESEARCH FIELD
neuropsychological, cognitive and cultural bases of innovative design

4TH RESEARCH FIELD
design regimes, economics and history of design

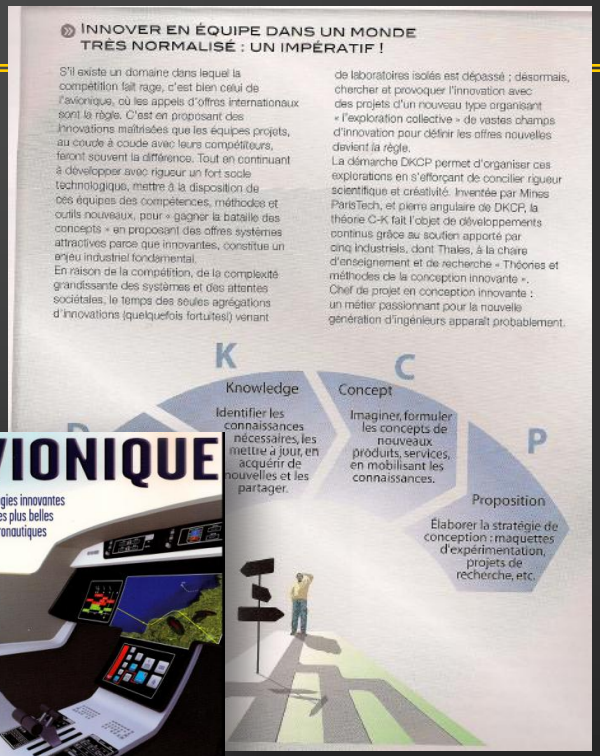


Recent chair highlights


Les Echos

Quand les scientifiques des Mines aident les cheminots à innover

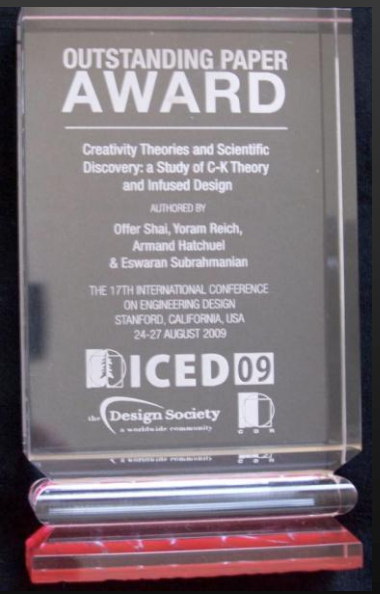
DKCP, la maintenance du ré seau ferroviaire fait partie de soucis cruciaux de la SNCF. L point le plus délicat consiste intervenir de façon efficace pou minimiser les perturbations, no tamment sur les zones du réseau les plus utilisées. Les enjeux sor essentiels, évidemment pour le usagers mais aussi pour l'entre prise, puisque la maintenance d l'infrastructure coûte enviro 1,8 milliard d'euros par an et qu


INNOVER EN ÉQUIPE DANS UN MONDE TRÈS NORMALISÉ : UN IMPÉRATIF !

S'il existe un domaine dans lequel la compétition fait rage, c'est bien celui de l'avionique, où les appels d'offres internationaux sont la règle. C'est en proposant des innovations maîtrisées que les équipes projets, au coude à coude avec leurs compétiteurs, feront souvent la différence. Tout en continuant à développer avec rigueur un fort socle technologique, mettre à la disposition de ces équipes des compétences, méthodes et outils nouveaux, pour « gagner la bataille des concepts » en proposant des offres systèmes attractives parce que innovantes, constitue un enjeu industriel fondamental.
En raison de la compétition, de la complexité grandissante des systèmes et des attentes sociétales, le temps des seules agrégations d'innovations (quelquefois fortuites!) venant de laboratoires isolés est dépassé ; désormais, chercher et provoquer l'innovation avec des projets d'un nouveau type organisant « l'exploration collective » de vastes champs d'innovation pour définir les offres nouvelles devient la règle.
La démarche DKCP permet d'organiser ces explorations en s'efforçant de concilier rigueur scientifique et créativité. Inventée par Mines ParisTech, et pierre angulaire de DKCP, la théorie C-K fait l'objet de développements continus grâce au soutien apporté par cinq industriels, dont Thales, à la chaire d'enseignement et de recherche « Théories et méthodes de la conception innovante ».
Chef de projet en conception innovante : un métier passionnant pour la nouvelle génération d'ingénieurs apparaît probablement.

K Knowledge — Identifier les connaissances nécessaires, les mettre à jour, en acquérir de nouvelles et les partager.
C Concept — Imaginer, formuler les concepts de nouveaux produits, services, en mobilisant les connaissances.
P Proposition — Élaborer la stratégie de conception : maquettes d'expérimentation, projets de recherche, etc.

Invitation to present C-K theory at the Shanghai World Fair 2010



Trophées Innovation Développement Durable Cap Gemini
2011 *Récifs artificiels*
2010 *Dessalement Eau de Mer*


ICED 11 København

ICED11 Reviewers' Favourite

IMPACTING SOCIETY THROUGH ENGINEERING DESIGN

This is in recognition that the paper:

A SYSTEMATIC APPROACH OF DESIGN THEORIES USING GENERATIVENESS AND ROBUSTNESS

authored by:

Hatchuel, Armand (1); Le Masson, Pascal (1); Reich, Yoram (2); Weil, Benoit (1)

1: Mines ParisTech, France; 2: Tel Aviv University, Israel

was rated in the top 5% papers based on reviewers' scores.

We would like to take this opportunity to congratulate the authors and wish the further success with their future research.

Tim McAloone
Conference Chair

Steve Culley
Programme Chair

Les défis de l'innovation : introduction à la conception innovante

1 - Les défis contemporains de l'innovation

2 - Raisonnement créatif et conception innovante

3 - La théorie C-K : fondements et propriétés

4 - Implications de la théorie CK pour l'organisation de la conception innovante

Why new theories? Contemporary challenges of innovation

- Changing the identity of objects (conceptual breakthrough)
- Rule breaking / creation of new competences (tech & sciences)
- Rejuvenation / creation of industries
- Collaborative design: alliances, platforms, communities and consortia for innovation


The house as a powerstation?


Hybrid car


Vélib'


Metronizar o onibus

Cloud computing, internet of things…

Lab-on-a-chip

Smart Grids

Home networking

Smart cities

Biomass

intel Leap ahead

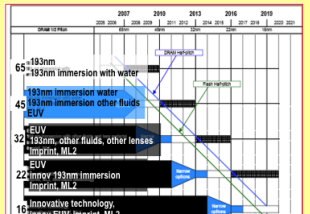
Intel Architecture Lab (Gawer et al)

ITRS (International Technology Roadmap for Semiconductor ind.)

EVERYTHING USB

intel VIIV

ITRS



Critical issues for industry (re)creation

- **(Innovation) bubbles** – hype and disappointment
- **Limited success of incubators and start-ups** (slow growth, low innovation rate)
- **Unsuccessful, costly innovations** (food, cosmetics,…)

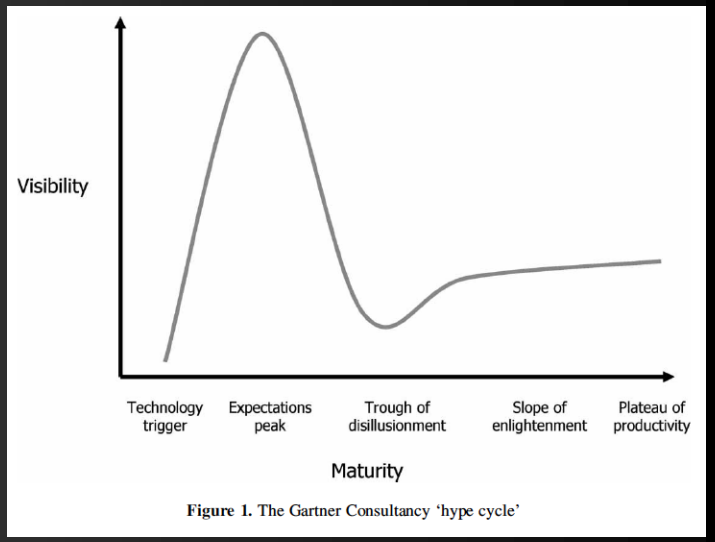
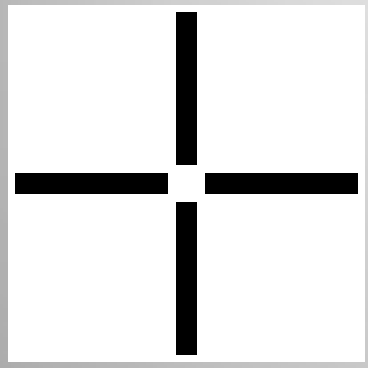


Figure 1. The Gartner Consultancy 'hype cycle'

- **Orphan innovations (Agogué 2012)**: autonomy of elderly people, 2-wheelers safety, real estate management, malnutrition,…
- **Forever technologies of the future**: fuel cell, domotic, biofuel,…

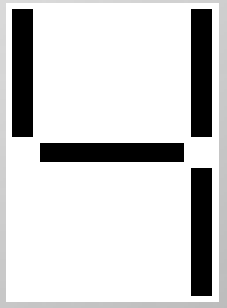
Issues: be prepared, monitor, collectively
Question: do we have the relevant methods and organizations to address these issues?

Qu’est-ce qu’un raisonnement créatif ? Une conception innovante ?



Comment obtenir un carré en ne bougeant qu'une seule allumette ?

Il y a plusieurs types de « carrés » !



- **Leçons de la psychologie et sciences cognitives**

Lutte contre « fixation effect » : analogies, métaphores => inconnu, idées « folles» et indécidables mais permet la redéfinition des objets !!

Qu'est-ce qu'un raisonnement créatif ? Une conception innovante ?

- **Leçons de la psychologie et sciences cognitives**

  Lutte contre « fixation effect » : analogies, métaphores => inconnu, idées « folles» et indécidables mais permet la redéfinition des objets !!

- **Leçons des sciences :**

  Expansion des connaissances : validation mais aussi ...source de nouveaux indécidables

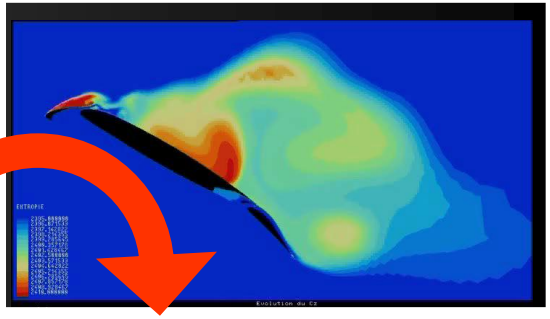
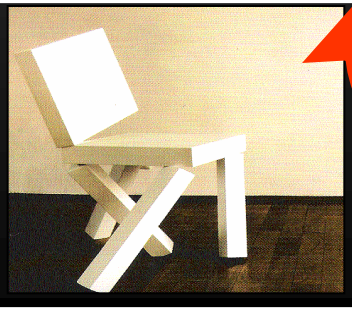
Créativité vs Connaissance ?

Théorie C-K = Combinaison des deux logiques !

Creativity and knowledge: The paradox of innovative design

Innovation = K production
technical, customer, social engineering...

Innovation = C production
creativity, « Out of the box thinking »

	C concepts	K knowledge
Engineering		
Creativity		

Provoquer une «expansion» = briser une règle ou un état du connu

Expansion mode 1 : **Interprétatif**
Donner un sens nouveau à une notion

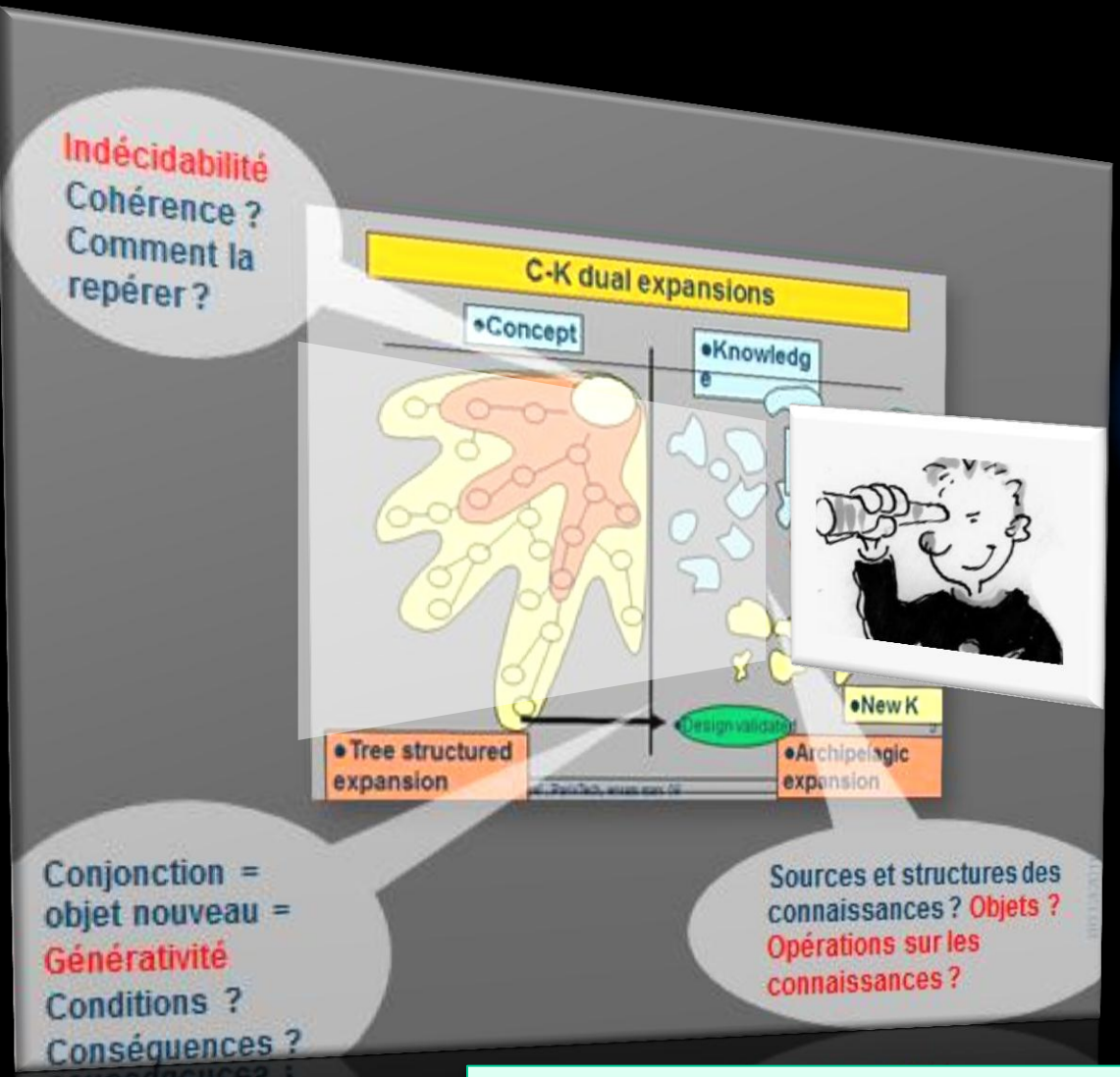
Fleuves impassibles

Expansion mode 2 : **Conception innovante**
Générer un objet nouveau

Un dessalement de l'eau mer low cost

- **C : Définition progressive d'un objet inconnu**

- **K : Construction des connaissances permettant cette définition**



Observe Space C? Imaginaries, indecidables, chimeras

Indécidabilité
Cohérence ?
Comment la repérer ?

C-K dual expansions

•Concept

•Knowledg e

•Old K

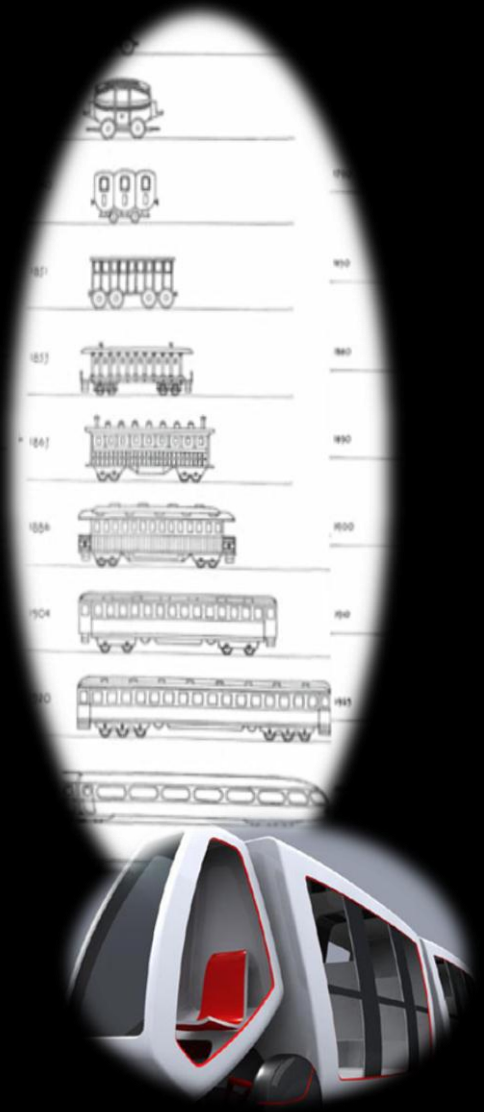
•New K

•Tree structured expansion

•Archipelagic expansion

onjonction =
bjet nouveau =
énérativité
onditions ?
onséquences ?

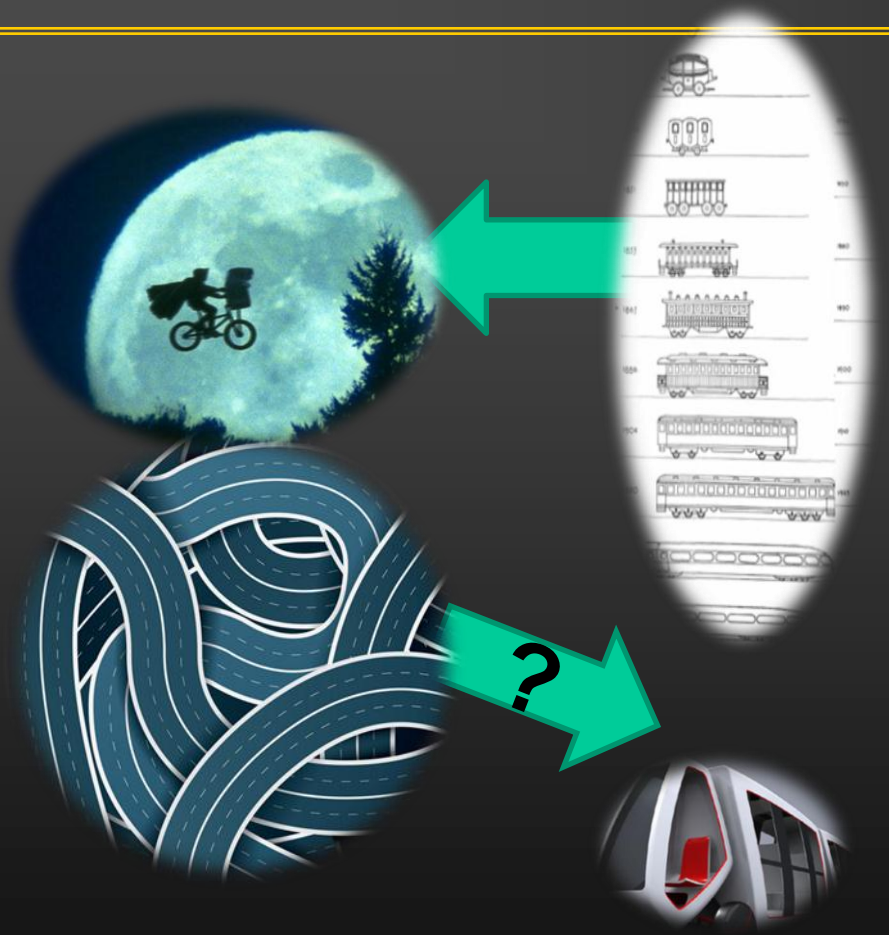
Sources et structures des connaissances ? Objets ? Opérations sur les connaissances ?

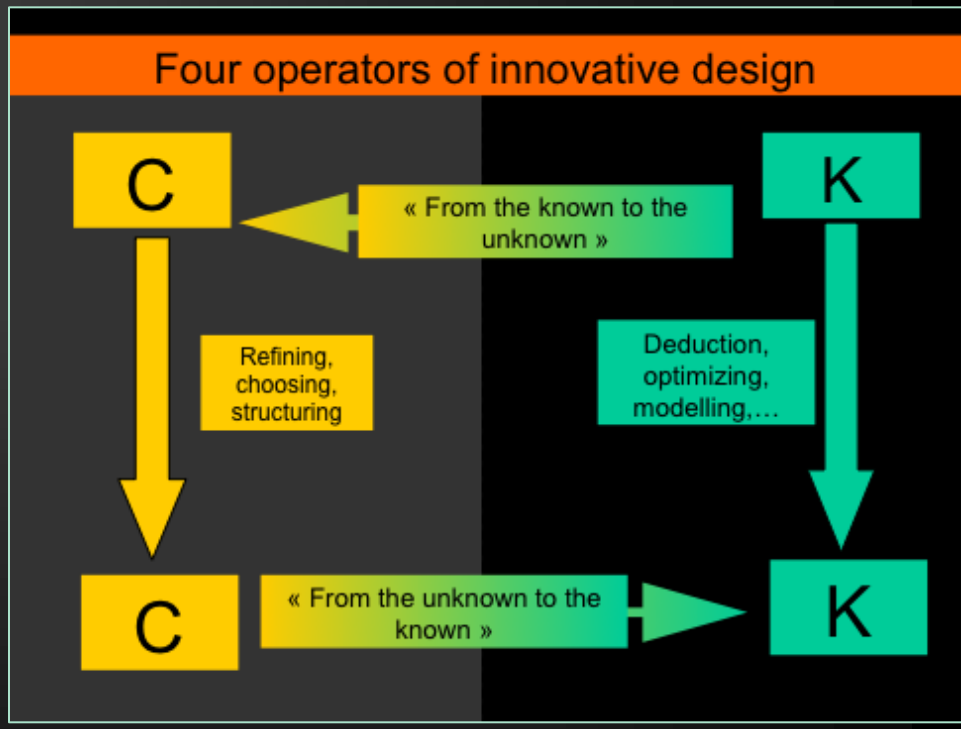


Observe space K? We tend to create fixed objects and heredities and we are not prepared to breakthroughs

Order.. and anomalies (new differences,… and future new orders?)

Innovative Design: interactive C and K expansions





Fondements mathématiques : une algèbre de l'inconnu

- **Extensions algébriques : nombres complexes : $i^2 = -1$**
- **Forcing : extensions génériques sur les ensembles (Cohen 1963, Médaille Fields)**

Théorie C-K = Forcing sur structures de connaissances (Hatchuel et Weil 2007)

La théorie C-K : une double expansion

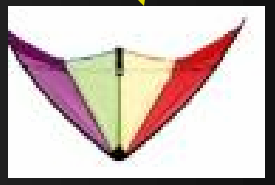
Hatchuel et Weil (2003)

Concepts (C)

Undecidable proposition

A flying boat that is not a seaplane

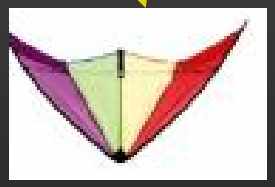
Expansive partition



Design means expanding concepts with new attributes until satisfactory definitions emerge.

The C-K diagram : a model of innovative design

C0 : A flying boat that is not a seaplane



Knowledge (K)

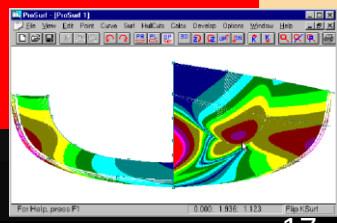
• « true » propositions about things (or people) that are used to:

• to formulate and expand concepts :

• to test concepts

• K-dependancy or K-illusions like « optical » illusions

Testing concepts generates new knowledge



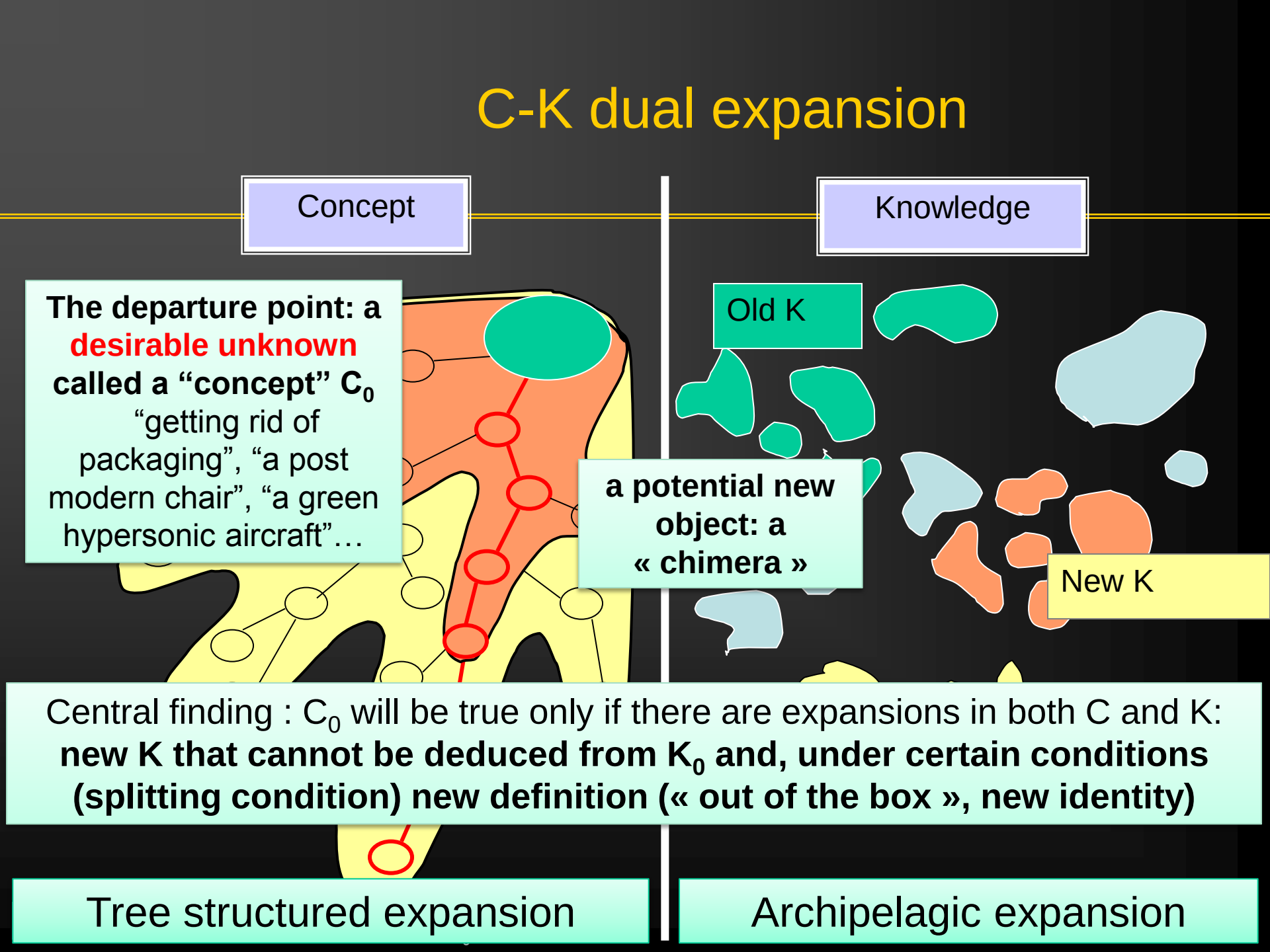
C-K dual expansion

Concept

Knowledge

The departure point: a desirable unknown called a "concept" C_0

"getting rid of packaging", "a post modern chair", "a green hypersonic aircraft"…



Central finding : C_0 will be true only if there are expansions in both C and K:
new K that cannot be deduced from K_0 and, under certain conditions (splitting condition) new definition (« out of the box », new identity)

Tree structured expansion

Archipelagic expansion

Modelling Innovative Design: expanding concepts

(Hatchuel and Weil, 2003)

Designing a cheaper and lighter chair…

Innovative design

A chair that is not a chair…

- Type of reasoning?
- How to model a type of reasoning that accounts for the design of such an object… and new ones?

C-K reasoning illustration

A concept is a proposition without logical status in K

in K all propositions have a logical status

Concept

Knowledge

A smaller, lighter camping chair

K on camping chair

0-leg form

1 leg

2 legs

3 legs

4 legs

N legs

The chairs we know have legs

A partition can be restrictive or expansive

An expansive partition revises the object identity

A concept is partioned by attributes from K

The « 0 leg » prototypes lead to learn on sitting equilibria on the floor

equilibria

equilibria ?

Cushion

Lotus position teaching

Hammock

Swing

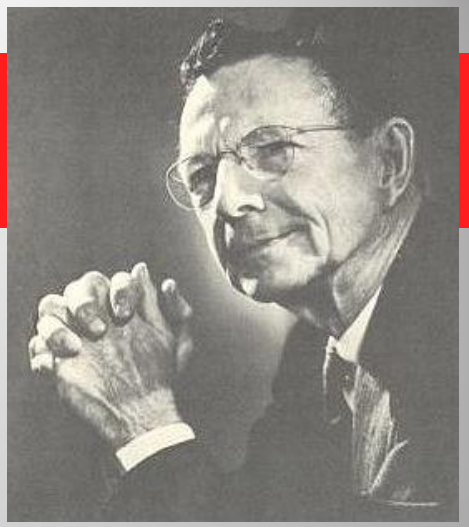
Concept leads

duce

Conjunction

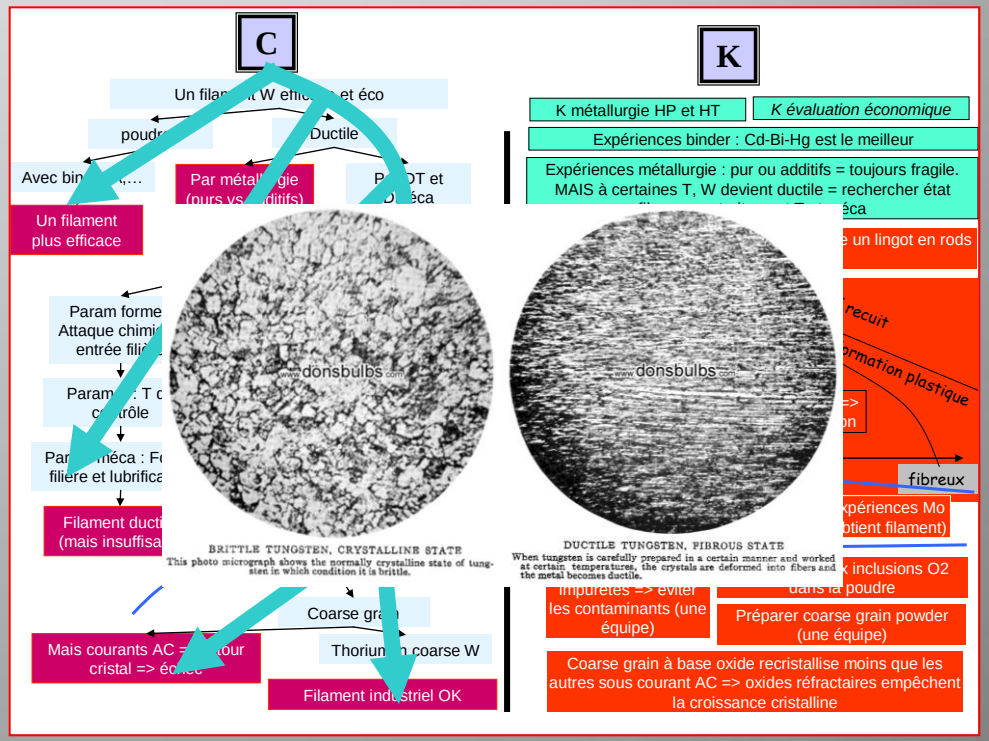
new K

The invention of ductile tungsten for filament lamp by William Coolidge at GE (1912)



Imagine then a man wishing to open a door locked with a combination lock and bolted on the inside. Assume that he does not know a single number of the combination and has not a chance to open the door until he finds the whole combination, and not a chance to do so even then unless the bolt on the inside is open. Also bear in mind that he cannot tell whether a single number of the combination is right until he knows the combination complete. When we started to make ductile tungsten, our situation was like that.

William Coolidge



C-K to support collective innovative design

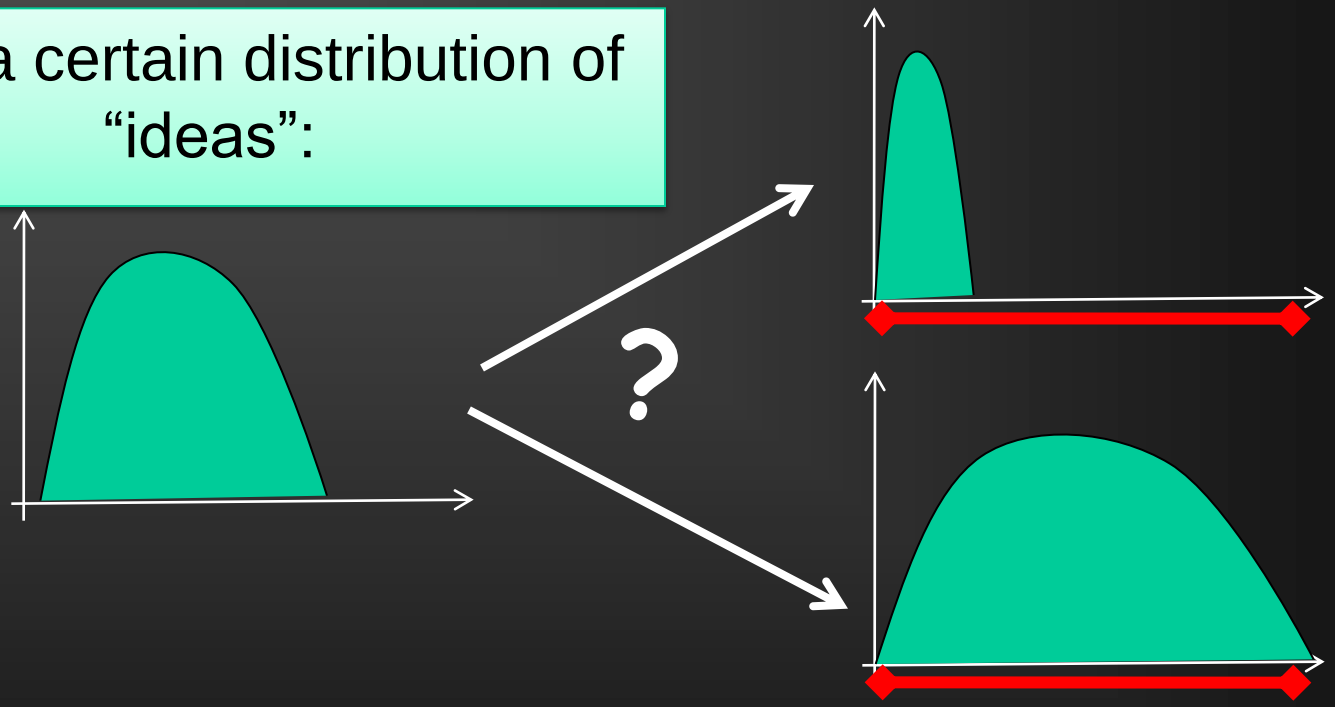
Diagnosis of individual fixations – « de-fixation » by provocative examples

Monitor and tune the innovative design strategies

Collaborative Design processes : KCP method

Experimental study of fixation and diagnosis (Agogué Cassotti 2012)

Given a certain distribution of "ideas":



Is there a bias ? (which norm?)

Is it due to a certain type of reasoning?

Theory-driven experiments

Modeling fixation effect and testing fixation and stimulation effects on creativity

Marine Agogué & Mathieu Cassotti

SORBONNE PARIS CITÉ
RECHERCHE ENSEIGNEMENT SUPÉRIEUR
PARIS DESCARTES
Théorie et Méthodes de la Conception Innovante
chaire de recherche et d'enseignement
Centre de Gestion Scientifique
Centre de Gestion Scientifique Mines ParisTech

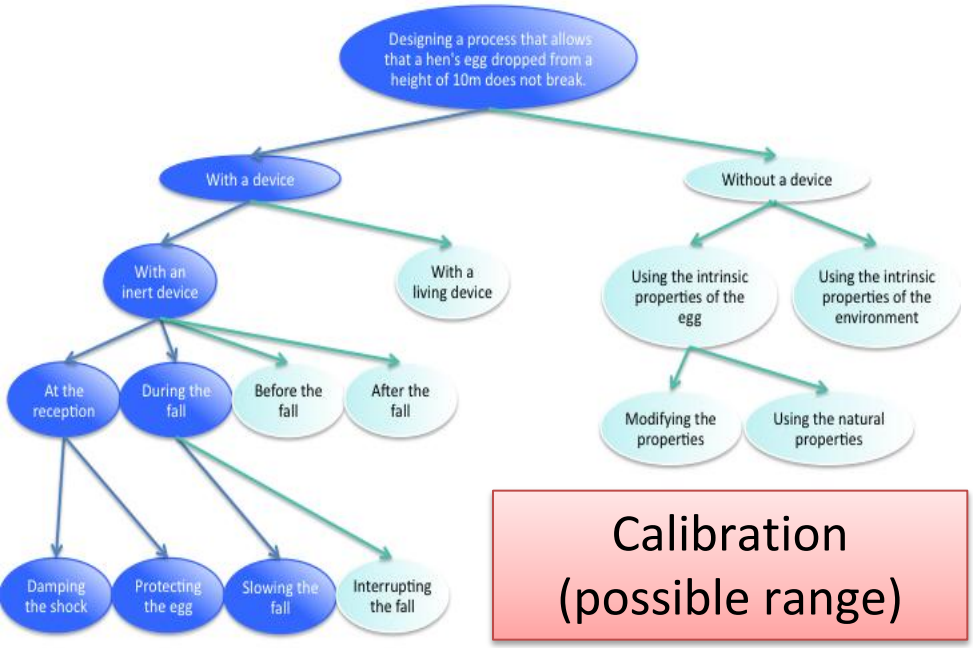
The design task

"You are a designer and you are asked to propose as many original solutions as possible to the following problem:

Ensure that a hen's egg dropped from a height of 10m does not break."

Determining fixation path using C-K reasoning

C space

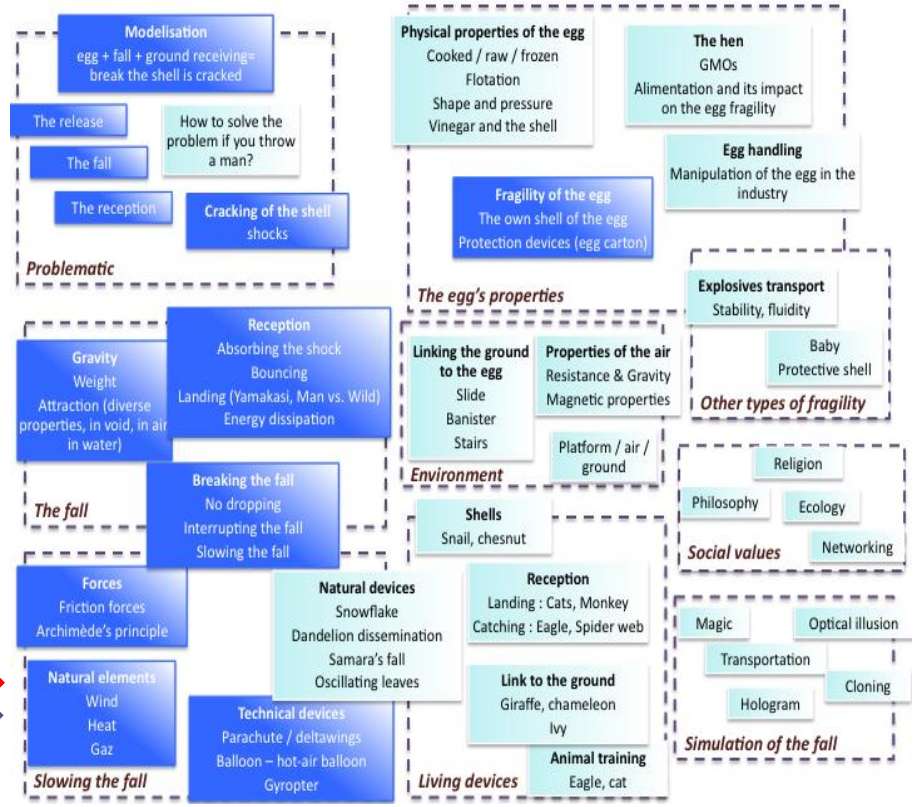


Calibration (possible range)

Restrictive reasoning

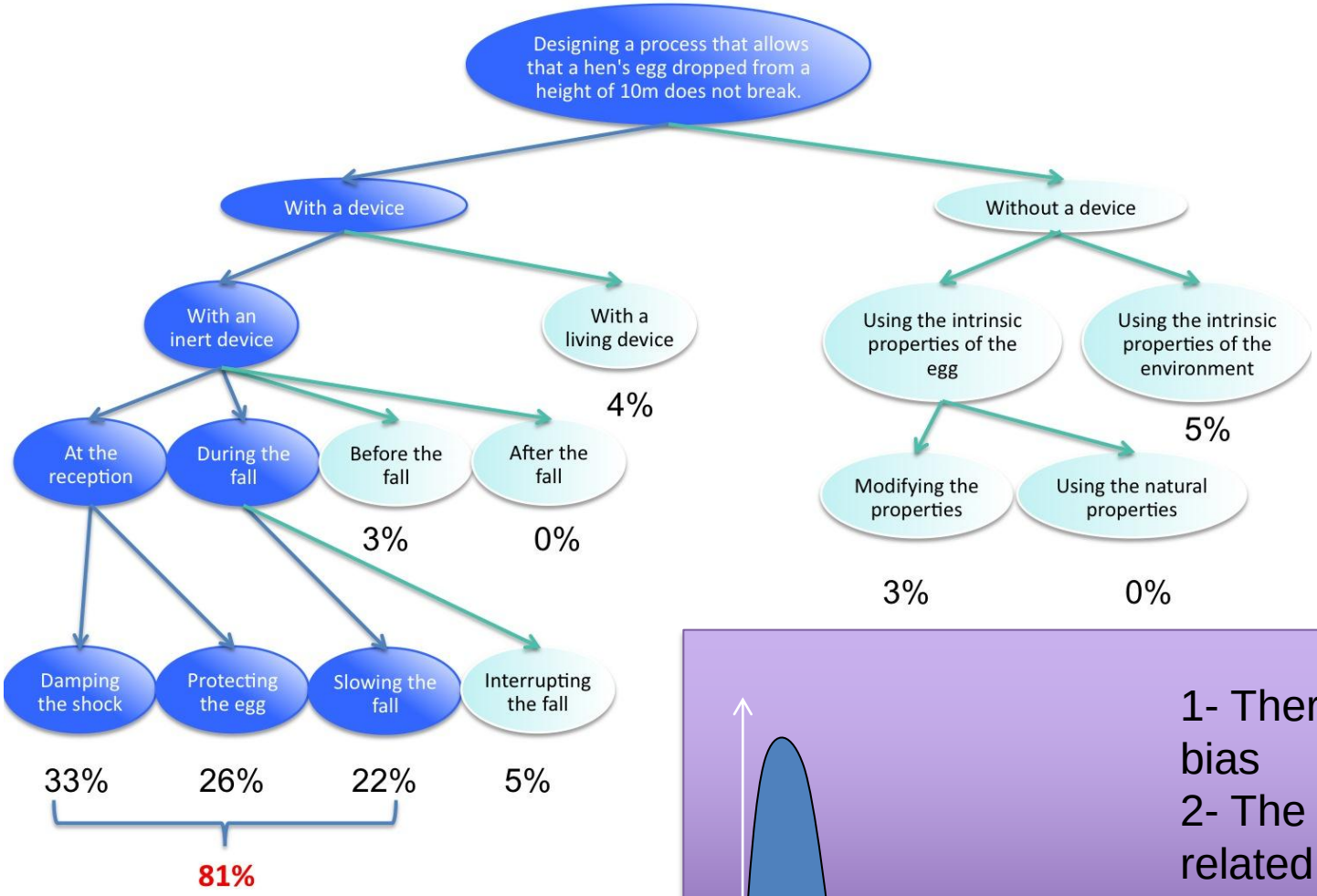
Expansive reasoning

K space

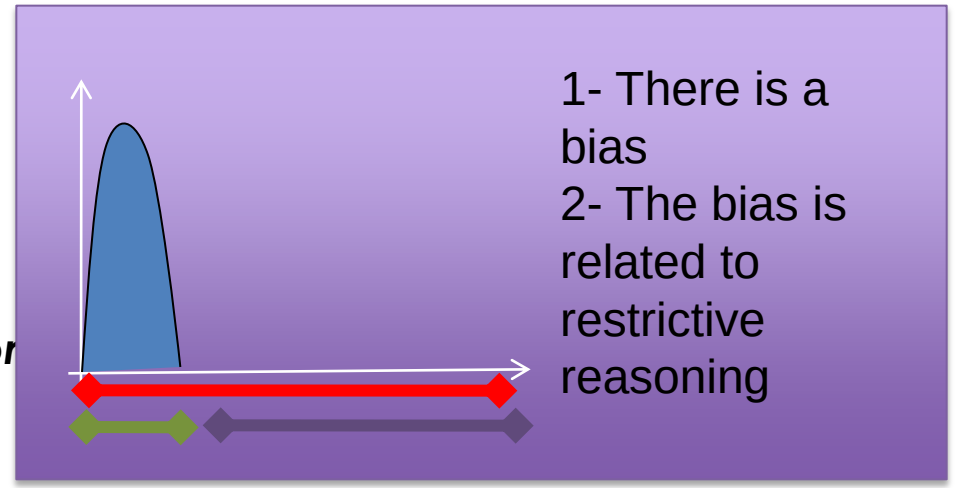


pace and in the K-space

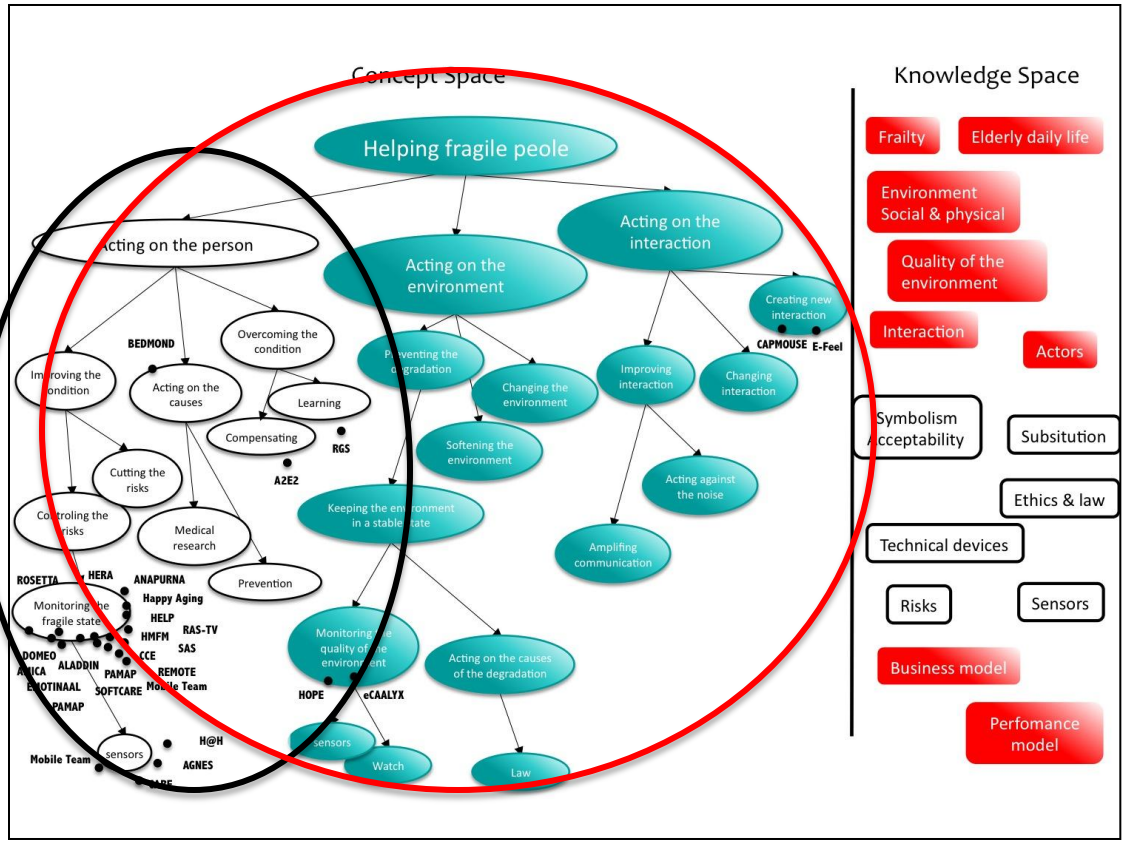
(1) Natural distribution of solutions of a design task



Result 1 : the paths identified as fixation
the fixation effect for adults



C-K referential on ICT for autonomy in Rhône-Alpes region

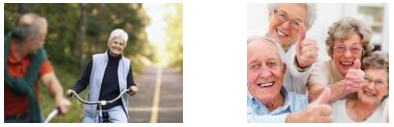


A C-K referential helps to diagnose the gap between reality and expectations, and provides a way to objectify the distance between attainable exploitation and possible exploration

ATTAINABLE EXPLOITATIONS

Known competences and skills
Established firms and interactions with partners
Stable identity of the objects

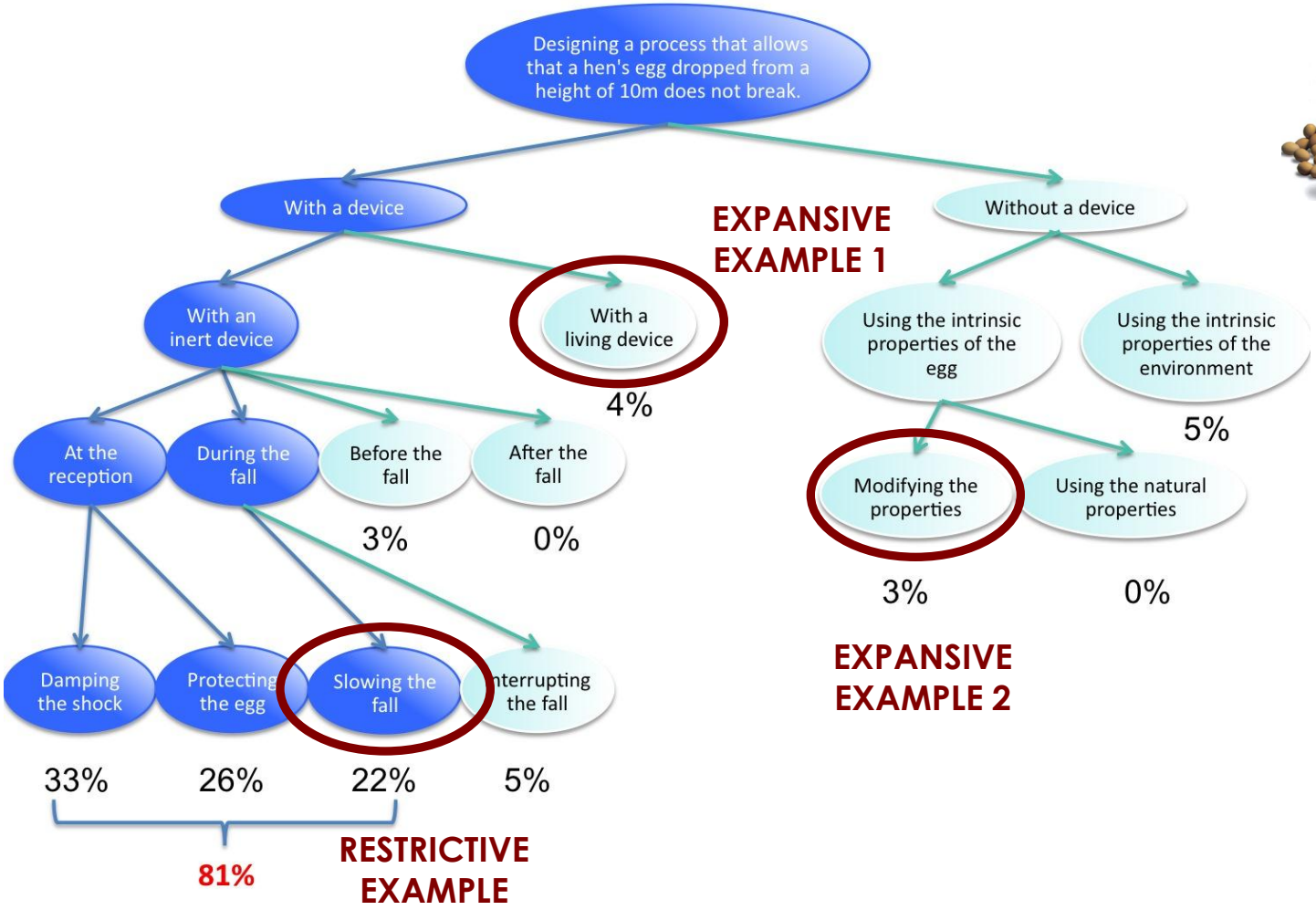
EXPECTED EXPLORATIONS



Re-discussing the identity of the objects
Exploring new ideas
Involving new actors

Data : workshop analysis, interviews of firms, questionnaire (22 responses)

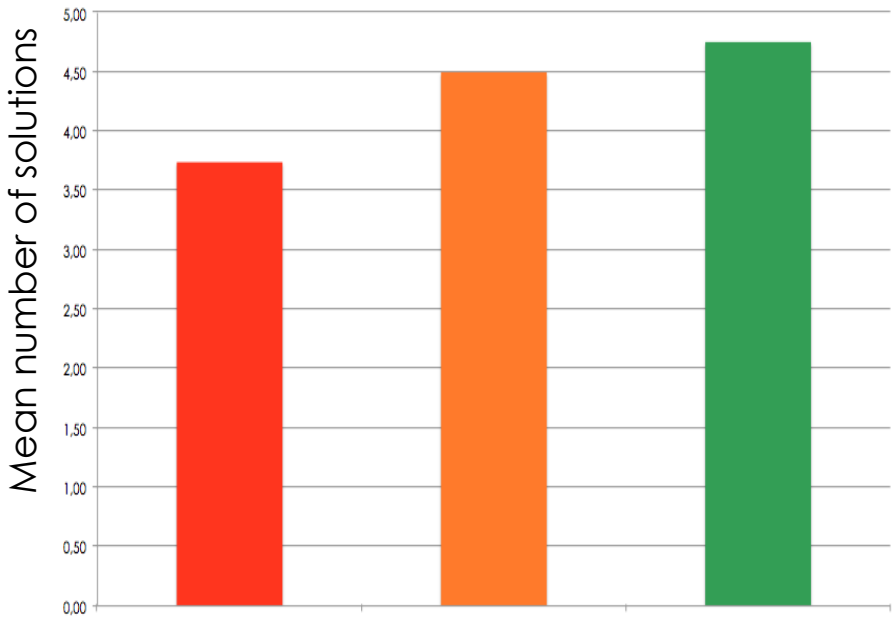
(2) The impact of examples on creativity

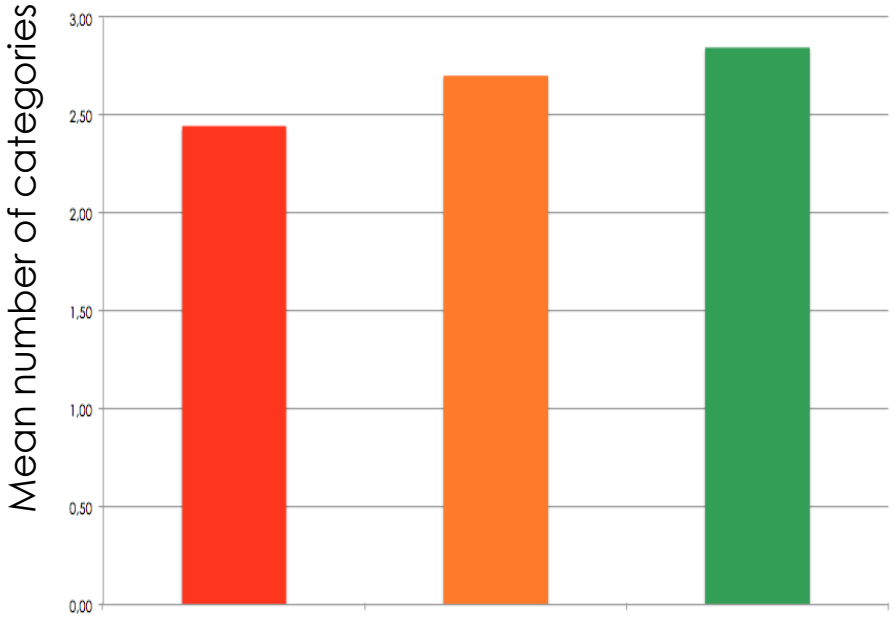


Do examples belonging to the fixation path and examples belonging to expansive paths have an opposite effect on participants' ability to generate creative ideas ?

(2) The impact of examples on creativity

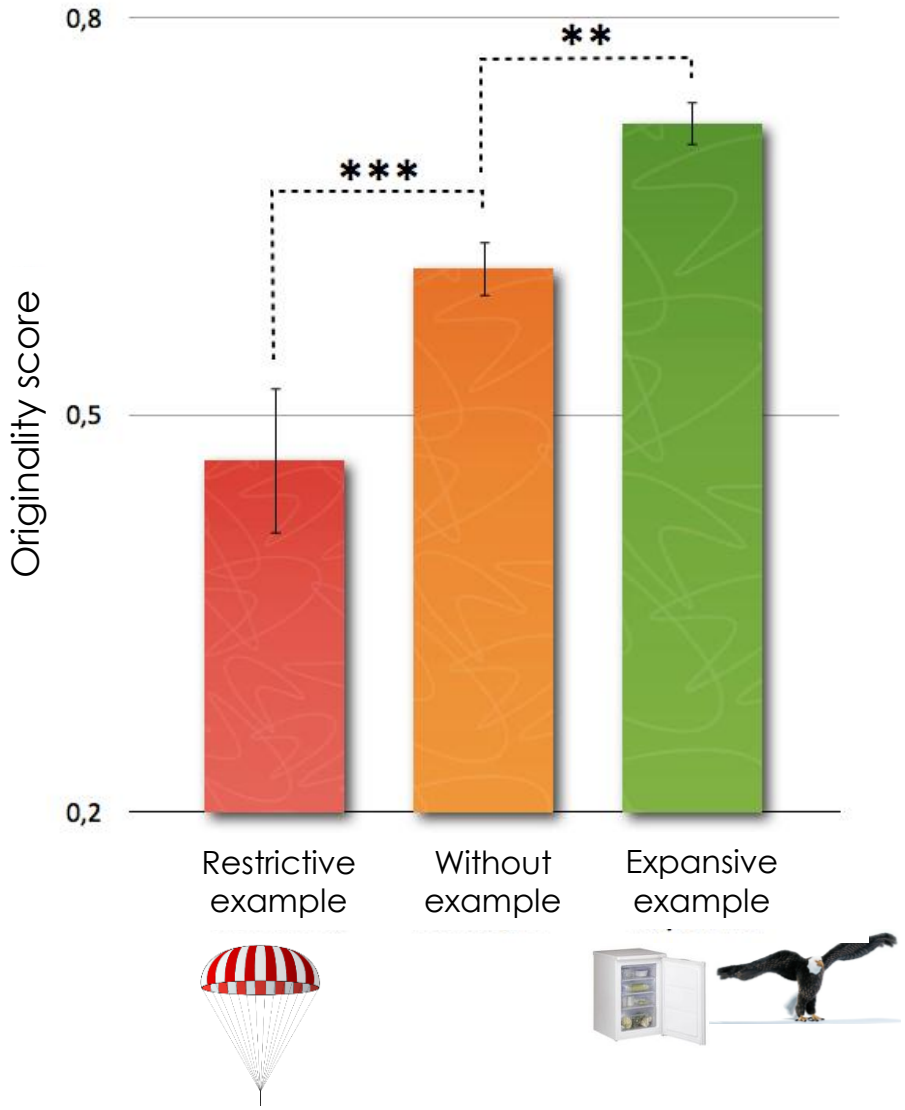
NUMBER OF SOLUTIONS AND OF CATEGORIES





(2) The impact of examples on creativity

ORIGINALITY SCORE



(4) The impact of training on creativity

STUDY 5 : The impact of a a design training

Population: 14 PhD students from Paris Universities and Grandes Ecoles

Pre-test

Control group

1 week training (35hours) on innovative design and C-K theory.

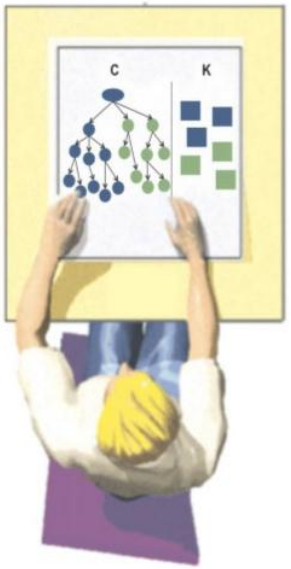
- identifying fixation effects
- using expansions to overcome them

Post-test

Population: 20 PhD students from Paris Universities and Grandes Ecoles

Pre-test

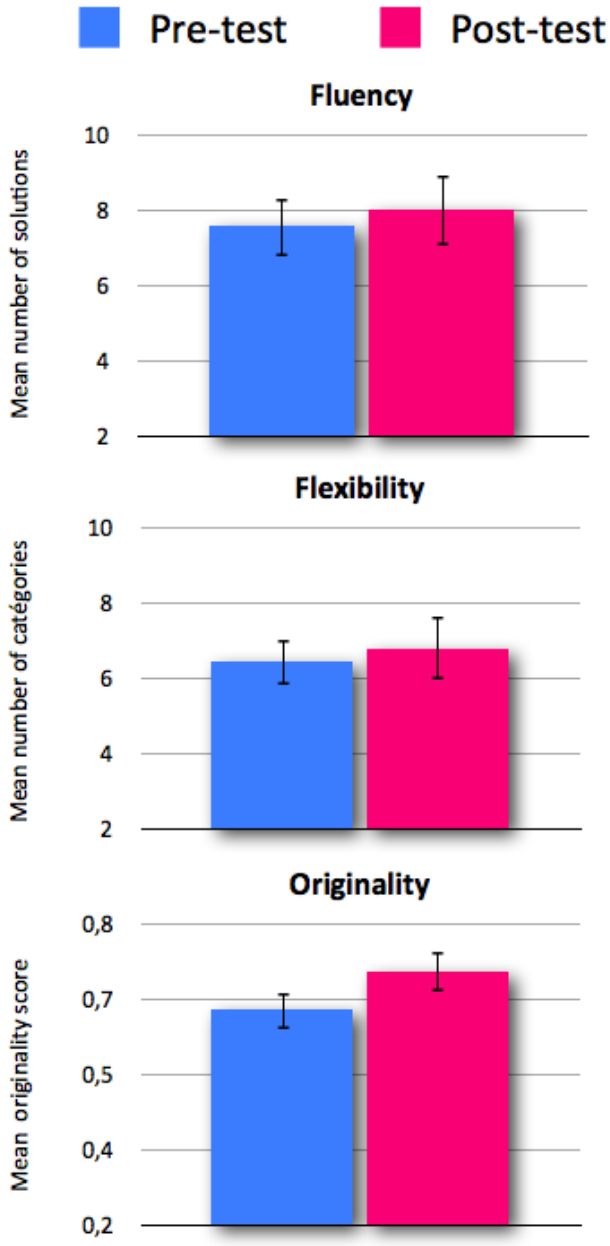
CK training



Post-test

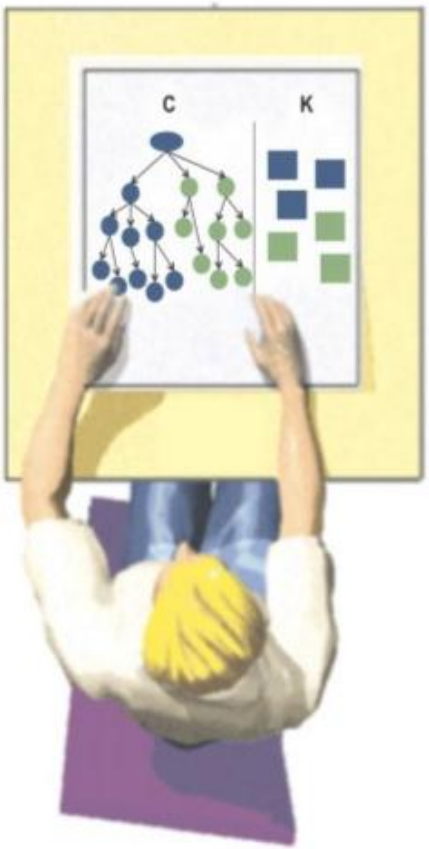
(4) The impact of training on creativity

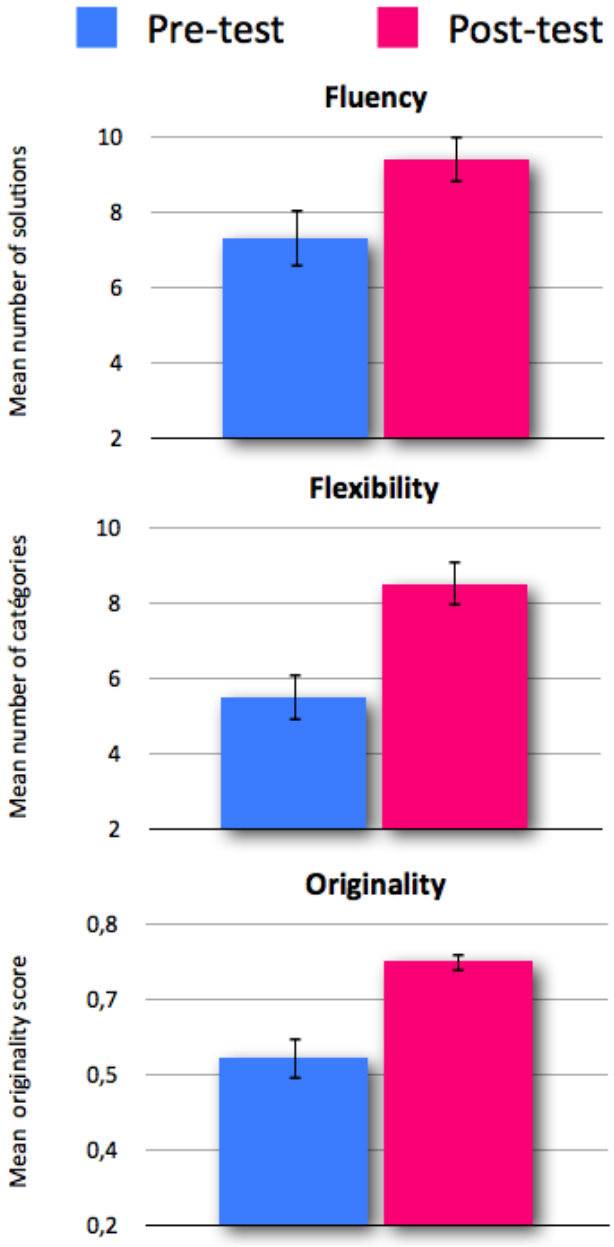
Control group



(4) The impact of training on creativity

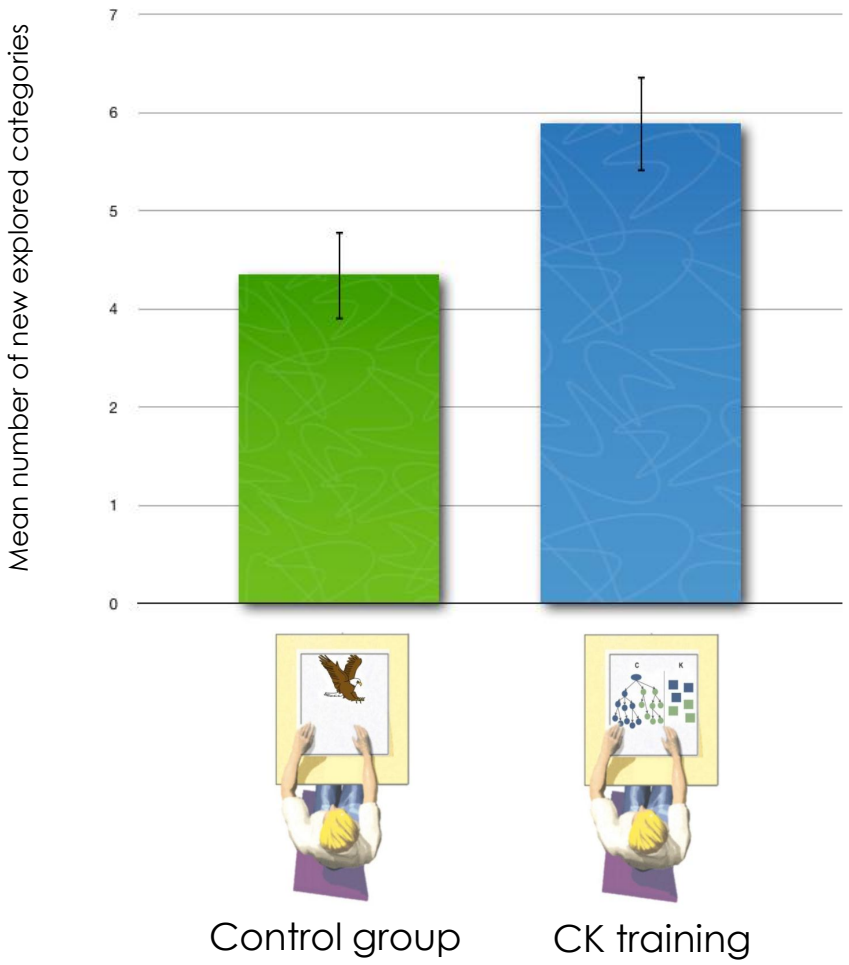
CK training





(4) The impact of training on creativity

Conclusion of Study 5



Result 5 : the solutions proposed by the group exposed to expansive examples were less original than those given by the group trained with a design methodology.

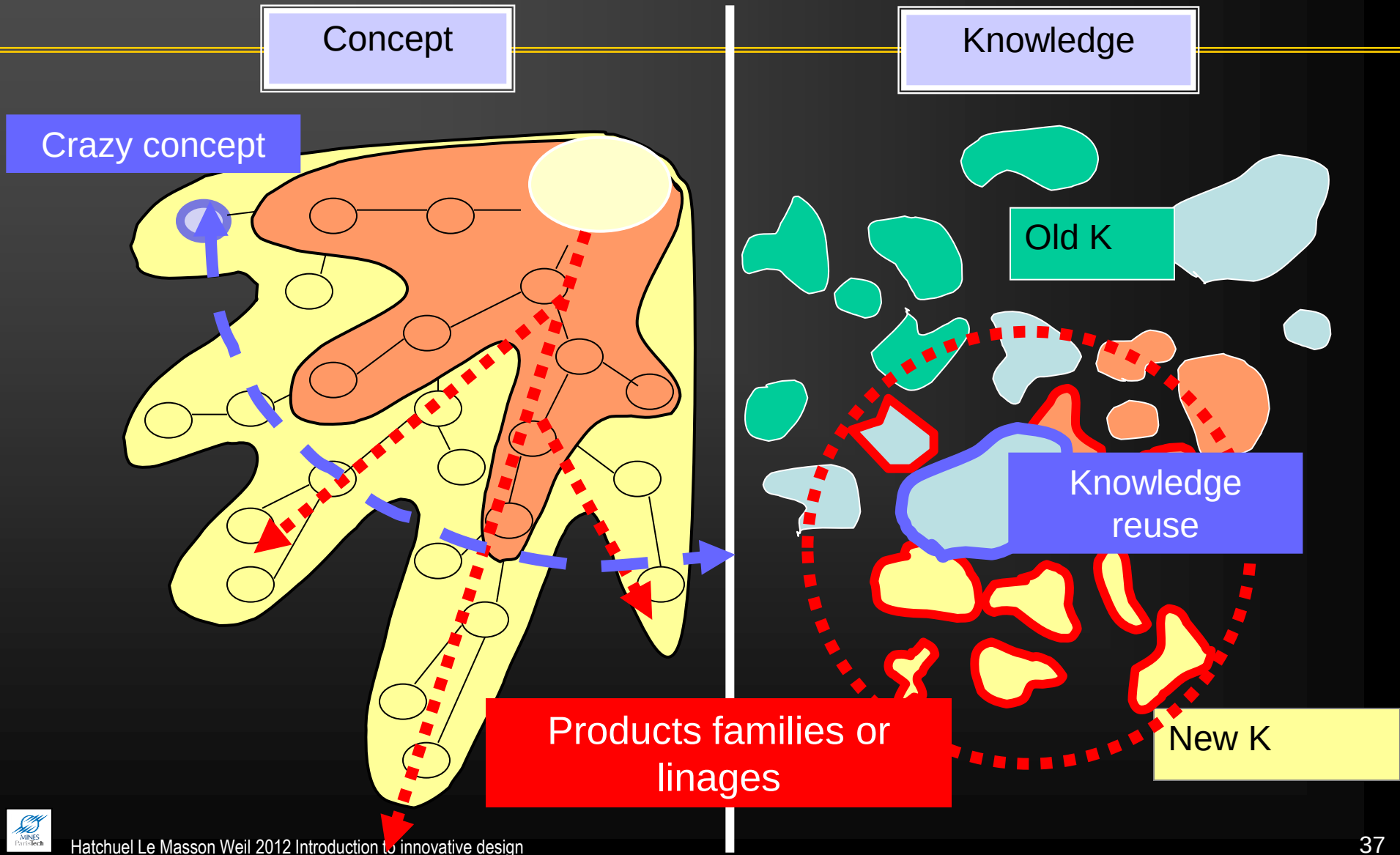
C-K to support collective innovative design

Diagnosis of individual fixations – « de-fixation » by provocative examples

Monitor and tune the innovative design strategies

Collaborative Design processes : KCP method

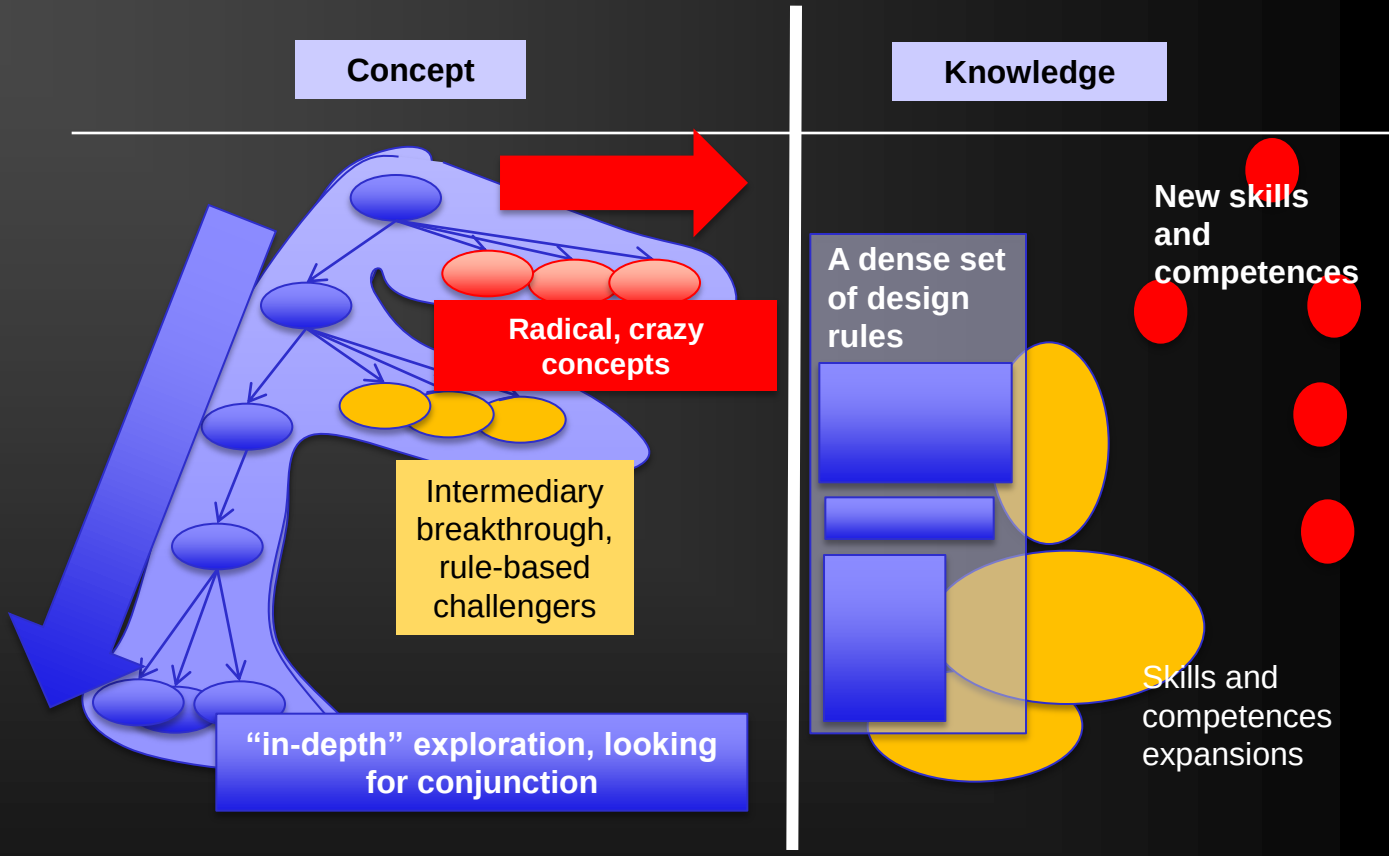
C-K theory explains crazy concepts and knowledge reuse



C-K implications: tuning the level of disruption!

On a given innovation field :

- In-depth exploration (complex Concepts, dense Knowledge)
- In-breadth exploration (original Concepts, large archipelago of knowledge)



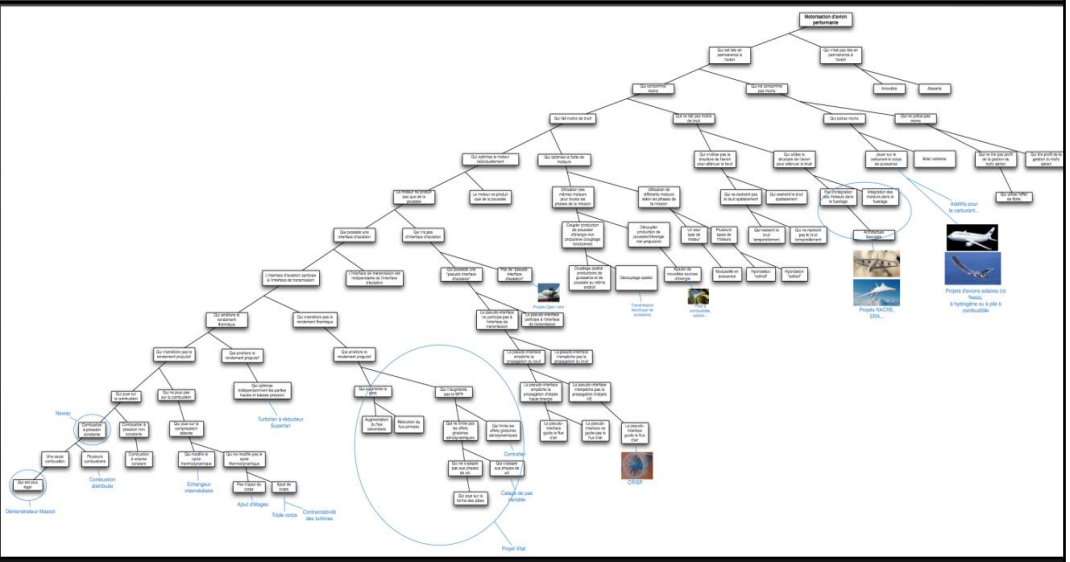
Beyond the system boarders: rediscussing the heredity of objects

Brogard Joanny 2010

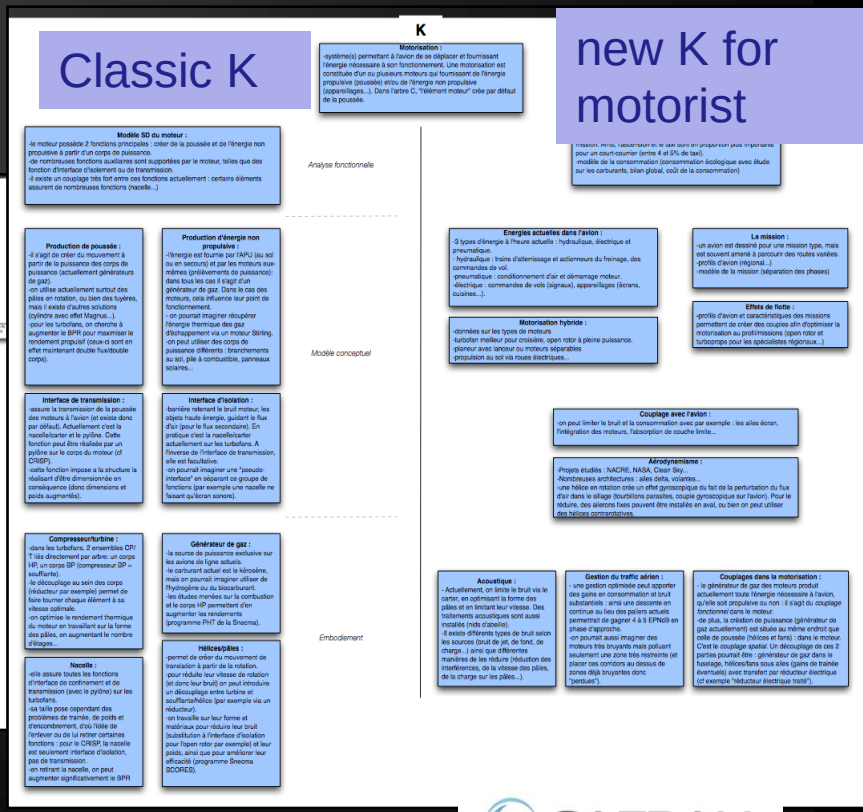
From a « solution »…

… to a field extension

Concept



Knowledge



Position the “open rotor” in the innovation field of “engines for green flights”

Standard Design

Concepts of new aircrafts and life on board

Classic design strategies for engine improvements

Innovative design

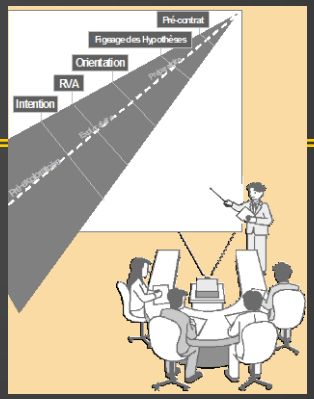
SAFRAN
Snecma

Brogard Joanny 2010

An interpretative and guiding method

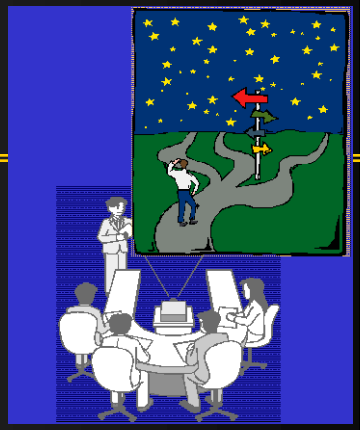
Rule-based design

Expansions in C and K are limited

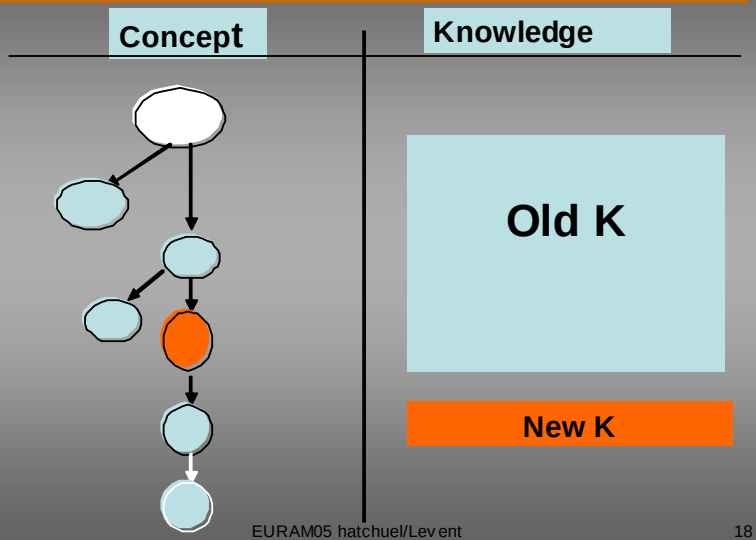


Innovative design

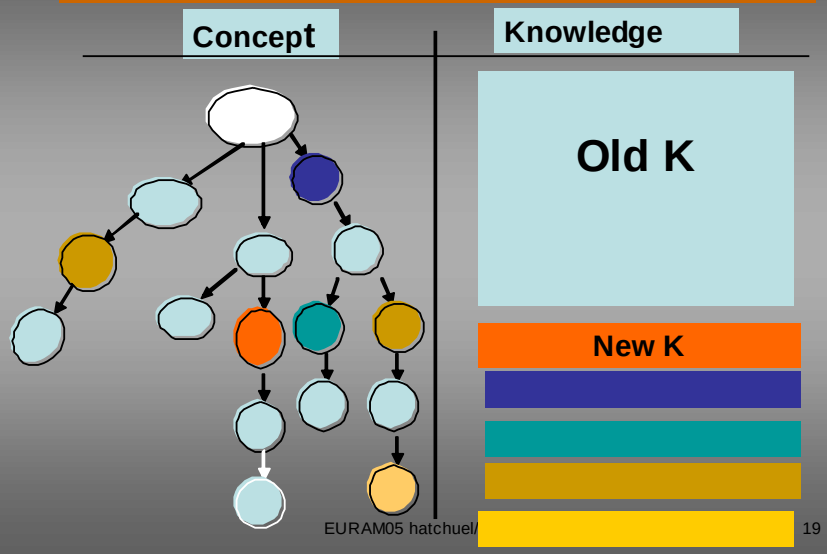
Expansions are important in C and K



C-K expansions : type 1



C-K expansions : type 2



Evaluation criteria: Quality, Cost, Delay

Evaluation criteria: Variety, Value, Originality, Robustness

C-K to support collective innovative design

Diagnosis of individual fixations – « de-fixation » by provocative examples

Monitor and tune the innovative design strategies

Collaborative Design processes : KCP method

One method for organizing collective innovative design: KCP®

Cognitive goals

- **knowledge and concepts expansion**
- **intensive innovation**
- **New identity of the objects**

« Creative taskforce »

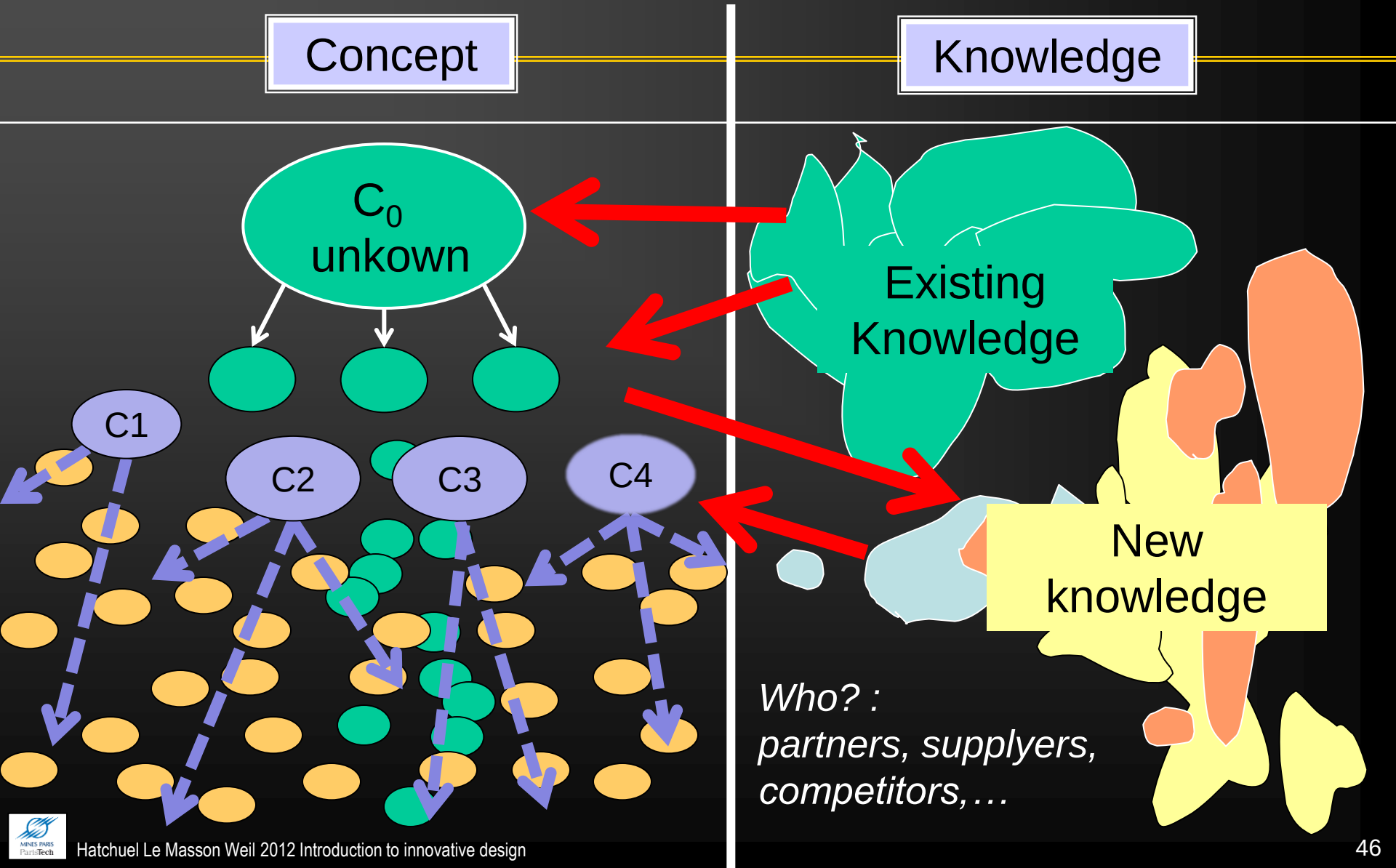
?

Participative seminar

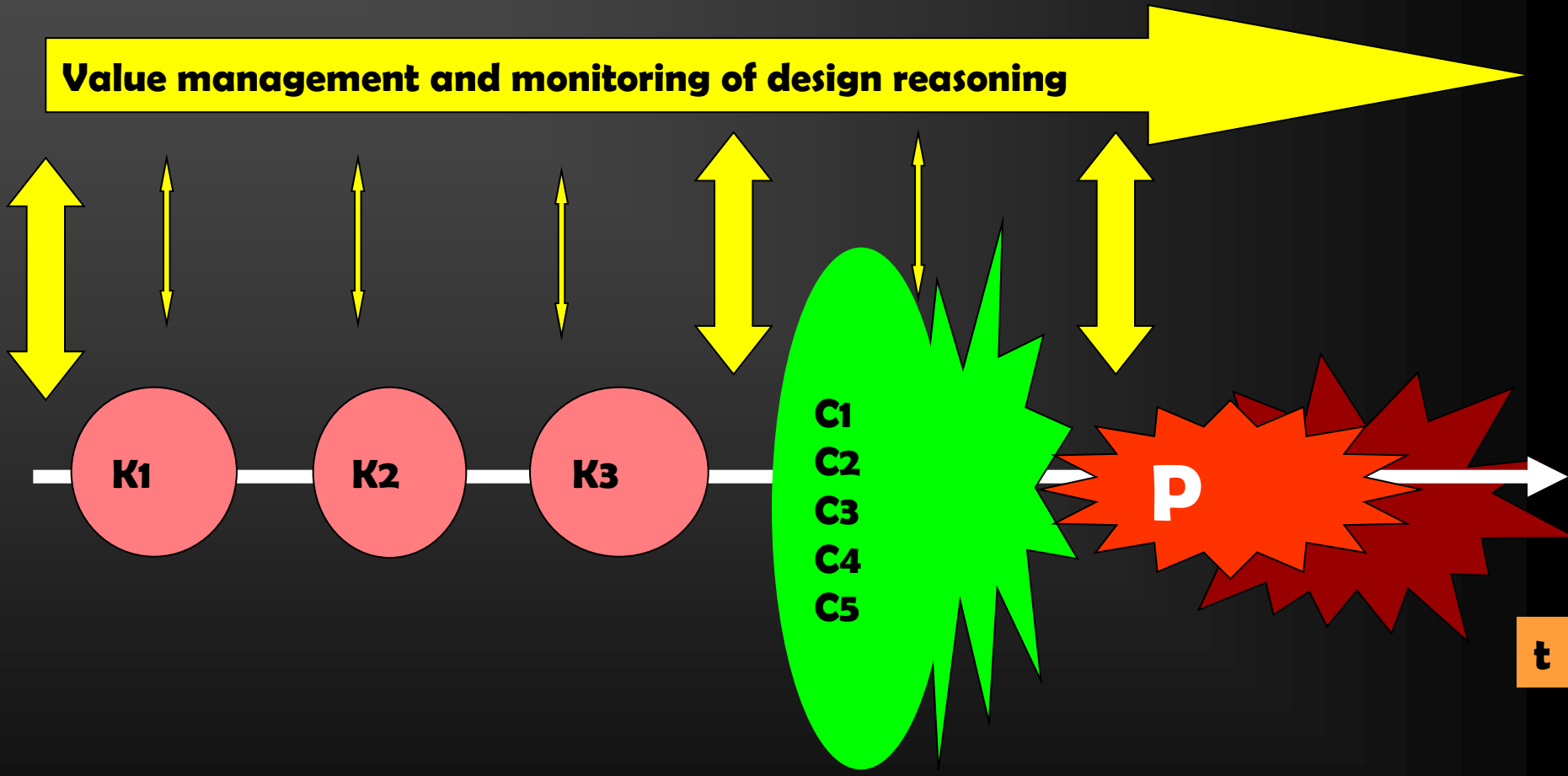
Experts and non-experts, partners, stakeholders, institutions

Collaborative goals

C-K theory and KCP workshop: approximate collectively the design expansion



KCP workshops: steps and steering

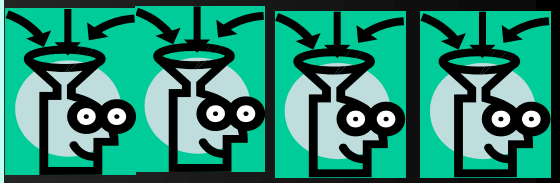


KCP principles

K : State of the « challenging art »

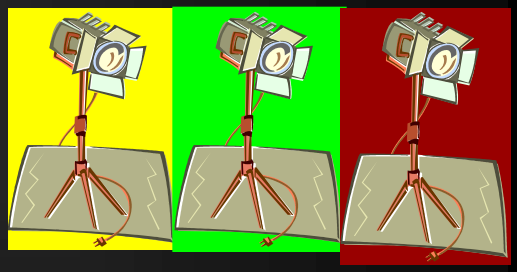
- Stop looking for solutions, avoid creativity and debates without knowledge
- Integrate and share new knowledge, from science to social…
- Provocative examples from other industries

→prepares revision of traditional concepts



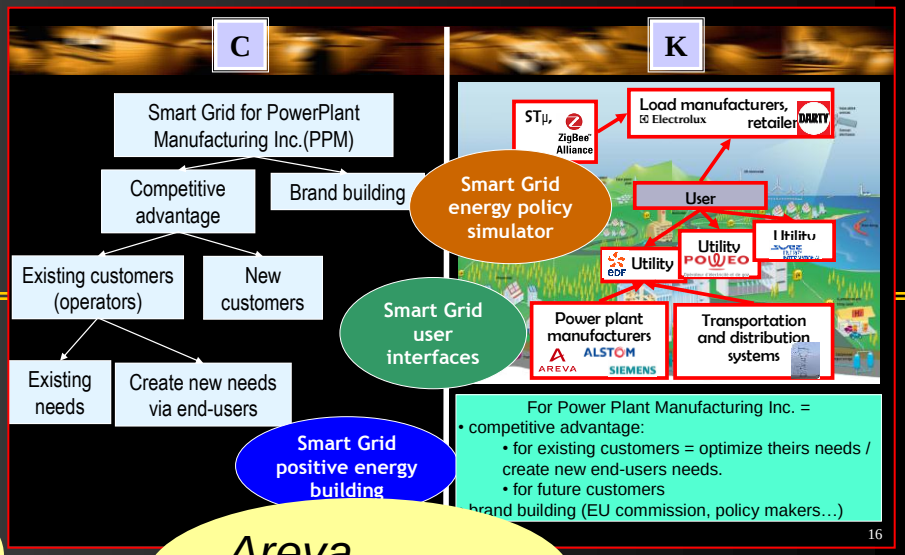
C: Maximizing expansion and rule-breaking

- Identifiy « C-projectors » (parallel expansions no competition between concepts)
- team work on each C-projector
- Sharing and reformulation across teams



P : Building an innovative design strategy (proposals, projects, prototypes…)

- Building a design strategy : new objects, new offers, new research questions, prototyping, demonstrators,…
- New networks building for an ecosystem of innovation



Thales
Cockpit of the future

Areva
Smart Grids

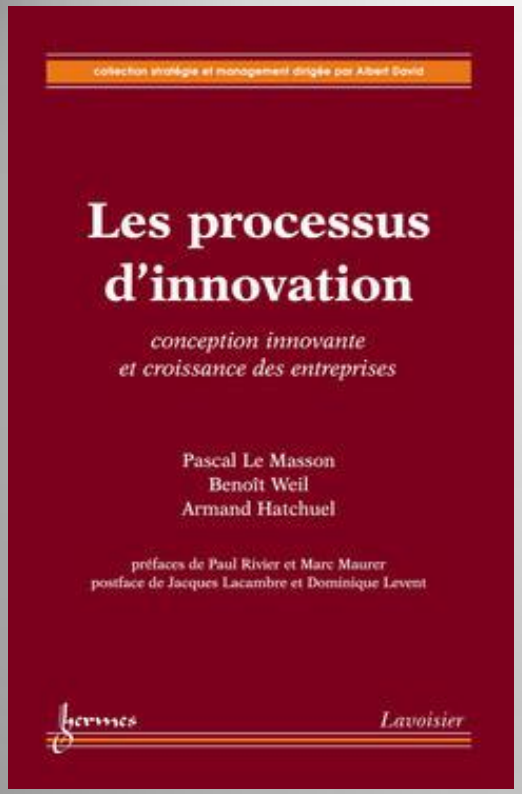
Some examples

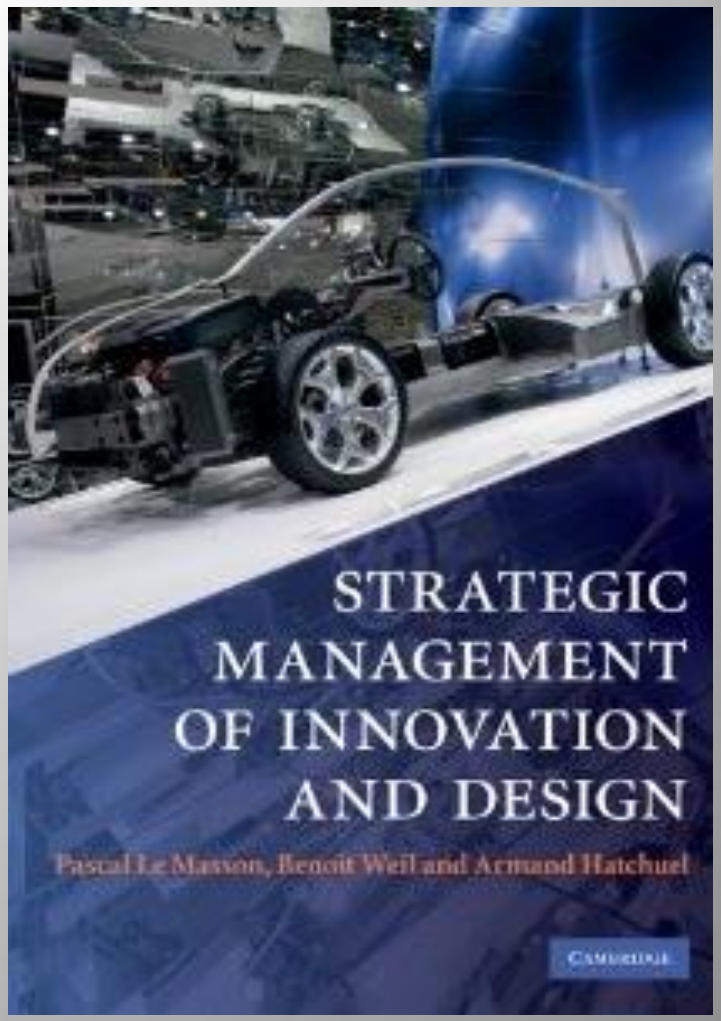
RATP
"walking"

Turbomeca, stratégies "vertes"

Vallourec
After Thread

- 2.0 city
- « Walking » constellation
- « Walking » station,….
- Meta-mode…





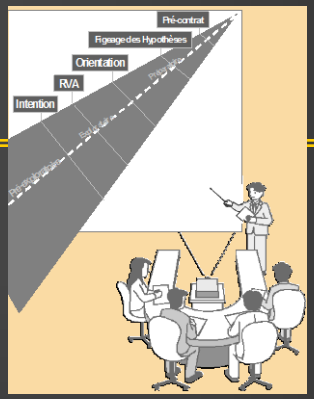
Papers available at :

http://www.cgs.ensmp.fr/design

An interpretative and guiding method

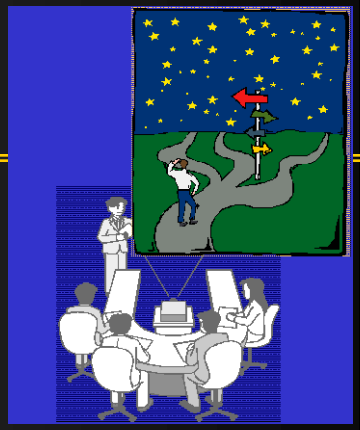
Rule-based design

Expansions in C and K are limited



Innovative design

Expansions are important in C and K



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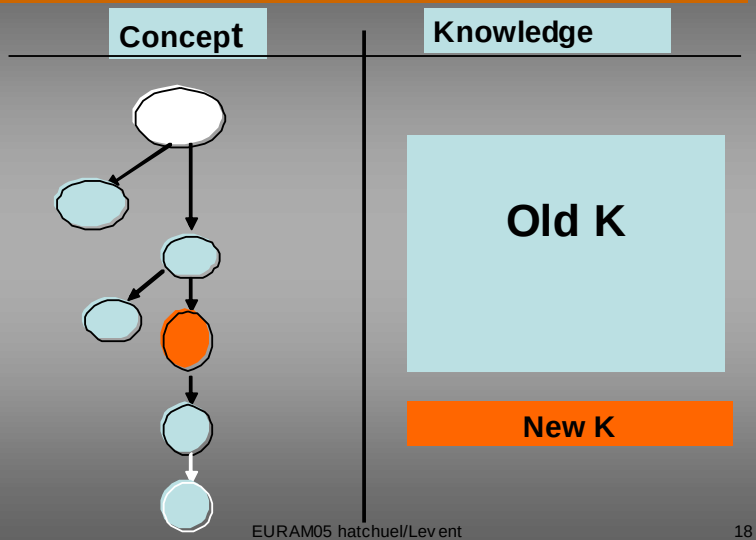
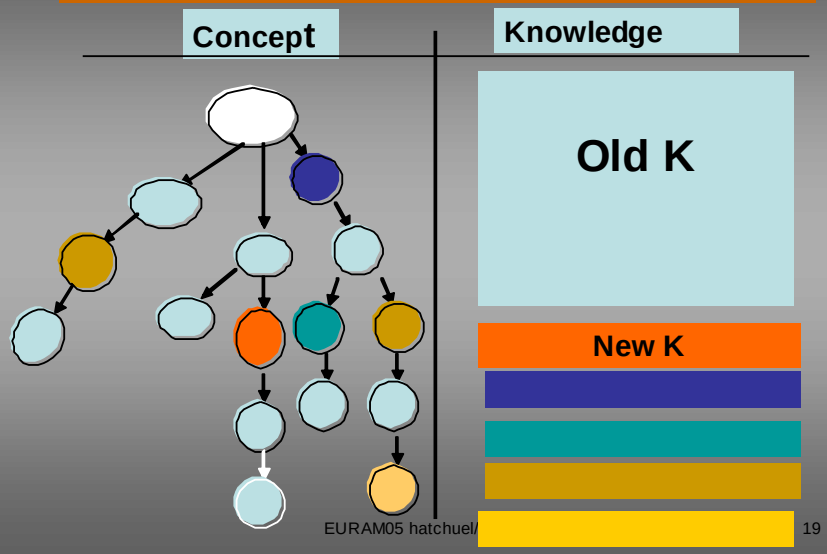


C-K expansions : type 2



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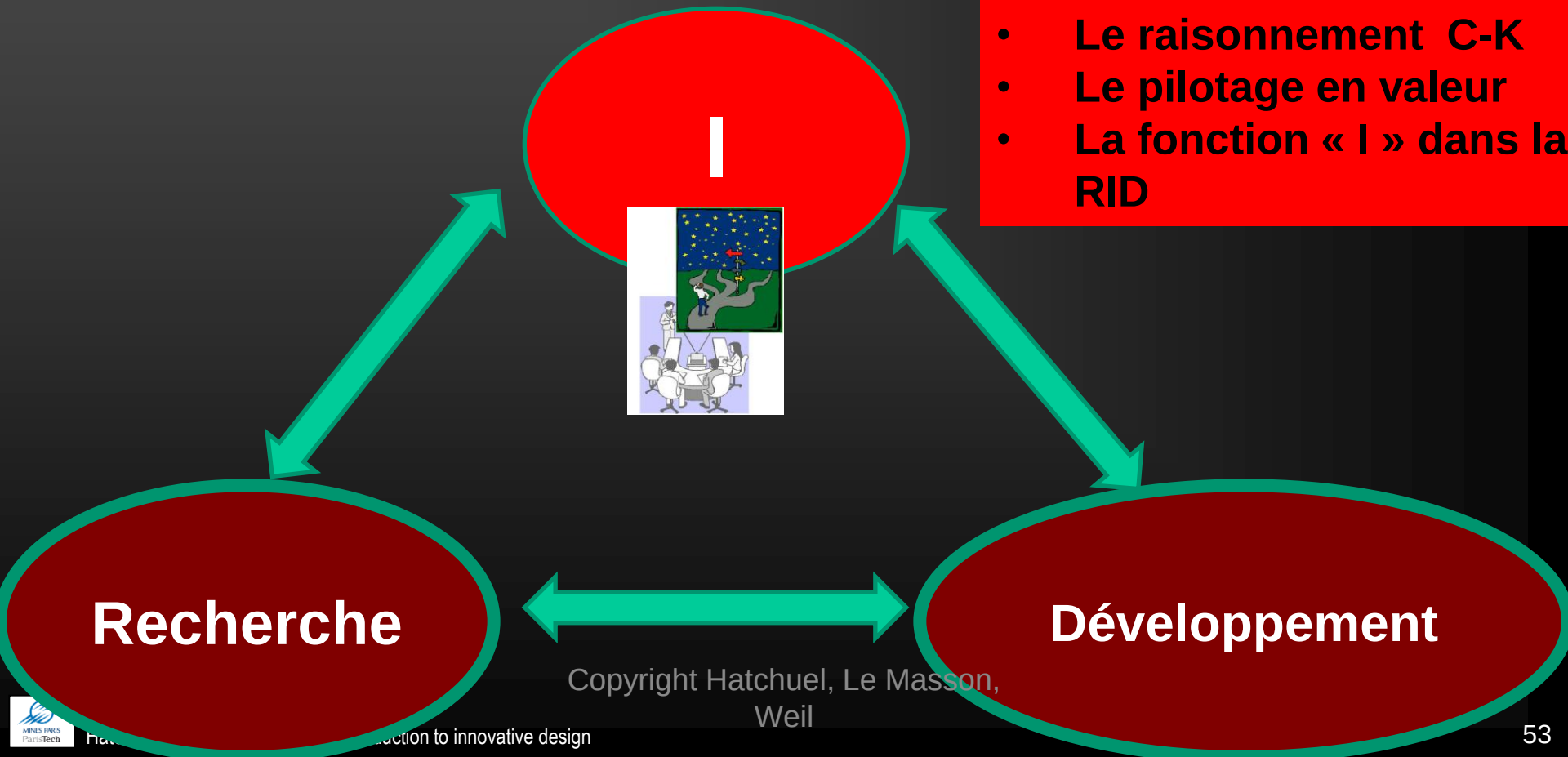
Principes et management de la Conception innovante

Ni Recherche, ni Développement, mais un processus R, I, D

- **Le raisonnement C-K**
- **Le pilotage en valeur**
- **La fonction « I » dans la RID**



Le management de la conception innovante

	Recherche (R)	Conception innovante (I)	Développement conc. réglée (D)
Mission / reporting	Problématique scientifique précise	Structurer et piloter un champ d'innovation/ comité « I »	« Cahier des charges
objectifs	Connaissances validées	Stratégies de conceptions (C-K, KCP, plateforms, lineages…)	Critères ex ante de réalisation du Project
Ressources	Laboratoires, universités, littérature…	Groupes, réseaux Communautés d'exploration et management en valeur	Equipe Projet, jalons décisionnels
Horizon	Dépend des techniques d'investigation	Flexible, Contingent & strategique (strategic milestones)	planifié
Valeur Economique	Valeur de la question	Valeur des options strategiques + rentes d'apprentissages et de répétition	Valeur du Projet selon modèle d'entreprise
Leadership	Chercheur	« I » leader	Project manager