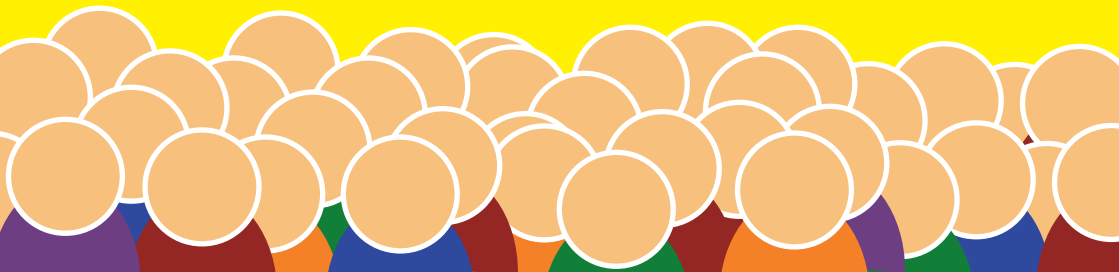


**Interdisciplinary Design for the Cyberspace**  
**by an Approach in *Kansei* Information**

*Methodology and Workgroup Communication Tool Design*

**Pierre LÉVY**









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Pierre Denis Lévy was born in Paris (France) in 1977. He started his studies in Mechanical Engineering and Industrial Design at Compiègne University of Technology (France) in 1997. In 2000, he participated to an international exchange program with the Industrial Design School of Carleton University (Canada). In 2001, he received his master's degree. In the meantime, he started to work for the Research and Development Department of Decathlon, S.A., and was sent to the Japanese branch to develop sport good innovative projects in cooperation with Japanese companies. In 2002, he received the Japanese National Scholarship (Monbukagakusho's scholarship), and entered in 2003 the doctoral program of the Graduate School of Comprehensive Human Sciences at the University of Tsukuba (Japan). He graduated with distinction (best dissertation award) in March 2006. Currently, he is a researcher for the 21st Century COE Program at Kansei Information Design Laboratory of the University of Tsukuba.

Interdisciplinary Design for the Cyberspace by an approach in *Kansei Information - Methodology and Workgroup Communication Tool Design*

感性情報アプローチによるサイバースペースのための学際的デザイン  
方法論とコミュニケーションツールのデザイン

by Pierre Denis LÉVY

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A dissertation submitted in partial satisfaction of the requirements  
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*À Jeanne et Juliette*

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# **Abstract | English**

## Introduction

The evolution of humanity, and notably of societies which are composing it, is marked all along its history, by evolutions, verily revolutions, of communication technologies (invention of spoken language, written language, of printing techniques, and so on...). The digital technology and the advent of the Internet are significant steps of this evolution. Nowadays, the impressive development and the intrusion of information technology at every level of the society, at the institutional levels as well as the private ones, bring the need for a new social and societal paradigm based on the knowledge and intelligence economy. This new paradigm includes the concept of Cyberspace to denote the virtual space for human and social exchanges based on human knowledge and experience. Each human being is a center of this paradigm. The individual, owner and retailer of intelligence, is emphasized by her/his own experience. Considering *Chisei* and *Kansei*, both cognitive elements of each individual, and descriptive and tacit knowledge, owned by each individual, there is a necessity to consider subjective (or personal) dimension in social communication while designing tools for the Cyberspace.

The actual evolution, brought by the new information technologies, makes possible for each individual to share and announce one's own knowledge with the rest of the group (by extension, with the whole humanity), whatever its size or nature. This is certainly a revolution. This is at the beginning of a new context allowing the design of relevant tools enable to help humanity to understand its common action. This understanding reaches to Collective Intelligence, a new opportunity for human community to progress. Thus there is a real need for new design objectives: creation of tools for Collective Intelligence.

*Kansei*, translated in English as a *mental sense of subjectivity*, is influencing human relationships. It has an influence on both the ideation and the understanding of interpersonal communication. Thus, *Kansei* becomes a key point in social context behavior of each individual, influencing not only the social context it-self (its structure and its operation), but also the information flow. Therefore, *Kansei* Information can contribute to integrate human subjectivity aspects in the design of tools for the Collective Intelligence.

Considering these points, the aim of this study is to understand how *Kansei* Information can contribute to the creation to the creation of a design methodology for Collective Intelligence, and thus to the improvement of communication structures of interdisciplinary workgroups.

## Interdisciplinary design methodology proposal

The artifact appears as an entity whose great complexity is induced by its context: the human society. Designers have to face with this complexity. They must take a great variety of dimensions of the artifact into consideration and collect them together in order to design each artifact more adapted to human beings, its users, and to the context. However, this point of view is theoretical. Whether the designer is working alone or within a design team, it is not realistic to expect from her/him to take all these dimensions correctly into consideration during the project. Therefore, the designer has to adopt an interdisciplinary behavior, in order to make an acquaintance with other fields, and to create an interdisciplinary workgroup.

The main concern encountered by interdisciplinary projects is about communication of knowledge between the different disciplines. The specificity of interdisciplinary groups is that the communication is not based on a single ontology<sup>1</sup>, but on as many ontologies as the number of disciplines gathering in the group. This specificity affects not only the tacit knowledge sharing, but also the explicit knowledge one. It affects tacit knowledge sharing since personal experience is partly coming from the activity in the discipline. Since ontology also gathers links between objects, and rules and actions being performed in the activity, it influences the way the activity is performed and tacitly understood. That is all the more important that explanations, trying to solve tacit knowledge related issues, can be only partially expressed in an explicit form. A part of it, most of the time fundamental, cannot be explicitly expressed because of its implicit nature. Explicit knowledge sharing is also affected since it involves concepts or methods that may be defined differently for each ontology (i.e. the same word

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<sup>1</sup> Here, the meaning of ontology is the one used in Knowledge Representation. It is a specification of a domain, of all that 'exists' in a domain, including terms, concepts, entities, axioms, theorems, laws, rules, and actions that can be performed on everything within the domain as well as how to reason about the domain.



may mean different things in different disciplines). Communication on concepts or methods defined specifically to each discipline is a barrier for the interdisciplinary group communication process. Indeed, divergence of definition for a similar concept or method can lead easily to misunderstandings and frustrations between members. This issue is independent from the kinds of interdisciplinary groups and from the involved disciplines.

To solve this issue, an interdisciplinary design methodology is proposed. This methodology is based on intuition, described and defined as the ability to understand or know something immediately, without conscious reasoning. It is considered in this study as a specific human cognitive strength, easing both descriptive and subjective communication and mutual understanding inside the interdisciplinary team. The theory of *ba* is defined by Nishida as a 'knowledge sharing space', i.e. a place where interpersonal interactions are possible, and where knowledge creation becomes possible. Defining the SECI Model, Nonaka proposes a spiraling interaction between explicit and tacit knowledge as a knowledge creation process.

This methodological proposition implies the introduction of an original concept, called *Evoked Metaphor*, defined as a set of intuitively transferable successful information and operative rules. In other words, an *Evoked Metaphor* is based on one or a few ideas that can be intuitively, but rigorously, linked by analogy with the design in the point of view in each involved discipline. The definition and the construction of an *Evoked Metaphor* are done by the two following aspects: a static one (or information), structuring the analogical context, and the dynamic one (or operative laws), structuring the processes existing in this context. This induces attributes and constraints that are developed in the following. The *Evoked Metaphor* evaluation can be realized thanks to a few criteria: It has to enclose the entire project, to be understandable and disciplinary validated by each member, and to be useful for each member in the frame of her/his involvement in the project.

The set *ba*/SECI Model/*Evoked Metaphor*, based on intuition, is shown as a very interesting and useful knowledge sharing support. Moreover, the *Evoked Metaphor* has showed its adequacy with the SECI Model in terms of information flow, and especially the cyclic flows bridging explicit and implicit knowledge.

Finally, the *Evoked Metaphor* is showed as perfectly adapted the design process, even improving knowledge sharing and creativity.

## ***MATiK*, a communication tool for interdisciplinary workgroups**

In order to illustrate the use of the interdisciplinary design methodology proposed in the previous part, an interdisciplinary design project is introduced here: the design of *MATiK*. It is introduced as a unified communication system designed for interdisciplinary workgroups to communicate on various topics, without limitation of space and time, and providing to each member the necessary information according to the consideration of individual specifications. *MATiK* is an original communication tool taking into consideration several human aspects in Cyberspace, for the profit of Collective Intelligence.

In order to design *MATiK* thanks to the interdisciplinary design methodology, to understand its philosophy of operation, an *Evoked Metaphor* is proposed: the *Loft*. This is a unique room (unity of space) in which various people have different activities (multiplicity of activities). However, interactions are possible between different people, and sometimes even unattended, thanks to the 'cocktail party phenomenon'. *MATiK* intends to simulate the same environment of communication as the *Loft* within the interdisciplinary workgroup communicating through information technology.

To determine intuitively the functional requirements of *MATiK*, the *Loft* is used as the context: from different scenarios occurring in the *Loft*, functions can be listed and validated by each member of the workgroup. The core function of *MATiK* is called the jump analyzer. It intends to evaluate and provoke information flow modifications, following the same pattern as the cocktail party phenomenon. Other original functions are detailed, all being supported by the jump analyzer. For the design of *MATiK*, some aspects of the jump analyzer functions require quantified information, such as the evaluation criteria used to decide whether to send an unattended message to a potentially interest user. For this purpose, an experiment has been carried out using ERP, to weight factors causing switch in the cocktail party phenomenon.

The *Loft* was used also to elaborate the technical requirements of *MATiK*. In the *Loft*, operation is mainly based on individuals communicating with each other in a unique environment. The multiagent system technology seems to be an adapted solution for *MATiK*. According to the constraints and the characteristics of multiagent systems, recommendations for the data processing design of *MATiK* using multiagent technology were set.

## Conclusion

Thanks to an original interdisciplinary design methodology, based on *Kansei* Information and especially on intuition, a new communication tool was proposed for the Cyberspace in the development of Collective Intelligence. From observation of the reality level (the interdisciplinary workgroup), an *Evoked Metaphor* had been created. The *Loft*, situated at a conceptual level, helped to understand intuitively the functional and technical level of the design. And through all these steps of the design process (a trans-design continuity, called the horizontal continuity), rigorous links remained between the three fundamental levels (a trans-level continuity, called the vertical continuity) for the respect of both objective and subjective requirements in the new design.

The success of the interdisciplinary quality of this design methodology comes from the co-existence of these two aforementioned continuities. They insure all the disciplines to understand, participate, and validate each step of the design process, from the beginning to the end of the project.

*Kansei* and its impact on human interactions were considered at all the levels of the design, and were regarded as key points within the interdisciplinary design method itself. Because interdisciplinary design groups apply *Kansei* Information principles at the core of their work process methodology, they can consider *Kansei* at all the steps and at all the levels of the design process, to obtain an artifact taking users *Kansei* into consideration.

摘要 | 日本語

## 序文

人類、そして社会の進化は言語、印刷技術、通信技術の進化と共に発展してきた。この中でも特にデジタル技術とインターネットの到来は、この進化の重要な一歩であり、情報技術の目覚ましい発達と社会のあらゆるレベルにおける浸透により、知識・知能経済に基づいた新しい社会パラダイムが必要とされている。この新しいパラダイムは、人間の知識と経験に基づいた人的または社会的交流のための仮想空間であるサイバースペースの概念を含む。個人はこのパラダイムの中心となり、知能を働かせることで個人の経験に基づいた社会を形成する事ができるようになった。この進化によって個人はグループ内の他の個人と自分の知識を公開したり共有することが可能になった。これは革命的な事実であるとともに人類に共通した行動の理解を補助するツールのデザインをすることを促す新しい状況でもある。

そこで要求されるサイバースペースのためのツールのデザインは個人が保有する記述的または潜在的知識とそれを活用する働きである知性と感性を活用する必要がある。このツールは、人間社会の発展の新たな機会でもある、集合的知性を可能にしなくてはならない。すなわち集合的知性のためのツールのデザインが必要となったのである。

感性は個人間でのコミュニケーションにおける情報の流れ、観念形成、理解、さらに社会的状況の構造と運用にも影響を与えることから、一般的な社会的状況における各個人の行動の原理だとも考えられる。すなわち、感性情報は集合的知性が働く際の原理のひとつでもあり、ここで考えるツールデザインにおける主観性の統合あるいは共有に寄与するのである。

以上のことを考慮に入れた上で、本研究の目的は、感性情報が集合的知性のデザイン方法論の創造にいかに関与することができるかということ、またそれによって横断的なワークグループのコミュニケーション構造の改善にどう結びつくのかを明らかにしようとするものである。

## 横断的デザイン方法論の提案

人工物とは多大なる複雑性がその文脈、人間社会によって統合された実体とも言える。デザイナーはこの複雑性に対し、ある人工物が持ち得る非常に様々な局面を考慮に入れ、それらを人間、ユーザー、またその状況により適応するよう各人工物のデ

ザインをしなければならない。しかしながらこの視点はあくまで理論的なもので、現実的にはデザイナーの関わり方によらず、プロジェクトにおいてこうした複雑な局面をデザイナー自身が全て正確に考慮に入れることは期待できない。そこでデザイナーは他分野と関わりを持ち、横断的なワークグループを形成するために学際的な姿勢を身につける必要がある。

分野横断的なプロジェクトにおいて最も問題となるのは、異分野間における知識交流、すなわちコミュニケーションである。横断的グループではコミュニケーションが共通のオントロジーに基づくものではなく、グループ内の横断的分野の数と同じだけの数のオントロジーに基づく可能性があるという点が特徴的である。この特徴は個人的な経験に依存するものであり、ある程度専門領域の影響を受けているため潜在的知識の共有に影響を与える。また、オントロジーは物体と、行動における規律、動作間の関連性を保持するため、その行動がどのように行われるか、また潜在的に理解されるかということに影響を与える。特に潜在的知識に関連した問題を解決しようとする際、潜在的知識の最も重要な部分はその潜在的特性のため明示的に表現することが不可能である。明示的知識の共有も各オントロジーにおいて違った形で定義されている概念や方法に関わるため、その影響を受ける(例えば異なる専門領域においては同じ単語が別の意味で使用されることがある)。各専門領域においてそれぞれ特定の定義をされた概念または方法に依存したコミュニケーションは横断的グループにおけるコミュニケーションの妨げとなる場合すらある。実際、類似した概念または方法の定義の相違はメンバー間での誤解やフラストレーションを起こしかねない。

本論文ではこの問題の解決のために、まず横断的デザインの方法論の提案を行った。特に、意識的な論理思考なしで即座に物事を理解または認知する能力と定義されている感性に注目する。感性は本研究において、横断的グループ内での記述的・主観的コミュニケーションと相互理解を促す、人間の認知能力のひとつであるとする。一方、野中は SECI モデルの定義として、明示的知識と潜在的知識間のらせん状の相互作用を知識創造の行程として述べている。

さらに、そうした知識が公開され交換される環境を「場」と考える。「場」は西田により「知識共有の場所」として概念的に定義されている。つまり、個人間の相互作用、知識創造が可能である場所のことである。

この方法論の提案では、独自の概念であり「直感的に伝達が可能で有効である情報と効力のある規律」と定義される「連想される隠喩」を導入する。これは各関連専門領域の視点において、デザインの共通点によって直感的かつ厳密に関連づける

ことができる一つまたはいくつかの概念に基づくものである。「連想される隠喩」の定義と構成は以下の二点の見地からなる。

- 類推的状况を構成する静的な見地(または情報)。

- この状況の中に存在する行程を構成する動的な見地(または効力のある原理)。「連想される隠喩」となり得るかどうかの評価はいくつかの基準によって明らかとなる。プロジェクトの全ての概念に対応できること、各メンバーによって理解されることができ専門領域において認証されていること、またそのプロジェクトにおけるメンバーの関与の範囲において実用性があること。

感性の立場から、「場」、SECI、「連想される隠喩」の組み合わせを考えることは非常に興味深くまた有用な知識共有サポートである。本論文では、「連想される隠喩」は情報の流れにおいて、特に明示的知識と潜在的知識の橋渡しの周期的フローにおいて効果があると考えられ、それは SECI モデルとの共通性が認められた。最終的には「連想される隠喩」がデザインプロセスに完全に順応し、知識共有と創造性を改善する可能性を示した。

## *MATiK* – 横断的グループのためのコミュニケーションツール

前章において提案された横断的デザイン方法論の説明として、ここでは横断的デザインプロジェクト事例として *MATiK* のデザインを取り上げた。*MATiK* は、横断的ワークグループが様々な主題について空間時間の制限にとらわれることなくコミュニケーションでき、各メンバーに必要な情報を個人の設定を考慮した上で提供するようにデザインされた集合的知性のための統合コミュニケーションシステムである。

実際に横断的デザイン方法論に基づき *MATiK* のデザインをする際に「連想される隠喩」として「ロフト」を用いたことが行程の概念的理解を促進した。すなわち、「ロフト」によって、様々な人々が多様性を維持しつつ知的な空間を共有した部屋であるが、多様な人々が集まった場で発生する相互作用として「カクテルパーティー現象」のように意識下で成立する直観的コミュニケーションのイメージを共有することができた。*MATiK* はロフトのようなコミュニケーション環境を、情報テクノロジーを使ってコミュニケーションをとっている横断的ワークグループ内において想定しようとするものである。

*MATiK* の機能条件を直感的に決定するためにロフトを背景として使用することで、これにかかわるメンバーはロフト内で起こっている様々な状況から必要な機能を挙げ、妥当性を検証していく。特に *MATiK* の中心的機能としてジャンプアナライザーを考える。これは「カクテルパーティー現象」と同様のパターンで情報のフローの修正を喚起するものである。*MATiK* のデザインにおいて、ジャンプアナライザーの機能のいくつかの側面として、興味を持つ可能性のあるユーザーへ意図されていないメッセージを送るかどうかを決定するのに使用される評価基準などの数量的な情報を必要とすることがある。そこで、カクテルパーティー現象における切り替えを起こす因子を測量するために ERP を使用した実験を行った。*MATiK* におけるロフトの概念は主に単一の環境内でコミュニケーションを取りあう個人に基づいているが、さらに具体的な設計のために、マルチエージェント技術を使用することによって *MATiK* のデータ処理が可能であるという設計解を得た。

## 結論

感性情報に基づいた横断的デザイン方法論により、集合的知性の発展のためのサイバースペースにおける新しいコミュニケーションツールを提案するため、現実的レベル(=横断的ワークグループ)の観察から、「連想される隠喩」を提案した。概念的レベルにおけるロフトはデザインの機能的、技術的レベルを直感的に理解するのに役立った。一方、新しいデザインの客観的または主観的な条件を満たすため、全てのデザインプロセス(トランスデザイン継続性、水平継続性という)において、三つの基本的レベル間での厳密な関係性(トランスレベル継続性、垂直継続性)も存在し、横断的なデザイン方法論の応用のなかで、それらの継続性を維持するためにプロジェクトの最初から最後まで、全ての専門領域がデザインプロセスの各ステップを理解、参加、検証できる環境を提供することが必要である。横断的デザイングループは感性情報の原理をそのプロセスの中心に適用することによって、ユーザーの感性を考慮した人工物をデザインし、そのプロセスにおける全てのステップと全てのレベルにおいて感性を考慮に入れることができるのである。





## Résumé | Français

## Introduction

L'évolution de l'humanité, et particulièrement des sociétés qui la composent, est marquée tout au long de son histoire, par des évolutions, voire des révolutions, des technologies de la communication (invention du langage parlé, de l'écriture, de l'imprimerie, etc. . . ). La technologie numérique, et l'émergence de l'Internet sont des étapes significatives dans cette évolution. L'impressionnant développement et l'intrusion des technologies de l'information à tous les niveaux de la société, aussi bien au niveau de la sphère institutionnelle qu'au niveau de la sphère privée, aboutissent à la nécessité de proposer un nouveau paradigme social et sociétal, fondé sur l'économie de l'intelligence et de la connaissance. Ce nouveau paradigme inclut également le concept du cyberspace, faisant référence à l'espace virtuel rendu possible grâce à la communication au travers des nouvelles technologies de l'information. Le cyberspace est un lieu d'échanges humains et sociaux fondé sur la connaissance et l'expérience humaines. Chaque être humain est un centre de ce paradigme. Chaque être, détenteur et éditeur d'intelligence, est valorisé par sa propre expérience. Considérant le *Chisei* et le *Kansei*, tous les deux éléments cognitifs de chaque être humain, la connaissance tacite et descriptive, possédées par chaque être humain, il est nécessaire de considérer la dimension subjective (ou personnelle) dans la communication sociale lorsque des outils sont développés pour le cyberspace.

L'évolution actuelle, apportée par les nouvelles technologies de l'information, rend possible pour chaque individu de partager, d'annoncer, et de mutualiser sa propre connaissance avec tout le reste du groupe (par extension, avec l'humanité tout entière), quelles que soient sa taille et sa nature. C'est une véritable révolution. Elle sera à l'origine d'un contexte permettant la mise en place d'outils pertinents capables d'aider l'humanité à comprendre son action commune. Cette compréhension aboutit à l'Intelligence collective, une nouvelle opportunité de progrès pour la communauté humaine. Cela augmente la nécessité d'avoir de nouveaux objectifs de conception : la création d'outils pour l'Intelligence collective.

Le *Kansei*, traduit en français par le sens mental de la subjectivité, influence les relations humaines. En effet, il influence à la fois l'idéation et la compréhension dans la communication interpersonnelle. Le *Kansei* devient alors un point clé

dans le comportement social de chacun, influençant non seulement le contexte social lui-même (sa structure et son fonctionnement), mais aussi le flux informationnel social. Par conséquent, le *Kansei* Information (étude de l'information liée au *Kansei*) peut contribuer à intégrer les aspects liés à la subjectivité humaine dans la conception des outils de l'Intelligence collective.

Dans ce contexte, cette étude a pour but de comprendre comment le *Kansei* Information peut contribuer à la création d'une méthodologie de design pour l'Intelligence collective, et donc comment il peut améliorer les structures de communication dans les groupes interdisciplinaires.

## **Proposition pour une méthodologie de design interdisciplinaire**

L'artéfact est perçu comme une entité dont la grande complexité est induite par son contexte : la société humaine. Les designers doivent tenir compte de cette complexité. Ils doivent considérer une très grande variété de dimensions de l'artéfact et les rassembler, ceci afin de concevoir chaque artéfact de façon plus adaptée aux êtres humains, ses utilisateurs, et au contexte. Toutefois, ceci est un point de vue théorique. Qu'un designer travaille seul ou dans une équipe de designers, il n'est pas envisageable que la totalité de ces dimensions soient prises en compte correctement dans un projet. Il lui faut donc adopter un comportement interdisciplinaire, afin d'aller à la rencontre des autres disciplines et de former un groupe de travail interdisciplinaire.

Le principal problème rencontré par les travaux interdisciplinaires porte sur le partage des connaissances entre les différentes disciplines. La spécificité d'un groupe interdisciplinaire est que la communication ne se base pas sur une unique ontologie<sup>1</sup>, mais sur autant d'ontologies qu'il y a de disciplines incluses dans le groupe. Cette spécificité a des conséquences non seulement sur le partage de la connaissance tacite, mais aussi sur celui la connaissance

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1 Ici, le terme ontologie prend le sens usuellement utilisé en représentation de la connaissance. Une ontologie correspond à la spécification d'un domaine de connaissance, à tout ce qui existe dans ce domaine, incluant les expressions, les concepts, les entités, les axiomes, les théorèmes, les lois, et les actions qui peuvent être exécutées sur tout ce qui appartient à ce domaine, aussi bien que le façon de raisonner sur ce domaine.

explicite. Elle affecte le partage de la connaissance tacite puisque l'expérience personnelle de chacun a pour origine partielle l'activité disciplinaire. Puisque l'ontologie rassemble les liens entre les objets, les lois et les actions exécutées au sein de l'activité, elle influence la façon dont cette dernière est accomplie et comprise tacitement. Ceci est d'autant plus important que les explications, essayant de résoudre des problèmes relatifs à la connaissance tacite, ne peuvent être exprimées que partiellement de manière explicite. Une partie, souvent fondamentale, ne peut être exprimée explicitement puisqu'elle est implicite. Le contexte interdisciplinaire affecte également le partage de la connaissance explicite puisque cette dernière implique des concepts et des méthodologies pouvant être définis différemment pour chaque discipline (c'est-à-dire qu'un même terme peut avoir différentes définitions dans différentes disciplines). La communication de concepts ou de méthodologies qui peuvent être définis différemment pour chaque ontologie constitue une barrière à la qualité de la communication dans le groupe interdisciplinaire. En effet, les divergences de définition pour un même concept ou une même méthodologie peuvent conduire rapidement au malentendu et à des tensions entre les membres du groupe interdisciplinaire. Ce problème est indépendant de la nature interdisciplinaire du groupe et des disciplines impliquées.

Afin de résoudre le problème précédemment soulevé, une méthodologie de design interdisciplinaire est proposée. Cette méthodologie est fondée sur l'intuition, décrite et définie comme une aptitude à percevoir et à comprendre quelque chose immédiatement, sans raisonnement conscient. L'intuition est présentée dans cette étude comme une force cognitive humaine facilitant la communication descriptive et tacite, et la compréhension mutuelle dans le cadre des équipes interdisciplinaires. La théorie du *ba* est définie par Nishida comme un espace de partage de la connaissance, i.e. un espace dans lequel les échanges interpersonnels sont possibles, et dans lequel la création de connaissance est rendue possible. En définissant le Modèle SECI, Nonaka propose une interaction en spirale entre la connaissance tacite et la connaissance explicite comme processus de création de la connaissance.

Cette proposition de méthodologie implique l'introduction d'un nouveau concept, appelé la Métaphore évoquée, définie comme un ensemble d'informations validées et transférables intuitivement, et de lois de fonctionnement. En d'autres termes, une Métaphore évoquée s'appuie sur une ou plusieurs idées qui peuvent

être intuitivement, mais de façon rigoureuse, liées par analogie au design du point de vue de chaque discipline impliquée dans le projet. La définition et la construction d'une Métaphore évoquée est réalisée suivant deux approches: l'une statique (l'information), qui structure le contexte analogique, et l'autre dynamique (les lois de fonctionnement), qui structurent les processus existants dans ce contexte. Cela induit des caractéristiques et des contraintes qui sont ensuite développées. L'évaluation de Métaphore évoquée peut se faire suivant quelques critères : elle doit englober le projet dans son ensemble, être comprise et validée par chaque membre au regard de sa propre discipline, et être utile pour chacun d'entre eux dans le cadre de leur participation au projet.

L'ensemble *ba* /Modèle SECI/Métaphore évoquée, basé sur le processus de l'intuition, est montré comme étant un support très intéressant et utile pour le partage de la connaissance. De plus, l'adéquation entre la Métaphore évoquée et le Modèle SECI en termes de flux d'information est démontrée, notamment en ce qui concerne les flux cycliques liant la connaissance explicite et la connaissance tacite. Finalement, l'utilisation de la Métaphore évoquée est totalement adaptée au processus de design, améliorant même le partage des connaissances et par conséquent, la créativité.

## ***MATiK*, un système de communication pour les groupes de travail interdisciplinaires**

Dans le but de mettre en œuvre une utilisation de la méthodologie de design interdisciplinaire présentée dans la partie précédente, un projet de design interdisciplinaire est réalisé : la conception de *MATiK*. Ce dernier est défini comme un système de communication unifié pour les groupes interdisciplinaires afin de communiquer sur des sujets différents, sans limitation d'espace ou de temps, fournissant à chaque membre l'information requise et appropriée suivant des critères personnalisés. *MATiK* est un outil de communication original pour le cyberspace, prenant en compte plusieurs 'caractéristiques humaines' des utilisateurs, au profit de l'Intelligence collective.

Pour concevoir *MATiK* suivant la méthodologie de design interdisciplinaire, afin de comprendre son concept de fonctionnement, une Métaphore évoquée est présentée: le *Loft*. Le *Loft* est une pièce unique (unité de l'espace) dans

laquelle plusieurs personnes ont différentes activités (multiplicité des activités). Dans ce cadre, les interactions entre les personnes sont possibles, et même parfois non-attendues grâce notamment au phénomène cocktail party. *MATiK* a pour objectif de simuler un environnement de communication similaire au *Loft*, pour les groupes interdisciplinaires communiquant au travers des nouvelles technologies de l'information.

Pour déterminer intuitivement les contraintes fonctionnelles de *MATiK*, le *Loft* est utilisé comme contexte : à partir de différents scénarios qui se jouent dans le *Loft*, une liste de fonctions peut être rédigée et validée par chaque membre de l'équipe de design interdisciplinaire. Le cœur de *MATiK* est une fonction appelée l'analyseur de saut. Ce dernier a pour mission d'évaluer et de provoquer les modifications du flux d'information, suivant un processus identique au phénomène cocktail party. D'autres fonctions originales sont détaillées, mais elles reposent toutes sur l'analyseur de saut. Pour la conception de *MATiK*, certaines caractéristiques de l'analyseur de saut ont besoin d'être quantifiées, comme par exemple les critères d'évaluation permettant de prendre la décision d'envoyer à un utilisateur potentiellement intéressé un message non-attendu. Pour cela, une expérience a été réalisée utilisant la mesure des potentiels évoqués afin de pondérer les facteurs à l'origine du changement d'attention dans le phénomène cocktail party.

Le *Loft* est également utilisé pour élaborer le cahier des charges techniques de *MATiK*. Le *Loft* consiste essentiellement en un groupe d'individus communiquant entre eux dans un lieu délimité. La technologie des systèmes multiagents paraît donc une solution technique judicieuse pour *MATiK*. Considérant les caractéristiques et les contraintes des systèmes multiagents, des recommandations pour le développement informatique de *MATiK* grâce à une structure multiagent sont formulées.

## Conclusion

Grâce à une méthodologie de design interdisciplinaire originale, s'appuyant sur le *Kansei* Information et notamment sur l'intuition, un nouvel outil de communication a été proposé pour le cyberspace et pour le développement de l'Intelligence collective. Grâce à l'observation du niveau réel (le groupe inter-

disciplinaire), une Métaphore évoquée a été créée. Le *Loft*, situé au niveau conceptuel, a aidé à la compréhension intuitive du niveau fonctionnel et technologique du design. Et tout au long du processus de design, à chacune des étapes (une continuité trans-design appelée continuité horizontale), des liens rigoureux ont été maintenus entre les trois niveaux fondamentaux (une continuité trans-niveau appelée continuité verticale) afin de respecter les contraintes objectives et subjectives du projet.

Le succès de la qualité interdisciplinaire de cette méthodologie de design est assuré par la coexistence des deux continuités mentionnées précédemment. Elles permettent en effet à toutes les disciplines de comprendre, de participer, et de valider chaque étape du processus de design, du début à la fin du projet.

Le *Kansei* et son impact sur les interactions humaines, ont été considérés à tous les niveaux du design et comme un point clé de la méthodologie de design interdisciplinaire elle-même. Puisque les groupes de travail interdisciplinaires intègrent les principes du *Kansei* Information au cœur même de leur méthode de travail, ils peuvent appréhender le *Kansei* à toutes les étapes du processus de design, afin d'obtenir un artéfact prenant en compte le *Kansei* des utilisateurs.





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## **Part A | Introduction**





# ***Chapter 1***

## **Background of the study - *Kansei* Information contribution for collective intelligence tools**

*Whatever we learn has a purpose and whatever we do affects everything and everyone else, if even in the tiniest way. Why, when a housefly flaps his wings, a breeze goes round the world; when a speck of dust falls to the ground, the entire planet weighs a little more; and when you stamp your foot, the earth moves slightly off its course. Whenever you laugh, gladness spreads like the ripples in a pond; and whenever you're sad, no one anywhere can be really happy. And it's much the same thing with knowledge, for whenever you learn something new, the whole world becomes that much richer. - Norton Juster [125]*

### **1.1 Cyberspace and Collective Intelligence**

Humanity went through a multitude of technological revolutions. Among them, communication evolutions have a particularly significant importance by their great impact on societies' evolutions. They are necessary tools for tribes and then societies' foundations and cultural development. Sign, speech and writing technologies, invented thousands or millions of years before our era, were necessary cement for individuals to live together, to communicate, and to create organizations, such as societies and countries. The publishing technology, invited by Gutenberg in 1452, is also fundamental for the emancipation of cultures and knowledge. It was a key technology which influenced the end of the Middle Age period and brought societies to the Century of Lights. Then, telecommunication technology, and its first great application, the Morse's electric telegraph demonstrated in 1844, brought strength and immediacy to communications over the countries and over the continents. The digital technology, and the beginning of the first Internet, the ARPANET in 1969, is the latest step among these fundamental communication revolutions, which have each time reshaped societies and influenced cultures drastically. When considering the structure of publishing and telecommunication technologies, it is most of the time a unique centralized

emitter sending information to a great quantity of passive and isolated receivers. Yet, some other structures are possible, such as the telephone or fax system: there is communication reciprocity, i.e. dialog is possible. These systems are 'individual to individual' (or 'peer-to-peer') and do not allow the creation of a community. The advantage of digital technologies, such as the Internet, is that they bring the possibility of interaction between people and the idea of collectivity and community beyond institutions and countries.

### **1.1.1 For the development of the Cyberspace**

One of the great creations brought by the usage of telecommunication technologies, and greatly emphasized by digital ones, is the Cyberspace. The term of Cyberspace was first used by the science fiction author William Gibson [79] to appoint an information space created by the global computer network, linking all individuals and machines in the world, in which information can move and navigate. This space creates new social, cultural, and economical frontiers. Also, information in the Cyberspace is not only passive. Information can act and control the state of a computer and its action: the Language Act Theory (cf. p. 276) can be applied in the Cyberspace too.

The Cyberspace refers to this space, so much present nowadays, of creation and navigation of information, inducing human and social relations above the borders of actual societies. However, the Cyberspace is still a space under construction, in which certain spots have not been discovered yet. As vocation, it has the interconnection and the interaction of all devices for creation and communication. Nowadays, the Cyberspace is so much present and in interaction with all the levels of the societies, with all the social and individual activities. Thus, its social, political, economical, aesthetic, and legal implications are at the origin of major transformations which have to be taken in charge by the humanity. Its progression and its achievement (if it can be reached) will have consequences which are yet beyond suspicion.

Therefore, in the project of the Cyberspace humanity needs a project, a path to follow (while building it) in order to prevent a destructive Cyberspace, but to the contrary, to make a constructive one for a stronger, a more creative and more intelligent humanity. The project inducted here is the advent of the global Collective Intelligence, that is to say of the intelligence of Humanity.



## 1.1.2 Toward the Collective Intelligence

### 1.1.2.1 Definition of the Collective Intelligence

The term collective designates the entity (the whole) composed of other entities (the elements) as parts of it. When associated with the term intelligence, the whole is any set of human beings: social relationships (friends, couples), social systems (markets, governments), politics (countries, cities, nations), families, communities, and so on. The elements are human beings. The term intelligence is the ability to solve problems, i.e. the ability to acquire and apply knowledge and skill [22]. Thus, there is, in the term intelligence, an idea of effective adaptation to the environment, either by changing oneself, by changing the environment, or by finding a new one. Piaget suggests this also by the following definition [198, p. 3-4]:

*Intelligence is an adaptation... To say that intelligence is a particular instance of biological adaptation is thus to suppose that it is essentially an organization and that its function is to structure the universe just as the organism structures its immediate environment.*

Starting from the two definitions provided previously, a first approach in defining this term would be: The ability of each individual (elements) to acquire and apply knowledge and skill for the benefit of both each and the whole. I propose here some definitions proposed in the rich literature attempting to define the term Collective Intelligence :

- A form of universally distributed intelligence, constantly enhanced, coordinated in real-time, and resulting in the effective mobilization of skills... No one knows everything, everyone knows something. — Lévy<sup>1</sup> [147]

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<sup>1</sup> By chance, it happens that Prof. Pierre Lévy, Professor in the Department of Hypermedia of the University of Paris-St.Denis, has the name as mine and is one of the most recognized professor in this field. In order to make the difference between Prof. Pierre Lévy and myself, I'll use systematically the third person for Prof. Pierre Lévy and the first person for myself.

- A specific property of a social structure, initialized when individuals organize, acquiring the ability to solve more complex problems than individuals can. This property amplifies if the social structure improves its synergy. — Szuba [232]
- Collective Intelligence is the capability for a group of people to collaborate in order to decide upon its own future and reach it in a complex context. — Noubel [186]

The Collective Intelligence is not new. It appears when first humans gathered to exchange and collaborate, and when then figured out that the group and each individual benefit more by being together than by being isolated. It is a foundation to groups, tribes, teams, communities, nations, etc... The Collective Intelligence experience is universal. Everybody had the experience of it, in any community, sport team, or music band experience. These have the common: individuals' senses and spatial engagement are involved the same way [186]. These universal experiences are called the Original Collective Intelligence.

To precise the philosophy of the Collective Intelligence, Lévy adds that the basis and goal of Collective Intelligence are the mutual recognition and enrichment of individuals rather than the cult of fetishized or hypostatized communities [147, p. 29]. Thus, the first axiom is the dissemination of intelligence in humanity. There is now transcending space of knowledge. Each individual owns a piece of the total intelligence, and therefore each one should be able to give value to it. Its nature, intrinsically social, requires the use of efficient communication tools, to coordinate these intelligences in real-time. A global and efficient Collective Intelligence has to lie on the use of digital information technologies to sustain high quantitative limits [147, p. 29-31].

### 1.1.2.2 Characteristics of the Collective Intelligence

The observable phenomena characterizing the Collective Intelligence are too numerous to be exhaustively cited. However, major ones can be listed here, in order to describe the main theoretical and practical principles of the Collective Intelligence (list proposed by Noubel [186]):

- A *emerging whole* — It is classic to attribute a personality or a style to a group. When describing the group, thanks to these attributes, then its unity, and its whole becomes obvious.
- A *'holoptical' space* — By nature, the group as the whole provides each member a complete and ever updated view of this whole. Each member refers to it to behave and coordinate her/his behavior with/in the group. Then there is a unceasing round trip between the individual level and the collective one (vertical flow). The holopticism is this set of properties, that is the 'horizontal' transparency (perception of the other participants), and the 'vertical' communication with the emerging whole [186].
- A *social contract* — Whatever is its nature (game rules, work legislation, etc...), a social contract is one of the foundation of the group. It can be tacit or explicit, objective or subjective, often both. The social contract is not only about values and rules of the group, but also the means of its self-perpetuation.
- A *polymorphic architecture* — In the group, the mapping of the relationships is unceasingly in motion, modified by circumstances, proficiencies, perceptions, tasks, and relational rules based on the social contract. Each evolution modifies the architecture of the group. For example, an expert, as recognized by the group, leads the progression of the group on problems which come under his/her expertise.
- A *circulating object-link* — Soccer players use the ball simultaneously as an index that turns between individual subjects, as a vector that *allows* everyone to design everyone, and at the main object, the dynamic link of the collective subject. Objectives of the group, melody of the music orchestra, ball for soccer teams are the objects for the convergence of individuals in a Collective Intelligence dynamics. When the object-link is symbolic, it has to be clearly identified by each member of the group to prevent fuzzy and difficult situation.
- A *learning organization* — The learning process does not take place only at the individual level. It implies also a social process to takes charge of mistakes, integrates and transforms them into shared cognitive objects. It originates the relational intelligence: what one learns is useful for others.

- A *gift economy* — In the currently dominant economy, called the ‘competition economy’, one picks something in exchange of a compensation (most often money or work). In the ‘gift economy’, one gives before receiving after the collective has increased its estate. Taking care of the elderly, raising children, N.G.O. are examples of the gift economy. It is the absolute base of social life. Communities are not sustainable on the long run if they rely on the dynamics of individual sacrifice: each individual has to find a personal advantage to be motivated and participate the best possible to the community. That is what the gift economy is based on. It organizes the convergence between individual and collective levels.

These first seven characteristics are the main qualities describing the Original Collective Intelligence. All these qualities have to be considered together and can not be separated: each of them is the cause and the consequence of others. However, Original Collective Intelligence meets two limits due to its nature:

- Members have to be limited in number, for them to interact efficiently. Too much members would increase complexity considerably, generating more noise than effective results.
- Members need to be physically close together for their natural interfaces (sensory senses) to interact. That is the way the holoptical space can work.

However, it seems that nowadays, both of these limits are surpassed. Communities present in the Cyberspace, in which Collective Intelligence can process, may be composed of a great number of people without any real spatial frontier. Five other characteristics are added, to shift from the Original Collective Intelligence to the Collective Intelligence:

- A *sufficient currency* — The gift economy does not require any accounting process for small groups. When the quantity of members increase, a ‘monetary’ information system<sup>2</sup> is required.
- *Standards and norms* — Standards and norms are indispensable to structure the cohesion, the degree of permeability, and the interoperability of large

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<sup>2</sup> The term ‘monetary’ is defined by the fact that it acts as a medium of exchange and store value [186].

communities. In the case of Collective Intelligence, they are issued from an ascendant process. Their aim is to maximize the interoperability and the capability to build more functional and more complex sets, rather than hegemonies.

- *An information system* — The information system organizes the symbolic space shared by the community. Therefore, it is implied in all the characteristics mentioned here. It connects members (through their senses) thanks to more and more powerful interfaces, creates and presents synthesis, processes calculus and simulations which we are not able to achieve by ourselves, organizes and indexes the collective memory, counts monetary transactions, applies the social contract, builds artificial holoptical spaces where Original Collective Intelligence is, puts people in relation with one another according to polymorphism's needs, and connects us to the Cyberspace.
- *A permanent inter-penetration with Cyberspace* — Collective Intelligence cannot exist anymore without exchanges through the Cyberspace. In it, the most advanced knowledge, the most fulfilling experiences can be found. In it, one can deposit its own experience, can communicate with others.
- *Personal development* — The evolution toward Collective Intelligence implies personal and societal transformations.

### 1.1.3 Human being as a 'decentralized center'

In the process of the Collective Intelligence, communication and its tools take a fundamental space. No Collective Intelligence is possible without communication. The Collective Intelligence can not be great if these tools are not adapted and efficient. This importance is not eluded by current societies and by industrial innovation which promoted continuously new networks for digital information to be always faster, always more numerous, and always more present. The famous information highways, the wifi wireless technology, the third generation cell phones are visible examples of this spectacular effort to create always more efficient communication tools for digital information and to ceaselessly push the quantitative and qualitative limits of knowledge transportation.

The continuous development of these communication tools transform societies considerably. A new social shape is in development. To go further on the path to Collective Intelligence, a new social paradigm is necessary. It has the aim to reveal a society based on the knowledge and intelligence economy, including the Cyberspace as a space of knowledge sharing between individuals.

Two major aspects are involved in this paradigm: information, which travels across the Cyberspace, and individuals, of which each emits and receives this information. Thus, the individual is an active decentralized 'center' of this paradigm, able to share and to receive knowledge emphasized by one's experience. Therefore, the success of this society, based on the knowledge and intelligence economy, depends on the quality of the link between one's knowledge and experience and on the ability of everybody to communicate with each other. In this Chapter, I focus on this relation that requires the consideration of human's subjectivity. This implies the consideration of *Kansei*'s influence on this relation, and thus, by extension, on communication.

## **1.2 *Kansei* influence on social context communication**

### **1.2.1 Diversity of knowledge**

#### **1.2.1.1 From knowledge to technological knowledge**

In the first place, knowledge can be briefly defined as the awareness and understanding of information gained by learning or experience, as a justified true belief. Knowledge differs with information in the way that knowledge has a purpose of use. In other words, knowledge is information with intention.

Focusing on technological knowledge, Baird [4] suggests an epistemic variation for what he calls the thing knowledge (which is called technological knowledge in this dissertation). This suggestion is explained well by Compton [39] as follow:

*Baird argues that whereas other domains (science for example) may hold to a 'justified true belief' or similarly propositional criteria for knowledge, in technology this should be replaced by an inter-*

*twining of a 'materials sense of truth with the notion of function'. Knowledge therefore, within the domain of technology, is validated not in relation to 'truth', but in relation to successful 'function'. The implications of this epistemological shift require a reconceptualization of the 'key features' of knowledge such as 'detachment, efficacy, longevity, connection and objectivity'. Baird explains how these features can all be explored in a material sense whereby truth is replaced by function.*

Therefore, the knowledge focused on is the one describing “how it works”, or “how it goes”, more than “how it is”. To understand how knowledge and *Kansei* are related, we will focus now on the nature of technological knowledge. This is important to differentiate the knowledge that can be articulated (related to Chisei [141]), from the one that cannot (related to *Kansei*).

### **1.2.1.2 Nature of technological knowledge**

Technological knowledge is composed of three categories [102, 246]:

- *Descriptive knowledge (DK)* represents statements of facts, such as technical information, quantitative data or artifact properties. It approaches an approximation of the formal knowledge of a 'discipline' since it describes things as they are, it can be in the form of rules, abstract concepts and general principles. It has often a consistent and comprehensible structure.
- *Prescriptive knowledge (PK)* results from the successive efforts to achieve greater effectiveness, such as improved procedures or operations, and is altered and added to as greater experience is gained. Prescriptive knowledge generated through experimentation, trial-and-error, and testing is used in specific ways to make predictions at a pre-theoretical level [167]. Because prescriptive knowledge is less wedded to scientific principles and law, and because it is an outgrowth of specific application, it is not easily codified in a general form, and therefore it is less amenable to the formulation of instructional generalizations that go beyond a particular activity. The easier a knowledge is codified, the easier it can be transmitted [196].

- *Tacit knowledge (TK)* is implicit. It is largely the outcome of individual judgment, skill or practice. It cannot be perfectly expressed formally. Supportive items, such as diagrams or pictures can only partially explain tacit knowledge. Moreover, they are largely results of individual practice and experience. Tacit knowledge is close to prescriptive knowledge in the way that both are procedural [246]. Tacit knowledge is personal, subjective, and immediate.

The two first knowledge categories are sometimes gathered in one category called explicit knowledge. In this two-category representation, implicit knowledge is defined as the one that is initially inaccessible to the person to whom it is attributed, and as such unable to be articulated [6]. Then, explicit knowledge is the one that exists in an accessible form, i.e. being able to be articulated, and implicit knowledge is the one that cannot be articulated fully. Nevertheless, to describe more in-depth, the two-category representation would require the specification of subcategories. These subcategories are introduced by Vicki Compton [39] and will not be detailed in the current study.

Each cognitive activity, each reaction, involves necessarily these three varieties of knowledge. One's experience (related to tacit knowledge) is influencing one's own motivation to focus and remember descriptive or prescriptive knowledge, such as a mathematics demonstration. Also, descriptive knowledge may help to deal with one's feelings and to elaborate an appropriate behavior (e.g. National laws to prevent personal revenge as a justice). In a real context, these three varieties of knowledge cannot be distinct.

## **1.2.2 *Kansei* and *Kansei* Information**

### **1.2.2.1 *Kansei***

Looking for a comprehend definition of *Kansei*, Harada collected definition of the word *Kansei* provided by researchers involved in the research related to *Kansei*, and analyzed the responses statistically. The figure 1.1 shows the resulting graph of the cluster analysis made on the keywords output from researchers' answers. The axis X (axis 1) is interpreted as a logical-psychological axis and the axis Y (axis 2) as a subjective-objective axis. Then, Harada proposed five major dimensions of *Kansei* [97]:



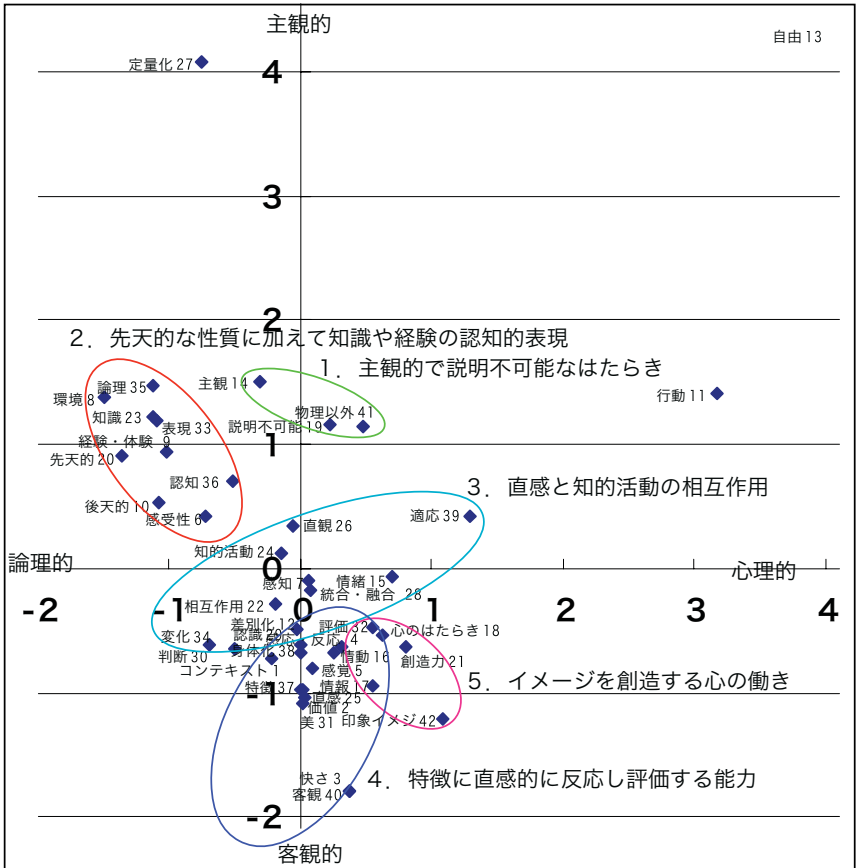


Figure 1.1 | Scatter Graph of Keywords of Kansei definition [97]

- *Kansei* is a subjective and unexplainable function.
- *Kansei*, besides its innate nature, consists of the cognitive expression of acquired knowledge and experience.
- *Kansei* is the interaction of intuition and intelligent activity.
- *Kansei* is the ability of reacting and evaluating external features intuitively.
- *Kansei* is a mental function creating images.

This proposition of definition of *Kansei* shows the multi-dimensionality of *Kansei* and is composed of multiple elements such as ‘subjectivity’, ‘expression of the inner (knowledge and experience)’, ‘intuition and intelligent activity’, ‘reacting toward external stimuli’, ‘reflective images’. Then, *Kansei* is an internal process (or function) of the brain, involved in the construction of intuitive reaction to external stimuli.

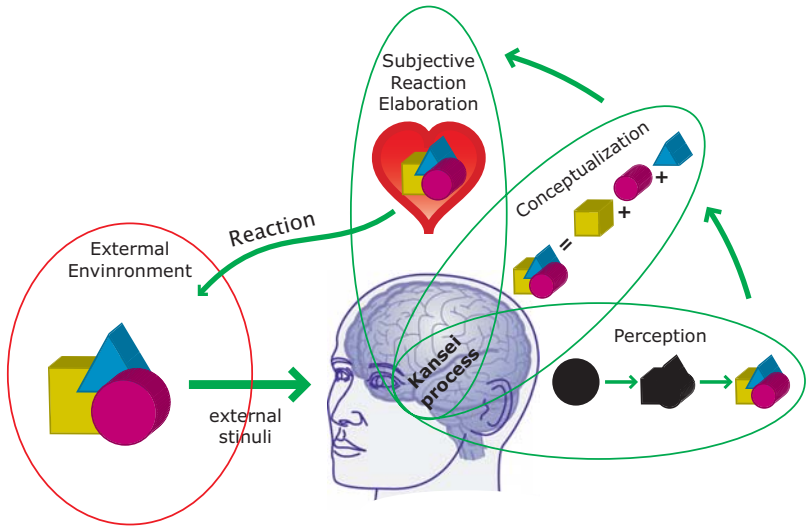
When a human receives an external stimuli (received by one of the five senses), it is perceived intuitively<sup>3</sup>. Then the perceived information is conceptualized by comparison with knowledge or experience acquired for a long time, inducing a reaction<sup>4</sup> (cf. Figure 1.2). This process shows the need of various disciplines to approach *Kansei*: design is concerned with the creation of artifacts which are perceived; cognitive sciences are concerned with the information processing; psychology is concerned with people’s knowledge and experience; anthropology and behaviorism are concerned with human reaction and behavior.

In most of the English literature, *Kansei* is assimilated to subjectivity (or related words such as emotion or affect). As notices Yoshikawa, subjectivity is

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3 For a detailed description of the intuitive perception process, please cf. section 6.1.1, p.135.

4 Lee [139] proposed a supplementary step between the comparison and the reaction ones. Indeed, he added that the human creates subjective image by interacting between intuition and intelligence [139, p.190]. According to the study presented section 6.1.1, p.135 on intuition, I consider that this step should be integrate to the former one (conceptualization). Also I argue that the image is not the only material that can be used by human, but also words. Images are used in the case of intuitive conceptualization by visual modality, and words by auditory or verbal modality.



**Figure 1.2 |** Process of *Kansei*

	Exclusion	Consideration	Focus
<b>Core fields</b>	Natural sciences	Fuzzy theory Psychology	Subjective Information Processing
<b>Attitude to subjectivity</b>	Lack of subjectivity	To be considered	Focusing on
<b>Problems</b>	Gap with real issues	Uninformative to treat	Unfamiliar & Unorganized

**Figure 1.3 |** Transition of evaluation of subjectivity in natural sciences [258]

different from *Kansei* in the way that subjectivity does not include only mental feature, but also all individual differences in processing results [258]. *Kansei* is a Japanese word that does not have proper equivalent in English. I would describe it then as close to ‘mental sense of subjectivity’, being a higher order function of the human brain. This cognitive function is taking part to all cognitive processes in which subjectivity is involved.

### 1.2.2.2 *Kansei* Information

In addition to *Kansei* Engineering, *Kansei* had been greatly involved also in information processing, structuring *Kansei* Information. When considering information processing, it is obvious that subjectivity is one of the most inherent human characteristics. But the consideration of subjectivity in natural sciences came progressively, as Ayumi Yoshikawa showed it [258] (cf. Figure 1.3):

- Most scientists attached great importance to objectivity of information, excluding subjectivity. Subjectivity was seen as objective information that lacks generality and covers only uncertain information. This complete exclusion of subjectivity brought some issues, such as differences in findings between theory and reality.
- Then subjectivity came into consideration of scientists, thanks to frameworks provided by theories such as fuzzyset theory. These theories, techniques and tools provided researchers the possibility to treat subjectivity, to obtain subjective findings, but not the knowledge of how to apply them.
- Finally, some fields such as human information processing fully integrate subjective aspects and express the necessity to treat it, and even to focus on it. All fields related to *Kansei*, such as *Kansei* Engineering or *Kansei* Information, intend to integrate fully human subjectivity in their process.

*Kansei* Information is the part of *Kansei* studies that is interested in the way human brain processes information. When human captors (eyes, hears, nose...) receive a stimulus, they transform it into electric current sent to the brain. This electric current is chronologically the first information *Kansei* Information is interested in. Any information entering the brain provokes a cognitive process which ends on a brain reaction. This reaction may not have a consequence such as

visible or conscious behavior, but still, it does exist. *Kansei* is involved in this process starting from the first information arrival and ending on the reaction. *Kansei* Information is aiming at figuring out this process.

### **1.2.3 *Kansei* Information and communication**

#### **1.2.3.1 Subjective Information Processing**

Information processing by/in humans originates from mutual communications [258]. It is associated with formulation and interpretation (cf. Figure 1.4). As the transmitter (or sender) and the receiver are two different human beings, their personalities, their recognition (understanding and semantic sense) toward received information are different. These differences are at the origin of subjectivity in the communication process.

At a social level, communication process gains in fuzziness. Firstly, the great quantity of information flow to receive, to manage, and to transmit has a tense impact on human behavior in a social context. Secondly, society owns numerous communication methods increasing the diversity of subjectivity. These two factors show that social context communication is even fuzzier and subjective than in a mutual communication.

Nakamura [179] proposed a classification of fuzziness according to three categories:

- Perspective is related to synthesis of information. It aims at providing a more adequate and more effective information. It is about conceptualization (groups of elements based on their similarities or differences (cf. part 6.1.1.2, p.141)), about approximation (grouping elements making their meaning vague), and about summarization (extract important parts of their meaning for quicker and easier understanding).
- Flexibility is related to interpolation of information. When a part of the information is missing or uncertain, a complement is added to improve the efficiency of the information. This interpolation can be elasticity (expand meaning

depending on the context), plasticity (adapt gaps using one's experience), or interactivity (learn how to treat unknown elements by trial-error process).

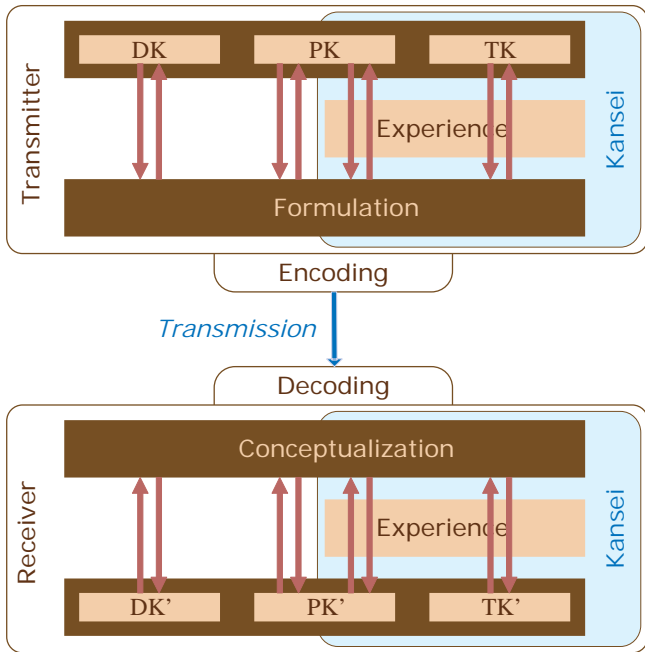
- Subjectivity is about the influence of emotion, intuition, *Kansei*, belief, etc... on information processing. It has a great impact on the differences in judgment and evaluation of the same element by different people. It concerns believability (processing information based on understanding and belief ), intuitiveness (processing information based on intuition, association and ellipsis), and emotionality (processing information based on emotion).

The later part, in which *Kansei* and intuition are involved, is the main interest for this study. Therefore it is necessary to consider subjective information and subjective information processing. The definitions proposed by Ayumi Yoshikawa are as follow:

Subjective information is defined as information that is originated in individual standards concerning judgment, definition or concepts, and methods for processing information. Subjective information is divided into following two kinds of information: one, containing subjectivity, and the other, processed subjectively. In a broad sense, any information is classified as subjective information because any information communicated in the real world is made by humans.[...] Subjective information processing is defined as both analyzing subjectivity in human information processing and applying the results to various fields. According to above definition of subjective information, subjective information processing is also divided into following two approaches: one is to analyze subjectivity within information and to apply the results to real applications. The other is to analyze methods of information processing subjectively done by humans and to apply the results.

### 1.2.3.2 *Kansei* impact on communication

While considering the Figure 1.4, the indirect impact *Kansei* has on the interpersonal communication process is immediate:



**Figure 1.4** | Influence of *Kansei* in the communication process

- On the first hand, when the transmitter formulates any artifact<sup>5</sup> (such as an idea), she/he requires acquired knowledge during the formulation process. As described in the section 1.2.1.2, three kinds of knowledge are involved: the explicit one, the prescriptive one, and the tacit one (respectively representing by EK, PK, and TK on the Figure 1.4). Experience is highly related to tacit knowledge, and partially to prescriptive knowledge. Experience can be the one that has been the event providing the individual to gain this knowledge, or it can be the current one in which the individual is trying to formulate the artifact in order to transmit it. In the first case, experience influences the way knowledge is acquired and then remembered through *Kansei* [177,163]. In the second case, experience is used in the memory reaggregation in the process of formulation [177]. In both of these processes *Kansei* is involved since *Kansei* and experience are fundamentally linked. Therefore, *Kansei* has an impact on the transmitter's content formulation.
- On the second hand, after the receiver received the information, he/she decodes it in order to obtain a meaning (conceptualization). As explained in the section 1.2.3.1, the interpretation of this information is at least partially subjective and is depending on the context the information is acquired. Thus experience and *Kansei* are also involved in this process. Note that the receiver's knowledge is noted DK', PK', and TK' to differentiate it from the transmitter's one.

Since it was shown that *Kansei* is involved in both content formulation and content understanding of an interpersonal communication, we can conclude that *Kansei* has an impact on communication process itself. Its impact is not direct since *Kansei* is not involved in the information flow itself, but on the way information is formulated and then understood. That is all the more important since the content of the information and its understanding is influencing human reaction, influencing then social behavior, influencing finally the social context itself (its structure and its way of being processed). Therefore, the impact of *Kansei* on the society and the way information is transported and understood should not be neglected. In this way, *Kansei* Information appears as an inter-

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5 'Artifact' means here human construction, to be opposed with the Nature construction. It gathers objects, processes, services and their systems.



esting path to solve some of the issues related with human subjectivity in the project of building the collective intelligence society.

### **1.3 *Kansei* Information contribution to collective intelligence**

#### **1.3.1 The role of the individual in the Collective Intelligence society**

The Collective Intelligence society is a proposition aiming at restructuring the process and the purpose of social interactions, developing and widening the concepts related to communities in the cyberspace. However, the elementary particle of these communities is similar to the one of actual societies: the human being. The identity, the originality, and the behavior of each one structure and define the society or the Cyberspace's community in which one is and communicates. In the Collective Intelligence society, one can interact and share one's knowledge directly with all others through the Cyberspace, beyond institutions or delegations. In other words, one can participate individually, for the benefit of all, to the elaboration, the development, and the functioning of the Collective Intelligence society.

Considering the individual as the motor and the elementary particle of the Collective Intelligence society, understanding human beings in all their dimensions, and considering them fully are essential to conceive cleverly the Collective Intelligence society and its tools. The individual, as a topic of research, has to be considered by all its dimensions since its entire being is participating and is influencing the social interactions, i.e. the information flows in the cyberspace and the functioning of the Collective Intelligence society itself.

#### **1.3.2 Toward the contribution of *Kansei* Information**

As described in the section 1.2.2, *Kansei* is an original approach to understand human subjectivity and its influence on communication. Therefore, *Kansei* can be proposed, and so it is in this dissertation, as a relevant approach to understand some of the basics of the Collective Intelligence society: the one related to the human's *Kansei* and subjective behavior.

Considering this first proposition, *Kansei* Information can then contribute efficiently to the design of communication tools for the Collective Intelligence. Indeed, thanks to *Kansei* Information, human's *Kansei* and subjective behavior can be taken into account for a proper and relevant design of communication tools considering fully the dimensions of the Collective Intelligence. This dissertation aims at applying this major consideration, i.e. the potential contribution of *Kansei* and *Kansei* Information to the Collective Intelligence, to design efficient communication tools for the Collective Intelligence society.

## ***Chapter 2***

### **Objectives of the study**

The previous chapter showed the role that *Kansei* Information could have to contribute to the development of Collective Intelligence. It would focus on the human being as is, considering all its dimensions, and on humanity, considering all its diversity. Starting from these considerations, this study intends to understand how *Kansei* Information can contribute to the creation of a design method for Collective Intelligence (and therefore intrinsically of an interdisciplinary nature), and thus to the improvement of communication structures of interdisciplinary groups. Detailing this global objective thanks to a step-by-step structure, following sub-objectives are enunciated:

- Objective 1: To understand how design, thanks to an interdisciplinary approach, can participate to the development of the Collective Intelligence — The opportunity, created by the possible contribution of *Kansei* Information to Collective Intelligence, to follow a new path for design exists and should be taken further. Then, the objective of a design in and for the Collective Intelligence would be to propose solutions for human beings as is, considering all its dimensions, and for humanity, considering all its diversity and its environment. To reach such an objective, two steps are required:
  - Objective 1.1: To understand not only the strength and the originalities, but also the issues and the risks, of an interdisciplinary design approach — In the first step, it is required to understand the necessity of an interdisciplinary approach when participating to the development of Collective Intelligence. Design requires an interdisciplinary behavior, and thus interdisciplinary design has to be defined and characterized, considering its complex information structure.
  - Objective 1.2: To propose an interdisciplinary design methodology in the context of Collective Intelligence — In the second step, once interdisciplinary design is defined, it is required to provide a methodology, for it to be able to operate efficiently. This methodology helps the design to enforce

its interdisciplinary quality, and thus to output interdisciplinary design solutions, while solving the issues related to interdisciplinary workgroups.

- Objective 2: To develop a tool to communicate in an interdisciplinary workgroup — In order to illustrate and bring the findings to a concrete level, the final objective is to design, up to the definition of the functional and technical requirements, a communication tool for the interdisciplinary workgroup to work in a framework based on Collective Intelligence. This design would use the interdisciplinary design method to create a tool for interdisciplinary workgroup. Therefore, this final objective aims at designing a tool complementary to the method, and thus empowers interdisciplinary design to a fully operative design process.

## ***Chapter 3***

### **Structure of the dissertation**

The structure of this dissertation is built with the purpose to reach each objective described in the previous chapter. From the list describing the objectives step by step, the structure can be shown (Figure 3.1 (p. 68) illustrates this description):

- The current part (Part A) introduces the study. It establishes the context, the objectives, and also the method used to attain these objectives. The definition of the context aims not only at stating the global and contextual problem of the current study, but also at vindicating a *Kansei* study approach of the present study: *Kansei* Information may profit to the development of Collective Intelligence.
- The Part B intends to define and to structure methodologically interdisciplinary design. This proposal is seen as a relevant design approach for the issues raised by the Collective Intelligence and not solved by currently existing design approaches.
  - In the Chapter 4, the term design is first defined, and then characterized as a discipline. These are necessary elements to define, thanks to an object approach, the concept of ‘interdisciplinary design’. This chapter is finally concluded by an experiment aiming at ‘*Kansei* mapping’ an interdisciplinary industrial workgroup to illustrate the subjective dimension and the complexity of interdisciplinary approaches. — Objective 1.1
  - The Chapter 5 focuses on the challenges of an interdisciplinary workgroup. For this purpose, the term ‘interdisciplinary’ is characterized and compared to other ‘pluridisciplinary’ terms, such as ‘multidisciplinary’ or ‘transdisciplinary’. Then, main issues existing in interdisciplinary context are analyzed, especially the one concerning knowledge sharing and communication. This chapter ends with a summary and a structure of these issues.

- The Chapter 6 intends to propose a solution concerning the issues raised in the previous chapter: a methodology for interdisciplinary work, and especially interdisciplinary design. The mental process of intuition is detailed in order to evaluate the opportunity to use it as a solution to the issues raised in the chapter 5. Then, the concept of *ba* and the SECI model are described as a base for the interdisciplinary design methodology. Finally, the methodology is described and vindicated. — Objective 1.2
- The Chapter 7 proposes a conclusion and a reflection on the methodology, analyzing its strengths and its dangers. — Objective 1
- The Part C is a design project using the methodology proposed in the Chapter 6. This design aims not only at illustrating the methodology, but also at providing the interdisciplinary workgroup a communication tool (called *MATiK*) to be able to work efficiently in accordance with the methodology, in the context of Collective Intelligence. — Objective 2
  - The Chapter 8 intends to introduce *MATiK* and to point out its originality. The requirement for a new generation of communication tools in the Cyberspace is shown, and currently existing or developed tools are analyzed. An comparison with these tools checks and defines the originality of *MATiK*. This chapter ends with the characterization of this originality.
  - The Chapter 9 starts the application of the methodology introduced in the Chapter 6. The method is started and validated. The originality of *MATiK* is analyzed by the methodology to obtain an intuitive understanding of it. The ideation and the originality of *MATiK* are then understood by the interdisciplinary workgroup, itself designer of *MATiK*.
  - The Chapter 10 continues to use the interdisciplinary design methodology in order to specify the functional requirements. Cognitive approach of communication is required to validate the propositions made intuitively thanks to the methodology. The cocktail party phenomenon is described cognitively and systemically. The chapter ends with an experiment using a psycholinguistics approach (with event-related potential (ERP) technique) to quantify some characteristics of the functional requirements. This shows

that even if the methodology is based on subjective elements, it does not prevent quantitative information to be used in the design process.

- The Chapter 11 proposes to go on the design process for the technical requirements of *MATiK*. For this purpose, multiagent technology is introduced and its relevancy for the design of *MATiK* is evaluated. Also, the mutual interest between *Kansei* Information and multiagent systems is analyzed. Then, the way a multiagent system could be used in *MATiK* is proposed. This chapter ends on the proposition for an original kind of experiment: a *Kansei* Information experiment for information science.
- The Chapter 12, the final one, proposes a reflection on *MATiK* and its design process thanks to the interdisciplinary design process. Questions frequently asked during my presentation on *MATiK* are resumed and answered.
- The Part 13 gathers the global conclusion and further considerations of this dissertation.
- The appendix presents additional data used for the experiments.

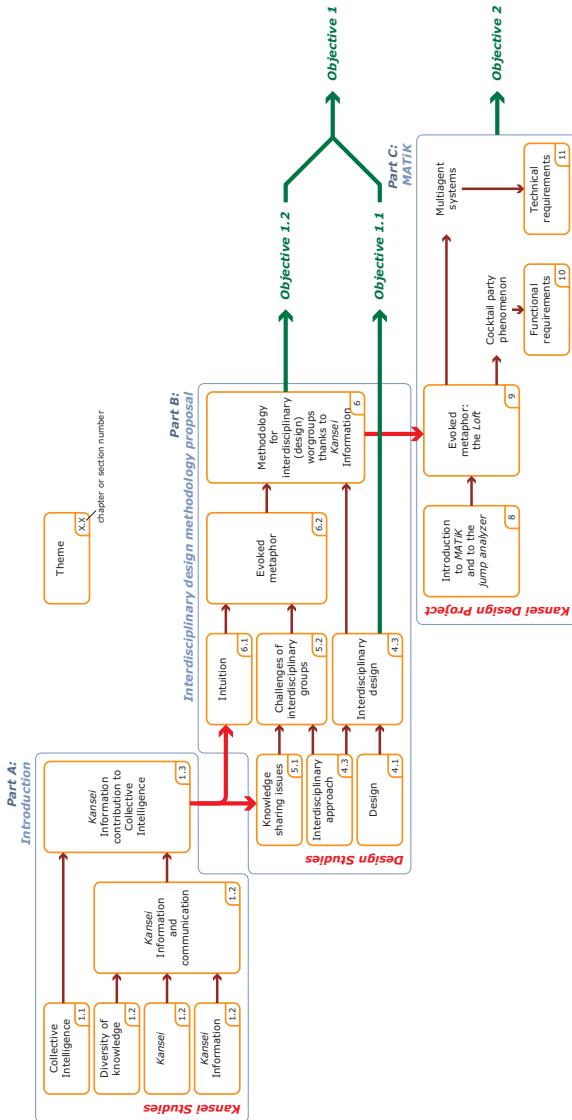


Figure 3.1 | Thesis flow structure





## **Part B | Design Method**

In the chapter 1, it was shown that the consideration of subjectivity in human behavior was required as a design constraint for communication, share and exchange tools for the cyberspace. Also, as such kind of design required consideration of the users' subjectivity, subjective approach has to be thought as a key innovation in design methodology to favor the success of future tools for the cyberspace.

*Kansei* was introduced as an original and relevant approach for such problematic. *Kansei* information design can help to elaborate solutions, with structured methodology, for the design and evaluation of tool for the cyberspace. There are currently few *Kansei*-participative approaches for tool and method design aiming at understanding better human subjectivity and behavior, and at inputting this understanding in decision making for product design.

We propose hereby to develop a methodology including *Kansei* approach considerations in interdisciplinary design methodology. After a short loop around interdisciplinary design, we will show how *Kansei* approach can help to concrete its methodology, and make possible its application. This explanation will then be used, from the following part: the conception of *MATiK*. Actually it appears that the first *Kansei* design application is more a praxis<sup>1</sup> than a practice of the method, in the way that this application helped to elaborate the present proposal.

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1 Praxis is practice in the way that it instructs theory.



# Chapter 4

## Interdisciplinary design

*All men are designers. All that we do, almost all the time, is design, for design is basic to all human activity. The planning and patterning of any act toward a desired, foreseeable end constitutes the design process. Any attempt to separate design, to make it a thing-by-itself, works counter to the fact that design is the primary underlying matrix of life. Design is composing an epic poem, executing a mural, painting a masterpiece, writing a concerto. But design is also cleaning and reorganizing a desk drawer, pulling an impacted tooth, baking an apple pie, choosing sides for a backlot baseball game, and educating a child. Design is the conscious and intuitive effort to impose meaningful order. - Victor Papanek [194]*

### 4.1 Defining Design

Defining design has been an incessant and evolutionary question. Over time, many design movements proposed numerous ones. Currently, the International Council of Societies of Industrial Design (ICSID) defines design as follow [111]:

*Design is a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles. Therefore, design is the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange.*

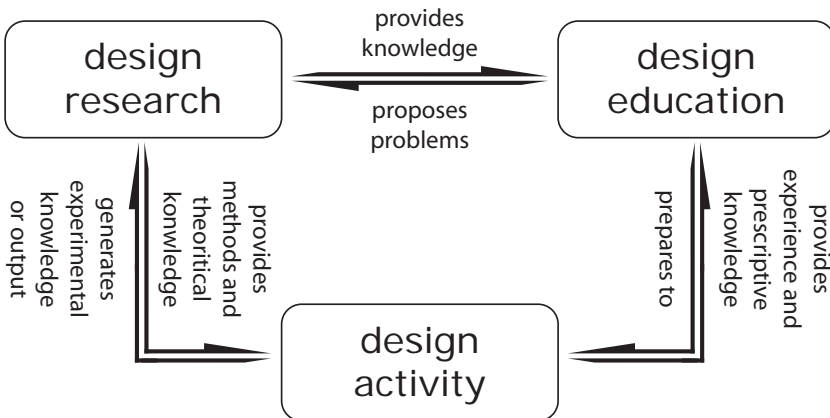
Design is a comprehensive creative activity such as described by the aforementioned definition. It focuses on human, environment, and artifact<sup>1</sup> [164] and their links in order to establish adapted artifacts usually called innovations. Nevertheless, development of design brought a global problem of understanding

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<sup>1</sup> As already defined page 58, 'artifact' means here human construction, to be opposed with the Nature construction. It gathers objects, processes, services and their systems.

links between human beings, artifacts, and environment in the scope of design (also called the world of designing), and thus of elaborating more relevant design paradigms, processes, and methods. Going further in this consideration, Reymen [209] proposed a definition of the world of designing, gathering three fields linked by design knowledge (cf. Figure 4.1):

- Design activity applies and generates knowledge by practice. It applies knowledge created by design research or generated by itself, and taught in design education. It provides experience (prescriptive knowledge) for education and practical feedback for research.
- Design research produces this knowledge (by itself or together with design activity). It develops theories, processes and methods by praxis, theoretical approaches or observation on education and design activity. It provides this elaborated and formalized knowledge to design education and activity.



**Figure 4.1** | The fields of design (inspired from [209])

- Design education transfers this knowledge to future designers (aiming at working as professional designer in a design activity). Design education also provides information to design research in order to create new problems and original answers.

This observation has the advantage to be comprehensive, simple and yet very close to reality. Getting more precisely in the definition of design would complicate the understanding of the concept drastically without bringing much more relevant information, which is not wished in the present study. Thus, we propose here to start from the ICSID definition and from Reymen's proposition in order to propose a deeper reflection on design and its structure.

One of the most confusing aspects of the term 'design' is its multi-applicability. It can be an activity or a practice, an artifact, solutions proposed by the activity, an input into the artifact, a state of the entity that will become the artifact, or the research field (interested into methods for the activity and artifacts). Jane Hesketh [103] summarized this point with some humor by saying 'Design is when designers design a design to produce a design'. But through this multiplicity of meanings, there is one common: design concerns and is concerned by the World of Artificial, its knowledge, and its links with people. It is about organizing in the world of artificial, about structuring its knowledge, and about keeping it being what it is created for: an extension for human being as it is in the natural world [208]. That is well explained by the ICSID definition: design is the central factor of innovative humanization of technologies.

Thus design is about organizing the World of Artificial. Herbert Simon separates the world into the natural one and the artificial one. Natural science is knowledge about the natural objects and phenomena [225, p.6]. Man-made world is composed of artifices, or artifacts<sup>2</sup>, gathering artificial and synthetic elements. The engineer, and more generally the designer, is concerned with how things ought to be - how they ought to be in order to attain goals, and to function [225, p.7]. Artifacts (artificial things) are characterized as follow [225, p.8]:

- Artificial things are synthesized (though not always or usually with full forethought) by man.

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2 as defined in this dissertation on page 58.

- Artificial things may imitate appearances in natural things while lacking, in one or many respects, the reality of the latter.
- Artificial things can be characterized in terms of functions, goals, adaptation.
- Artificial things are often discussed, particularly when they are being designed, in terms of imperatives as well as descriptives.

From these characteristics, the following statement can be output: Artifacts are designer-made elements aiming at reaching a goal and processing a function. Designers are the ones which device courses of action aimed at changing existing situations into preferred ones [225, p.129]. So considered, design is not restricted to engineers and so called designers, but embraces any intellectual activity producing artifacts, giving meaningful order to any system. We finally return to the definition proposed by Victor Papanek and cited on the beginning of this chapter:

*Design is the conscious and intuitive effort to impose meaningful order [194, p.4].*

Design is a conscious and intuitive effort. Papanek characterizes the effort of designing by two aspects: the conscious and the intuitive ones. Consciousness implies intellectualizing, cerebration, research, and analysis. It is highly related to descriptive and prescriptive knowledge<sup>3</sup> (gathered in the term ‘explicit knowledge’). Whereas intuition<sup>4</sup> [...] affects design in a profound way, and is related with tacit knowledge.

Design aims at imposing meaningful order to the world of the artificial, the one created by humans for human kind. The term ‘meaningful’ is extremely important since it gives to design all its reason of being, its ethic and its duty to societies. Indeed, it explains that this order should be made with a proper target: it is not about bringing new elements if these are not improving humankind’s condition and relationship with the environment and nature. As an example, disposable tissues may not be considered in one way as a correct design innovation since

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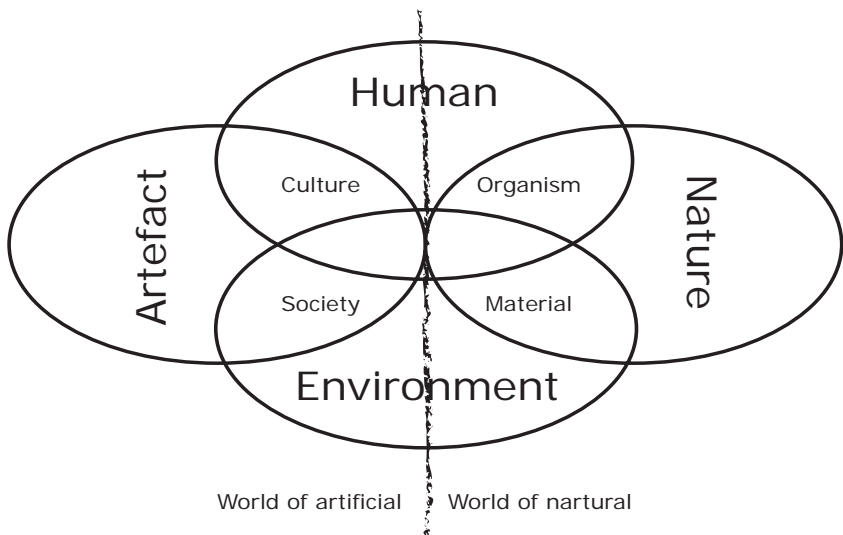
3 The terms descriptive, prescriptive and tacit knowledge are defined at the chapter 1.2.1.2.

4 The concept of intuition will be deeply developed in the chapter 6.1.1.



they are not more useful than handkerchief, and create environmental issues. But they may be considered better design in another way since they improved personal hygiene of everyday life. It is through design that human beings take the responsibility of structuring the world by making design decisions, while increasing its influence thanks to the artificial. And since the world is becoming more and more artificial, less and less natural [164, p.120], this concern of design ethic should be more and more considered by each designer, for each design. That is becoming all the more important now that artificial world is taking over natural one by biosciences and biotechnologies such as genomics [241].

The figure 4.2 intends to conclude the current definition of design by a comprehensive illustration. To synthesize this part, the description of the entire world could separate into two parts, the Natural World and the Artificial World, and composed of four main elements: Nature, Artifacts, Humans and Environment. The natural world is composed of all the natural objects and phenomena, whereas the artificial one is composed of all artifacts. Nevertheless, elements are not simply shared among these two worlds. It is immediate that Nature (i.e.



**Figure 4.2** | Paradigm for design

natural objects) is part of the natural world and that artifacts are part of the artificial one. But Humans and Environment are parts of both worlds, actually created interactions between the two worlds. Human beings (Homo sapiens) are part of the natural world on the physical aspects (body), and part of the artificial world on the cultural or social dimensions. The Environment is also dual: part of the natural world because composed of eco-systems and natural materials, part of the artificial world since it is permanently structured for the profit of human beings (societies, artificial materials, pollution, etc. . . ). The role of design is to develop and to organize the world of the artificial. An artifact is made to reach one or more goals by processing one or more functions offered to human beings. These goals and functions are supporting the meaning of the design and of its output artifact.

Design holds a crucial role in the development of humanities and societies. Knowledge and methods involved in design should be understood more in order to improve it. This effort can be done by researching on design and by teaching it, thanks to the discipline of design. The following section (section 4.2) the design introduced and described as a discipline.

## **4.2 Design as a discipline**

Based on the point of view presented in the previous chapter concerning design, this part aims at defining design as a discipline more concretely, in order to introduce interdisciplinary design. Interdisciplinary design is defined as a design methodology based on not only design's knowledge and methods, but also on other disciplines' knowledge and methods gathered to propose new ways to investigate for innovative solutions [148]. In the first step, we will define quickly the term discipline. Then, by an artifact approach, interdisciplinary design will be structured, and the importance of such an approach in solving design problems will also be explained.

### **4.2.1 Definition**

The variety of definitions of discipline is numerous and it is not of the problem here to enter debate aiming at defining this term rigorously. We just intend to introduce basic and pragmatic criteria that could drive us to the basis of interdis-

ciplinary design. After defining the notion of discipline, it would be interesting to present how design had integrated academic world and had been accepted by it. Finally, a deeper characterization of design as a discipline will be done to make the link with interdisciplinary design.

Discipline can be simply defined by field of study [170] in the way that it is a field that has:

- Specific teachings.
- Specific research field and themes.
- Knowledge that is the content of teachings and are developed by research studies.

#### **4.2.2 Discipline of design**

Nowadays, design is recognized as an academic field. As other fields, it can be described the following three criteria listed in the part 4.2.1. In order to qualify design as a discipline, we propose here to detail the teachings, the research, and knowledge in the field of design.

##### **4.2.2.1 Historical approach**

Modern history of design started from a dynamic confrontation between the Art-and-Craft and Art Nouveau movements at the end of XIXth century. The Art-and-Craft (1860-1900) is an English movement favoring the craft by rejection of the industrial processes which are not able to produce pleasant products for the users. The Art Nouveau (1890 - 1910), from Belgium and France origins, aimed at proposing industrial solutions for product's aesthetic beauty improvement. Particularly modern industrial materials, such as steal and glass were used in order to reproduce curves and shapes of Nature. The concerns, brought by both of the movements, launched the starting point of industrial creative activity toward more aesthetic and pleasing industrial products [91, 204].

The Bauhaus movement (1919 - 1933) presents the first attempt to bring some theoretical foundations to this creative activity, thanks to a rational approach of

design (Grundkurs ) and to various theories such as perception theory, form theory, and color theory. This attempt was reinforced in the sixties by the Design School of Ulm (1955-1968). It proposed to bring to design knowledge coming from other disciplines, such as psychology, ergonomics or sociology. It proposed also to develop more and more objective design methods, using especially scientific approach. The consequences of this approach were the design of very neutral, rational, and often impersonal products. However this movement, thanks to its methodological approach, made it possible for industrial design to enter academic world during the seventies. During the same period, the interest for human science, such as semantics in the United States of America or the theory of product as a semiotic process in Germany, increased drastically [26].

Since the end of the nineties, various events have shown that industrial design has succeeded to enter and to be accepted in the academic world. Since the first design conference in 1999 at the State University of Ohio, and by the numerous knowledge bilateral exchange between industrial design and other fields [70] (data processing, engineering...), industrial design succeed to impose itself as a relevant field for the academic world.

In addition, Nigel Cross [44] noticed that industrial design has undergone a forty year long cyclic evolution:

- The Art-and-Craft and Art Nouveau movements (1880) launched the activity of industrial design.
- The Bauhaus and De Stijl movements (1920) started to attempt to establish scientific foundations to the Arts-and-Crafts tradition.
- The Design School of Ulm and the Design Methodology movements (1960) persevered and finally succeeded to set up industrial design as an academic field.
- Current works aiming at defining Design as a science (Science of the Artificial, cf. Chapter 4.3.1).

#### 4.2.2.2 Teachings in design

As it entered the academic world in 1970, design has been well established in educational systems. The theme of education in design has become also an unceasing topic in international conferences in design. However, the doctoral level in industrial design has not yet been fully developed. Its level of development depends mainly on the country. These differences are mainly due to the differences of view on the role of industrial design as a profession and its socio-economic impact [143].

As medicine, engineering or law studies, design educators think that design education has to benefit the professional activity. Each of these fields has a different level of outcome, and is separated from the professional activity, but all of them still support it. Currently, education is mainly structured on projects, aiming at educating students for the professional activity, more than for the research one. Nevertheless, research in design already exists and is structured mainly into two areas (these two areas are present in design education):

- There are the researchers considering design as a domain to study (cognitivists, psychologists, historian, etc. . . ). They are the pioneers in the academic research of design. They have a double function for design research. Firstly, they use their own disciplinary knowledge and methods and analyze design in their own disciplinary point of view and interest. This tends to create links between design and other disciplines, which is helping very much the insertion of design in the academic world, and also the emergence of interdisciplinary design (cf. chapter 4.3.1). Secondly, they drag a flow of knowledge that design gains and adapts to its own objectives, problems and methods.
- Then there are researchers coming from design which consider directly their own field as a research field. There are still few in this category. But this kind of researchers is essential to give design its status of academic field. All these researchers, coming from different backgrounds, are actively participating to the establishment and the enrichment of design education.

#### 4.2.2.3 Research in design

The dense and flourishing literature in this domain shows its great activity and complexity. Research studies in design are mainly of four types [209]:

- *Descriptive studies* - “What is design?” and “How people design?” are the main interrogations that descriptive research intends to answer. This concerns cognitive and psychological approaches on designers’ processes, specificities of design skills, design processes and organizations.
- *Prescriptive studies* - “How to design?” and “How to support design?” are main concerns of prescriptive studies. They gather strategies, methods, techniques and tools to do and to support design. Communication issues and computer use (which are the main focus of this dissertation) are among the main topics of prescriptive studies.
- *Philosophical studies* - “What is design?” and “What is, and how to evaluate, coherency in design?” are among the main concerns of philosophy in design. Fundamental (ex: research on the Artificial, differences and links with the Natural), epistemological (ex: nature of design knowledge), ethical (ex: responsibilities of designers), and methodological (ex: types of methods, problems and constraints) issues are addressed by philosophical studies in design.
- *Research on design education* - “How to teach design?” is finally the question that research on education is focusing on. It concentrates on methods, contents and tools involved in design education.

From these main categories defining design research, some themes can be pointed out (presented here by examples).

- *Philosophical issues* - Terence Love [155] examines philosophic problems related to the construction of a coherent and unified knowledge basis and a theory associated with the design methodology. Expressing the lack of philosophical, theoretical and terminological fundamental for design, he proposes definitions for fundamental concepts related to research in design and to the artifacts output from design process. Also he proposes to pursue reflection on epistemological and ontological issues for the construction of design theory.

However, two predominant paradigms exist in philosophy of design: the positivism and the constructivism, as described by Eide:

*Basic beliefs in the positivist paradigm are that the world is external, the observer is independent, and science is value-free; a researcher should focus on facts, look for fundamental laws, reduce phenomena to elements, and test formulated hypothesis; preferred methods are operationalizing, measuring, and taking large samples. Basic beliefs in the constructivist paradigm are that the world is socially constructed, the observer is part of the observed, and science is driven by human interests; a researcher should focus on meanings, try to understand, look at totality, and inductively develop ideas; preferred methods are establishing different views on phenomena and investigating small samples in depth [58].*

- *Artifact* - Lars-Erik Janlert [118] considers that artifacts, as human beings, have characters<sup>5</sup> and then develops an approach in order to allow design methods to gain a more comprehensive vision on the artifact. Other researchers, such as Herbert Simon (for *The Science of the Artificial* [225]) and Victor Margolin (for *The Politics of the Artificial* [164]) propose fundamentals to set up the research on the Artificial. The present dissertation actually proposes a design methodology for interdisciplinary design based on this theme: considerations on the artifact and its characters show the necessity of interdisciplinary attitude in design (cf. Chapter 4.3.1).
- *Methods* - Kees Dorst and Judith Dijkuis [56] propose, analyze and compare two paradigms based on epistemology, for describing design process: the rational problem solving and reflective practice:
  - The first paradigm is based on problem solving theories built en 1969 by Herbert Simon [225]. Design is seen as a rational process of problem solving (logical positivist point of view). It is the dominant approach for current existing design methodologies. Willemien Visser [247] brilliantly

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<sup>5</sup> Coherent set of characteristics and attributes that are applied to behaviors and presences, which is going against value, situational and functional systems, providing a basis for anticipation, interpretation, and interaction.

goes back over Simon's theory and shows its implication in product design methodology, notably on the cognitivist ergonomics point of view.

- Fourteen years later, Donald Schön proposed a totally different approach. He proposed design as a reflexive process (introspective). He deplored the fact that Simon's theory does not take into account the work of the actor (the designer) during the design process. The designer<sup>6</sup> drastically influences the design process itself. Issues are pointed out and analyzed thanks to the designer's vision. Methods to be used and solutions are depending on the cognitive path took by the designer (this path is itself depending on the skills and experience). Yet, the designer is an essential parameter in the design process, and cannot be ignored. Schön's paradigm has the great quality to be relevant for the study of design activity and for design education.

Kees Dorst described them as follow (cf. Table 4.1):

*In the paradigm of rational problem solving, design is seen as a rational search process: The design problem defines the 'problem space' that has to be surveyed in search of a 'satisfying' design solution. Seeing design as a rational problem-solving process entails adopting a positivist view of science, taking natural sciences like physics as the model for a science of design. There is a strong emphasis on the rigor of design research: Objective observation and logical analysis should lead to general, formal models of the design process. Simon quotes 'hard' models and methods, as are used in optimization, as prime examples of what a real science of design could and should be. In the reflective-practice paradigm, design is described as an activity involving reflective practice. This constructivist theory is a reaction to the problem solving approach, specifically made to address some of the shortcomings that Schön perceived in mainstream design methodology. Schön particularly objects to training programs for design that are defined in terms of generalities about design processes. He stresses the uniqueness of every design problem, and identifies the core skill of designers*

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6 Human being with professional skills adapted for design work.



**Table 4.1** | Two paradigms for describing design (from [209])

	<i>Rational Problem solving</i>	<i>Reflective practice</i>
<b>Designer</b>	Information processor	Person constructing his/her reality
<b>Design task</b>	Ill-defined, unstructured	Essentially unique
<b>Design process</b>	A rational search process	A reflective conversation
<b>Design knowledge</b>	Knowledge of design procedures and 'scientific' laws	Artistry of design: when to apply which procedure or piece of knowledge
<b>Example or model</b>	Optimization theory, the natural sciences	Art, the social sciences

*as their ability to determine how every single problem should be approached. Schön calls this the essence, 'the artistry' of design practice, and finds it unacceptable that this cannot be described in the prevalent analytical framework. To describe the tackling of fundamentally unique problems, Schön proposes an alternative epistemology of design practice, which describes design as 'reflective conversation with the situation'. His view on design research is modeled in accordance with the social sciences [55].*

- *History* - The great quantity of literature concerning the history of design is impressive, and shows the unceasing activity on this theme. Manfredo Tafuri was suggesting that the task of history is the recover, as far as possible, of the original functions and ideologies that, in the course of time, define and delimit the role and meaning of architecture [234, p.228] and add that we are obliged to see history not as a great tank of codified values, but as an enormous collection of failed utopias, failures and betrayals [234, p.230]. By these words, he means that history does not help for new concepts and new

design inspiration, but provide still existing issues and previous trials pushing the present to face problems and difficulties, and then to attempt to challenge them. Also, Cornelis Baljon [5] warns the need for a critical and ongoing study of the history of design history. If carried out in the light of concepts developed in philosophy of history (as the latter's empirical dimension, so to say), the project would be all the more fruitful. Then he proposes to include into education the familiarization with a limited range of styles and periods, i.e. with the canon. Thus the designer would first proceed to gain insight into mechanisms governing the choice of canonical artifacts, and then appropriate for him-self non-canonical territory of his liking.

- *Activity* - Notably for the improvement of tools and methods, various researches are focusing on design activity. For example, the research group ODIC [90] works on design tools development mainly based on semantic and sensory test analysis approach. Also Brijitte Borja de Mozota [16] proposes a reflection (and methodological basis) on design management in companies.

To finish the description of the discipline of design, our last focus should be on knowledge in design, which unifies education and research.

#### **4.2.2.4 Knowledge in design**

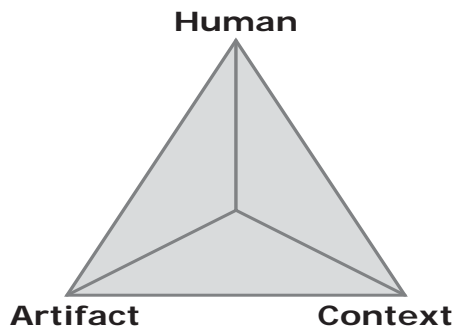
As seen on Figure 4.1 (p.74), knowledge unifies the two fields: education and research. It is the cement of between both.

Terence Love's [155] analysis points out the necessity of an ontology as the culminating key point for the building of a theory of design and determine a set of artifacts through a philosophical approach. In the manner of Terence Love's works [155, 156], studies based on the Maslow hierarchy need [15, 86, 137] show the existence problems of social, cultural, and potentially spiritual nature. They also show that design can greatly help to study these problems. Research in design tends to study not only each level of the hierarchy, but all the jumps between these levels.

Another interesting aspect of knowledge in design is the relation between the creator (or designer) and his/her environment. Churchill illustrated this notion by We are designing our buildings, and then our buildings shape us. This clearly

shows the interaction between design and sociology. This idea is very important for design since it points out that design activity goes beyond the short-time market and fashion constraints, which are often, but also awkwardly, considered as main basis of design activity. This implies that produced artifacts are more than simple goods, but they are the expression of human beings in their psychological, cognitive and spiritual dimensions. Yet, they express human values.

It appears that knowledge in design is related to a great varieties of problems. Thanks to a systematic approach, Terence Love [156] characterizes this knowledge according to three poles: Human, Artifact and Context (or Environment) (cf. Figure 4.3). Design would take any knowledge related to at least one of these three poles into consideration. That actually gather a lot of domains (cf. Table 4.2) which lead design to an interdisciplinary dimension. To increase knowledge involvement in design and thus to improve design process, it seems necessary to bring this induced interdisciplinary dimension of design to the foreground of the design activity, leading to interdisciplinary design.



**Figure 4.3** | The Triangle of Theories

**Table 4.2** | Areas of theories and discipline (from [156])

<b><i>Area of theory about designing and designs</i></b>	<b><i>Disciplines that address this area of theory</i></b>
<b><i>Behavior of individual humans</i></b>	Biology, Psychology, Anthropology, research into designing, History...
<b><i>Behavior of contexts</i></b>	Environmental Studies, Geography, History, Physics, Social Psychology, Sociology, Management, Business Studies, Systems...
<b><i>Behavior of objects</i></b>	Engineering, Natural Sciences, History...
<b><i>Human to human interactions</i></b>	Psychology, research into designing, Sociology, Anthropology, Social Psychology, History, Management, Soft Systems...
<b><i>Object to object interactions</i></b>	Engineering, Natural Sciences...
<b><i>Human and object interactions</i></b>	Æsthetics, Ergonomics, Philosophy, Psychology, research into designing, research into designs, Social Psychology...
<b><i>Human and context interactions</i></b>	Æsthetics, Ergonomics, Psychology, History, Geography, Philosophy, Social Sciences, Anthropology...
<b><i>Object and context interactions</i></b>	Engineering, Natural Sciences...
<b><i>Interactions involving human(s), object(s) and contexts together</i></b>	Æsthetics, Biology, Engineering, Environmental Studies, Ergonomics, Philosophy, Psychology, Natural Sciences, research into designing, research into designs...

### 4.3 Interdisciplinary design

The unceasing accession of the cultural and the communication exchanges in the world is described well by Frederico Mayor [242] by the following statement:

*One cannot limit the wind, one cannot partition the thought, one cannot simplify the complex without cutting the powerful wings of the creative capacity, which is the distinctive sign of the mankind, without mutilating the imagination, the invention, the capacity of innovation.[...] The future of the knowledge - as the future of the world - is mongrel, gradually mongrel. All the voices, all the musical ranges, all the cultures will intersect, take part, to control the extent and the complexity of reality. To follow rhythms of the life. To precede them - the key to success - and to make the most 'human' choice for the possible futures.*

Industrial design should point to this movement and get strength by the share of knowledge between the disciplines. It is industrial design's duty to learn from other disciplines in order to progress and then to make the product progress for a better 'human' future.

#### 4.3.1 Interdisciplinary design, artifact approach

When a product is described, whatever it is, it is of use to evoke its functional, formal, structural or material aspects. They are immediate aspects of the product. Recently (relative to the history of industrial design), the influence of the product on the five senses has been considerable [202]. To this are often added either more specific or more general aspects. Thus, one speaks about the ergonomics aspect and the emotional aspect of products [51].

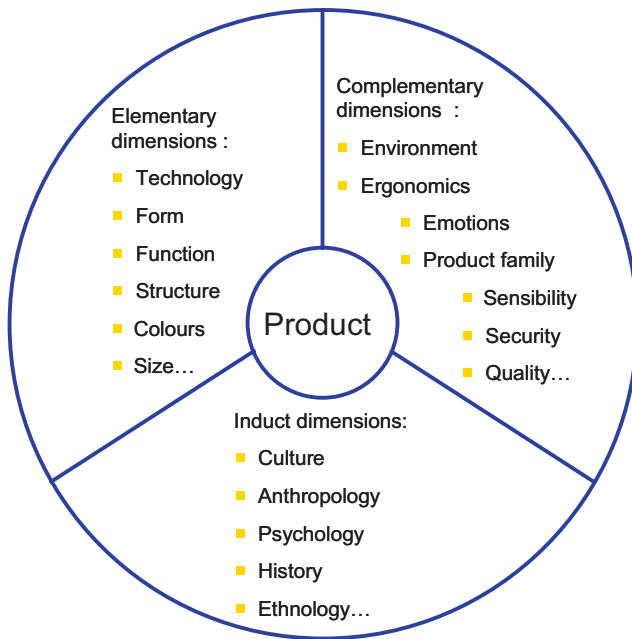
But beyond these immediate aspects of the product, there is a great quantity of other factors, which give meaning and identity to the product. A product can be separated neither from its design, nor from its manufacture, even from its use or from its disuse. It is thus inherently related on history, on the society and on the mankind (represented by its users, its designers and its producers). The artifact has also many dimensions of cultural nature (dimensions related

on the religion, the practice, the mood, the culture and the human knowledge), historical nature (the product is inherently binds to the historical and temporal context in which it is conceived) and technological nature (related to the state of the art of technologies).

The connection between the human being and the artifact is fundamental for both. The history of one of them was permanently related to the one of the other one [80]. This is all the more significant since the users ascribe to certain artifacts a sentimental value, a value of regard and characters similar to those which they can ascribe to their counterparts [118]. Actually, a strong emotional connection between the user and the product can exist. With the artifact are associated an identity and a meaning on the social standard. It is thus possible to consider factors of value, identity and symbol. These are the stakes and the consequences of the connection between the artifact and the society (or context), which emphasize the symbolic, social, anthropological, and even ethological aspects of the product.

Therefore, the product appears as an entity whose great complexity is due to its integration in the human society. That is what the designer has to face. He or she must take this variety of dimensions of the product into account and collect them together in order to design the product. But this point of view is theoretical. Whatever the designer is alone or within a design team, it is not realistic to expect that he or she would be able to take all these factors into account during its work. These factors can be gathered in three different factorial categories [148] (cf. Figure 4.4):

- The elementary factors are currently regarded as fundamental for the industrial design. These factors are consciously taken into account for each design. For instance, the functional, formal, anthropometric aspects of the product can be regarded as elementary factors.
- The complementary factors are recognized by the designer as significant concerns to the design work. However, these factors are placed on a second level compared to the elementary factors. The environmental and emotional aspects of the product are included in this category.



**Figure 4.4** | Product dimensions

- The induced factors are not consciously studied by the designer. Because of his or her human nature, the designer chooses intuitively solutions. The suggested solutions ensue primarily (not to say completely) from his or her own experience (cultural, historical or identical experience...). These solutions are exceptionally validated. Moreover, their relevance and their evolution are often hazardous. Theological or ethological dimensions of the product are induced factors in the majority of the designs of products, since even if the designer does not take them into account consciously, the product cannot get free from them.

### 4.3.2 Interdisciplinary design and knowledge sharing

The development of knowledge was conducted with the profit of disciplinary specialization, and vice versa. During the last century, the rate of knowledge advancement had declined due to the limits of each individual, as the knowledge of each individual was restricted to only his or her own specialization. This dam was to be overcome by the application of interdisciplinary research as an extension of each specialization, instead of a substitution [245].

The main concern encountered by interdisciplinary is the communication between the disciplines (their vocabulary and their visions). Whereas an 'interdisciplinary translation' is necessary, it can be in the meantime the reason of a failure of the interdisciplinary project. A translation provokes mandatory a loss of information, which can be fatal. However, as it remains inevitable, the interdisciplinary team has to assume this limit and cannot be released from it. The success of these translations will appear in the relevance of the results and in the consensus inside which the interdisciplinary team works. This consensus is not *'the result of a synthesis, but of a new meaning which emerged from the collective work, which was "co-produced", which derives from the new system of knowledge founded by the interdisciplinary practice'* [245].

This approach allows taking all the measurements of the interest of interdisciplinary in design. The designer does not acquire a too much quantity of knowledge, which he or she cannot fully comprehend. A design-centered interdisciplinary structure can be created to permit to choose judiciously new solutions for the design of industrial products. The 'interdisciplinary' solutions create (or emphasize) one (or several) solution for one of the factorial categories of the



product. These dimensions are complementary from the product elementary dimensions. This complementary is not distinctive: all these dimensions interact of course between themselves. The principal mission of the designer is to coordinate them in order to extract some new products, which improve in their social and human dimensions without disturbing formal, functional and emotional qualities of the product [242].

The study made by Rajic Urska on Japanese chopsticks [205] proposes a great example of interdisciplinary approach. Investigating on the opportunity of design improvements on such simple and traditional products which are Japanese chopsticks, she structures her work based on:

- historical, cultural and social aspects to understand the object of product;
- material, usage and environmental approach to describe the artifact;
- analysis tools to get more information on what happened with chopsticks in today generations and society.

This study is then concluded by design prospectation to provide hint and proposition for the design of chopsticks.

### **4.3.3 ‘*Kansei Mapping*’ experiment**

#### **4.3.3.1 Introduction**

Actually, the industrial world plunges the design activity into an interdisciplinary environment, at the intersection of marketing, design, and engineering. The objective to bring to the user satisfying products involves information tension and waves in the industrial process. Interrelations between marketing, design, and engineering becomes a necessity to support the continuous information flow, from the user’s understanding to the product distribution. Indeed, through the industrial process there are several concepts that may affect the information for planning, evaluating or innovating in product conception. Surrounding the user, there may be concepts as, for example, morality, social status or nostalgia, while some others such as innovation, efficiency or disposability, may come out from the product side.

In each particular case, even that the information is transformed, communicated or ignored, the evaluation of the connections of the marketer, designer and engineer vanishes during the process since the applied method for understand it, so far had been structured on a non-dynamic interpretation basis. Hence, the resultant product of the industry presents ‘misquality’, because of the sources through which it was conceived didn’t consider the real individuality of the involved professionals. Unfavorable interpretation of the information within the industrial activities affects the decisions of marketing, design and engineering, and therefore the final product suffers a miss-match with the one of the objectives of the company, which is to satisfy the user expectations.

According to *Kansei*, the human being is not universal but singular and so are the professional actors that participate on the development of the product. So, if considering also the fact that products have evolved within a range from tangible to intangible, therefore the approach for analyzing the industrial environment should be flexible in its structure, and consider the variability of perception of the individuals involved in each field related.

The objective of this experiment is to create an illustration (or map) of the interrelations between the three fields. This map, understandable subjectively, should provide a better overview of the relation between the three fields in order to improve interdisciplinary communication and cooperation.

This experiment had been presented under the title Illustrative Industrial Interactions Through *Kansei* — Toward a dynamic reflection of *Kansei* in the marketing/design/engineering relationship, in proceeding of the Sixth Asian Design Conference in Tsukuba, Japan in 2003 [215].

#### **4.3.3.2 Hypothesis**

In the scope of this experiment, we observe first that professional relations between the three fields are mostly built on standards. Personal perception is usually missing [99, 109]. Then showing the way actors perceive these relations would help reciprocal understanding. This improved situation would result in better adaptation of each other toward others’ point of view, improving greatly communication inside the workgroup and then efficiency of the latter.

Further considerations of the experiment would consider that, due to *Kansei*, there is a link (i.e. a correlation) between one's perception of professional inter-relations and one's personality.

#### **4.3.3.3 Method**

This experiment is composed of two steps: The '*Kansei* mapping' task and the '*Kansei* mapping' validation task.

##### **The '*Kansei* mapping' task**

This consists in generating a first map. This step requires knowledge from the three fields of marketing, design, and engineering. The three authors have the profile (by education and professional experience) to define the three concerned fields (cf. paragraph 4.3.3.4).

In order to obtain the liaisons between the three fields, we carry out a brain storming, using a method similar to the KJ one. From this session, keywords are yielded and clearly defined. These keywords, or concepts, represents various factors which has to be considered by one of the three fields.

To obtain an illustrative overview of the relations between marketing, design and engineering, we plan to map these concepts on a non-scaled perpendicular axes plan. The 'non-scaled' criteria is to assert the subjective approach of the problem. The axes are perpendicular because the definition of the two axes are independent. Indeed, the horizontal axis (Ox) considers the relative proximity of the concept between the user and the product, and the vertical axis (Oy) the 'level of tangibility' or 'level of abstraction' of the concept perceived by the mapper. The map in the Figure 4.5 provides an illustration of such a map.

##### **The '*Kansei* mapping' validation task**

In order to create a more comprehensive map, ten subjects are asked to create their own map based on the same concepts and the same coordinate system. The '*Kansei* mapping' validation task was done over the Internet, using

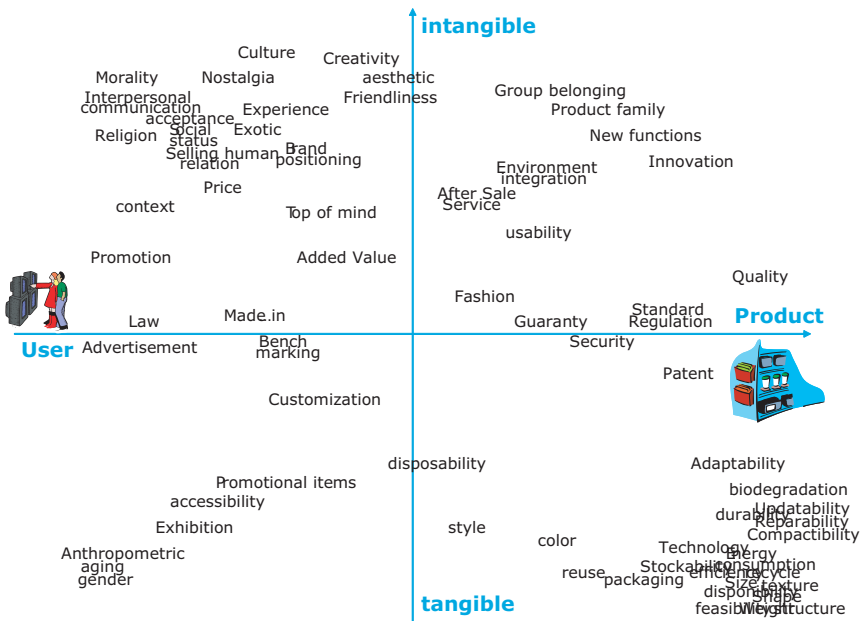


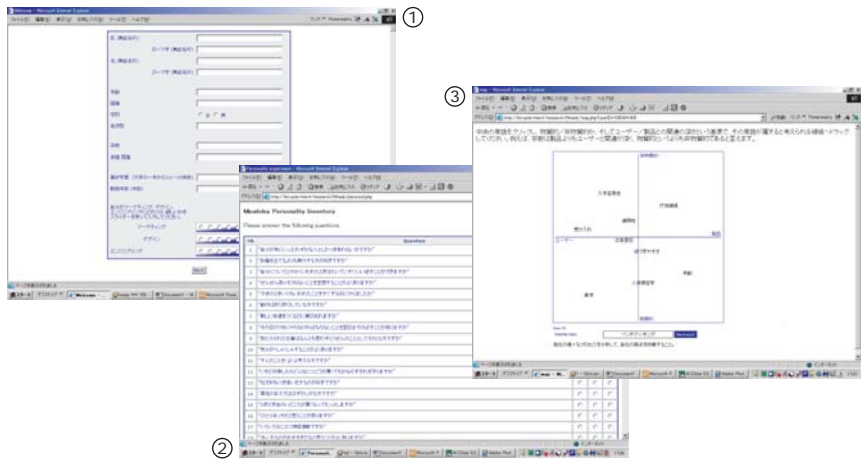
Figure 4.5 | First positioning of the concepts on the map

mainly a Macromedia Flash Player interface. In the first screen, subject are asked about (cf. screen 1 on Figure 4.6):

- some personal data (Age - 年齢, Gender - 性別, Nationality - 国籍, Religion - 宗教, Bloodtype - 血液型, Study level - 最終学歴, Work experience (in years) - 勤続年数, Marital status - 未婚・既婚);
- an evaluation of their activity concerning the involvement in the three fields: Marketing, Design and Engineering (‘自分がマーケティング、デザイン、エンジニアリングにどれくらい詳しいかをスライダーを使って入力してください。’), scaled from 1 to 10 (from low to high, respectively).

The second screen is a Eysenck Personality Inventory that will be discussed in the paragraph 4.3.3.6 (cf. screen 2 on Figure 4.6).

The third screen is the actual mapping task (cf. screen 3 on Figure 4.6). The sixty-seven concepts are shown to the subject who has to place them on



**Figure 4.6** | Screens for the ‘Kansei Mapping’ validation task

the map. The use of a Macromedia Flash interface provides complete freedom of placement for the user and digital records of concept coordinates for further analysis. When a word appears to be placed on the map, its definition is shown also, in order to standardize its meaning for all subjects.

#### 4.3.3.4 Proposed definitions

##### Marketing

The original concept of 'marketing' was focused on how to sell more without considering the satisfaction of the consumer. Drastic changes in the society have influenced deeply into its essence. How to do marketing of something you are not actually selling?; How to promote a charitable group?; How to share the idea of stop smoking?; How to impulse a political candidate?; How to sell a product that is actually a service?, among other issues, were situations that marketing had to face and solve through time. Just as Human Kind has evolved, also the market has been changing drastically, and at present there is a fresh concept of marketing looking for being understood and applied.

Based on the American Marketing Association (AMA) [1], marketing<sup>7</sup> is the process of planning and executing the conception, pricing, communication, and distribution of ideas, goods and services to create exchanges that satisfy individual objectives and organizational objectives respecting the society, culture, and natural environment.

Evolution in marketing involves the use of Internet, also called 'e-marketing', an attractive environment that invites the audience to interact, besides considering the facts that it is easy to measure, and it is scaled at a lower cost. Finally, it is important to underline that changes in the market environment had made clear

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<sup>7</sup> Marketing also involves marketing research that, as defined by AMA, is the function that links the consumer, customer, and public to the marketer through information used to identify and define marketing opportunities and problems; generate, refine, and evaluate marketing actions; monitor marketing performance; and improve understanding of marketing process. Marketing research specifies the information required to address these issues, designs the method for collecting information, manages and implements the data collection process, analyzes the results, and communicates the findings and their implications.

the fact that marketing is not just a matter of products; it is mostly a matter of perceptions. Once the product is perceived one way, the effort for changing that perception may be intense and even worthless. A 'drop' of consumer's perception on the original product will definitely transform it into a new concept [133, 158].

### **Design**

Design is the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer [112].

One of the main roles of the designer is to create an efficient link between the members of the development group. The designer expresses concepts that embody all relevant design criteria determined by the group [112]. The designer focuses on any aspect related to the human being and finds solutions to satisfy usage, selling and manufacturing.

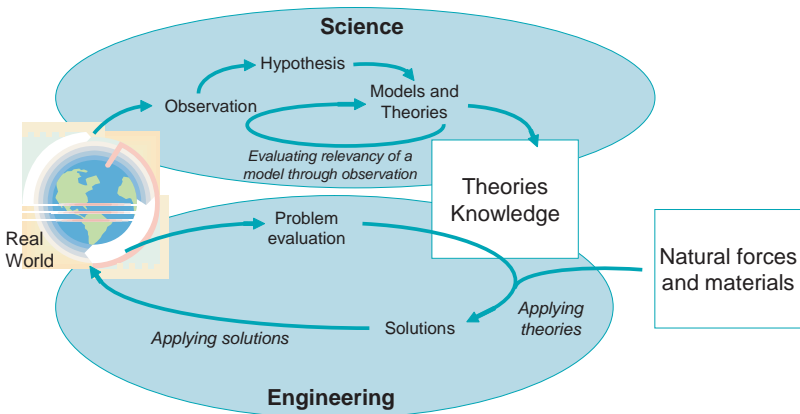
This study is mainly focused on the communication task of the designer. This study considers some of the designer's main objectives as creating and managing the links between marketers and engineers, and as proposing solutions that satisfy both marketers and engineers' specifications with a full consideration of human characteristics.

### **Engineering**

One of the most illustrative sentences explaining the essence of an engineer was wrote by Gordon L. Glegg: A scientist can discover a new star, but he cannot make one. He would have to ask an engineer to do that [81]. The main idea held in this perspective is that engineers are not scientists. The clarification of this usual confusion can help to precise the role of engineering. The role of a scientist is to explain the world through models and theories, whereas the role of engineers is to apply these scientific theories to practical ends: Scientists discover the world that exists; engineers create the world that never was (Theodore Von Karman).

Engineering is the art of using knowledge developed by sciences in order to design organized systems (tangible or intangible products). From the obser-

vation of the world, the engineer notes a solvable problem. Then, using science theories and models, the engineer translates the problem into formal objects upon which theories can be applied. By the application of the theories and models and using the natural forces and materials, the engineer obtains solutions that can be applied to the world after reverse translation (cf. Figure 4.7). This process can be applied to a broad panel of issues depending on the kind of issue (i.e. material flow issues may be solved by mechanical engineering; data processing issues may be solved by information engineering; Industrial engineering will process on management and quality issues in industry; Human engineering (or ergonomics) will focus on the triptych human/environment/product relation issues (anthropometric, security, usability...)).



**Figure 4.7** | Sciences and Engineering



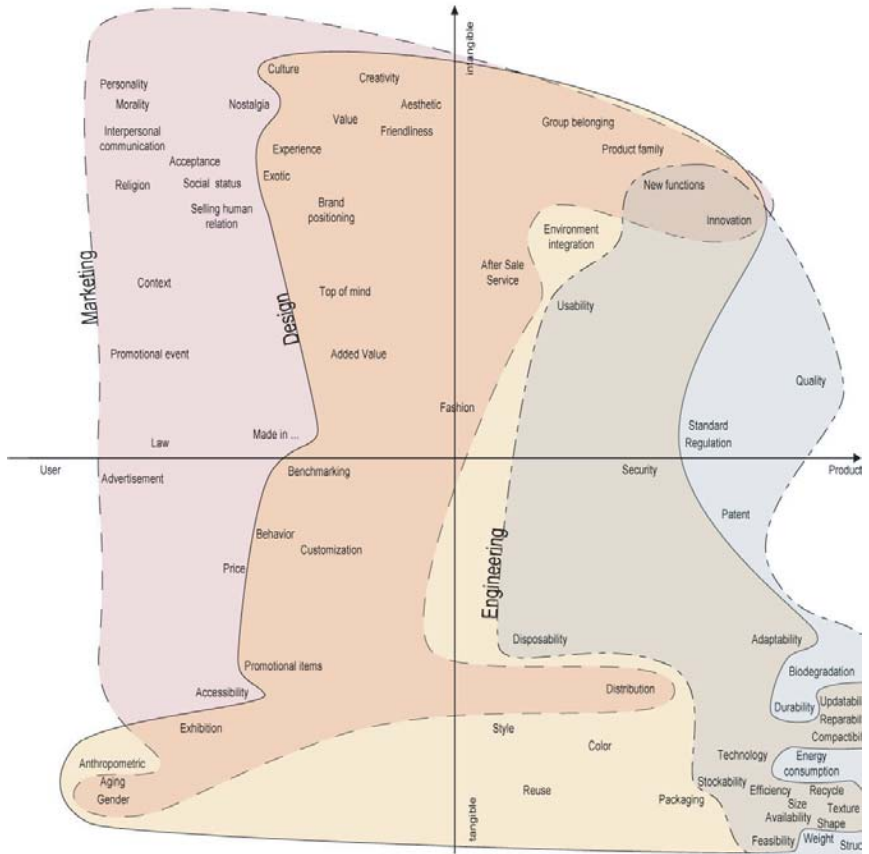


Figure 4.8 | Pilot-map (after coloring)

### 4.3.3.5 Results

#### The '*Kansei* mapping' task

From the brain storming session, numerous keywords have been yielded, clearly defined, and finally reduced to sixty-seven concepts listed in the appendix A.1. These concepts have been distributed on the Pilot map, and split in three main groups (Marketing ('m')/Design ('d')/Engineering ('e')) and four subgroups at the intersection of the main groups ('md', 'me', 'de', and 'mde') (cf. Figure 4.8).

#### The '*Kansei* mapping' validation task

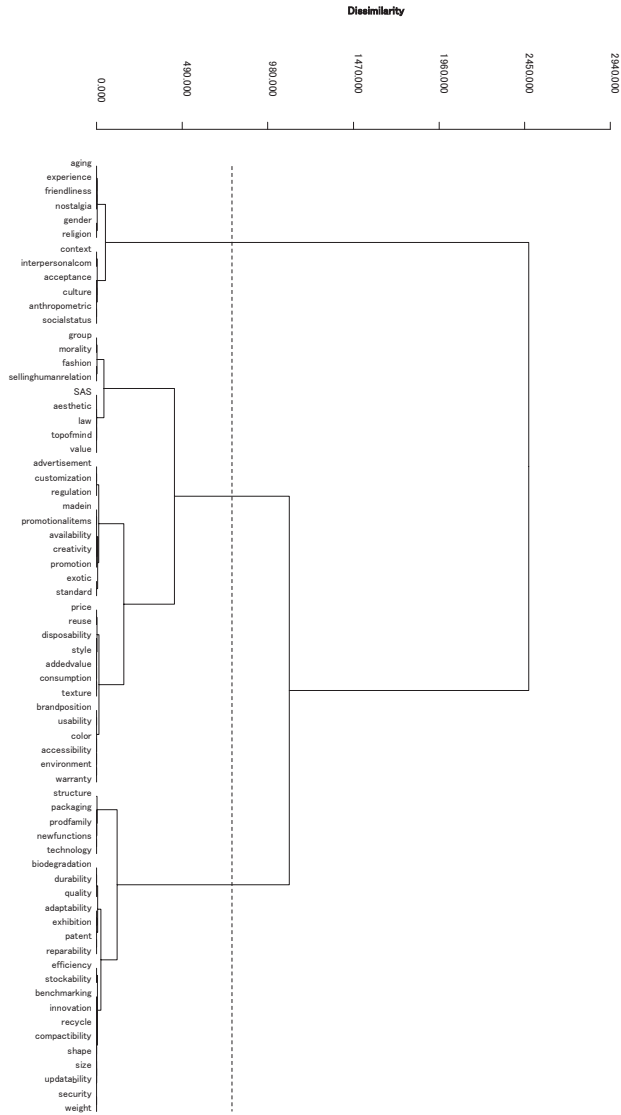
Ten subjects have participated the validation task. Personal data (cf. Table 4.3) and concepts' coordinate have been recorded into a database. Their maps (the ten Subjects' maps ) were average out to create a Validated map (cf. Figure 4.10). To evaluate the relevancy of the Validated map, a correlation analysis has been done by facing the Validated map data (on a vertical index) versus the Subjects' map data placed on a horizontal index (cf. Table 4.4).

As the correlations values were validated, a deeper study was done on the keywords of the Validated map. The arithmetic distance between all the words were evaluated by the following formula:

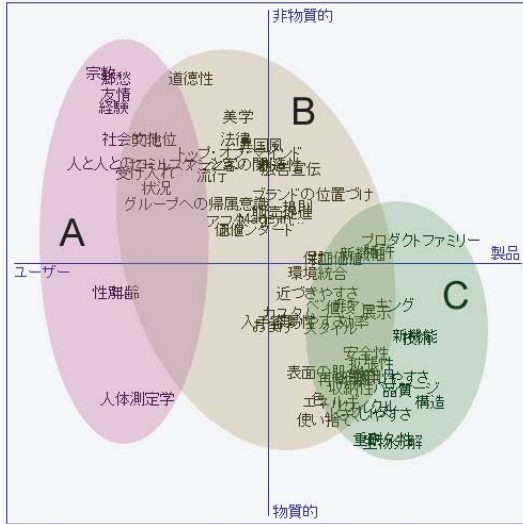
$$d = \sqrt{((x_2 - x_1)^2 + (y_2 - y_1)^2)} \quad (4.1)$$

where d is the distance between two concepts, (x1,y1) and (x2,y2) are the coordinates of the two concepts, respectively. Thereafter, on the distance results have been applied a Ward's aggregation method for agglomerative hierarchical clustering (AHC) (cf. Figure 4.9). Three clusters were drawn on the Validated map (cf. Figure 4.10):

- The first group, called 'A', is clearly related to the user.
- The second group, called 'B', represents the link between the user and the industry.



**Figure 4.9** | Groups by agglomerative hierarchical clustering



- A** acceptance, aging, anthropometric, context, culture, experience, friendliness, gender, interpersonal communication, nostalgia, religion, social status.
- B** accessibility, added value, advertisement, aesthetic, availability, brand position, color, energy consumption, creativity, customization, disposability, environment, exotic, fashion, group, law, made in..., morality, price, promotion, promotional items, regulation, reuse, after-sale service, selling human relation, standard, style, texture, top of mind, usability, value, warranty.
- C** adaptability, benchmarking, biodegradation, compactness, durability, efficiency, exhibition, innovation, new functions, packaging, patent, product family, quality, recycle, reparability, security, shape, size, stockability, structure, technology, updatability, weight.

**Figure 4.10** | Resultant groups drawn on the Validated map

**Table 4.3** | Subject profile

	Age	Gender	Blood Type	Religion	Nationality	Marital	Study	Work	Marketing	Design	Engineering
<b>S1</b>	31	M	A	CA	MX	M	1	6	8	4	0
<b>S2</b>	24	M	B	N	JP	M	2	0	0	6	1
<b>S3</b>	31	F	B	N	CH	M	5	6	1	7	4
<b>S4</b>	24	F	O	N	CH	S	4	0	0	6	5
<b>S5</b>	29	M	A	CR	KR	S	7	1	4	7	2
<b>S6</b>	23	M	O	N	JP	S	5	0	2	7	0
<b>S7</b>	27	M	A	N	JP	S	6	0	2	6	7
<b>S8</b>	26	M	A	N	JP	S	7	0	2	4	3
<b>S9</b>	37	M	AB	N	JP	M	6	12	2	2	7
<b>S10</b>	25	M	A	J	FR	S	7	2	2	6	7

**Table 4.4** | Correlations between the VM and the Subjects' maps

<i>Map</i>	VM	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	S <sub>4</sub>	S <sub>5</sub>	S <sub>6</sub>	S <sub>7</sub>	S <sub>8</sub>	S <sub>9</sub>	S <sub>10</sub>
<b>Cor.</b>	0.805	0.829	0.758	0.606	0.799	0.641	0.659	0.609	0.609	0.732	0.823

- The third group, called 'C', is related to the industrial process characteristic of the product.

The Validated map shows a clear flow from the user to the product (and vice-versa) and intersections between the three groups. It is not possible to make an analogy between the triptych marketing/design/engineering, proposed by the Pilot map, and the triptych A/B/C. However, an interesting rapprochement is possible.

#### 4.3.3.6 Discussion

The Validated map is an interesting illustration of the relations between the concepts. It shows proximities of the issues related to the product creation in a marketing/design/engineer point of view. Nevertheless, the average calculated to obtain this map reveals a certain 'impersonality' quality of this map. The personal perception of each subject is not taken into consideration.

This limitation of the Validated map lead us to a deeper reflection on the approach, to be based on a *Kansei*. As a further study proposal, we introduced the notion of *Dynamic map*. This map was defined suggesting a path to consider 'dynamically' subjects' *Kansei*. To include *Kansei*, we considered thanks to subjective criteria, as suggested by Lee [142]. The Eysenck Personality Inventory [61] is recognized as being reliable and moreover suitable to *Kansei* evaluation [142,140]. The Eysenck Personality Inventory aims at analyzing people's temper, which is defined by two main dimensions<sup>8</sup> [14]:

- **Extraversion/Introversion (E\*/E)** — This is about shy and quiet people, and outgoing or even loud people. Eysenck hypothesized that extraversion-introversion is a matter of the balance of inhibition and excitation in the brain itself. *Excitation* is the brain waking itself up, getting in to an alert, learning state. *Inhibition* is the brain calming itself down, either in the usual sense of relaxing and going to sleep, or in the sense of protecting itself in the case of overwhelming stimulation. Eysenck hypothesized that extraverted people have strong inhibition, whereas introverted people have weak inhibition of the brain.

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<sup>8</sup> The Lie (L) dimension is used in this experiment to evaluate the pertinence of the questionnaire results. More details can be seen at [60].

Extraverted people's brain would inhibit itself in case of traumatic stimulation, and thus would remember very few of the event related to the stimulation. Because they have very few memory of the event, and thus mental impact, they may not have any future apprehension related to this kind of event. If an introverted person is exposed to the same traumatic stimulation, her/his brain would have a poor inhibition, and then a good memory of the event related to the stimulation. The strong mental impact provoked by the traumatic event would create an apprehension, the reason of a certain shyness of introverted people.

- **Neuroticism ( $N^+/N^-$ )**— Neuroticism is a dimension that ranges from calm and collected people ( $N^-$ ) to one's that tends to be quite nervous ( $N^+$ ). Eysenck showed that these nervous people tends to suffer more frequently from a variety of 'nervous disorders' (i.e. neuroses), and are more susceptible to neurotic problems. He suggested an explaining (reminded hypothesis) by looking at the sympathetic nervous system. This is a part of the autonomic nervous system that functions separately from the central nervous system and controls much of our emotional responsiveness to emergency situations. For example, when signals from the brain tell it to do so, the sympathetic nervous systems instructs the liver to release sugar for energy, causes the digestive system to slow down, opens up the pupils, raises the hairs on your body (goosebumps), and tells the adrenal glands to release more adrenalin (epinephrine). The adrenalin in turn alters many of the body's functions and prepares the muscles for action. The traditional way of describing the function of the sympathetic nervous system is to say that it prepares us for fight or flight. Eysenck hypothesized that some people have a more responsive sympathetic nervous system than others. Some people remain very calm during emergencies; some people feel considerable fear or other emotions; and some are terrified by even very minor incidents. He suggested that this latter group had a problem of sympathetic hyperactivity, which made them prime candidates for the various neurotic disorders.

In addition to the two dimensions of the Eysenck Personality Inventory, personal information of the subjects are taken into consideration (cf. Table 4.3) to search for the most influencing personal characteristic on the map making process.

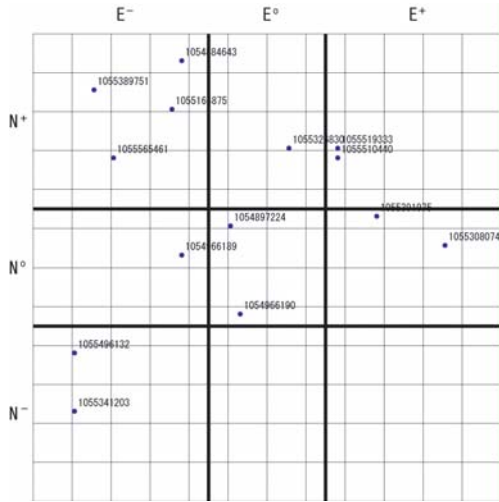


Figure 4.11 | Eysenck Personality Inventory results

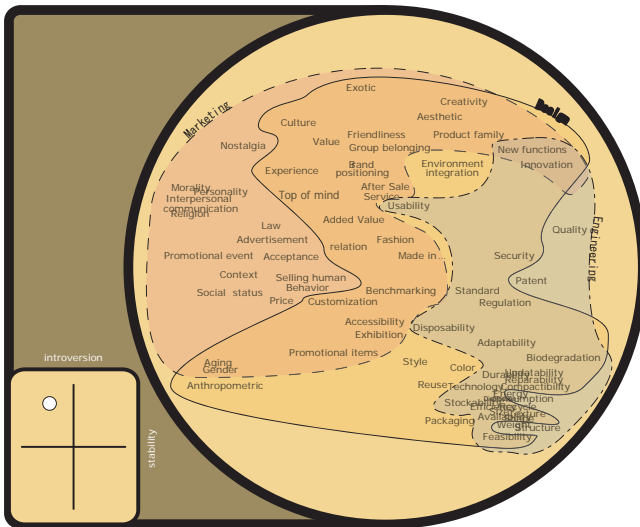


Figure 4.12 | Dynamic map



The results of the Eysenck Personality Inventory (shown on the Figure 4.11) suggests the an evaluation between subject's personality and their mapping. If the correlation is good enough, one's map could be drawn based on one's personality. To illustrate our purpose, a proposition of Dynamic map is shown in Figure 4.12.

The Dynamic map is presented in Figure 4.12. This proposal was not ruled with a scale corresponding to the inventory results, since there was an emphasis on understanding *Kansei* as a subjective matter, and personality as a similar concept yet different to *Kansei*. The Dynamic map consisted of a circular main area that included the 67 concepts of the industry that were obtained in the brainstorming of the initial stage of this research. In a similar path as the two-dimension Oxy on Figure 4.11, subject's personality was represented by a cursor on a non-scaled plan that showed the area for introversion and stability. The non-scaled plan is shown in Figure 4.12 as a small square to the left-bottom of the main circular area, containing a white circle as the movable cursor.

The concept of a Dynamic map suggests that after retrieving several subjects' perception of the keywords location, a standard location of the keywords could be assigned depending on the personality of each subject. In this fashion, the simulation suggested that for every position of the cursor in the personality 'non-scaled plan', it would correspond a new arrangement of the keywords in the main circle area. The simulation showed in the Figure 4.12 shows the different grouping of the keywords belonging to marketing, engineering and design that came out from this research. The groups would not change when the keywords were rearranging location. When a professional's personality is input, the distance between the keywords belonging to the three groups would change. Therefore, the perception of the closeness of the keywords from field to field would be exposed, letting others to know the way in which that particular professional might perceive the industry.

Some benefit of the Dynamic map could be reflected in improved communication skills, as well as acceptance of other professionals' differences, preparing people to be more able to adapt to interactions. From this research emerges the possibility of associating personality as the *Kansei* factor, and creating a map as the activity for measuring performance.

#### 4.3.3.7 Conclusion

This experiment pointed out how the perception of the relations between three disciplines can be peculiar to each one. The Validated map provided a 'standard' perception, but it is clear that it does not correspond to any one's perception. These differences may be at the origin of misunderstanding, frustrations, or collisions in an interdisciplinary group. The Dynamic map proposes to report on perception differences subjectively, to let people notice the existence of differences.

This experiment was an interesting approach to show that each person has a different perception of her/his environment, of the workgroup she/he is involved in, and of the tasks and the interrelations which this workgroup has to deal with. For an interdisciplinary design workgroup, it is important to show these differences. Keeping them invisible is a potential danger for the workgroup and its activity. Pointing them out can convert this diversity to a strength, by creating a clearer and richer environment for communication and exchanges. The Dynamic map is potentially a great tool to achieve this objective. A very interesting research project for the structural development of interdisciplinary design would be the creation of a comprehensive Dynamic map, shifting from the three fields considered in this experiment to all the disciplines potentially involved in interdisciplinary projects. This Interdisciplinary map would provide the workgroup a strong base to understand the diversity, structuring its strength and its unity.

### 4.4 Reflection on interdisciplinary design

Since the publication of the Brundtland report [37], the industrial world evolved somehow. The end of the Eighties saw the development of the 'green consumerism', and the Nineties its disappearance. Agenda 21 launched the sustainable consumerism that Cooper [40] defines as follows:

*Patterns of consumption through which the purchase and use of goods and services meet people's basic needs while minimizing any environmental degradation.*

The concept of durability takes the entire environmental impact of the design, the manufacture and the consumption of products into account. Some tools are used to evaluate and compare the impact of various products and of their mode of consumption on the environment, in particular by counting the whole of the raw materials used during the life cycle of these products. Moreover, sustainability is also interested in the social and human aspects whatever they are concerning space, intergeneration or intrageneration. Even if these aspects are currently much less developed than the environmental aspect, it is one of the two major orientations of the sustainable development.

Within the framework of sustainable development, the role of design is immediate. Papanek [194] suggests (even before Agenda 21) to designers to look further into the social and environmental aspects of their designs. Since then, some progresses have been made with the development of eco-design and sustainable design [83]. To challenge it, the designer must understand the current consumerism's socio-cultural and psychological dimensions in order to understand better how he or she can act. The human and social meaning of the product must reach the same level of comprehension as that one concerning functional or anthropometric dimensions of the product [41]. Therefore, sustainable design sets itself the task of reconsidering its process and adopting a more responsible behavior (and thus more reasonable objectives). Within the framework of a sustainable design management, the product design team will put at the core of its reflection, and at the same level, the whole of cultural, socio-logical, historical, technological, harmonic and functional dimensions. Thus, there is a double challenge (identical to the sustainable development's one): to obtain viable products from an economic and marketing standpoint, without decreasing the importance of their socio-cultural and environmental viability. This defines the responsibility for the designer toward the company and toward Gaïa (as defined by Lovelock [157]).

The previous section points out that interdisciplinary design can find an answer for the problems of setting up sustainable design and sustainable consumerism. The difficulty, which moves us away from the sustainable design, can be found in the factorial complexity of the product. As we figured out that interdisciplinary will help the designer to apprehend more correctly a greater number of dimensions, we can affirm that the more the designer will develop interdisciplinary in his or her work, the more he or she will be able to approach sustainable design

activity. It is a fundamental acknowledgment to explain the importance of such a process. It will make industrial design and societies advance positively.

This undertaking of designers in the way of interdisciplinary, and thus of the sustainable design will enable them to respect their social responsibility which they are carrying each time they are designing a product [250]. It is a significant factor and it will make design progress intrinsically.

## Chapter 5

### Challenge of interdisciplinary projects

It was six men of Indostan  
To learning much inclined,  
Who went to see the  
Elephant  
(Though all of them were  
blind),  
Might satisfy his mind

The Third approached the  
animal,  
And happening to take  
The squirming trunk within  
his hands,  
Thus boldly up and spake:  
That each by observation  
"I see," quoth he, "the  
Elephant  
Is very like a snake!"

The Sixth no sooner had  
begun  
About the beast to grope,  
Than, seizing on the  
swinging tail  
That fell within his scope,  
"I see," quoth he, "the  
Elephant  
Is very like a rope!"

The First approached the  
Elephant,  
And happening to fall  
Against his broad and sturdy  
side,  
At once began to bawl:  
"God bless me! but the  
Elephant  
Is very like a wall!"

The Fourth reached out an  
eager hand,  
And felt about the knee.  
"What most this wondrous  
beast is like  
Is mighty plain," quoth he;  
" 'Tis clear enough the  
Elephant  
Is very like a tree!"

And so these men of  
Indostan  
Disputed loud and long,  
Each in his own opinion  
Exceeding stiff and strong,  
Though each was partly in  
the right,  
And all were in the wrong!

The Second, feeling of the  
tusk,  
Cried, "Ho! what have we  
here  
So very round and smooth  
and sharp?  
To me 'tis mighty clear  
This wonder of an Elephant  
Is very like a spear!"

The Fifth, who chanced to  
touch the ear,  
Said: "E'en the blindest man  
Can tell what this resembles  
most;  
Deny the fact who can  
This marvel of an Elephant  
Is very like a fan!"

Moral: So oft in theologic  
wars,  
The disputants, I ween,  
Rail on in utter ignorance  
Of what each other mean,  
And prate about an Elephant  
Not one of them has seen!

*The Blind Men and the Elephant, by John Godfrey Saxe  
(1816-1887)*

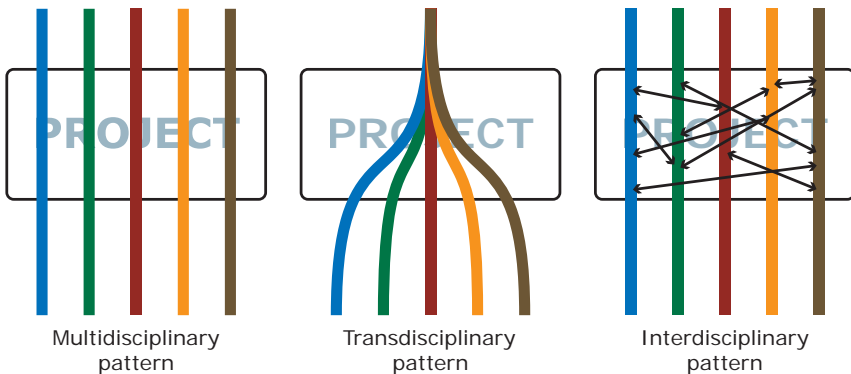
### Introduction

Interdisciplinary approach is necessary to engage research on complex issues, numerous in the real world. A uni-disciplinary approach often concludes on an incomplete, or even incorrect solution proposals. The lack of comprehensiveness and the disregard of some of the issues related with the topic research, but not with the scope of the discipline, are at the origin of the criticisms made on disciplinary research and the promotion of multidisciplinary research. This

chapter focuses on the current necessity for interdisciplinary approach, for knowledge development and management. Then, it points out related issues, especially concerning the communication aspects.

In this introduction, the term interdisciplinary needs to be specified, especially by comparison with the terms multidisciplinary, transdisciplinary pluridisciplinary, and cross-disciplinary (cf. Figure 5.1).

- A multidisciplinary activity suggests the juxtaposition of disciplines on a common topic or objective, but without any intention to interact. For example, the junior high-school and high-school teaching systems are basically based on this system: Students have classes about different topics (Mathematics, Geography, Literature...), but these classes usually never interact.
- A transdisciplinary research has the objective to emphasize a new epistemology (to 'transcend' the academic disciplinary structure [24]). In other words, it intends to 'combine' existing disciplines to create a new discipline enable to create its own methods and knowledge. *Kansei* science, as developed at the



**Figure 5.1** | Three different pluridisciplinary patterns

University of Tsukuba, is typically a transdisciplinary project [98]. However, new disciplines, actually born from transdisciplinary projects are numerous: informatics, biosociology, geophysics, and so on.

- An interdisciplinary approach proposes a collaboration between different disciplines for a common topic. Still, disciplines keep their specificities and build ‘bridges’ to interact and to provide a holistic and systemic outcome.
- Finally, the terms of pluridisciplinary and cross-disciplinary are similar and appoint the set of the three terms described previously.

## 5.1 From disciplinary to interdisciplinary work

### 5.1.1 Knowledge and disciplines

Since ever, human beings had made an effort to understand their environment, especially natural phenomena surrounding them. Sciences were created from this effort, and their modern pattern comes from the XIVth century. Francis Bacon describes the scientific method as setting aside empiricism and the supernatural in favor of observing a phenomenon, classifying it, and determining its causes. The René Descartes’ *Discours de la Méthode*<sup>9</sup> [50] is the basis of the modern scientific method. The generalization of the institutionalization of western sciences occurred in the XIXth century over the world. Since then, great progresses of sciences and their practical consequences on the societies and people’s everyday life has become obvious.

Today, the production of knowledge by research is impressive. In 1997, de Meis [48] was announcing about one million articles published a year (referenced in the ISI database), and about sixty thousands just for the field of biological chemistry. This impressive production of knowledge prevents a single researcher to stay ‘up-to-date’ even in the entire field she/he belongs to. Nowadays, to go on producing new knowledge and to be at the edge of a domain, researchers need to be ‘super-specialized’. Thanks to this ‘super-specialization’, research go on to produce specific knowledge more and more, faster and faster.

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9 Discourse on method

### 5.1.2 Toward interdisciplinary work

Nevertheless, specialization of researchers brings crucial issues that cannot be ignored. By essence, or necessity, specialized knowledge is based on reductionist approach. It captures only the part of an issue related to the specialization, and neglects the rest. Compartmentalization is not adapted for complex and practical problems<sup>10</sup> [207], as most of the ones related with Nature are. If one practical issue is studied by different disciplines, it is doubtful the set of the utterances of the disciplines makes a coherent solution. That is because each issue studied by each discipline is not independent from the ones studied by other disciplines (as illustrated by the poem in introduction). Therefore, for a project to be successful, any problems must be approached commonly by different disciplines.

Moreover, the gap between disciplines can create contradictions on ontologies<sup>11</sup>. This issue is very important because it can point out a great mistake of a discipline. Knowledge from different disciplines should not be contradictory, because both are part of a Unity of Knowledge. For example, it may happen that one discipline may rely on theories invalidated among the originating one [166, pp. 81-82].

*Insulated from related disciplines and lacking a clear notion of its bearings relative to what others have done, intensive study within a single discipline sooner or later leads to floundering into territories already explored by other. The result is confusion and displays of need less ignorance... [182].*

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<sup>10</sup> Ravetz makes a distinction between the ‘technical problems’ and the ‘practical problems’ [207]. The formers can be addressed by a disciplinary approach, i.e. using the within disciplinary boundaries. The later need the contribution of other sources of specification, evaluation, and judgment. Ravetz noticed the emergence of the later type of issues with some common features: uncertain facts, subjective values, and high stakes. To address these issues, a new way to process scientific activity is required, integrated a broad variety of sources of knowledge and methods, to enhance the quality of the work’s group and its output.

<sup>11</sup> Here, the meaning of ontology is the one used in Knowledge Representation. It is a specification of a domain, of all that ‘exists’ in a domain, including terms, concepts, entities, axioms, theorems, laws, rules, and actions that can be performed on everything within the domain as well as how to reason about the domain.



However, in a survey on projects involved in the European Fifth Framework Program (FP5) [24, 42], Bruce et al. pointed the actual wish of researchers to solve this issue and the benefits of such an effort (cf. Table 5.1).

Many analyzes also noticed that some issues are neglected by discipline studies because they fail to fit in with disciplinary boundaries thus falling in the interstices between them [110, 129]. These areas, called 'gray interstices' or 'cracks', are niches hard to attain by disciplinary approaches. Yet, they often represent important topics requiring interdisciplinary approach. Thus a disciplinary approach runs the risk of a tunnel vision. The compartmentalization and tunnel vision of the research, due to disciplinary characteristic of knowledge, are at the origin of many great mistakes (even when they are advised by 'experts'), which can have a great intellectually and socially harmful impact on the world [182, p. 206]. Therefore, they have to be reduced, even avoided when possible [57, 75, 197].

*To sum up, many complex or practical problems can only be understood by pulling together insights and methodologies from a variety of disciplines. Those who forget this simple truth run the intellectual risk of tunnel vision and the social risk of irresponsible action. In some areas, interdisciplinary research has long been practiced, e.g., materials research or American studies. Such areas, and the habit of holistic vision they foster, should become more numerous. Future specialists will perhaps be able to see their field 'as part of a wider context, to reflect on the impact of their discipline's activities on society, and to enhance their ability to contribute to social developments' [182].*

It is clear that interdisciplinary approach is a necessity to work on 'practical problems', where disciplinary approach is inefficient, or even dangerous. Disciplines build their own ontology, and their own field of research. But most of the practical problem straddle these fields or are situated in their cracks. A disciplinary approach is then irrelevant and only interdisciplinary one can point them out and solve them properly.

Two different structures are possible to operate an interdisciplinary approach:

**Table 5.1** | Developing an interdisciplinary project (from [24])

<b><i>Motivations</i></b>	<b><i>Benefits</i></b>
The nature of the subject is interdisciplinary (e.g. transport, environment)	Bringing together parallel sets of knowledge to achieve synergy between them
Researchers were transferring information from the laboratory to the real world	Better technology transfer in IT related industries
The research was user driven (not necessarily commercial) and heavily applied	More accurate understanding of markets and opportunities
The research was particularly relevant to policy and many strategic issues can only be effectively addressed by interdisciplinary approaches	More effective research on complex application areas, e.g. in regional development, health or transport, where an interdisciplinary approach is needed to cope with complexity
Single discipline research had encountered a bottleneck and more than one discipline was needed to make a breakthrough	Overcoming bottlenecks in technological process development

- A community of interdisciplinary researchers has the advantage of gathering people aware from the danger of 'narrowism'. This structure is qualified of Mode 2 by Gibbons [78]. They are ready to investigate deeply, even in yet unknown directions, to find cracks and original solutions to practical problems. Nevertheless, since most of advanced knowledge is created by disciplinary research, such a community can easily slide to generalism, often naive and rarely productive of relevant solutions.
- A community of experts with different disciplinary backgrounds may be more aware of advanced knowledge and keep on being 'updated'. This structure is qualified of Mode 1 by Gibbons [78]. Nevertheless, 'difference of background' means different knowledge, different methods, and different ways of thinking, different ways to perceive information, and so on. That is both the richness of such a group, and its danger. In this pattern, knowledge sharing becomes difficult, even perilous.

## 5.2 Communication issues concerning knowledge sharing

Communication is one of the fundamental tasks in a group constitution and operation. For obvious reasons, the group cannot intrinsically exist without communication. The specificity of interdisciplinary groups is that the communication is not based on a single ontology, but on as many ontologies as the number of disciplines gathering in the group. This specificity affects both implicit and explicit knowledge (cf. part 1.2.1.2 for the description of the different types of knowledge).

### 5.2.1 Implicit knowledge sharing issues

It affects implicit knowledge since each discipliner's experience is partly coming from the activity in the discipline. As an ontology also gathers links between objects, and rules and actions being performed in the activity, it influences the way the activity is performed and experimentally understood. However, discipline experience creates most of the tacit knowledge content to be exchanged in the interdisciplinary group. Then an important part of the tacit knowledge involved in interdisciplinary workgroups is actually directly related to the disciplines. That is all the more dangerous that, as a conflict can occur

because direct experience conflict, explanations and trials aiming at resolving any issues related with implicit knowledge cannot be directly explicit, because of the nature of implicit knowledge. The risk of an inextricable, or even worse, invisible issue is possible and dangerous for interdisciplinary workgroups.

### 5.2.2 Explicit knowledge sharing issues

Interdisciplinary environment also affects explicit knowledge sharing as it involves concepts or methods that may be defined differently for each ontology (i.e. the same word may mean different things in different disciplines). Communication on concepts or methods defined specifically to each discipline is a barrier for the interdisciplinary group communication process. Indeed, divergence of definitions for a similar concept or method creates a gap between member's technical cultures and can easily lead to misunderstandings and frustrations between them. Nassani proposes an example as an illustration of this issue [24]:

*Most books, one noted economist says, discussing environmental and resource problems begin with the proposition that there is an environmental and resource crisis. If this means that the situation of humanity is worse now than in the past, then the idea of a crisis – and all that follows from it – is dead wrong. In almost every respect important to humanity, the trends have been improving, not deteriorating. [Therefore, global and U.S. trends will go on] improving instead of deteriorating.*

*Had our economist consulted an introductory logic text, he might have perceived that this passage employs a persuasive definition of “crisis” (humanity’s situation is worse now than in the past), instead of the more appropriate lexical definition (“an unstable state of affairs in which a decisive change is impending” — Webster International). Had he consulted a middle-of-the road ecology text, he might have realized that this passage ignores the widely accepted theoretical definition of “crisis.”*

Solving this kind of issues involves and depends partially on member's personality, tolerance for ambiguity, and willing to accept other's methods and

concepts. The notion of ‘acceptance’ here includes ‘welcoming’, ‘understanding’, and even ‘exploring’ other disciplines. Such a behavior, coupled with trials, is a great path to find a solution to the previous issue. It is a key of the success for such project. The Table 5.2 gathers the proposition made by Bruce and al. to characterize a good interdisciplinary project coordinator.

### 5.2.3 Solving the problem

These issues imply a longer time to bring together an effective interdisciplinary team, and are demanding a bigger effort to the team coordinator. They request members also a double effort to introduce one’s own discipline and to value the interest and the potential contribution of other’s discipline, without having a full understanding of other’s discipline. At this point each member’s personality and attitude in willing to understand and accept other’s approach and discipline is crucial. The intention of each member should be to create an emulsion by sharing and debating on concepts and sub-objectives, in order to integrate judiciously each member’s contribution (i.e. disciplinary contribution) to target the global objective properly.

To sum up, interdisciplinary workgroups are facing two original kinds of issues, compared to disciplinary ones:

- Interdisciplinary conversations involve different ontologies potentially not compatible to each other. For example, a similar word can have different definitions depending on the ontologies. This issue concerns mainly explicit knowledge sharing.
- A discipliner gains an experience from the practice of the discipline she/he belongs to. As methods and points of view are different from one discipline to another, tacit knowledge sharing also faces issues in the interdisciplinary workgroup.

Both of these issues concern the structure of the shared content and method, i.e. the ontology. At the group level, members have to break the communication aspects linked with their discipline and to find a discipline-independent communication system. It means that instead of using technical terms and disciplinary-related structure to communicate, they need to find an equivalence that could be

common to all the members, aside to the disciplines. In the chapter 6, I propose a methodology, based on intuition, as a solution to this problem.

**Table 5.2** | Qualities of a good interdisciplinary project coordinator

A good understanding, not necessarily in depth knowledge, across the project's main discipline domains, aided by a varied career trajectory and broad range of interests;

A good understanding of the application areas, in industry or the public sphere, for the project's outcomes (particularly for Mode 2 research);

An ability to plan effective division of responsibilities related to disciplinary and organizational roles of participants;

A focus on work in teams and on practical results, to overcome differences in disciplinary orientation and differences between, say, participants from public and private sectors;

Respect for other disciplines, which in turn calls for an interest in these disciplines and some understanding of the general principles that underpin them, as well as a recognition of the depth of knowledge that exists in other fields;

A good level of expertise in their own discipline, although not necessarily a burning ambition to pursue a career in that discipline which would inhibit willingness to invest attention outside that discipline;

Ability to balance openness to new ideas and maintaining the progress of the project;

A good team leader which includes skills in building relationships, trusting the judgment of others, good interpersonal and diplomatic skills and a pro-active approach to partners;

A clear vision of the project and what it is trying to achieve;

An interest in real world problems;

An ability to bridge the gap between theory and practice.





## **Chapter 6**

### **Proposition for a methodology**

*L'homme est un être de sens et c'est par sa conscience qu'il est tel. Il est sens de plaisir, de douleur, des couleurs, des bruits, de la lumière, de la nuit, des choses, des objets, des êtres, des jugements, des raisonnements. Il est sens du non-sens, de l'interrogation de sens. Et cette vie du sens par sa conscience présente un caractère immédiat, qui fait qu'il est sens intuitivement, c'est-à-dire comme sans préalable, sans préparation de pensée, dans une lumière de l'intelligence qui saisirait, exprimerait dans et par cette saisie le plaisir, la douleur, cette couleur bleue, cette lumière, ce raisonnement (je comprends), ce rapport de cause à effet (le chien court après le lapin...)<sup>12</sup>. – de La Garanderie [47]*

#### **6.1 About intuition**

##### **6.1.1 Intuition**

Concisely, the term of intuition would be defined as the ability to understand or know something immediately, without conscious reasoning [23]. But this simplistic definition does not clarify us about the way intuition works. The Oxford Companion to Philosophy explains it more deeply:

*Intuition. Originally an alleged direct relation, analogous to visual seeing, between the mind and something abstract and so not*

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<sup>12</sup> Human being is a being of meaning, and it is thanks to his (or her) conscious that he (or she) is such. He is meaning of pleasure, of pain, of colours, of sounds, of light, of the night, of things, of objects, of beings, of judgements, of reasoning. He is meaning of meaningless, questioning of meaning. And this is this life of meaning by his conscious which outlines an immediate character, which makes that he is intuitive meaning, i.e. as without prerequisite, without preparation of thought, in a light of intelligence which would comprehend, look into and by this capture the pleasure, the pain, this colour blue, this light, the reasoning (I understand), this cause-and-effect relationship (the dog runs after the rabbit...).

*accessible to the senses. What are intuited (which can be derivatively called 'intuitions') may be abstract objects, like numbers or properties, or certain truths regarded as not accessible to investigation through the senses or calculation; the mere short-circuiting of such processes in 'bank manager's intuition' would not count as intuition for philosophy. Kant talks of our intuiting space and time, in a way which is direct and entirely free from any mediation by the intellect - but this must be distinguished from an alleged pure reception of 'raw data' from the senses; the intuiting is presupposed by, and so cannot depend upon, sensory experience [108, p. 415].*

Considering the philosophy of Kant, the crucial question is not how we can get to understand the world, but how the world comes to be understood by us. Then, one of the main philosophical works, the Critique of the Pure Reason [127], aims at showing how reason determines the conditions under which experience and knowledge are possible. Instead of making our concepts match the nature of objects, we must allow the structure of our concepts shape our experience of objects. This turn of mind helps a lot to understand the way intuition works and the purpose of it.

According to David L. Thompson [237] 'Intuition' relies on a notion of presence which is abstracted from time and so is available only to either a timeless God - Cartesian philosophy - or an instantaneous ego stripped of all historicity - Husserlian philosophy.

When it comes to real spatio-temporal knower who live in the hic et nunc, we must substitute for absolute presence the embodied temporal process of making sense of the world. Absolute seeing is an illusionary product, a product generated by the processes of our bodies which structure our experience, integrating both objects and conscious selves over space and time.

Both Kant's philosophy and Thompson's remarks on Cartesian and Husserlian philosophies point out main of the important notions related with intuition, which is going to be explained later in this section. The intuition is the primary human understanding of the environment. So it is highly related with one's own experience, integrating both objects and consciousness over space and time. It

is the way one can perceive and conceptualize the world without requiring any prior knowledge. Mainly based on the works of de La Garanderie [47], the way intuition works for perception and conceptualization will now be explained.

### 6.1.1.1 Intuition and perception

When one calls up objects, it is visually, auditory or verbally<sup>13</sup>. This categorization of calling up does not divide people distinctly since anybody is potentially able to understand and use another mode of understanding than the one he/she is used to. Even it is potentially possible, that would not be done with ease and it would probably cause communication and appreciation issues.

By the analysis of perceptive activity and its modalities, differences of understanding processes may be pointed out. There are two ways for observing an object: by visual evocations or auditory/verbal evocations (further explanation on this topic is illustrated by the Figure 6.1). In order not to confuse the reader in this chapter, the difference between the mental evocation and the nature of the perceived object has to be cleared. For example, an auditory stimulus (auditory perceived object) can be mentally evoked visually, and vice versa. Many people could understand this concept while listening The Four Seasons from Antonio Vivaldi: People listening to this music sometimes 'visualize' Nature and the changing seasons. As another example, de La Garanderie [47] is recalling the words from Napoléon:

*Faites en sorte que, lorsque je vous aurai entendus, je pense avoir vu<sup>14</sup>.*

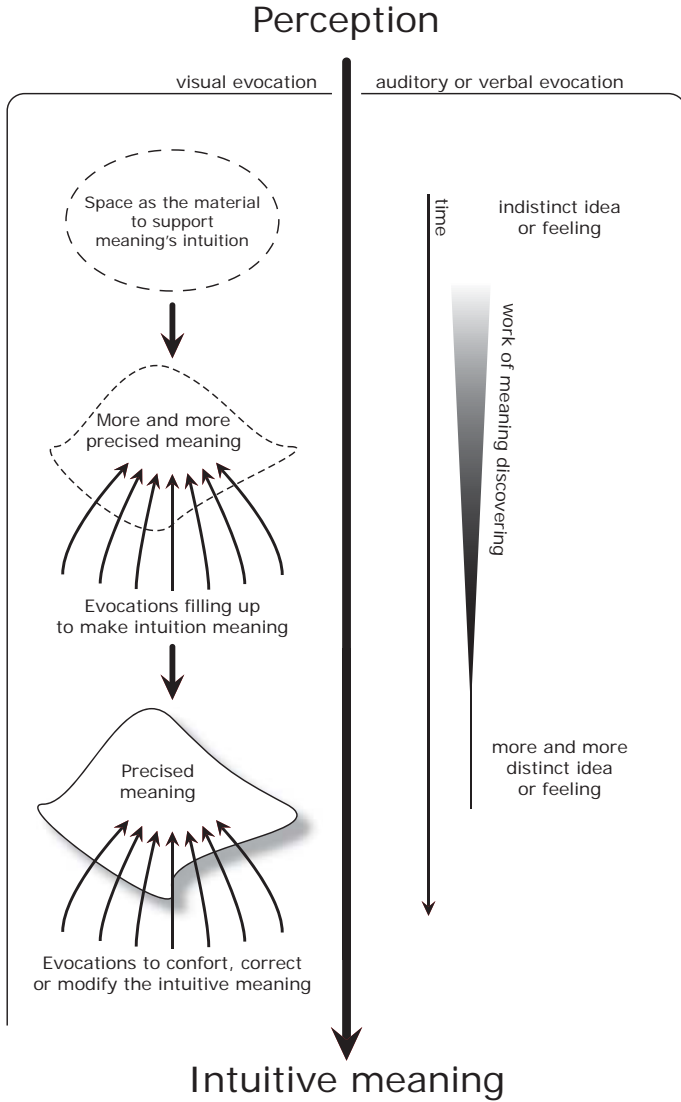
### Visual modality

The project here is to give oneself a global image of the object. The observation starts by the creation of an image (different from a simple impression) being able to be filled up (c.f. Hurssel). This filling up is done thanks to further perceptions evoking details of the object. Once the global image is filled up

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<sup>13</sup> Words and sounds are called up as auditory in their tonality, whereas verbally, the subject tells or sings what he/she hears or sees.

<sup>14</sup> *Let do so that, when I have heard you, I think of having seen.*



**Figure 6.1** | Intuitive meaning from perception

by perceived details, other perceptions will cause confrontation with already perceived elements, creating 'expert' judgments. Evocations are carried out by visual expressions.

Thus, when using visual evocations for perceptive activity, the meaning of the perceived object is captured in the space and by the spatial dimensions: in the filling up of an evoked global image. It is important to notice that the global image created in the first place does not generate the meaning of the perceived object. It is only a way to obtain the meaning. As it is filled up, the intuitive meaning of the object is being clarified.

The perceptive activity needs to be endorsed on a global image to input into it further evocations of the perceived object. This global image furnishes then the material for the meaning's intuition: the space. The left side of the figure 6.1 resumes graphically the intuitive understanding of perceived object's meaning by visual evocation.

To illustrate my point, let's imagine a budokan (place to train martial arts) in which a judo training is taking place. Two judoka (i.e. judo player) are fighting and others are looking at them. If somebody (having evocations in visual mode) enters the room, the first evocation would be about the dojo (the ground, or the place, on which martial arts are trained). The group and the fight between the two judoka is not seen in the first time. Following evocations will be for the portion of the dojo where the fight takes place and the entire group of judoka. Then, the fight, composed of two persons, is perceived. After only, the perceiver will separate the two individuals fighting, and finally, will be able to perceive the movements of each of the judoka. In the first global image, the dojo, is filled by its components: the part of the dojo where the action takes place, the group, the two fighting judoka, their fight, the movements composing their fight, etc... From the filling up of the space, the meaning is created.

### **Auditory and verbal modalities**

For the same reason as the visually perceiving person, the auditory or verbally perceiving one needs a material to give meaning to the perceived object. In this case, the material is the time and the project to be executed thanks to a work of meaning discovering: it will be in following a path, i.e. in a temporal context. At

the starting point, an indistinct idea or feeling will serve as a project of meaning and will drive the perceiving activity toward other ideas or feelings received by further observations. This path is heading toward a more precise feeling, becoming the observer's one. It is similar to the dialectical scheme introduced for the visual modality, in the relationship between the starting evoked concept and the following ones. The auditory or verbally modal perceptive activity is based on a path in which details of the perceived objects will gather in an indispensable temporal order, heading to intuition of meaning. Thus, the project has time as material for the meaning's intuition. The right side of the figure 6.1 resumes graphically the intuitive understanding of perceived object's meaning by auditory and verbal evocation.

### **Meaning and perceptive activity**

The perceptive activity is thus the phenomenological analysis of attention. The perceptive activity aims at obtaining a meaning for the perceived object. In this target, it takes the project to evoke the perceived object and its aspects that can help to provide a meaning. This is done by the observation of aspects gathering thanks to the support by the material for the meaning intuition: the space in case of visual evocations, and the time in case of auditory or verbal evocations. This process will have, as first effect, to precise the meaning of the perceived object, and then by further observations, to comfort, correct or modify this meaning.

Perceptive activity brings the ability to grasp meaning relations between objects and beings (e.g. the sun lights up less since a cloud stands in the way). Perceptive activity reaches its goal to understand objects only if it is driven by the thought that aims at evoking their composition. In the project of giving meaning to the perceived object, elements are set against each other recursively, requiring recursive evocations to proceed. This enables the project to progress to a new understanding state of the object. In the case of visual modal evocations, this process is based on a global image in which evoked elements are input to fulfill the objective. In the case of auditory or verbal modal evocations, this process is based on a self given speech telling a feeling or an idea about the evoked elements. This speech will then served as constant support

for temporal placement of following evocations. Considering this process, it is immediate how perceptive activity can shift to a conceptual activity.

#### **6.1.1.2 intuition and conceptualization**

Whereas perceptive activity has the project to determine a meaning for the perceived object, conceptual activity aims at determining differences and similitude of visual, auditory or verbal evocations by comparison of evoked objects. Concerning perceptive activity, a sequence of linked events in a common situation occurs. Evoked aspects are linked to each other, sometimes showing out cause and effect relationships. It may also happen that previously acquiring evocation is recalled because of the close similarity with the currently perceived object. Still, this is not a conceptual activity since the rapprochement is sensitively related, whereas conceptual activity aims at comparing elements in order to perceive similarities and differences intellectually.

#### **Abstraction and generalization**

In the case of visual modality, space is the meaning material. It provides then an homogeneity of site, assuming a form of generality. In the case of auditory/verbal modality, time is regarded as the meaning material, providing heterogeneity of moments, assuming a form of abstraction. Thus, the target for meaning can be generalization (generality of the homogeneity of site), or abstraction (abstraction of the heterogeneity of time).

Actually, the one who has visual evocations gives oneself the mean to abstract, and vice versa for auditory/verbal evocations. In the first case, the beginning of the project is to consider the set of the object, in a generalized space. Then, following steps (or evocations) will be to let details enter into this space (always from the most general to the most detailed element, i.e. the elements that takes the most room to the one that takes the least room in the space). Generalization is the guide of this mental progression. In the second case, the first step is to abstract a meaning of the object (generally an emotion or a sensation). Then, following evocations will serve to go on the investigation, but this time with the firstly acquired abstract meaning, in order to look for other elements confirming the first perceived meaning. This is an abstractive process.

any direct role in the meaning construction. In contrast, Émile Beveniste<sup>17</sup> ([117, p. 117, cited in [47]]) thinks that words are the bearer of the meaning. Drawings used to express one's thoughts are only an intermediate for the communication of the meaning beard by the words. For people like Ferdinand de Saussure, the signifier is the word and the signified the image, and vice versa for people like Émile Beveniste.

For the perceptive activity, we saw that space and time had the role of material of meaning for intuitive perception. This is also the case for intuitive conceptualization, but it is not the only role of time and space. Indeed, when space is used, the meaning is determined thanks to the position of the elements, by their relative size and by their possible interlocking; In the case of time, meaning is revealed thanks to articulations which link elements to each other. The meaning is determined thanks to the successive order of the elements. In the case of space, these elements are facts or objects; In the case of time, they are relations. However, the determination of the meaning is not completely distinct for each modality. As for the case of space, the conceptualization will have to link facts and objects to structure the meaning, including a sense of temporality; As for the case of time, conceptualization has to describe things the way they are (also) spatially organized.

### 6.1.1.3 Conclusion on intuition

Intuition enable people to perceive and conceptualize objects of their environment, without out the use of long term knowledge, but thanks to attention. Two modes can be used for the intuition process: visual or sound/word modalities. The mechanisms and the supports of both of these modalities were explained, their interactions also. Focusing on the problem developed in chapter 6, it is now necessary to see the impact that intuition mechanisms can have on interdisciplinary workgroup communication. Could it solve the problem of knowledge sharing?

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<sup>17</sup> who was certainly intuitively understanding thanks to verbal modality.



The problem posed by Henri Bergson [10] about the interweaving between abstraction and generalization<sup>15</sup> is here split into two processes according to the project and the material of meaning: one subject targets generality and intuition coming from space, and the other one targets an abstraction and intuition coming from time.

### Conceptualization

Perception and conceptualization are similar and may present continuity because they use space or time as meaning material to reach the intuition of meaning. Nevertheless, perception activity has the project to input in space or time elements that come directly from objects in contact with one's sense. In this case, intuition is inside the perceptive activity and is exclusively targeting the meaning of the observed object. In psychology, the intelligence used for perceptive activity is called *direct intelligence*.

Conceptualization activity uses indirect intelligence. It uses space or time to feed it with elements that are not perceived but that are picked up in order to be compared and to determine similarities and differences. In the case of the visual modal conceptualization, space is used to gather schemes or sketches representing global structures of the objects (visual representation of the concepts). In case of the time modal one, descriptions are based on words gathered on the time scale. Such descriptions are compared, and similarities and differences are output on a temporal structure [47].

In the case of visual evocations, words are used to communicate or to express the image or the scheme. They are signifier, i.e. a convention. The meaning is in the signified, i.e. the image which is the intelligibility itself. Ferdinand de Saussure<sup>16</sup> explains that words are used to communicate with others, but they don't have

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15 Henri Bergson states that abstraction needs beforehand generalization and vice versa. This voluntary confusion can be explained by the Bergson's theory knowledge evolution: in spontaneous cognitive activities, there would be captures of intuitive, implicit or resemblance nature, which would be already specifications. Bring to the level of reflection, these captures would become concepts thanks to settling words.

16 The analysis of Saussure's works reveal that he was certainly intuitively understanding thanks to visual modality.

## 6.1.2 Using intuition in interdisciplinary communication

The chapter 5.2 pointed out the difficulties of knowledge sharing in interdisciplinary groups. These difficulties may concern explicit knowledge because of the ontologies proper to each discipline, and also tacit knowledge because humans' experience is also communicated.

Descriptive knowledge, especially within the workgroup, is mainly composed of disciplinary content. As shown in the chapter 5.2.2, interdisciplinary context is not favorable to disciplinary content sharing. Intuitive conceptualization can be effective here since it does not require the usage of long-term memory, which disciplinary knowledge memory is part of. If disciplinary knowledge can be expressed such as it would be understood thanks to intuition, then the explicit knowledge sharing would be solved. This idea is possible: science literature to the large public is very popular and active.

Tacit knowledge sharing is also, but to a lesser extent, concerned by disciplinary knowledge sharing in the interdisciplinary group. Disciplinary-related tacit knowledge comes mainly from the activity and the experience gained by disciplines. Intuition can also be used to perceive and conceptualize other discipline's methods and practices. However, a transformation is required for intuition to be fully usable for interdisciplinary tacit knowledge exchange.

The two previous points suggest that intuition can be used as a mental process for explicit and tacit disciplinary knowledge in an interdisciplinary context. This would solve the issues expressed in the chapter 5.2.2, while keeping the ability for the interdisciplinary workgroup to understand and to share knowledge, and to progress in the project. However, both points are also required a transformation (or translation) of the knowledge for the intuition to be applied naturally. Therefore, a support insuring correct transformation is required. The 'correctness' of the transformation means that there is no distortion of the knowledge during its transformation, and that the result can be validated by the discipliner and intuitively understood by others.

## 6.2 Proposition – *The Evoked Metaphor*

Actually, this transformation process needs important elements to be operational: a context of operation and an operation support. The context of operation is the communication and sharing knowledge organization of the interdisciplinary group. It will be based on the *ba*, presented in the paragraph 6.2.1. The *Evoked Metaphor*, presented in the paragraph 6.2.3, is the operation support tool to transform disciplinary knowledge correctly into an intuitively understandable one. The structure of *ba*, including the *Evoked Metaphor*, is presented here as the methodological solution for the correct operation of sharing knowledge in interdisciplinary workgroup context.

### 6.2.1 The concept of *ba*

#### 6.2.1.1 Introduction

Nonaka and Konno introduced the concept of *ba* for knowledge creation and management in firms [185]. The term *ba* comes from Japanese (場) and was introduced first by the philosopher Kitaro Nishida [184]. They define it as a 'shared space' for knowledge, i.e. a place where interpersonal interactions are possible, and where knowledge creation is possible:

*For those unfamiliar with the concept, ba can be thought of as a shared space for emerging relationships. This space can be physical (e.g. office, dispersed business space), virtual (e.g. e-mail, teleconference), mental (e.g. shared experiences, ideas, ideals), or any combination of them. What differentiates ba from ordinary human interaction is the concept of knowledge creation. Ba provides a platform for advancing individual and/or collective knowledge. It is from such a platform that a transcendental perspective integrates all information needed. Ba may also be thought of as the recognition of the self in all. According to the theory of existentialism, ba is a context which harbors meaning. Thus, we can consider ba to be the shared space that serves as a foundation of knowledge creation. – [185]*

This description suggests that *ba* is more than a place of meeting and interaction. Knowledge is included in the *ba* and is intangible (outside, it becomes information and is mainly tangible). It is actually the place of exchanging knowledge, acquiring by one's own experience or reflection on the experiences of others.

*Ba* is defined as a frame, in the mean that it has borders of space and time. In this frame, knowledge and its flow are source of creation.

### 6.2.1.2 The SECI Model

Nonaka proposes a spiraling interaction between explicit and tacit knowledge as a knowledge creation process. The process is described following four steps (cf. Figure 6.2): The socialization, the externalization, the combination, and the internalization ones (SECI Model). Each step is a conversion process from one of the two types of knowledge to the other one:

- Socialization involves the sharing of tacit knowledge between individuals. The Nishida's concept of 'pure experience' (純粹經驗)<sup>18</sup> is a basis of this step. The tacit knowledge is shared by being in a common environment (living in the same environment, being together, and so on), rather than explicit path of communication (written or verbal). Thus in a certain sense, tacit knowledge can only be shared if the self is freed to become a larger self that includes the tacit knowledge of the other. Socialization is the process of acquiring tacit knowledge through direct interaction, by tacit knowledge dissemination.
- Externalization is the expression of tacit knowledge for other to understand it. In Nishida's philosophical terms, the individual transcends the inner and outer-boundaries of the self. During this step, the individual (one's intentions and ideas) merges with others to become the unity of the group in which tacit knowledge is converted into explicit knowledge. Externalization process is mainly supported by two factors:

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<sup>18</sup> Nishida defined the concept of 'pure experience' as an immediately intuited experience at the root of thought, as prior of the inception of thought, and as the origin of thought.

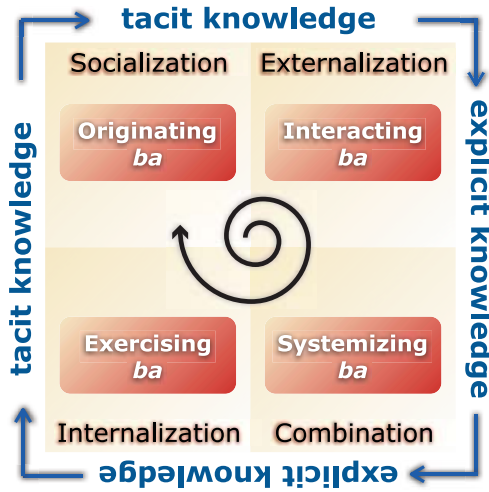


Figure 6.2 | The SECI Model

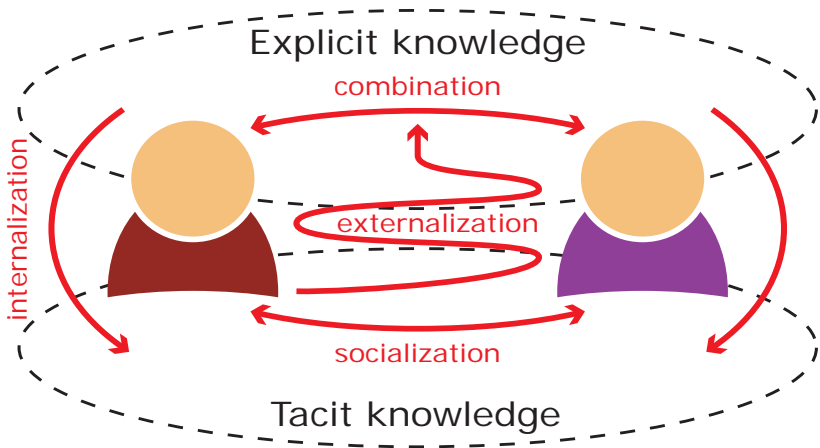


Figure 6.3 | Knowledge conversions in the ba

- The conversion of tacit knowledge into explicit knowledge involves techniques which help to express one's ideas (images, concepts, figurative language (such as metaphors, analogies or narratives), and so on).
- The translation of others into understandable form. This may involve deductive, inductive, and/or abductive reasonings.
- Combination consists in the conversion of explicit knowledge into more complex sets of explicit knowledge. By being diffused and systemized, the knowledge transcends the group. Capturing, integrating, editing the explicit knowledge are the main activities in this step.
- Internalization is the conversion of newly created explicit knowledge into group's tacit knowledge. The individual absorbs relevant knowledge. Philosophically, for it means the individual to find oneself in a larger entity. Experimenting, trying, training are possible methods.

The SECI Model is describing a dynamic process in which tacit and explicit knowledge flows and are shared by members situated in the group. Inside the *ba*, knowledge creation is achieved in real-time through self-transcendence [223].

### 6.2.1.3 Characteristics of the four steps of the SECI Model

The four steps of the SECI Model are actually four different *ba*. These *ba* support each process, and globally the knowledge creation process (cf. Figure 6.2):

- The *originating ba* is supporting the socialization step. The individual lets herself/himself 'infuse' and 'be infused' in/by the originating *ba*. In this existential place, one transcends oneself, sympathizes and empathizes with others, removing barriers between people. Ideas, feelings, experiences are shared. Nishida expresses this original step by the metaphor [184]:

*I love so I am.*<sup>19</sup>

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<sup>19</sup> This metaphor is inspired from the Descartes's *I think so I am*, but with the purpose of contrasting it. Descartes's utterance intends to be an logic original step. Nishida's

- The *interacting ba* is supporting the externalization step. It is built in a more organizational way than the originating *ba*. Through interaction (i.e. conversation), people's mental models and skills are explained using common terms and concepts. Individuals reflect their own mental models and share the others' ones. This externalization process aims at expressing tacit knowledge. Dialogue, including extensively metaphor, is an important skill for the good process in this *ba*.
- The *systemizing ba*<sup>20</sup> is supporting the combination step. The new explicit knowledge, created in the previous step, is combined with the already existing knowledge owned by the group. A systemic approach is required in this step and is applied to explicit knowledge. Communication tools, such as groupware, on-line networks or database are advised to support this combination step.
- The *exercising ba* is supporting the internalization step. Exercising the previously gathered knowledge is necessary for individuals to embody explicit knowledge and convert it into tacit knowledge. Exercising is preferred to teaching technique to embody through action and success the conversion of knowledge.

### 6.2.2 A *ba* for the interdisciplinary workgroup

In a workgroup, the *ba* can be generated thanks to an organizational effort. By adopting the SECI Model as a guideline, this organization can support its members to share and to create knowledge.

In the part 5.2, I showed that interdisciplinary characteristic of the workgroup which this dissertation is focusing on meets problems during the sharing of both tacit and explicit knowledge. Then, the *ba* can be an adapted support for the interdisciplinary group if it includes a method or a tool to ease tacit and explicit

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utterance expresses in opposition the necessary emotional, i.e. subjective characteristic required in the originating *ba*.

<sup>20</sup> I prefer here the term systemizing to cyber as proposed by Nonaka [185] in order to separate it clearly from the term of Cyberspace used in this dissertation. Nevertheless, Nonaka describes this *ba* as a virtual one, by opposition with real space and time, which justify also the use of cyber *ba*.

knowledge sharing. In the part 6.1.2, I showed that intuition, which everybody can use and disciplinary independent, could be a path to solve such issue.

I propose then to use intuition as a basis to create a supporting concept to support sharing knowledge in the *ba*. This concept, I call '*Evoked Metaphor*', will make possible the efficient use of *ba* for interdisciplinary workgroups. Then, the *ba* and its included *Evoked Metaphor* will be the frame for an interdisciplinary workgroup working process method. As an example, the Part C is a design project using an *Evoked Metaphor*.

### 6.2.3 The *Evoked Metaphor*

#### 6.2.3.1 Description of the *Evoked Metaphor*

My proposition is to create a metaphor, related to the project on which the interdisciplinary workgroup is working on. This metaphor, called the *Evoked Metaphor*, is defined as a set of intuitively transferable successful information and operating laws (cf. Figure 6.4):

- Intuitively transferable information and operating laws — The *Evoked Metaphor* is based on intuition and its process, which are supporting knowledge sharing in the interdisciplinary group. The main requirement for this metaphor is that members can understand it and interact with it intuitively. In other words, this *Evoked Metaphor* would be an image analog to the current problem, that each member would be able to understand not due to disciplinary skills, but thanks to intuition. This description induces attributes and constraints that have to be developed here illustrating the following explanation.
- Successful information and operating laws — One of the most important aspects to be considered while designing the *Evoked Metaphor* is its analogy between the *Evoked Metaphor* and each of the disciplines' points of view involved in the workgroup. This analogy means that the 'relation' between the *Evoked Metaphor* and each discipline is two-ways:
  - The discipline has to be able to validate the structure of the *Evoked Metaphor* and its processes in full. Each evolution in the description of the



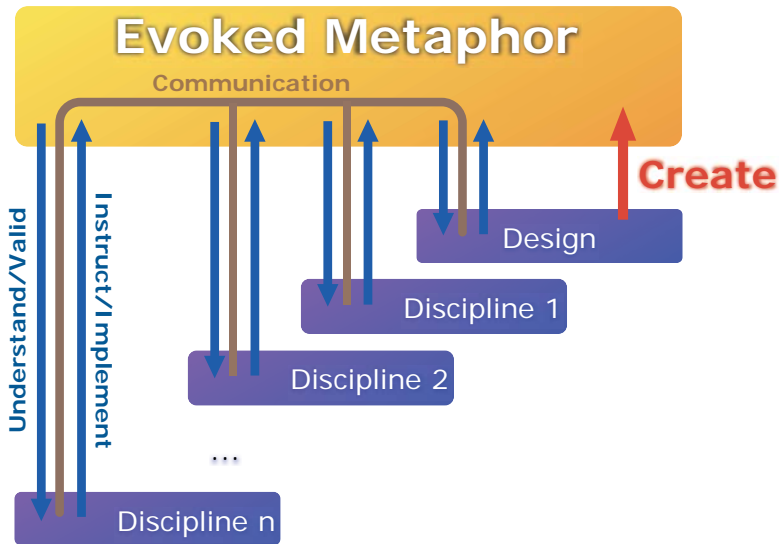


Figure 6.4 | The Evoked Metaphor Model

*Evoked Metaphor* should be in accordance with each discipline's paradigm. Any contradiction should be corrected in the *Evoked Metaphor* in order for it to be validated it completely by each discipline.

- Any discipline should be able to include in the *Evoked Metaphor* an aspect of the discipline's paradigm (i.e. to instruct the *Evoked Metaphor*), without creating contradiction among the various processes existing already in the *Evoked Metaphor*.

If the relation between the analogy and the *Evoked Metaphor* respects the constraints listed in these two ways, then the *Evoked Metaphor* is said successful.

As it is based on intuition, the understanding of the *Evoked Metaphor* should not require any specific disciplinary knowledge. The *Evoked Metaphor* has to refer to concepts understandable by any body (even people outside of the interdisciplinary workgroup), thanks to their own intuition and/or their own experience. The *Evoked Metaphor* has to be a meeting point between disciplines in their quest of sharing knowledge.

Following this process, during the entire process, would help each discipline to participate, or at least to follow and comment each step of the project, finally making the latter a fully interdisciplinary project.

### **6.2.3.2 Characteristics of the *Evoked Metaphor***

Most of the characteristics of the *Evoked Metaphor* were actually expressed in the aforementioned description:

- The main characteristic of the *Evoked Metaphor* is that it is in total accordance with each disciplines' ontology. There should be no contradiction with any of the disciplines involved in the project. If this happens, the instructing discipline and the contradicting one should check first if their own ontologies are not contradicting with each other (which would explain the contradiction found in the *Evoked Metaphor*). Then, an agreement should be found before including it in the *Evoked Metaphor*. If it appears that there is no contradictions between

the two ontologies, then the *Evoked Metaphor* should be rephrased to remove the contradiction.

- Another very important characteristic of the *Evoked Metaphor* is that everybody can understand it intuitively. As seen previously, intuitive understanding does not involve disciplinary knowledge, and can be succeeded by anybody. Actually, it is not possible to make sure that everybody conceptualize the *Evoked Metaphor* in the same way. This requires then tolerance of points of view and curiosity about others' point of view. If that succeeds, thanks to conversation and open minds, these differences can become the richness of the group, and a vector of its creation by comparison. Yet, these different points of view should be complementary, and contradiction should be avoided. That is one of the challenge of the interacting and systemizing *ba*.
- The *Evoked Metaphor* is not static throughout the project. The spiral cycle of the SECI Model provides the opportunity to be dynamic and to evolve at each cycle. The *Evoked Metaphor* should evolve, integrating new factors, created elements, deeper reflections from the group member's, and so on. Its evolution means its maturity and its increasing relevancy.
- The *Evoked Metaphor* should have a bilateral relation with each member. First, the *Evoked Metaphor* should be understood intuitively (cf. Figure 6.4), and its elements should be validated according to the discipline paradigm of each member. That is all the more important for the relevancy and the use of it. Second, each member has to be able to instruct or implement the *Evoked Metaphor* with new elements or ideas to make it progress.
- Thanks to this bilateral relation between the *Evoked Metaphor* and each member, the former should be used as communication intermediate between members. Previously, it was shown that there were issues in the direct communication of tacit and explicit knowledge between people with different disciplinary backgrounds. The *Evoked Metaphor*, involving the intuition abilities of both persons, is a communication support to prevent, or at least to reduce these issues. That is one of its very interesting and great functions: Thanks to it, people can converse about the project and understand others' points of view intuitively.

- Finally, it is important to consider construction step of the *Evoked Metaphor*. As spaces such as the *Evoked Metaphor* are included in design skills, the field of design can be in charge of elaborating it before its validation by other disciplines [233]. If no designer is involved in the project, then the project coordinator should be in charge of the *Evoked Metaphor* construction and ‘maintenance’.

#### 6.2.4 *Evoked Metaphor* in the practice of the SECI Model

For an efficient knowledge sharing in the interdisciplinary workgroup, the *Evoked Metaphor* has to be included into the SECI Model. To be useful, the *Evoked Metaphor* has to be present at each step of the project, i.e. in the four steps of the model. However, the first cycle is dedicated to the creation of the *Evoked Metaphor*. Therefore, this ‘initial’ cycle is different than in the following ones. The four steps of the first cycle are as follow<sup>21</sup> (cf. the left part of the Figure 6.5):

- At the very beginning of the project (during the first cycle), the *Evoked Metaphor* does not exist. However, it is a crucial step since the designer (of the *Evoked Metaphor*) will get to know other members of the group and to feel the group. Then, this step of socialization corresponds to the context of early gestation of the *Evoked Metaphor*. In the case of *MATiK*, the concept concerns the interdisciplinary design workgroup. Which field can bring what kind of information? What is the global goal of the project? These are some questions which emerge during socialization.
- The next step corresponds to the first concrete action of the designer: the basic concepts and objects of the *Evoked Metaphor* are defined. In the case of *MATiK*, the notion of groups, subgroups, and conversation (as a natural way to interact) are defined. Also, notions about unity of the space and multiplicity of conversations are introduced.

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<sup>21</sup> At the end of each point, in italic, the first cycle of *MATiK* design will be briefly described as an example. This design project, aiming at creating a communication system for wide workgroups, will be deeply developed in the part C.

- Then, objects are gathered and articulations (or mechanisms) between them are de- fined. The entire set {objects, mechanisms} forms the *Evoked Metaphor*. In the case of *MATiK*, the group is gathered in a *Loft*, in which subgroup are formed naturally for the various possible activities. Mechanisms related to the group in the *Loft* are conversations inside the subgroup, and the cocktail party phenomenon between the subgroups.
- Finally, *Evoked Metaphor* has to be validated by the members of the work- group. This validation endorses that the *Evoked Metaphor* (i.e. its objects and its mechanisms) is compatible with each discipline’s paradigm involved in the project. In the case of *MATiK*, it is important that each discipliner understands the concepts involved in the *Loft*, and validate them. In the first place, that is especially important for the disciplines such as design, psychology, and cogni- tive sciences.

The following cycles are structured on the pattern illustrated on the right part of the Figure 6.5:

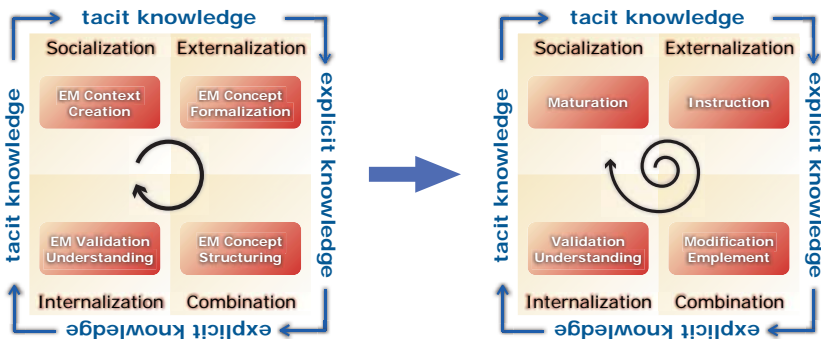


Figure 6.5 | The *Evoked Metaphor* in the SECI Model

- During the socialization step, the individual is 'infusing' or being 'infused' in/by the originating *ba*. Concerning the *Evoked Metaphor* evolution, it is a step of maturation, of assimilation, i.e. of 'infusion' of the *Evoked Metaphor* in the inner part of the individual, on its tacit aspects.
- During the externalization step, the interacting *ba* is supporting the expression of tacit knowledge among members. Following the same pattern, new elements, brought by the maturation step during the previous step, need to be expressed to be instruct in the *Evoked Metaphor* and included in the project.
- During the combination step, the explicit knowledge expressed in the previous steps are combined in the systemizing *ba*. As for the *Evoked Metaphor*, it is modified to implement new elements expressed during the previous step.
- During the internalization step, the individual embodies explicit knowledge and convert it into tacit knowledge. That is the time for each discipliner to validate new implementation in the *Evoked Metaphor*. The effective validation of the cycle induces that:
  - Each discipliner understands intuitively the new state of the *Evoked Metaphor* and its evolution comparing with the previous cycle.
  - The *Evoked Metaphor* is not in contradiction of any kind with any discipline involved in the project.

It is interesting to notice here that the shift between tacit and explicit knowledge in the SECI Model is preserved in the *Evoked Metaphor* :

- The maturation step is an evolution of tacit knowledge.
- The instruction step helps the tacit knowledge owned by each discipliner to be converted and output into explicit knowledge.
- The implementation step is the systemizing process to integrate tacit knowledge into the *Evoked Metaphor*.

- The validation step is required for the intuitive understanding of discipliners, which means a partial conversion of explicit knowledge to tacit knowledge.

### 6.2.5 The *Evoked Metaphor* and the design process

It was shown how the *Evoked Metaphor* fits perfectly within the SECI Model in order to propose an efficient knowledge sharing system in the interdisciplinary workgroup, thanks to intuition as a mental process. To finish this introduction of the *Evoked Metaphor*, it is now required to describe it in the industrial process.

The design process considered here (introduced by [191, 256]) is divided into two main steps aiming at transforming ideas (most of the times related to “user’s needs”) into artifacts for the real world (left side of the Figure 6.6):

- The ***top-down process*** — This step aims at defining, characterizing and analyzing the issues the design has to face. The problem statement establishes the context of the design project and optimizes project goals (problem definition) [192]. This definition is essential since it finds the bases of the design project, and characterizes it. Then, these characteristics are analyzed (following various analysis methods) in order to output different solution elements. This step is qualified as ‘top-down’ since it starts from a global aspect of the project (or system), the top of the pyramid, and aims at detailing it by a segmentation process. Owen described a four-level segmentation (system-modes- activities-functions) [191], describing the system more and more precisely, going down to the list of functions.
- The ***bottom-up process*** — Once the functions are known and detailed, the designer uses this knowledge to conceptualize the design. Starting from the functions listed by the previous step, the designer clusters them to define a global information structure. During this information structuring, ideas are generated and output, for a better anticipation of the conceptualization step.

In this design process, the first cycle of the *Evoked Metaphor* (right side of the Figure 6.6) is operated during the problem definition. The first cycle of the *Evoked Metaphor* is used to define, structure and validate it. Therefore, there is a strong parallelism between the design goal creation (i.e. defining the problem)

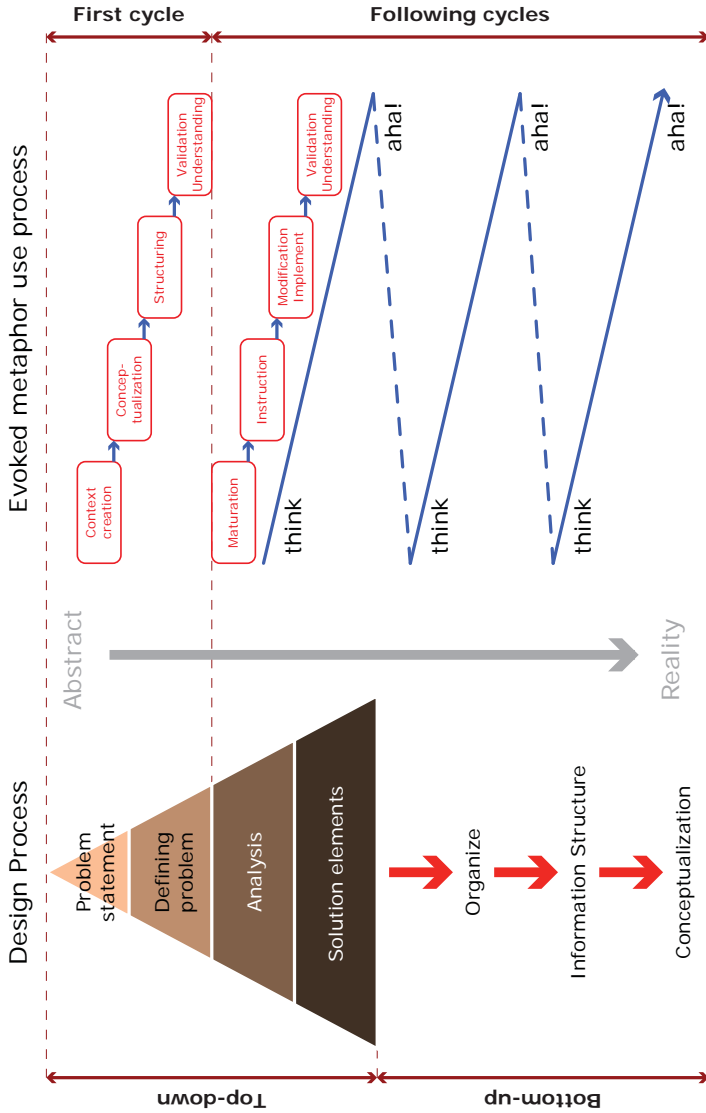


Figure 6.6 | The *Evoked Metaphor* and the design process



and the *Evoked Metaphor* one, which explains and is explained by the analogical aspect of the link between the design and its *Evoked Metaphor*.

Concerning following cycles, the *Evoked Metaphor*'s progression follows that of the design project's. Each analysis should be accompanied by a cycle of the *Evoked Metaphor* process:

- The Maturation step takes place during the pre-analysis information gathering step;
- The Instruction step takes place during the information structure;
- The Modification/implement action step happens during the actual analysis process;
- The Validation/Understanding step accompanies the validation step of the analysis, emerging the understanding and characterization of a new function (the first aha! result), part of the solution elements.
- Finally, the unconscious (although very important) time located between the Validation/Understanding and the Maturation steps, and represented by the dot lines in the *Evoked Metaphor* use process of Figure 6.6, is the time required for information to settle its position in each one's mind, before one is able to relaunch a new cycle. However, this step is not properly part of the *Evoked Metaphor*, as it is an individual internal process.

During this period (analysis and solution elements), *Evoked Metaphor*'s cycles should be numerous and may be processed in parallel since one cycle (at least) should be used for the determination and the formulation of each function. This would result in the structured list of functions fully 'translated' and validated in the *Evoked Metaphor*.

For the bottom-up process, cycles are much less numerous since they only aim at helping and partially validating the information structuring process. The information clusterization can be also applied to the *Evoked Metaphor*, as a creative process, to end on new mental representation of the *Evoked Metaphor*, source of creation (the second aha!).

Finally, output of the information structure process, emerging on the conceptualization and being the most creative step of the design process, can be interdisciplinary understood and validated by each member thanks to the last cycle.

To conclude, it can be now argued that the SECI Model/*Evoked Metaphor* method can be fully integrated to the industrial design process, preserving and fitting to the design steps. Moreover, the *Evoked Metaphor* can now be considered as an adapted and efficient tool for better knowledge sharing abilities of the interdisciplinary workgroup, with a great integration into the design process. The *Evoked Metaphor* can be used for this purpose, and that will be applied in the Part C.

## ***Chapter 7***

### **Reflection on the method**

The *ba*, leaning on the SECI Model, is a sharing knowledge structure particularly well adapted for design workgroups. It permits a constant and interactive flow between tacit knowledge and explicit one. Thanks to its cyclic process, the workgroup finds in it a dynamic organization to manage the combination, the diffusion, and the diffusion of knowledge.

Nevertheless, even if it helps the management of knowledge, it does not satisfy the problem related with knowledge sharing in interdisciplinary context. It has to be supported by a tool for knowledge management which is able to satisfy interdisciplinary constraints. This is the purpose of the *Evoked Metaphor*. It has not only functional but also structural abilities.

On a functional point of view, the *Evoked Metaphor* permits knowledge sharing thanks to the mental process of intuition. Due to intuition, people can perceive and conceptualize external things thanks to processes not based on a long term memory, and thus not based on disciplinary knowledge.

On a structural point of view, the *Evoked Metaphor* is adapted to the structure and the cyclic dynamics of the SECI Model. Moreover, it is synchronized relatively to the process of exchange between tacit knowledge and explicit one (Externalization and Internalization), and relative to the evolution of both (Socialization and Combination).

Then, the interdisciplinary design workgroup finds in it a tool for the knowledge management and creation satisfying knowledge sharing constraints, and workgroup aspiration. However, this tool is delicate to use, for a few reasons:

- It requires strictness concerning the quality of the metaphor, i.e. on its analogy with the ontologies of the disciplines involved in the interdisciplinary project. If this constraint comes to be disrespected, then the *Evoked Metaphor* would

lose all its relevancy and its usage may provoke wrong decisions in the design process.

- It demands to each member an additional effort to operate the *Evoked Metaphor* properly, and to process a correct transformation of the knowledge to share.
- It requires to workgroup members a certain tolerance and flexibility of mind, and a motivation to converse.

However, this methodology has not yet got to the ‘time of maturity’ and have to be evaluated, and certainly optimized, thanks to its application to concrete projects. Moreover, the description of the methodology, as shown in the Chapter 6, is quite abstract and an example would be appropriate. Therefore, in the Part C of the present dissertation, I propose to introduce an application of the *Evoked Metaphor*: the design of *MATiK*.

I have actually done this design in the same time as I have conceived this methodology. This design served as an evaluation and validation process during the conception of the *Evoked Metaphor*. This has allowed me not only to keep a concrete approach of the *Evoked Metaphor* conception, but also to present this methodology more concretely, more clearly. That was a very important point to interact positively and constructively with people. Chronologically, the *Evoked Metaphor* and *MATiK* are very linked.



## **Part C | *MATiK***

As a methodology for interdisciplinary design has been introduced in the Chapter 6, an application is proposed here for a new design project. This design will be a gain for this research, for various reasons.

Firstly, as the methodological proposal itself was proposed on an abstracted approach, it seems to be appropriate to include an application, in order to clarify the design methodology. An interdisciplinary methodology that could not be widely understood is opposite to this project itself. Moreover, this research would not have real significance if the methodology could not be applied. Therefore, this application is important to present the relevancy of this research.

Secondly, since the beginning of this dissertation, a need for new tools is expressed. These tools have to meet with the new requirements raised by the collective intelligence. Also, communication is cited as one of the most probable sources of issues for interdisciplinary design. Thereof, to reinforce interdisciplinary design activity, the design of a communication tool for interdisciplinary workgroups seems to be a judicious choice.

Nevertheless, in the scope of this dissertation, the design of this tool will be limited to the ideation step, the functional requirement determination step, and the technical requirement determination and description steps. These three steps are indeed the most relevant to show the way the interdisciplinary design methodology can be used. This part intends to show how the *Evoked Metaphor* is flowing through the design process and is linking both issues for more meaningful solutions on one side, and actors of the design process for a fully interdisciplinary design on the other side. This illustration on a few steps will still be easy to comprehend to other steps to understand how this methodology operates in the complete design process.





## **Chapter 8**

### **Introducing MATiK**

*What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it. - Herbert Simon [224]*

#### **8.1 Immediate considerations on workgroups**

This design project was launched after some issues were risen from the observation of the *Kansei* research group<sup>1</sup> [149, 150]. As this group had an interdisciplinary structure, discussions were launched from the beginning of the project to gather ideas, concepts and methods from the different disciplines. To support such discussions, different tools had been used:

- Mailing list system was probably the most quickly and widely used tool in order to encompass most of the members of the group. The easiness on installation and use made it a very practical tool to start with.
- Different projects of forums were launched but none of them actually lasted.
- Meetings (such as seminars or workshops) were organized also quickly and found a stable form.

However, as the group is wide, has interdisciplinary concerns, and is working on various research themes in the same time, people estimated that most of the emails they were receiving were not interesting for them, were highly time consuming and were finally bringing inefficiency and confusion to each member's

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<sup>1</sup> The research group called here *Kansei* research group is the one researching for the 21st Century COE program Promotion of *Kansei* Science for Understanding the Mechanism of Mind and Heart (J03), sponsored by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) [200]. The present dissertation and its research are sponsored by this 21st Century COE program.

work. Since the communication system was intended to bring efficiency at the group level, the issue became quite consequential as it brought actually stress, inefficiency and confusion at the individual level. Existing tools were not satisfying the group in terms of communication, and many trials were required in order to find at least the minimally acceptable structure. Currently, a few mailing lists, a published journal, and regular meetings structure an approximately stable communication support system.

This experience revealed a lack of appropriate tools for wide interdisciplinary workgroups. In a group in which each person does not know all other members, does not work directly with everybody, and does not have the same concerns and interests than all other members, what would be an appropriate communication system? Which communication tool would satisfy each member, reducing inefficiency and confusion?

Starting from this observation and these questions, I have started to look for a solution. Then I proposed to start a design project that would output an artifact satisfying the following description:

*A unified communication system, including or not already existing ones, designed for interdisciplinary workgroups to communicate on various topics, without limitation of space and time, providing to each member the necessary information according to the consideration of individual specifications.*

The artifact resulting from this design project, solution of the previous proposition, was named *MATiK*. It includes a few key points that are necessary to be analyzed in order to understand the proposition :

- *MATiK* is said unified. I suggest here that *MATiK* should appear as one tool satisfying the requirements. As it simplifies the relation between the user and the tool, this is preferred to a group of tools which would be gathered to complete the different requirements.
- *MATiK* could include already existing system. It is not useful to reinvent the wheel if the project can be done based on already existing solutions.

Nevertheless, this inclusion has to be well evaluated since a priori already existing tools are not satisfying the collective intelligence requirements.

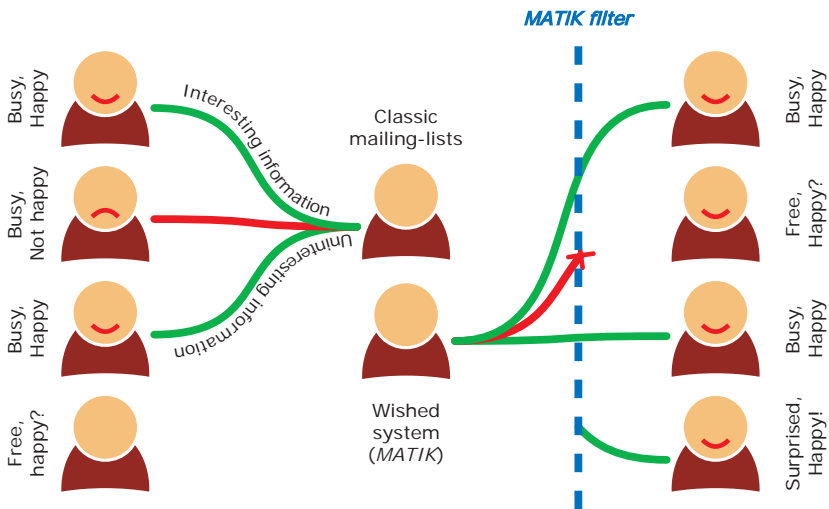
- As it was explained previously, interdisciplinary workgroup conversations are concerning various topics which may interact or not, but which are flowing at the same time in the workgroup information process. *MATiK* should not be built for any specialized information content, since it is dedicated to a comprehensive information support system.
- It is probable that members may be located all over the globe, as the workgroup is wide and research is now becoming more and more international. This required a non limitation of space and time, i.e. the information flow should not have any spatial limitation, and the conversation should not be based on access time by the user. For example, meetings have a spatial limitation since it requires people to be all together at a certain place at the same time. To solve the spatial limitation, video conference systems over the Internet were created. However, these systems still impose users to meet at a certain time, which may be very hard due to time differences or other time organization issues. The requirement for *MATiK* is that time and space should not be an issue for the quality of information flow.
- The most important point of this design project is included in the last part of the proposition. The main criticism concerning the currently existing tools was that information received by each member was, for most of it, inappropriate, i.e. irrelevant, time consuming, and frustrating. Then this is seen more as a constraint in the work, and is devaluing the communication tool. When considering a big group, it is important that information is limited to the interesting part. But as the group has an interdisciplinary activity, interests may differ for each member. Individual specifications are different and should be carefully considered to evaluate the relevancy of the information. Information flow should not be structured following the group requirement (global level), but following each member's requirements within the group (individual level), i.e. in the consideration of individual specifications . Information should not be sent to everybody, or to people depending on their position in the group, but people according to their own characteristics. It is important to notice here that *MATiK* is not only a filter that is preventing the irrelevant information to reach the receiver, but it can also submit the information to people for whom

the information would be relevant, even if this person was not considered by the transmitter as a receiver in the first place. This is an important point that will be detailed later in the part 8.3.2. The figure 8.1 shows an information flow process according to the global level on the left side, and on the right side, an information flow process according to the individual level. That is the strength of *MATiK*, and its originality should be pointed out.

## 8.2 Other systems

### 8.2.1 Classic systems

In order to compare *MATiK* to other systems, a survey had been done on 'classic communication tools' (cf. Table 8.1). The term gathers any communication system widely used by people. They are not necessarily computerized. Non electronic systems can be tangible ones (newspaper, mail, board, post-it note, or telegram) or others (face-to-face conversation, meeting, party, propa-



**Figure 8.1** | The expected information flow

ganda, or rumor). Electronic systems can be computer based ones (blog<sup>2</sup>, chat, email, forum, SMS<sup>3</sup>/cell phone mail, mailing list, video-conference or website) or others (cell phone call, one-giri call<sup>4</sup>, phone call, radio, television).

To compare these different tools, some criteria had been established according to the requirements introduced in the part 8.1:

- The geo-independence requirement is separated into two criteria: the 'localization independence access' and the 'tool dependency'. These two criteria specify the ease to connect to the service.
- The time-independence requirement is also separated into two criteria: the 'time independence access' (Does the user need to connect at a specific time, as for the video-conferences, or chat systems?), and the 'content life duration' (for how long the information is accessible? -  $\infty$  means that the information can be available all the time, without actual time constraint (like a mail); 1 means that the information is available during the session of use (like a message on the board); 0 means that the information is volatile, and disappears as soon as it is edited (like during a conversation)).
- It is also required that *MATiK* should be capable of not only explicit information transfer, but also tacit information transfer. That is important in the scope of collective intelligence requirements. The way tacit knowledge transfer is considered in this study needs to be precised here. As defined in the section 1.2.1, page 50, tacit knowledge communication is largely resulting from individual practice and experience and cannot be perfectly expressed formally. Therefore, tacit knowledge is not transferred by the information content (explicit aspect of the message), but by the way the information is transported, i.e. related to the support characteristics and to the information flow. Starting

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2 The blog is an abbreviation for "Weblogs" [128].

3 SMS is an abbreviation for "Short Message Service" [144].

4 The One giri call communication process is currently in fashion among young people in Japan. A cell phone user is calling a friend and hangs up after his/her friend's cell phone rang only once. The called friend has no time to pick the call but can see whose friend had been one giri calling. The objective of this free, extremely short, content empty call is simply to inform that one had have a nice friendly thought of the other one.

from this consideration, the following communication systems are considered as able to transfer tacit knowledge:

- Since they allow a reaction in real-time of the receiver, and thus a real-time interaction between both of the protagonists, synchronous systems are enable of tacit knowledge transfer.
- Some asynchronous systems may also be able to transfer tacit knowledge. Their particularity does not concern the temporal structure between the users, but the way information is processed and the aim of the tool. Two systems are meeting this situation in the present analysis: the mail and the blog. The mail transfers tacit knowledge in the case of personal (i.e. non-professional) relation, because it transports the hand-writing of the sender, being a mark of tacit expression (mainly since the high development of emails). The blog has nowadays the purpose to provide everybody the ability to publish on the Internet anything on any topic (even personal concerns usually written in diaries) to let anyone to comment. Moreover, the way blog pages are organized lets readers learn quickly about the owner. Indeed, thanks to personal information, creation of categories, and to chronological sorting of the last posted messages, the readers have quickly access to a global view of the blog, the owner, and a history of latest 'picture' of the publisher (whereas web site usually proposes a global picture, without particular temporal aspects). It is here to notice that the ability of tacit knowledge transfer in blogs is not due to the technology (for which blogs and forums are about to be similar), which is similar to forums, but the way the information is structured, is used, and is circulated.
- Because of the interdisciplinary workgroup characteristics, relationships between people should be considered. Thus, four major criteria are listed here: The 'previous contact independence' notifying of the transmitter and the receivers have to know each other previously to the communication start; The 'known receiver only' notifying if the transmitter has to list the exhaustive list of receivers or if people not listed by the transmitter may receive the information too; The ability of the receiver to reply directly is expressed by the 'direct reply possible' criterion; And the 'multi-person communication' specifying if the information flow can include more than two persons or not. These for criteria are important when expecting a good quality information flow in the workgroup.

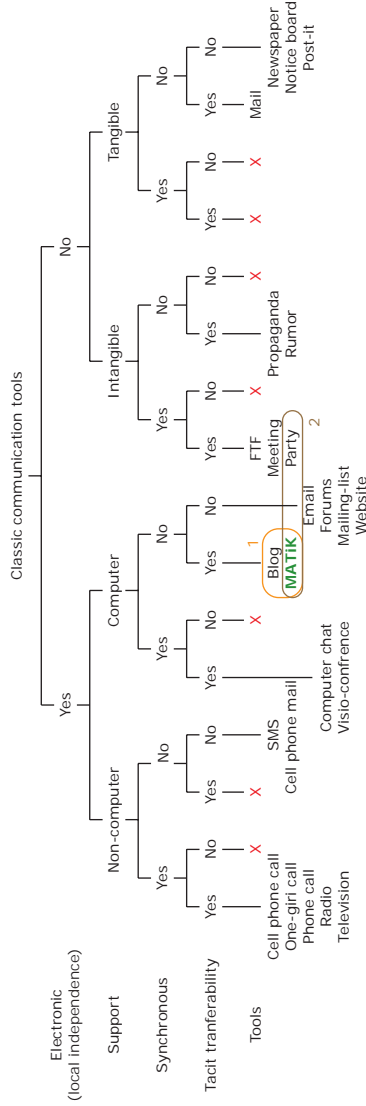
- Finally, *MATiK* required that only relevant information should be sent to the receiver. That means that a kind of filter (to be specified later) should be personalized for each user, according to the consideration to individual specifications. This requirement is checked by the criterion 'personalized filter for the receiver'. The table 8.1 gathers the results of this survey. A line is added to include the *MATiK* requirements and to compare them to other tools:
- *MATiK* should be accessible from anywhere at anytime, using high accessible tools. The tool dependency is not yet defined for *MATiK*, but it is considered that nowadays, the computer and the Internet are highly accessible (as this study focuses on professional workgroups). Based on these two considerations (space and time independence), *MATiK* is very close to the email system.
- *MATiK* should allow the communication of tacit knowledge, as for explicit knowledge, by considering subjective or member's personal characteristics.
- It is not necessary for the sender to know and select exhaustively all the desired receivers. The system may judiciously select other receivers, according to the specifications of each member. Regarding this point, *MATiK* and emails are opposite. Emails propose three levels of receivers ('To:', 'Cc:', and 'Bcc'), all together gathering the exhaustive list. This system is thus inappropriate for *MATiK* requirements. An alternative solution should be proposed.
- Finally, as most of chat systems, *MATiK* should permit multi-member conversations. This requirement is obvious for any group communication system.

It should be notified here that the tools called groupware are not included in this survey. These tools are actually a collection of tools included in this study, adding also other tools such as calendars or data storing system, useful for workgroups. The great specificity of a groupware is that it blends various tools, creates links for better interaction between them, and eases their use. Nevertheless, they are not a fusion of tools included in this survey, but a superposition of them. Depending on the function of the groupware (i.e. the tool) the user intends to use, the described issues related to the function will be encountered. Therefore, *MATiK* is different from any groupware.

**Table 8.1** | Classic communication system analysis result

	Localization independence access	Time independence access	Tool dependency	Transferability of DK	Transferability of TK	Content life duration	Previous contact independence	Known receiver only	Direct reply possible	Multi-person communication	Personalized filter for the receiver
Blog	+	+	CI	+	+	∞	+	-	+	+	-
Cell phone call	+	-	C.Ph	+	+	∞	-	+	+	-	+
Computer Chat	+	-	CIS	+	+	∞	-	+	+	+	-
Email	+	+	CI	+	-	∞	-	+	+	+	-
FTF conversation	-	-	No	+	+	0	+	-	+	-	-
Forums	+	+	CI	+	-	∞	+	+	+	+	-
Mail	-	+	Pa	+	+	∞	-	+	+	-	-
Mailing list	+	+	CI	+	-	∞	-	-	+	+	-
Meeting	-	-	No	+	+	0	-	+	+	+	-
Newspaper	-	+	Pa	+	-	∞	+	-	-	+	-
Notice board	-	+	Bo	+	-	1	+	-	-	+	-
One giri call	+	-	C.Ph	+	+	1	-	+	+	-	+
Party	-	-	No	+	+	0	+	-	+	+	-
Phone call	-	-	Ph	+	+	0	-	+	+	-	+
Post-it	-	+	Pa	+	-	∞	-	+	-	-	-
Propaganda	-	?	?	+	+	1	+	-	-	+	-
Radio	+	-	Ra	+	+	0	-	-	-	+	-
Rumor	?	?	No	+	+	1	+	-	-	+	-
SMS/Cell phone mail	+	+	C.Ph	+	-	∞	-	+	+	-	+
Telegram	-	+	Pa	+	-	∞	+	+	+	-	-
Television	+	-	TV	+	+	0	-	-	-	+	-
Video-conference	+	-	CIS	+	+	0	-	+	+	+	-
Website	+	+	CI	+	-	∞	+	-	-	+	-
<i>MATiK</i>	+	+	<b>CI</b>	+	+	∞	+	-	+	+	+





**Figure 8.2 | Classic tool classification**

Looking closer to the Table 8.1, a few remarks can be pointed out and assist the reflection on the originality of *MATiK*. The Table had been split in three groups of columns (cf. Figure 8.2):

- The first group gathers the operating constraints (space/time/tool dependency). From the constraint considerations, four groups can be pointed out: intangible non-electronic systems, tangible non-electronic systems, electronic non-computer systems, and computer-mediated communication systems. Electronic systems are characterized by their localization independence, which actually points out the interest of this technology. Among computer-mediated systems, the asynchronous ones are characterized by the time independence. It is this group that *MATiK* intends to be part of.
- The second group gathers the kind of transferable information. Two kinds exist: the descriptive knowledge and the tacit one. It is interesting here to notice the correlation between the transferability of the tacit knowledge and the synchronous quality of the tool. Among electronic tools, all and only synchronous tools are able to transfer tacit knowledge, except for the blog. The blog (cf. a more precise definition in [128]) is a new tool on the Internet, easy to set up and to use. The two main specificities of the blog is the ability of the writer to send a new text very easily, from any digital writing system (email, Internet, cell phone message... ), and the ability of each reader, i.e. anybody on the Internet to comment directly and freely any text in the blog. This relationship system, added to the easiness of use, creates a complex information flow able to transfer tacit knowledge. *MATiK* aims at participating to this new generation of Internet communication tool, the one I consider of the first generation for the Collective Intelligence society.
- The third group gathers the other characteristics concerning the classic tools. It is noted here simply the originality of *MATiK*, and its proximity with the blog and the party:
  - Beside the last column (which is actually useful for message systems only), *MATiK* and the blog are identical (they are gathered on the Figure 8.2 by the item 1). The commons between *MATiK* and the blog are related to the "social" aspects of the tools. Both have the purpose to gather people

and make them share their knowledge, even though they don't know each other.

- Beside the first column (which is about the vanishing of the information), *MATiK* and the party are identical (they are gathered on the Figure 8.2 by the item 2). The commons between *MATiK* and the party concern the way the information flows inside the group. This point will be developed from Chapter 9.

From these considerations, *MATiK* can be described, and its originality is pointed out. *MATiK* is an asynchronous computer-mediated communication system for the Collective Intelligence society. To do so, this asynchronous system has to be able to transfer descriptive and tacit knowledge, which currently the peculiarity of the blog systems. As a group communication system, *MATiK* intends to create an information flow close to the one of parties, creating the same opportunities of meeting and communication between members even they don't know each other before the opportunity occurs. The originality of *MATiK* is not on the content of the message, but the way the message flows. For all these points, *MATiK* is different from any other classic tools currently existing. Notwithstanding, a survey on the current development is also required for the *MATiK* design project to find its position in the current research and development projects in this field.

## 8.2.2 Similar systems

The previous survey concerned mature tools. A brief survey on tools currently in development should also be done in order to place *MATiK* among other in-development tools. This survey does not intend to be exhaustive and will only introduce main projects seen in the research literature which are relevant to put in relation with the present topic.

### 8.2.2.1 The Interdisciplinary Communication Medium Project (ICM)

This project is very close to the *MATiK* project: The objective of this project is to develop a computer environment which will improve the communication among designers in an interdisciplinary team [73, 74]. This research is based on

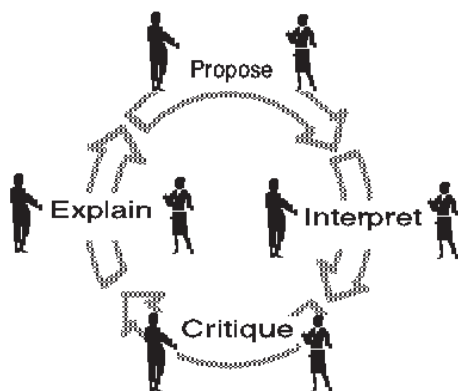


Figure 8.3 | Propose-Interpret-Critique-Explain paradigm [73]

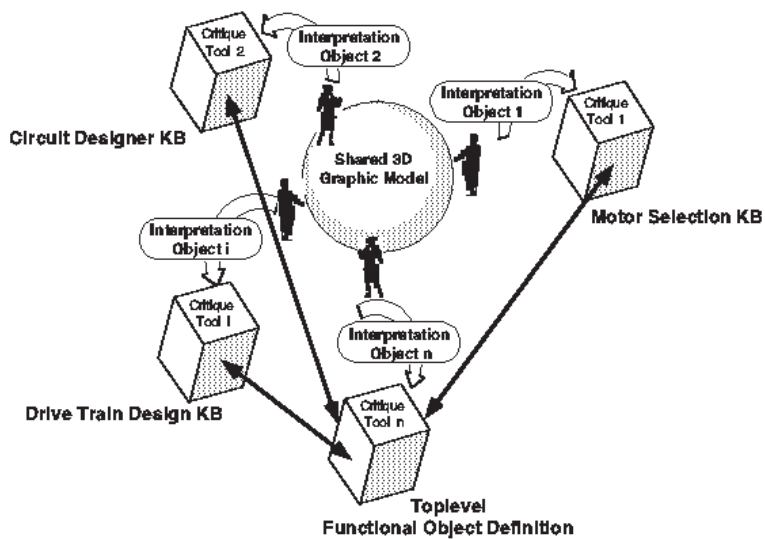


Figure 8.4 | Interdisciplinary Communication Medium (ICM) [73]

a design collaborative process paradigm called the Propose-Interpret-Critique-Explain (PICE) paradigm (cf. Figure 8.3):

- *Propose* - The design is proposed by the designers using a shared 3D graphic form model. It consists of the union of all graphic discipline models.
- *Interpret* -The interpret activity identifies the features of the shared 3D graphic form model within specific discipline and use the semantic of this discipline to annotate the resulting disciplinary form model. This step is explicit and dynamic in the sense that the annotations may be inspected, displayed, manipulated, and changed.
- *Critique* - Thanks to a disciplinary knowledge based analysis and evaluation of the disciplinary form model, critique step derives behavior from the form and compare it to function. Causes of the performance issues pointed out by disciplinary methods.
- *Explain* - These causes are visualized in the shared 3D model.

To validate the PICE paradigm, a working software prototype, called Interdisciplinary Communication Medium (ICM) was constructed (cf. Figure 8.4). This software, gathering already existing different ones, is proposed as a new kind of computer-aided design system. It ables designers from different fields (hence interdisciplinary communication medium for design projects ) to work better together by a powerful community design software. Then, the main difference between ICM and *MATiK* is on the notion of interdisciplinary team. ICM considers designers from different fields, whereas *MATiK* considers people from different disciplines, design field being one of them. Nevertheless the ICM proposed a deep reflection on model sharing and a promising tool.

### 8.2.2.2 FreeWalk

The project FreeWalk was introduced in 2004 by Hideyuki Nakanishi as a social interaction platform where people and agents can socially and spatially interact with one other [180]. Built on three steps, this tool brings the ability to move in an 3D virtual environment while being able to talk and interact with others.

FreeWalk1 allows people to move dynamically during meeting. The aim is to recreate in the cyberspace the casual meetings which differs from video-conferences in the way that each person's spatial position in the group is not taken into account.

It has been noticed that users had difficulties in starting and advancing their conversation in the cyberspace, due to the lack of feeling of presence in the digital world and the difference of context in the real one (between users which can be in different places across the world). Thereof, FreeWalk2 proposes judiciously the introduction of mediating agents. These agents act as coordinators to maintain social interaction between people, by proposing conversation topics or suggesting orientations to go on these conversations.

FreeWalk3 aims at creating a virtual scene of a disaster where many remote users are assigned their role and participate in an evaluation drill. This version steps over our concern for this study.

FreeWalk is a very interesting project in the sense that it proposes real solution for group interaction going further than video-conference systems. Tacit knowledge seems to be better transmitted than video-conference systems. Nevertheless, FreeWalk's objectives differ from *MATiK*'s ones since it is based on synchronous communication.

### **8.2.2.3 Shine**

Shine is a socialware, i.e. a cyber-community application platform introduced by NTT Communication Science Laboratories [257]. A socialware aims at supporting social activities among the cyberspace. This support is achieved by cooperation, coordination and collaboration of all the elements involving in the socialware (users, agents...). Shine is a platform based on a multi-agent architecture, providing a structure for various socialware application to operate. Basic functions proposed by Shine, and presented as normally required by socialware are:

- The dynamic adaptation of acquaintance relations of group formation;
- An analysis of each person's features, role, and situation within a community;

- An interface that links a user's community feeling and a system's logical information;
- Flexible and intuitive communication utilities.

Community Organizer is a prototype software that had been developed on Shine [100]. Each user 'owns' an agent that has to acquire the user profile and visualize potential communities around the user. The other agent, the community agents, have the function to collect user's profile and community information. Upon user agent, a community agent send data about potential communities around the user. Then the user agent displays a 2D map of the users centered on the requester. The distance between them express the relevancy (degree of common interests) among them. This map is highly interactive and even modifications can be suggested by the user, in which case the agent would modify the weights of the keywords in order to fit again with the new situation.

Shine proposes a very comprehensive approach on the problem of social interaction in the Cyberspace. As it will be explained in the Chapter 11, some of the technical choices are similar between Shine and *MATiK*. Yet, a slight difference of concept between Shine and *MATiK* is the openness of the communities. Shine is working for open communities and communities or members to interact, whereas *MATiK* aims at being used by one community only, the interdisciplinary workgroup, in which subgroups are working, interacting and changing permanently.

#### **8.2.2.4 Conclusion**

Among many of other researches, some can be seen at [71, 175, 210].

Researches on topics close to *MATiK* are numerous. Concepts of socialware, cyber-communities, workgroup tools, and so on are widely met in the literature. Therefore, *MATiK* is not an isolated project and is part of a wide concern that intends to create systems for communities to interact in the Cyberspace with a better consideration of human dimensions, and more relevancy on qualitative aspects in information exchange.

## 8.3 Originality of *MATiK*

### 8.3.1 Reflection on the two former surveys

The first survey shown that none of the classic communication tools was satisfying the requirement established for the design of *MATiK*. The latter is part of a new type of tools, as the blog is, which aims at proposing new ways for social and Collective Intelligence activities over the Internet. Thus, it is an original project that is taking part of a more comprehensive research on socialware, research involving numerous researchers and laboratories around the planet, as shown by the second survey. The need of new tools of this kind is required, because the need is already known and formalized. Different paths are experimented, and *MATiK* is focusing on the information management.

The last key point, discussed when *MATiK* requirements have been described (cf. part 8.1), is actually expressing the main difference between *MATiK* and the other investigated tools: *MATiK*'s objective is to manage information intelligently. This intelligent manager aims at sending to the users (being the potential receivers) only information she/he would feel relevant or worth while.

### 8.3.2 The originality of *MATiK* : the user-content link

The originality of *MATiK* is then on the relation between the content of the message and each member of the group it is dealing with. Indeed, whereas most of the existing filters evaluate the message content according to criteria which can or cannot be in relation with the user profiles, *MATiK* intends to evaluate the interest in both ways:

- On one hand, *MATiK* evaluate the interest of the content of a message according to the user's potential interest. Thus, if a message is sent to a group of people, *MATiK* can filter the message and finally limit the number of receivers to the ones interested in the message. This evaluation techniques have been intensively investigated for emails to limit spam mail pollution. However, *MATiK* intends to give much more importance to the personal information of both sender and receiver to propose a more user-adaptive filter. In a first version of *MATiK*, this analysis will mainly help *MATiK* to evaluate its own analyzing



process by associating its own evaluation and the behavior of the receiver (i.e. an evaluation of the receiver appreciation of the message). Thus, the objective of *MATiK* is to learn and to improve its analyzing tool, yet without the choice of the sender regarding the list of attended receiver. A further version of *MATiK* would include an active message filter in order to improve even more the user-content link.

- On the second hand, *MATiK* evaluates other potential receivers among the rest of the group. As the group is wide, a priori each member does not know all other members. Whereas the message could interest a member (in which case opportunities of better group work is possible), other systems do not send information to this person since she/he is unknown by the sender. *MATiK* intends to bridge over this lack of group interaction by linking people according to the content of the message.

*MATiK* proposes a complete analysis of the qualitative relation between a message content and each member of the group: Could this message interest this member? Would this member be interested in this message? These are the two questions *MATiK* have to solve for each message, for each member in order to reach her/his goal. This user-content link is the originality of *MATiK*.

The user-content link is built and analyzed thanks to a function of *MATiK*: the jump analyzer. This function is the core of the *MATiK*'s information flow management. It is able to consider three groups of informations (the content of the message, the personal information of both the sender and the receiver) in order to take a decision regarding the interest that can have the receiver concerning the message, even if it was not addressed to her/him. The jump analyzer is the core and the originality of *MATiK*. It will be developed more precisely in the section 10.2.2, p. 204.

### **8.3.3 Reflections on *MATiK* and on the user-content link**

In this study, the communication support used by *MATiK* is the computer-mediated writing system, in the manner of the email systems. The reason of this choice is due to the nowadays available technology: yet, there is no technology well recognized for the analysis and the filtering of drawings, oral, video systems (concerning CMC analysis, cf. [178]). However, if such analysis technology

appears in the future, it is quite possible to include them in the *MATiK*'s analysis system. The current presentation of *MATiK* introduced in this paper does not impose an constraint on the analysis technology choice. The current description of *MATiK* is at a more 'conceptual' level and in not dependent from the available technology. In other words, the evolution of the technology concerning computer-mediated communication and computer-mediated content analysis does not influence or endanger the concept of *MATiK* and its originality.

During the presentations, I have made on this function of *MATiK*, many people expressed security and discreetness concerns. Indeed, *MATiK* may decide to send the message to somebody not chosen, even not known by the author of the message. This should not be totally neglected. I propose that the sender may exclude one or few members from being able to receive the message, to prevent from discreetness issues. Also, I argue that *MATiK* is a work tool for a workgroup that is supposed to work together. Secrets, shortcuts, and other 'anti-team' actions are at the origin of deterioration of confidence in trust within the group, which reduces dynamism and efficiency of the workgroup [29] and goes, of course, opposite to the philosophy and the goal targeted by these research.

# Chapter 9

## Loft

*It is better to have loft and lost than never to have loft at all.*  
— Julius Henry ‘Groucho’ Marx [168]

### 9.1 Intention

The basic target of the *MATiK* design had been expressed in the previous chapter. To go on with the design of *MATiK* following the interdisciplinary design method proposed in the Chapter 6, an *Evoked Metaphor* is now required. For this purpose, a brief recollection of the fundamentals of *MATiK* is necessary.

*MATiK* is a communication system for wide interdisciplinary workgroups in the Cyberspace. Regarding a wide workgroup, it is extremely rare that all the members works on the same project, or the same part of the project at the same time. In most of the case, subgroups are formed according to the tasks or the various projects the entire group has to deal with. Nevertheless, as all the members intend the group to stay as is, subgroups stay close and interconnections are numerous. The communication flow is then on two levels: the subgroup level in which members of the subgroup only communicate together, and the (whole) group level in which information is spread to all members (cf. Figure 9.1).

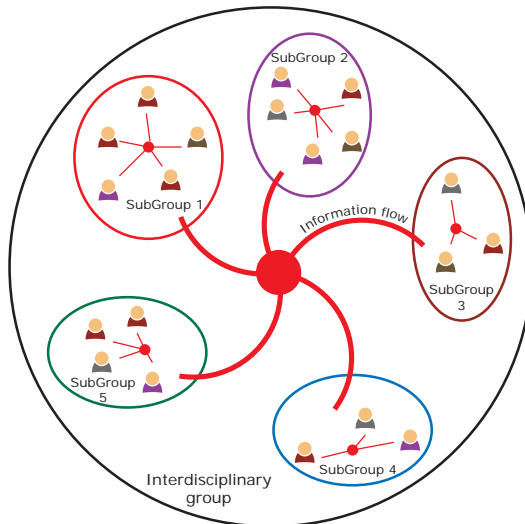
Two phenomena can be seen here as information flow issues (these two points are illustrated by the Figure 9.1):

- Firstly, because the group level flow brings information to all the members about an event happening in one subgroup (i.e. about a subproject), this information may not be considered as relevant by a member not part of this subgroup in terms of contribution to her/his activity. This could become a real problem since the information flow in these groups is usually heavy and all the informational noises may provoke waste of time, confusion, disapprobation from members, and/or deterioration of the team work. *MATiK* aims at filtering

information in order to send members information they would judge as beneficial, relevant or interesting.

- Secondly, in a wide workgroup, each member may not know all the other members. Yet, as the subgroup level flow stays by nature inside the subgroup, other members do not get the information. If a member of the workgroup is not part of a subgroup and is not known by the members of this subgroup, there is no chance that she/he could receive any message from this group. However it may happen that some information transmitted inside the subgroup would interest the outside member. Moreover, by knowing the problem the subgroup is facing, this external member could greatly help. This situation shows a great lack of group interaction opportunities, a lack of dynamism and inefficiency in human resource usage in the group. *MATiK* intends to create this interpersonal links by confronting the content of the message to the interest of all the members of the interdisciplinary workgroup could have for this message.

Then, it is possible to describe the interdisciplinary workgroup using *MATiK* as follow:



**Figure 9.1** | Section of the entire group in subgroups, information flow structure

*This group is divided into subgroups. Each subgroup is facing a different problem from others, having a different activity, and thus different mental estates. By using MATiK, information flow inside each subgroup and the entire group is filtered, so that each member receives information that she/he would estimate as interesting or relevant for her/his own activity. Also, information flow jumps are possible, bringing the information to people who would greatly estimate the interest of the information, whereas the sender of the information did not select them as receiver (or even didn't know them) in the first place.*

The interesting point in this description is the notion of information flow jump inside the group. *MATiK* can be at the origin of non expected information flow modifications. This phenomenon can also occur when people are in a same room in which little subgroups are formed. Little subgroups are formed, but since all these subgroups are in the same room, discussion in a subgroup can be heard eventually by people outside the subgroup. Considering this room, I propose here the *Evoked Metaphor: the Loft*.

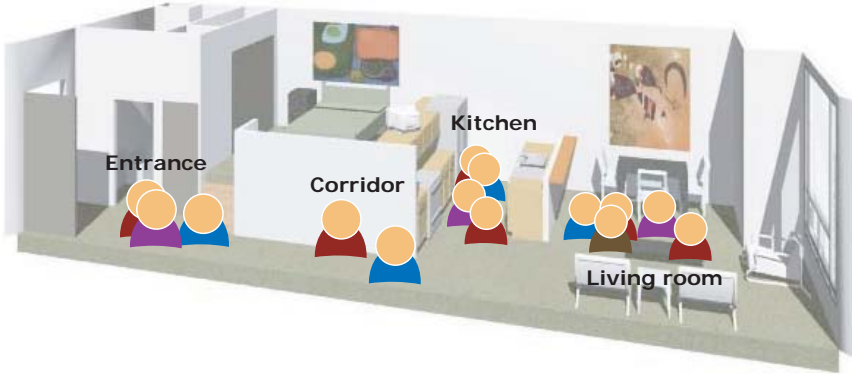
The *Loft* will gather elements (individuals) and operating rules (for interaction between individuals to occur), representing successfully the desired functionalities of *MATiK* and being able to be understood anyone, thanks to intuition.

## **9.2 Description of the *Loft***

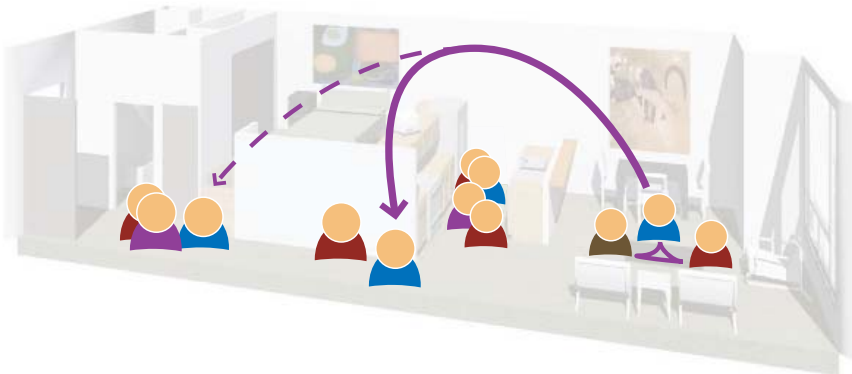
### **9.2.1 Definition**

A *Loft* is a floor consisting of a large unpartitioned space. In this space, different activities can be performed. For example, in a *Loft* used as an apartment (cf. Figure 9.2), kitchen, bedroom, and living room can be in the same room: there is no separation walls. In this environment, different people may have different activities (cook, sleep, watch television, or read...).

As people in the *Loft* are in different areas, their activity differs. They are doing different tasks, having different mental estates. If a few people are in the same part of the *Loft*, then interaction can be greatly probable. These interac-



**Figure 9.2** | The *Loft*



**Figure 9.3** | Information flow in the *Loft*

tions involve discussions between the persons in the same part of the *Loft* (in the figure 9.3, the group in the living room is having a conversation). Yet, as the place is a *Loft*, other people, not taking part of the conversation, can still hear it as a background noise. They may not really pay attention to it since they are in another place of the *Loft* and have their own activity to focus on. Generalizing this pattern to all the areas, it is possible to describe the *Loft* as a place in which non-clearly delimited and isolated groups are formed.

As conversations are going on, it may happen that one or few individuals, initially not taking part in a conversation, get interested in to it (thanks to the phenomenon such as the ‘cocktail party phenomenon’<sup>5</sup>). For this new listener, the attention draws her/him to an unexpected source of information. As an example, this phenomenon happen when somebody hears one’s own name: automatically this person focuses on the source of the information whatever this person’s attention was on previously. In the Figure 9.3, this phenomenon is represented by the two arrows. The difference between the two lines (solid and dashed) suggests that the level of reaction and focusing of the two people may differ, because of personal characteristics, or contextual aspects such as their position in the *Loft*.

## 9.2.2 The cocktail party phenomenon

The ‘cocktail party phenomenon’ or ‘cocktail party effect’ (term first used by Cherry [35] in 1953) refers to the human ability to selectively attend to and follow one source of auditory input in a noisy environment (noises produced by either sources of sound or speech). Giard defines the cocktail party phenomenon as follow:

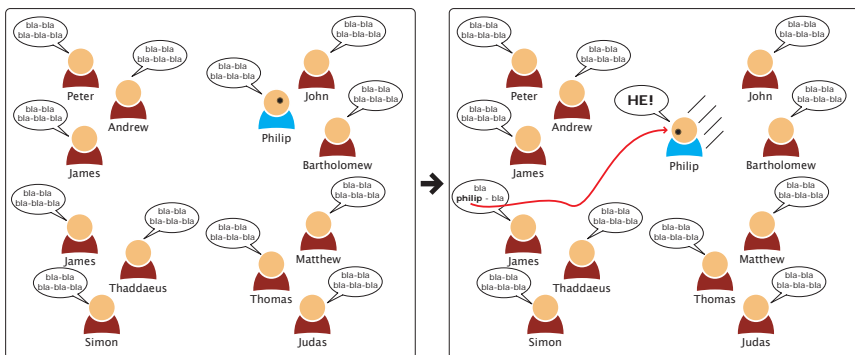
*Auditory selective attention refers to the mental ability to resist distractor stimuli and select relevant information from the surrounding acoustic events, as illustrated in the ‘cocktail party effect’. This effect has been primarily conceptualized in the so-called structural models of attention. These models hold that*

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5 The ‘cocktail party phenomenon’ refers to the human ability to selectively attend to and follow one source of auditory input in a noisy environment, where the noise is produced by independent sources of sound or speech signals. It will be detailed in the chapter 9.2.2.

*attentional mechanisms have a limited-capacity and can perform only one task at a time. In these models there would be a fixed location in the system for an ‘attentional bottleneck’ beyond which the parallel processing capacity is limited. A key issue is the level of processing at which this bottleneck is located – that is, the level of processing at which auditory inputs from relevant and irrelevant channels are differentially processed (reviewed in [176]). — [77]*

From a listener’s point of view, this phenomenon is not difficult to understand: In a crowded and noisy environment, this phenomenon allows an individual to follow only one discussion and to attenuate the concentration on other sources. Also in the same environment, if a special information (such as one’s own name) comes from a source an individual is not focused on, then the listener react to the stimulus and focus automatically on the source (even it is far). On the psychological, cognitive, and physiological point of view, there is a vast and complex array of evidence that has been pieced together to explain the effect — there are many interactions between the signal, the auditory system, and the central



**Figure 9.4** | Switching in the cocktail party phenomenon



nervous system. Also the research in acoustic is interested on this phenomenon [19].

The cocktail party phenomenon is an ability of the human brain, based on three processes performed by the auditory system [2]:

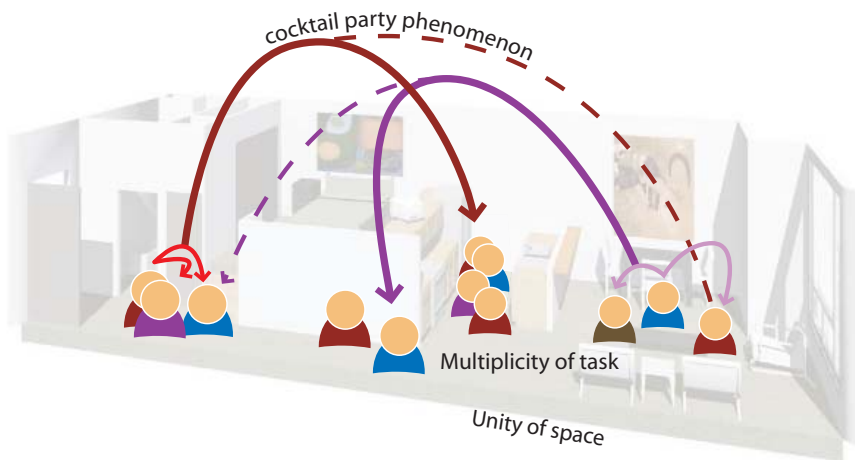
- *segmentation/segregation* - The segmentation process separates the incoming auditory signal into individual channels. Cherry proposed five factors on which the brain process is based to separate the sources: The spatial location of the sources, the visual information (lip-reading, gestures, source displacement, and so on), the differences between voices (pitches, speeds, gender, and so on), the accents, and the transition probabilities (subject matter, voice dynamics, and so on).
- *selective attention* - The selective attention process allows the brain to focus on one specific channel while attenuating attention to irrelevant channels.
- *switching* - The switching process involves the ability of the brain to switch attention from one channel to another one. Unlike the visual system, where cortical top-down feedback only goes as far back as the Thalamus, in the auditory system the cortical feedback exerts its effect all the way down to the outer hair cells in the cochlea via midbrain structures. So the potential for an early selection process in audition is very high. Details can be seen at [253].

### 9.2.3 Discussion

In the *Loft*, the cocktail party phenomenon is very important. Even when little subgroups are created in the different areas of the *Loft*, the cohesion of the entire group is still possible because information jumps are possible among the subgroups. The importance and the effectiveness of the cocktail party phenomenon in the *Loft* is due to two critical aspects of the *Loft* structure: the multiplicity of activities and the unity of space. The architectural characteristics of the *Loft* allow the group to have different activities in the same time without real separation of the members (multiplicity of activities). Because of the unity of space, which enables the group to interact among all the members and not only inside the subgroups, cocktail party phenomenon is possible and support the link among all the members of the groups.

Multiplicity of activities, unity of space and cocktail party phenomenon are the indispensable elements for the *Loft* to operate with efficiency. Same thing can be said for *MATiK*.

From this point, it is possible to wonder why the *Loft* had been chosen as the *Evoked Metaphor* for *MATiK*. Some may consider a cocktail party as a preferable choice. Indeed, as the cocktail party phenomenon is very important in this *Evoked Metaphor*, a cocktail party, and its description, would seem to be more judicious and adapted than a *Loft*. However, I argue here that in the cocktail party, the main aim is to communicate with others, and guests come for this purpose. In the *Loft*, the main activity is hardly the communication. Speaking with others is a tool to share or progress in another activity regarded as the main one. Communication is important, most of the time even necessary, but it is not there as on why people meet in this unique room. That is the case also for interdisciplinary workgroup: Communication is essential, even mandatory, but it is a tool to accomplish the main task, i.e. the interdisciplinary project. Because of this I consider the *Loft* as more suitable for being *MATiK*'s *Evoked Metaphor*, preferred to a cocktail party.



**Figure 9.5** | The three keypoints of the *Loft*

## 9.3 Analogy with *MATiK*

### 9.3.1 Multiplicity of activities

In the part 8.1, it was explained that wide workgroups split into a few subgroups to focus on different tasks in the same time. The parallel structure, involving a task distribution in the group, allows great efficiency. Members join a subgroup to accomplish a task, and regularly, subgroups meet to debrief about the global project advancement. In this way, subgroups in the interdisciplinary workgroup are equivalent to the different areas in the *Loft*. There is an analogy concerning the multiplicity of activities.

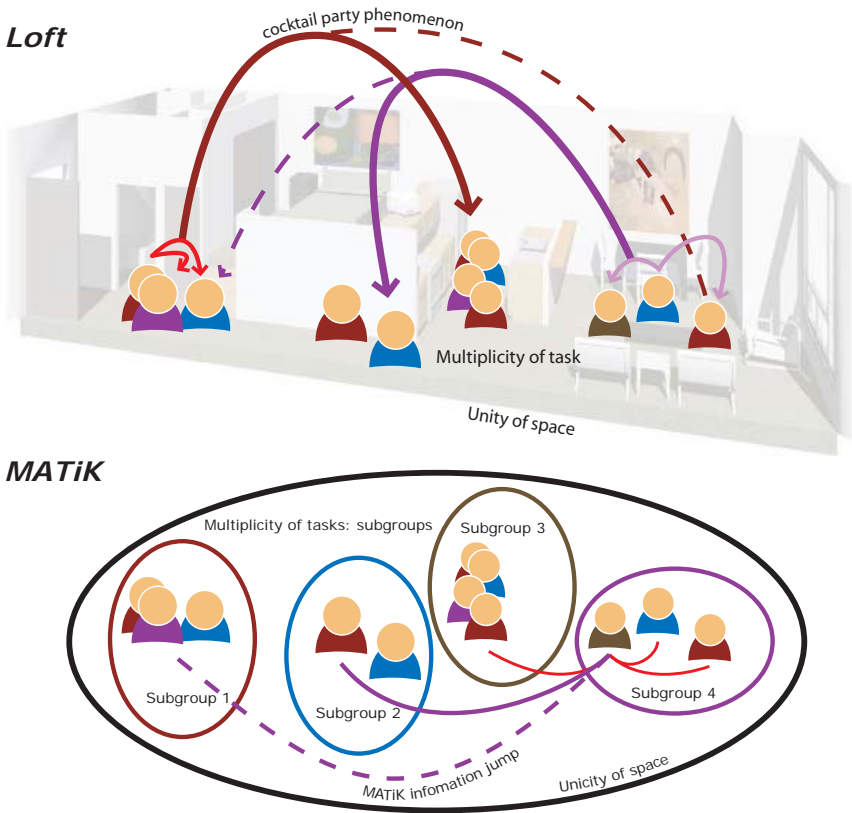
### 9.3.2 Unity of space

However, an interdisciplinary project is not a parallelism of sub-projects. All members may interact for the profit of the entire project. All members have to be aware of the global project, as much as the sub-projects they may be involved in. This unify structure of the entire group is a necessary condition for the project to succeed. In the *Loft*, this is equivalent to the unity of space: Without this unity, the *Loft* becomes a classic apartment in which people are separated from each other and communication becomes harder between rooms.

### 9.3.3 *MATiK* function

Finally, *MATiK* is proposing an 'intelligent' information filtering system. If the information is not interesting for a specific receiver, then the information flow is cut before it reaches this receiver (selective attention function of the cocktail party phenomenon). If the information would interest a member of the group whereas she/he is not selected by the transmitter as a receiver, then *MATiK* sends the information (complete or partially) to her/him (switching function of the cocktail party phenomenon). Therefore, *MATiK* information jump function simulates the cocktail party phenomenon in the *Loft*.

The Figure 9.6 gathers the three aspects showing the analogy between *MATiK* and the *Loft* : the multiplicity of activities, the unity of space, and the



**Figure 9.6** | The equivalence between the *Loft* and *MATiK*

cocktail party phenomenon. The *Loft* is a metaphor evoking the Cyberspace in which the interdisciplinary workgroup is using *MATiK*.

- In the *Loft*, a group of people is in the same room. With *MATiK*, an interdisciplinary workgroup is doing the same project.
- In the *Loft*, people are in different areas, having different activities. With *MATiK*, members are in different subgroups, focusing on different issues.
- In the *Loft*, as the room is unique. Information jumps are possible because of the cocktail party phenomenon.

With *MATiK*, as the group interacting in Cyberspace is unique. Information jumps are possible because of the *MATiK* function.

### **Comparing *MATiK* and the email system**

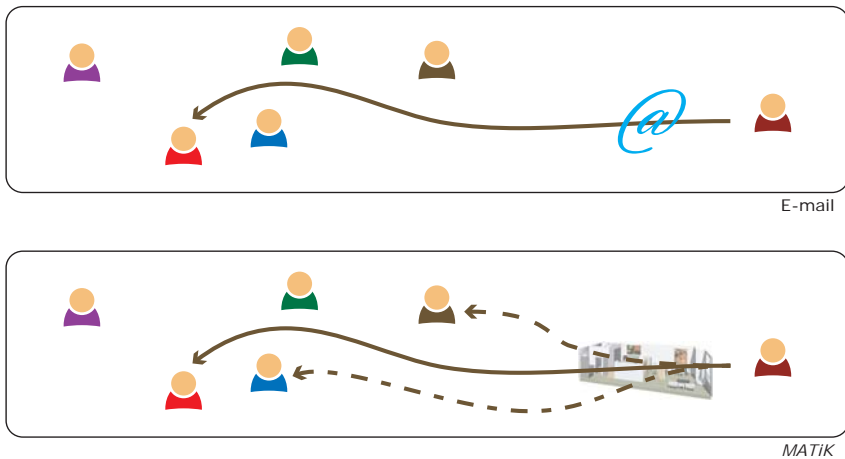
In order to finish this description of *MATiK*, this section and the following one are presenting a brief comparison of *MATiK* with two well-known and very used communication systems: the e-mail (cf. Figure 9.7) and the face-to-face conversation.

When a message is sent by an e-mail, the sender decides who should receive the message. Actually, three kinds of receiver can be selected: the direct receiver(s) (listed in the heading 'To:'), the one(s) to whom a copy of the message is sent (listed in the heading 'Cc:' (Carbon copy)), and the one(s) to whom a copy of the message is sent discreetly (listed in the heading 'Bcc:' (Blind carbon copy)). In a normal use of the email system, if somebody is not listed in one of these three headings, then she/he will not receive any information about the message: neither its content nor the information that this email ever exists. Then the sender has to list all the people which could be interested in this email.

The way to send a message in *MATiK* is different. The list of receivers selected by the sender is not the definite one. The way the sender selects receivers will be detailed in part 10.2.1. However, the sender selects a list of people who have

to receive the message and a list of people who are forbidden to receive the message (this list should not be used unless exceptional circumstances, as explained in the part 8.3.3). Then, because of the cocktail party phenomenon, some other people could receive the message (completely or partially) according to the strength of the link between the message and the personal characteristics of each individual.

Considering the interdisciplinary workgroup structure, this difference is extremely important to understand the interest the workgroup should have in tools such as *MATiK*. It proposes the group a kind of link between members that has disappeared because of the great quantity of people, of discipline and because of the spatial and temporal dispersion of the entire workgroup. How many members there are, how many disciplines are involved in the project, wherever people are and whenever they access the message, interesting information, even unattended one is received.



**Figure 9.7** | Difference between the email system and *MATiK*

### 9.3.5 Comparing *MATiK* and face-to-face conversation

The comparison between *MATiK* and the face-to-face verbal conversation<sup>6</sup> raises a few reflections that should be developed here. Indeed, the FTF is considered commonly as the most complete communication method in terms of explicit and tacit knowledge sharing. However, constraints are numerous since FTF is a verbal/nonverbal, linear, synchronous, and localized system. As for *MATiK*, it is a written, explicit, global, asynchronous, and unlocalized system. In spite of these differences, the *Loft*, in which FTF takes place, is used as the *Evoked Metaphor* of *MATiK*, in which CMC<sup>7</sup> takes place. In order to justify this choice, and to precise better how the *Loft* is interesting to represent *MATiK*, a deeper comparison is necessary. It has to be noted first that *MATiK* does not intend to replace in any way FTF or meeting<sup>8</sup>. *MATiK* is an original tool for communication over the Cyberspace, and intends to improve these links and communications only. FTF stays the gold standard of communication [190].

The FTF has a few characteristics which would be interesting to note here. Before all, FTF is synchronous, i.e. it works in real time and the message is received approximately in the meantime it is emitted. One of the main consequences of such an aspect is that the reaction can be rich and in real-time too. Thus, the message emitter can perceive the first relations of the receiver even the message emission is not completed yet. The exchange between the two protagonists is then continuous, mainly because the communication is not only verbal. Body postures, face expressions, spatial positions, etc... are also important information emitters. That is possible because FTF is a localized communication process. Therefore, it constraints protagonists to be in presence, and is a pluri-medium communication process. Space, Body posture, face expression, smell, environment, touch are also participating as emitter and receiver of non-verbal

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6 The face-to-face verbal conversation will be written FTF from now on. I focus in this part on the verbal aspect of the communication, excluding any external tool help such as a blackboard. The non-verbal communication is probably the most important aspect (in term of quantity of emitted information) face-to-face conversation and can be reviewed in [94].

7 The type of communication used by *MATiK* is called Computer-Mediated Communication as the intermediate between two correspondents is necessarily computers. The *MATiK* system will then be written CMC for the current comparison.

8 A meeting is considered as a FTF between three people or more, and can be helped by the use of tools such as a blackboard.

information in the FTF. Lastly, as FTF's conscious content is mainly of auditory nature, FTF is characterized by the temporal linearity of the verbal process. Information is sent and received in the progression of time and cannot be disjoint from it. This aspect is especially interesting in the framework of the present dissertation and will be developed later in this section by comparison with the non-linear aspect of the CMC.

The CMC, as used in *MATiK*, is essentially explicit and asynchronous. The advantageous consequence is its temporal and spatial independence. Indeed, with *MATiK*, a message can be received in a totally different place and time than the ones in which it had been emitted. However, it prevents to take advantage of real-time communication and of the pluri-medium aspect of the message. The main opposition with the FTF is probably the non-linearity of the perception and conceptualization in the receiving process. The receiver perceives the entire message as a whole before segmenting it, detailing it, associating to elements (words) a semantic meaning and to sentences a syntactic structure.

Then, the perception and conceptualization process of the received information is different between the FTF and the CMC. The FTF is defined in a quasi-linear time, and is perceived as so, whereas the CMC is defined in a whole of space and is not linear. The perception, the conceptualization and the understanding of the message are then structurally different:

- The perception of a message in an FTF context is mainly related to time. The reception follows a temporal path, and its perception and analysis follow it. It is obvious that a listener starts to understand the meaning of a message, and even most of the time of a sentence in the message, before the speaker ends. In the passage of time, one starts with an indistinct idea or feeling, resulting from the first information received related to the beginning of the message, and then refines and precises the meaning thanks to the following received information. Details are organized in an indispensable temporal order.
- The perception of a message in a CMC context is mainly related to space. The complete message is first perceived on a screen, as a global image. Then, elements are segmented, first by lines and then by words, based on the spatial position. Finally, semantic and syntactic meanings are associated to the message for conceptualization and understanding of it. But it is clear that



the meaning of the perceived message is created by the filling up of the space originated from the visualization of the screen.

Without developing the point, I wish to note here the clear closeness of the current point with the intuitive perception and conceptualization processes (cf. p. 125). Two modalities exist concerning these processes: the visual modality, using space as a material of meaning, and the auditory (and verbal) modality, using time as material of meaning. The closeness of processes between CMC and visual modality, and between FTF and auditory modality is interesting for a global approach on perception processes. But this is not the point of the present dissertation, and it will not be further developed.

It is now possible to focus again on the initial question: Why using the *Loft*, in which the FTF takes place, to be the *Evoked Metaphor* of *MATiK*, in which CMC takes place? To answer correctly to the question, the way the aspects of *Loft* are interesting for the design of *MATiK* first needs to be precised and well understood. In a global point of view, the entire *Loft*, as it is described and as it can be perceived intuitively, has to be validated by each discipline involved in the interdisciplinary design project. However, in the scope of the design of *MATiK*, it is possible, and actually is wise, to focus on specific processes and situations taking place in the *Loft*. It is obvious that the current research is concentrating on the interpersonal verbal communications, especially concerning the explicit information flows. The actual center of this investigation is the way information perception can launch the switch of attention, provoking a significant modification of information flow in the *Loft*.

This type of unconscious flow modifications exists in the FTF processes in social context, but is absent from any written communication processes. Therefore, the objective of *MATiK* is to input the existence of this type of modifications for written communication processes, by having inspiration from the very sophisticated cocktail party phenomenon, which exists in the FTF processes in social context. This points the answer to the former question and the justification for using the *Loft* as the *Evoked Metaphor* for *MATiK*: the originality of the latter is to propose an improved social computer-mediated communication system by creating a phenomenon which is able to improve qualitatively the information flow mechanisms, similar to the cocktail party phenomenon for social face-to-face communications.

## 9.4 Conclusion

This Chapter intended to introduce the *Loft* and to justify its usage as the *Evoked Metaphor* for MATiK. Concerning the *Loft*, the most important characteristics are the unity of space, the multiplicity of activities, and the social context in which the cocktail party phenomenon can occur. The cocktail party phenomenon is seen as a very important function, optimizing the information flow in the workgroup. The main objective of this design project is then to create a computer-mediated communication system including a data processed function equivalent to the cocktail party phenomenon in the *Loft* (and also in the reality).

Whereas the understanding of MATiK and its implication are not immediate, the *Loft* is intuitively understandable. Even people who have never entered a *Loft* can understand the way it works, and the phenomena which can occur in such a place (as the cocktail party phenomenon). Yet, by understanding the *Loft* and its implication, it is now possible to understand MATiK and its implication by analogy, using the *Loft* as the *Evoked Metaphor*. As the *Evoked Metaphor* is now defined, we can get to the next step of the design process using the interdisciplinary design methodology introduced in the Chapter 6.

# ***Chapter 10***

## **Functional requirements**

*Form follows function.* — Louis Henri Sullivan [230]

### **Introduction**

As the *Evoked Metaphor* is set, it is possible to use it to determine the function requirements for *MATiK*. In this part, it will be shown how the *Evoked Metaphor* can be used to determine functions to be considered in *MATiK*, and to support original validation or quantification techniques.

### **10.1 Describing the functions in the *Loft***

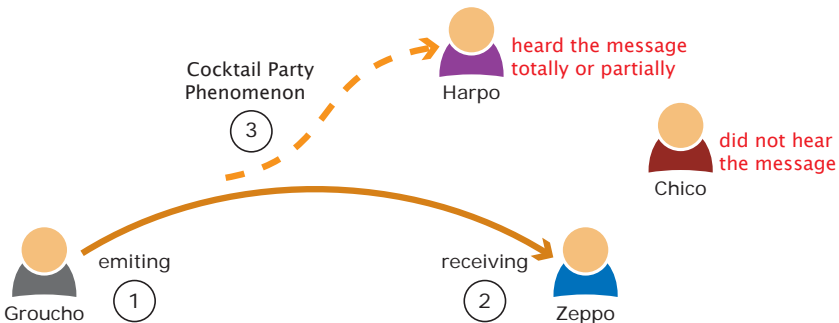
To determine the required functions of *MATiK*, the mechanism of the *Loft* should be first analyzed. The most important phenomenon happening in the *Loft* is the communication between people. People formulate and emit messages, receive and understand them. Because of the cocktail party phenomenon, the flow may evolve unexpectedly. All these aspects of the conversation should be analyzed thanks to the *Loft* before being translated as *MATiK* functions. Also, other tools will be briefly analyzed in this part.

#### **10.1.1 Conversation**

When people gather in a group, communication is one of the most important activities. The group is including intrinsically the notion of communication, i.e. the group is most of all a place of exchange and conversation. In the scope of the present study, there are three main aspects which has to be precisely detailed concerning the information: the formulation and the emission of the message, the reception and the understanding of it, and the *Loft* effect. The Figure 10.1 illustrates these three points.

These three points will be presented following two different approaches:

- Understanding the cognitive mechanisms involved in the conversation will brighten the understanding of the way it works, and will be used later to propose a technical model for *MATiK*. This cognitive approach is not properly a part of the *Evoked Metaphor* since it is highly disciplinary oriented. Nevertheless, it is necessary to validate the proposition of functions and the way they are presented. Indeed it is very important to remind that all propositions made in the frame of the interdisciplinary design method have to be validated by proficient disciplines. The psycho-cognitive approach is used to validate the relevancy of the descriptive approach of the *Loft*.
- The descriptive approach structures the foundation of the *Evoked Metaphor*. This description should be intuitively understandable, i.e. no specific knowledge should be necessary to follow it.



**Figure 10.1** | Conversation in the *Loft*

### 10.1.1.1 Cognitive approach

#### Emitting a message

In the communication process, the first step is the transmission of the message. As described in the part 1.2.3.2, before emitting the speech, it has to be formulated by the transmitter. This takes place in the brain, on the left side (in 95% of people) in the language cortex. It is composed of two main areas (important in terms of function): the Wernicke's and the Broca's areas, both linked by the arcuate fasciculus (cf. Figure 10.2):

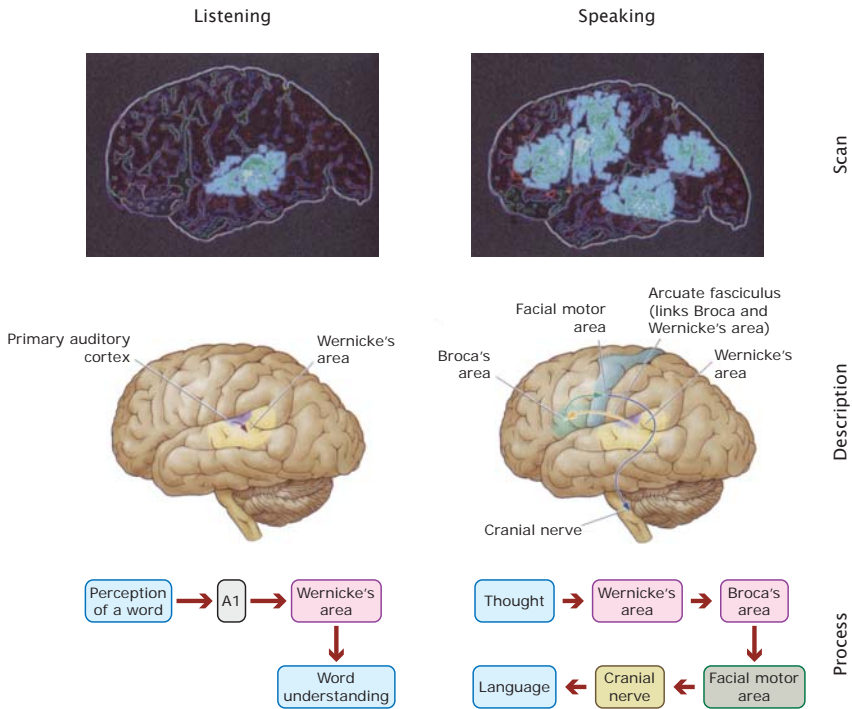
The Wernicke's area (Brodmann's area BA22) is situated on the posterior region of the temporal lobe. It contains the sonorous representations of the words [130].

The Broca's area (Brodmann's areas BA44 and BA45) is part of the frontal cortex of the brain. Its function in speech production is that it is coordinating the speech organs for the actual production of the language by interacting with the facial motor related area (situated very close).

When the brain wishes to pronounce a speech, the latter is sent to the Wernicke's area. The sonorous representations of the words to be used are sent to the Broca's area by the arcuate fasciculus. In the Broca's area, the program that elaborates the motor activity to produce the sounds is activated. The result is sent to the face motor related area, notably the mouth related motor area (in the primary motor cortex M1), responsible for controlling the physical movements of the mouth and articulators used in the speech production.

#### Receiving a message

The pronounced speech is received by the listeners being in the *Loft*. The speech is received as a sound among others by the ears (outer, middle, and then inner ears) and is sent to the brain through the cochlear nerve. In the cortex, the information arrives first at the primary auditory cortex (cf. Figure 10.2). The role of the primary auditory cortex is involved in tasks such as identifying and segregating auditory elements (that means that sounds entering the same time in the



**Figure 10.2** | Hearing and speaking activities in the human brain (from [130, 31])

ear are segregated and separated for further analysis. This aspect is important for this study and will be detailed in the following section), and identifying the spatial position of sources in space. Then the auditory information is sent to the secondary auditory cortex (among others), which is actually the Wernicke's area on the left hemisphere of the brain. This area has a very important function in the speech analysis: It is the place where auditory information is analyzed and transformed into a set of word information, enabling thereafter the understanding of meaning of it.

### **The cocktail party phenomenon**

To understand on a cognitive point of view, it is necessary to describe the three processes performed by the auditory system and related with the cocktail party phenomenon [2]:

- The stream segregation process - This takes place in the primary auditory cortex. Different factors are used to determine the different streams [19, 89]: timbre (spectral shape) [114, 122], fundamental frequencies proximity (pitch) [115, 122], temporal proximity [21], harmonicity [45, 181], intensity [32, p. 187-242], spatial origin [59], cumulative effect of repetition, continuity of movement (if occurs). Albert Bregman [19] noticed that it is composed of two processes: One is primitive, non-attentive, and unlearned; The other one schema-based, attentive, and learned. The former one is a bottom-up process<sup>9</sup> whereby streams are parsed according to the correlations of acoustical cues. The latter one is a top-down process<sup>10</sup> that arises from experimental and cognitive factors. This study is focusing on the former one, since it is the one involved in the cocktail party phenomenon.

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<sup>9</sup> Attention is captured by external stimuli, usually unexpected events. It is a very rapid, reaching its maximum 100-200 milliseconds after the perception of the stimulus. Examples are a bright flash light, impact of an object, or hearing its own name in unexpected time.

<sup>10</sup> Attention is controlled consciously, using information residing in memory. It is a purposefully process and is influenced by expectancy and relevancy of the stimulus, and by prior knowledge and experience. Examples are looking for a known person in a crowded environment or concentrating on performing a task.

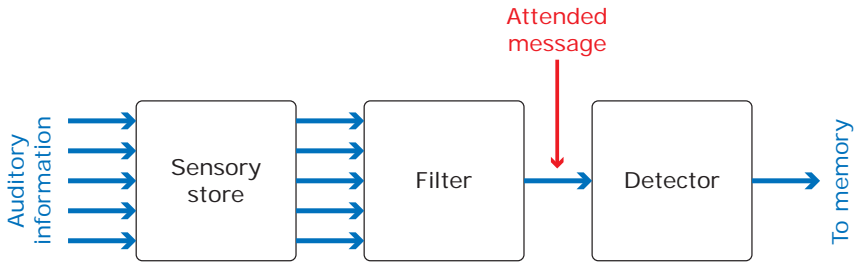
- The selective attention process - When the auditory stimuli have been segregated, the brain has to select a few of them, to bring attention to them, and to ignore others. It appears that there is a limited number of elements that can be processed (i.e. focused on) simultaneously [203]. Selective attention is then a necessary and important process for listening in a noisy environment. Models on attention:
  - The Broadbent's filter model [20] is based on an information processing approach (cf. Figure 10.3). When the auditory stimuli enter the ear, they become auditory information to be transported by the auditory nerve to the brain. According to Broadbent's filter model, the first step consists in a sensory store, holding briefly the information before sending it to the filter. The filter aims at applying the segregation process as explained previously to send the attended information only to the detector. The attended information is processed to determine meaning in the detector. The output from the detector to the short-term memory to be used immediately, sent to long-term memory or lost. This model proposes a filter based on the physical characteristics of the information coming in (i.e. similar to mechanical or electrical filters), adapting itself to allow a message to pass through it while blocking others. As the filter occurs before any semantic treatment, it is called an early selection system (cf. Figure 10.6). However, later works challenged this model and pointed out that also unattended information were also semantically treated [63] (for example, the cocktail party phenomenon is in contradiction with the Broadbent's model). This phenomenon is called the breakthrough.
  - Anne Treisman proposed another early selection system, the attenuation model, to integrate new findings based on two components [238] (cf. Figure 10.4). The auditory information is sent to an attenuator that analyzes the information in terms of physical characteristics, language and meaning. The aim is to process the information enough to distinguish all incoming information and to determine which one should be attended (and shadowing the others). Treisman proposition is not a filter because it doesn't cut unattended sources, but just attenuate them to retain high attention and (mental) abilities on it. The attended and unattended information are sent to the dictionary unit. The latest works as a word memory system. Each word has threshold to be activated: The lower the threshold is, the more



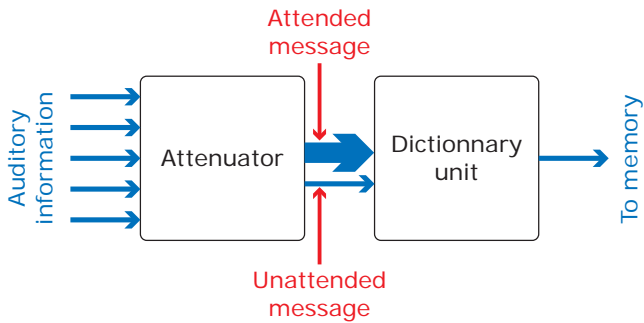
one is sensitive to this word. For example one's own name has a very low threshold. It was shown that the analysis of unattended messages could occur below the level of conscious awareness. However, this model does not explain completely the way the semantic filter works, and the nature of the attenuation process.

- Deutsch and Deutsch proposed a radically different filter model [52] (cf. Figure 10.5). This model implies that all incoming information is semantically treated before being filtered. Thus this proposition is based on a late selection model (cf. Figure 10.6). The selection is based on the relative importance of the information. Although, this model proposes a possible alternative to the Broadbent's filter model, it seems to be less plausible than the Treisman's one, and more wasteful ([239, 240] and [62, p. 197]). Other late selection model scan be seen at [43, 151, 160]. Many models have been proposed to explain focused auditory attention. Broadbent has proposed an early selection filter model, assuming that the selection was based on physical characteristics of the auditory input. However, evidence has shown the error of Broadbent, and two main answers have been proposed: the Treisman attenuation model and the Deutsch and Deutsch's late selection filter model. The former one had been more supported by the literature than the later one [104, 176, 254]. In the following of the current study, the Treisman's attenuation system will be considered as the model for the stream segregation process.
- *The switching process* - This third process is related to the ability of the human brain to switch from one channel to another [253]. In the auditory system, the cortical feed back exerts its effect all the way down to the outer hair cells in the cochlea via midbrain structures. So the potential for an early selection process in audition is very great (supporting the Teisman's model). This process is probably a top-down one by 'gating' the incoming signal [101]. Moray suggested that the switching time from one channel to another is of the order of 0.25 seconds [174].

This three processes are essential for enabling the cocktail party phenomenon to occur. The first process, stream segregation, provides the human brain the ability to separate sounds all coming in the two ears. The second one, selective attention, allows the human brain to analyze the auditory information and to



**Figure 10.3** | Broadbent's Filter Model [20]



**Figure 10.4** | Treisman Attenuation Model [238]

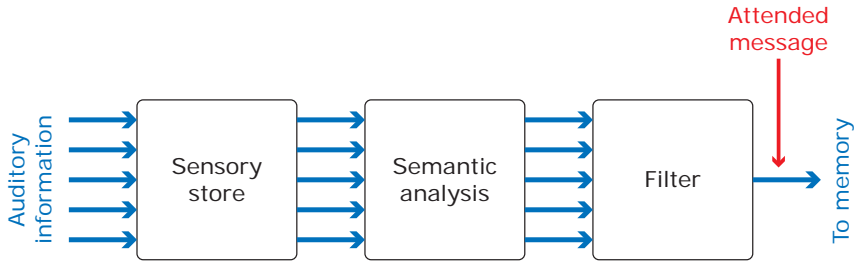
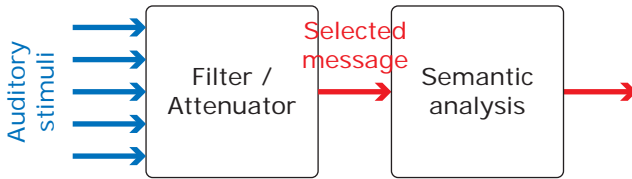


Figure 10.5 | Deutsch & Deutsch Filter Model [52]

**EARLY SELECTION**



**LATE SELECTION**

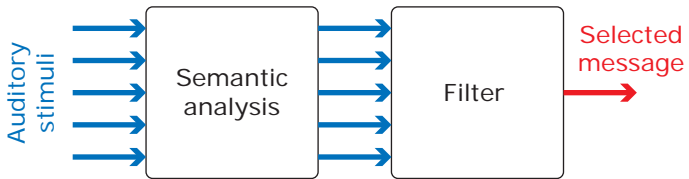


Figure 10.6 | Early and late selection models [20]

focus on the ‘most important’ one(s). The third and last one, switching, permits to change very quickly the channel to focus on.

### **10.1.1.2 Scene description**

#### **Emitting a message**

In interpersonal context, emitting a message implies first the wording of a thought and the existence of potential receivers. The wording process was explained in the previous part and is ending when the message is emitted. Therefore, message emission can be described thanks to three elements: the content of the message, the medium, and the target. In the *Loft*, the content of the message is a priori related with the activity or the area the person is in. In the scope of this study, it will be considered that the medium is the voice: communications are only oral. The listeners are the other persons around the speaker that may be concerned by the message.

#### **Receiving a message**

Listeners (i.e. receivers) are, to some extent, in the same area as the speaker. They will receive the message thanks to their ears, and understand it by the process explained previously. Then they may have different reactions, such as answering, go on listening with expression of interest or passively, and so on. One of the important points to consider is that the message they receive become an information that they may remember, but it may affect their mental estate and their representation of the context they are in.

#### **The cocktail party phenomenon in the *Loft***

Considering *MATiK*, the cocktail party phenomenon is probably the most important process to consider and to describe. The *Loft* is a very favorable for the cocktail party phenomenon to occur. Even though people have different activities, speak with people in the same area probably doing the same thing, the *Loft* is not a closed room and most of the people receive others’ discussion. As described in the cognitive approach, speeches from other areas are not attended by the brain which would not get really focus on. The brain will focus on

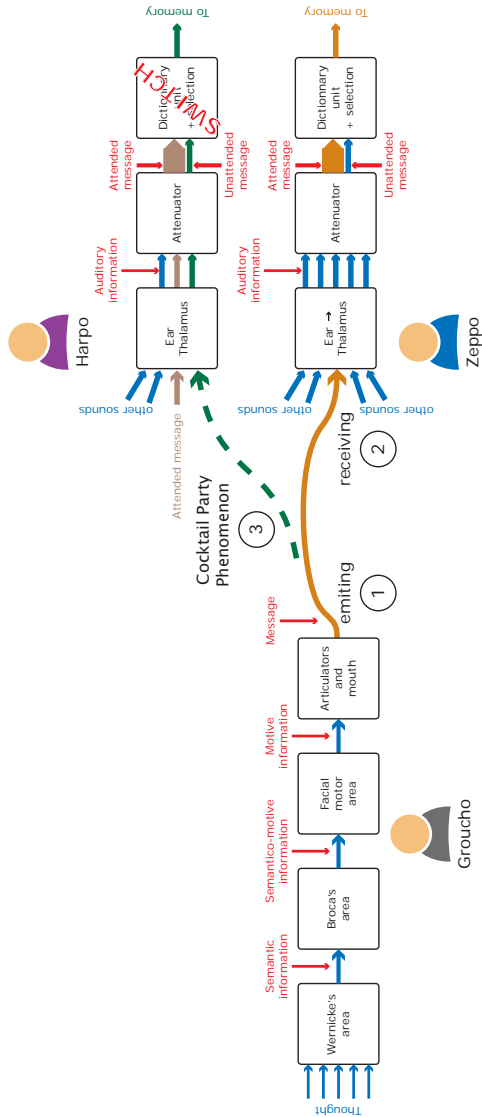


Figure 10.7 | The conversation in the *Loft*, cognitive point of view

the attended speech that is the one the person is participating to, that is taking place in the area of the lofts she/he is in at the moment. Nevertheless, other discussion are still treated, to some extent, by the brain and a switch can occur at anytime, if some specific threshold are reached in the dictionary unit (cf. the Treisman model).

If the switch occurs, then a few following events can happen. The switch will bring the information to a conscious estate, launching a mental process reaching a reaction. This reaction can be of three kinds: The receiver may decide to refocus on her/his previous activity, to try to listen to the conversation from faraway, or to enter more actively in the conversation. The choice between these different possibilities is essential since it may influence the information flow, the knowledge distribution, and even the spatial position of the people in the *Loft* (if this member decides to move to participate to the discussion with more efficiency and less noises of others).

### **10.1.2 Other tools**

Even though this study aims at focusing mainly on the conversation process in the *Loft*, some other tools are introduced here. They may be included in *MATiK* to improve workgroup communication efficiency and *MATiK* service to the users.

#### **10.1.2.1 The board**

When people live in a group system, they need some tools and rules to share the commons. For example, flatmate have to share the tasks for the maintenance of the flat. It is the same for the loftmates, as they don't have to share anything but knowledge and news concerning the group. As it is about news and knowledge communication, it is equivalent to a board that would be attached to one of the walls of the *Loft*, for everybody to be able to post, to check and collect information. This tool is called the 'board'.

#### **10.1.2.2 The ancestor**

In some groups (families, communities, workgroups...), it is sometimes possible to meet the person or the few people which 'owns' the historical

knowledge of the group. These persons are able to remember others past stories, past successes, or failures. This knowledge is often very precious because it permits to sustain past experiences in the approximately the same environment with the same problems. In the *Loft*, the ‘ancestor’ has this function to sustain the memory of the group and remind it to people.

### 10.1.2.3 The window

A window is always important in a *Loft* : It provides information from the outside. In the *Loft*, the windows may bring information about the weather or so on, i.e. not so interesting for the life in the *Loft*. In *MATiK*, it is no doubt that the Internet would increase noticeably the interest for the ‘window’.

## 10.2 Transferring the function descriptions to function requirements for *MATiK*

As the functions have been described in the *Loft*, it is now possible to transfer them to *MATiK*. As *MATiK* is a communication system, functions will be explained by a description of the activities of each member at the interface level, and a description of the processes *MATiK* has to own in a deeper level. Explanations are illustrated by the Figure 10.10.

### 10.2.1 Emit a message

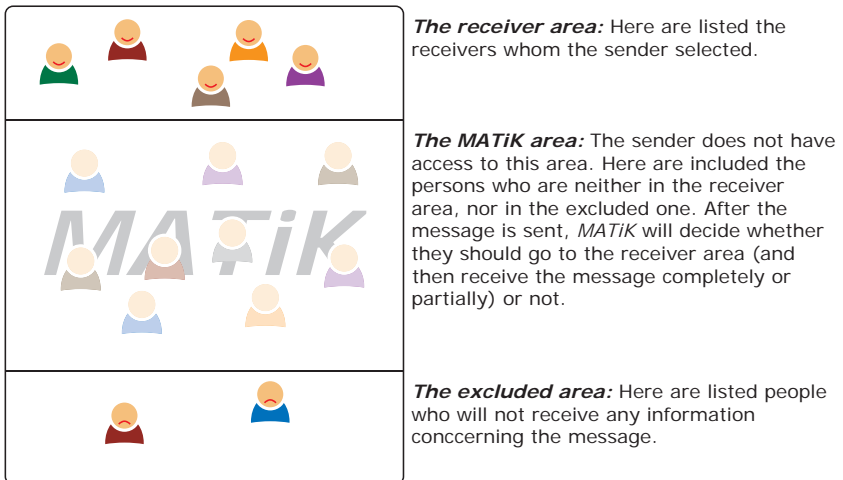
The proposition made here concerning functions of *MATiK* is for text-based messages with possibility of file attachment (as the email system). The use of other technologies such as voice messages or even videos could also be acceptable according to the requirements of *MATiK*. However, as a first proposition for *MATiK*, i.e. as a first version of it, it is wise to stay with text-based messages. Without reducing the interest for *MATiK* and the relevancy of its original function, it would provide a much reasonable approach to design its structure and to include existing tools such as text analysis ones, more developed and efficient than current sound or video analysis tools. Then, the sender writes the message she/he intends to send. A title or attached documents can optionally be added (similarly to emails).

The main originality of *MATiK* is about the ‘receiver list’ construction. As described in the part 8.2.1, the ‘To:’, ‘Cc:’, and ‘Bcc:’. do not exist in *MATiK*. Considering the *Loft*, there are three kinds of people when a message is sent (cf. Figure 10.8):

- The expected receivers (in the receiver area ) - The sender put into this category the list of people which is attended to receive the message. They are by default the persons already participating to conversation she/he is writing about, or people she/he wants to start a conversation with. It is recommended to limit the number of persons in this area, as a conversation starts usually among two to six people. *MATiK* would increase the number of receivers if others are potentially interested in the topic of the conversation.
- The non-receivers (in the excluded area ) - It may happen that the sender wishes one or a few persons of the group not to receive the message, even this behavior is not satisfying workgroup philosophy and efficiency (cf. part 8.3.3). People paced by the sender in this area cannot receive the message: even *MATiK* excludes them from the analysis process.
- The others (automatically in the *MATiK* area ) - If people are neither in the receiver area nor the excluded one (which should be the case for most of members of the workgroup), then they automatically enter the *MATiK* area. After the message is sent, *MATiK* figures out if there is an interest for each of them into receiving the message, or a part of it.

Replacing then the To-Cc-Bcc system of the emails, *MATiK* proposes another three-category system, based on a simple categorization of people in the *Loft* : the one that participate to the conversation, the excluded people (for concrete reasons of communication tools), and the others which are not necessarily permanently excluded from the conversation, thanks to the cocktail party phenomenon. This system is much more relevant than the email one when considering the fuzziness of the information flow.





**Figure 10.8** | The sender's receiver proposition during sending process

## 10.2.2 The cocktail party phenomenon in *MATiK*

As described in the part 10.1.1.1, the cocktail party phenomenon requires firstly a content analysis, and secondly an activation system (a threshold activation like system) for the switch ability.

### 10.2.2.1 Content analysis

Researches on communication transcript analysis are numerous, mainly in the field of Computer supported collaborative learning (CSCL). Roughly, two approaches exists [229]:

- A *quantitative analysis* proposes communication encoding, summarizing, frequency or percentage evaluation, etc... are used for content comparison, evaluation, and statistical testing [92, 96].
- A *qualitative analysis* proposes participant observation, case summaries, ethnomethodology [136, 154, 227, quoted in [229]]

Quantitative approaches, based on statistical analysis, are prospective and require hypothesis derived from theories, whereas qualitative approaches are retrospective and require less explicit expectations. However, for both approaches, evaluation of reliability is important.

Considering *MATiK*, this study intends to focus on quantitative content analysis. It is defined as a research technique for the objective, systematic, quantitative description of the manifest content of communication [9]. Liam Roule [211] listed the four fundamental criteria which depends on the relevancy of the quantitative content analysis:

- *Objectivity* - Quantitative content analysis is an objective technique. This criteria is all the more important that transcript encoding can be the place of subjectivity in the analysis. As subjectivity cannot be completely avoided from the analysis, a tolerance can be set up. However it should come with a requirement of analysis refining in case of excessive degree of subjectivity.

- *Reliability* - The reliability is expressed by an agreement level between two independent coders [229]. It is a very important information, part of the content report. Any report with missing reliability should be considered with caution, or even considered as useless [183, p. 141]. A common method to report reliability is the percent agreement statistic reflecting ratio between the number of agreements and the sum of coding decisions. The Holsti's coefficient of reliability (CR) [107] aims at calculating the percent agreement:

$$CR = 2m / (n_1 + n_2) \quad (10.1)$$

where  $m$  is the number of coding decisions upon which the two coders agree and  $n_x$  is the number of coding decisions made by the rater  $x$ . Other reliability evaluation techniques can be seen at [211], among which the Cohen's Kappa statistic, a chance-corrected measure of interrater reliability.

- *Replicability* - The applicability is the ability of multiple and distinct application of a coding scheme reliably. Liam Rourke [211] views it as the definite test of a coding scheme. Unfortunately, the literature shows no successful attempt of replication, and is raised currently as a serious and unsolved issue in content analysis.
- *Systematic* - The term of systematic refers to a more or less well structured set of ideas, assumptions, concepts and interpretative tendencies, which serves to structure the data of an area. Lyam Rourke argues that this field is not yet mature and is still into a investigation step.

A review of the major content analysis schemes can be seen at [249].

### 10.2.2.2 Activation

After the content is analyzed and categorized thanks to content analysis techniques, *MATIK* has to decide to forward the message or not to any potential unattended receiver. To do so, a decision process has to be set up. The design of this decision process is not directly a part of the functional requirements as it is directly related with the technology used by *MATIK*. Nevertheless, whichever is the technology, the weightings of the different factors at the origin of the switching

process in the cocktail party phenomenon need to be quantified. This quantification is realized by an experimental approach presented in the part 10.3.

### 10.2.2.3 Jump analyzer

As evoked in the section 8.3.2, the content-user link analysis, leading to the decision of activation, is processed by the jump analyzer. Thus, this tool aims at simulating, in the *MATiK*, the cocktail party phenomenon present in the *Loft*.

#### Content analysis

The first analysis of the jump analyzer concerns the content of the message (cf. section 10.2.2.1), and many tools exist to analyze the content of text [82, 123, 126, 213, 248]. It has the function of the dictionary unit in the Treisman model. The kind of output interesting for the present dissertation is a list of words or expressions, contextually important in the text, considered as global keywords by the jump analyzer.

#### Switch evaluation for potential unattended receivers

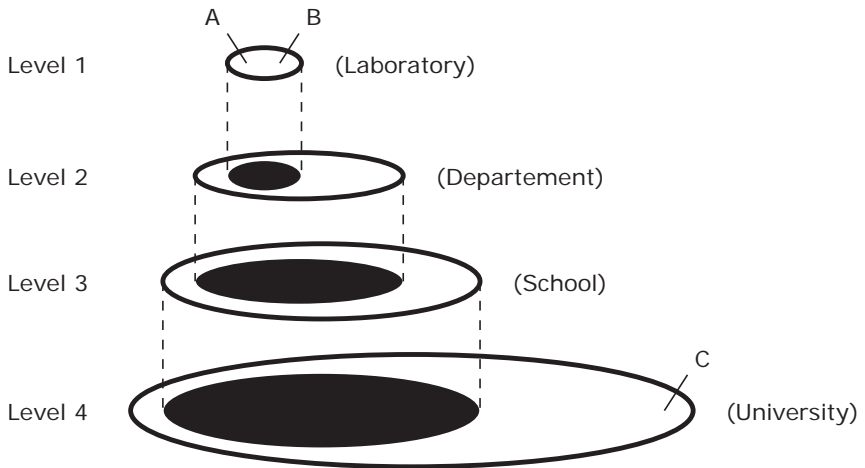
The second analysis is the evaluation process (cf. Figure 10.10) and aims at taking a decision or not concerning the activation of the switch for potential unattended receivers. The process consists of determining which potential receiver can become interested by receiving the message, i.e. if keywords found in the first analysis can be considered as having a high-relevancy when associated to a member's profile (member's data). Two aspects are important in this analysis:

- The relevancy of the keyword for an individual is called the individual relevancy of this keyword in the context defined by the individual's profile. Its level is dependent on the individual's profile. The higher is the individual relevancy, the more the message should be considered as interesting.
- The relevancy of the keyword for the entire group, called the group relevancy, has the opposite impact on the message evaluation. If the keyword has a high individual relevancy for each member of the group, then it is considered

as having a highly group relevancy. A high group relevancy discredits the individual relevancy by reducing the peculiarity of the relation between the keyword the individual's profile in the context of the group.

In other words, a word output from the first analysis is globally interesting if it has a high individual relevancy and a low group relevancy. The aim of this group relevancy minimizing aims at preventing the selection by the jumper analyzer of a too great number of receivers because of a common concern. This allows the jump analyzer to operate even in a multidisciplinary or specialized workgroup. This way, the jump analyzer would focus on more personal keywords than disciplinary ones. The global relevancy of disciplinary terms is inversely proportional to the interdisciplinary quality of the group.

When considering a more complex organizational structure, the evaluation process should be adapted. I will take here an example where *MATIK* is used in a university setting. The sender (A on Figure 10.9) is hierarchically part of a laboratory, a department, a school, and the university, successively. As described previously, the relevancy of keyword cannot be evaluate in the



**Figure 10.9** | Workgroup organization and keyword relevancy evaluation

same way between an unattended receiver member of the same laboratory (B on Figure 10.9), and an unattended receiver from another school in the same university (C on Figure 10.9). The reason is that A and B have the same specialty, and therefore the group relevancy brings to a low level all the terms related to this specialty, whereas it is the opposite for A and C, as both are from different schools (so, supposedly from different specialty).

Therefore, an inter-level graduation of the group relevancy is required. By letting *MATiK* know about the organization of the entire workgroup (in this example, the complete university with a four-level organization structure), it will be able to evaluate the required subgroup relevancies, i.e. a different group relevancy for each level of the organization. A subgroup relevancy is used for each level, excluding the lower level the sender is part of (In Figure 10.10, it corresponds to each white surface, excluding the black section). The aim of subgroup relevancies is to determine a group relevancy adapted to each receiver, according to its organizational link with the sender.

### **Relevancy analysis for attended receivers**

Another analysis operated by the jump analyzer is the relevancy analysis for attended receivers. In this version of *MATiK*, the aim is not to filter the message<sup>11</sup>, but to obtain information used in the next step to improve the jump analysis. Indeed, during this step, the jump analyzer evaluates the relevancy of the message for all the attended receivers before sending it to them. The aim of this action is for the jump analyzer to check the performance of its own analysis capabilities. The result of this analysis is compared with the observation of the receivers toward the message, as explained in the following paragraph.

### **Output and further evaluation**

The result of this analysis is a list gathering all the receivers, i.e. attended and unattended ones. The output is the reception of the message by all listed members. Then after, feedbacks (cf. section 10.2.3) and observation of their

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11 However, in a further version of *MATiK*, the filter system to limit the volume of messages addressed to a member should be installed at the step of the information management process.

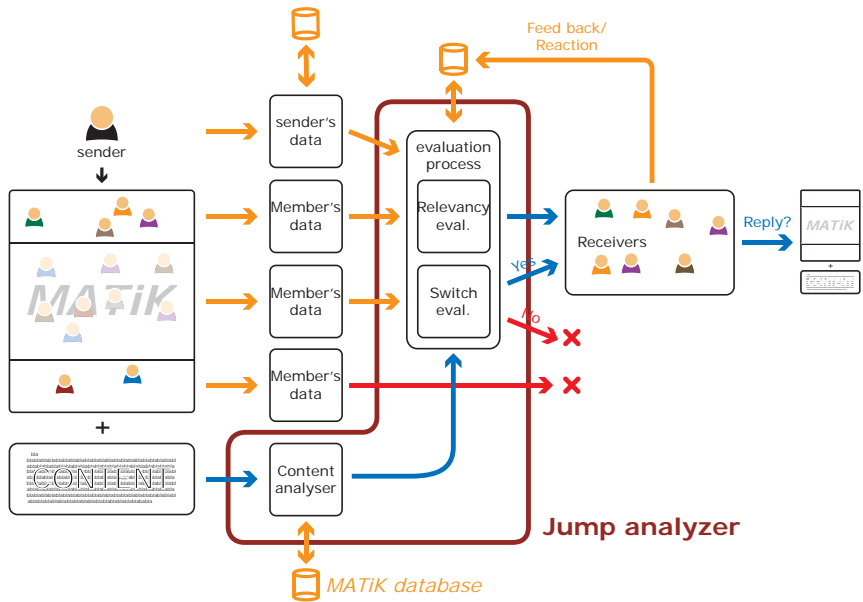


Figure 10.10 | The sending process

behavior by *MATiK* (reactivity, replying or not, erasing...) can occur in order to evaluate the preciseness of the analysis described in the previous paragraph. Then, the result of this evaluation is saved and is used for the jump analyzer to improve its analysis abilities and for *MATiK* to know better about each member.

### 10.2.3 Receiving a message

The receiver of the message accesses two kinds of information: the message itself (title and content), and the list of attended receivers. Of course excluded area list is not shown. The unattended receivers, who would have receive the message due to the cocktail party phenomenon in *MATiK*, are not shown in the receiver list. The possibility to announce oneself in further messages is left to each unattended receiver's will. That corresponds to the case the unattended receiver decides to participate or not to the discussion, as described in the *Loft*.

Any receiver (attended and unattended ones) can react to a message on two levels:

- Informing *MATiK* about the relevancy of message (feedback). *MATiK* is estimating the relevancy of the message before sending it to (attended and unattended receivers) in order to decide if the message should be sent or not to a potential unattended receiver, and to strengthen its ability of relevancy evaluation concerning each attended receiver. This is important for *MATiK* to progress in its evaluation skills and also to learn more about each user (for more explanation, see section 10.2.2.3, Output and further evaluation).
- Replying the message to participate in the conversation (reply/reaction). As it is this interest of communication systems, each receiver can reply to a message in order to go on the conversation. The reply of each member, mainly unattended receivers, can also provide interesting feedback to *MATiK* as to strengthen its relevance evaluation process.

### 10.2.4 Other functions

Other functions will not be detailed as the conversation one. Main concepts will be explained and illustrated by a figure. It is important to show how the



features may integrate *MATiK*'s environment (*MATiK* has to be a unified communication system) with conversation functionality and complexity of the structure of *MATiK*.

Other functions can be operated in two different situations:

- A user can send a request to operate the function. It is used then as a direct service and is required to provide a result. Also, this result can be evaluated by the user to improve during further utilization. For example, the user can ask *MATiK* to check the board and return any interesting news which is on it; The user can use the ancestor as an archive mining system to research in the past conversation; The user can use the window as an Internet research agent to get some information about any topic.
- However, these functions can also operate in the background of conversation and provide information automatically when it seems relevant. Then they interfere in the conversation and provide some more information to the participants. For example, if a conversation topic is about a robot design and a new announcement in the board is about the publication of a book on robot design, then the board would provide automatically the information about this new book; The ancestor can inform members that a similar discussion occurred some months or some years ago; The window can provide Internet links found on the Internet close to the discussion going on. To limit their relevant messages, this background service prevents itself from sending the information to the creator of it, and introduce itself as a service for the member to differentiate it from other members.

#### 10.2.4.1 The board

To post an announcement in the board, the member sends the content (also the title and attachment files can be added) via the message system, but lists 'the board' as the unique expected receiver. Then *MATiK* considers this message as a posting to the board, analyzes the member's data and the content information to classify the message correctly and learn more again about the member.

To access the board directly, a member sends a content-free request to the board. The member's data are analyzed by *MATiK* to figure out the most inter-

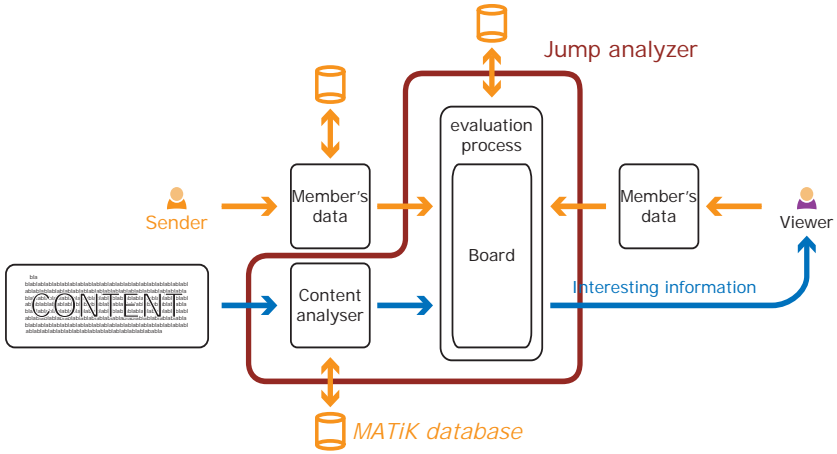


Figure 10.11 | The board usage process

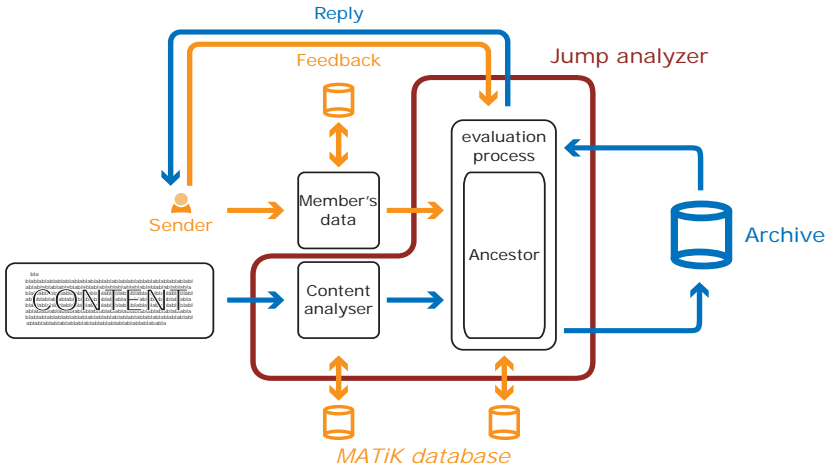


Figure 10.12 | The ancestor usage process

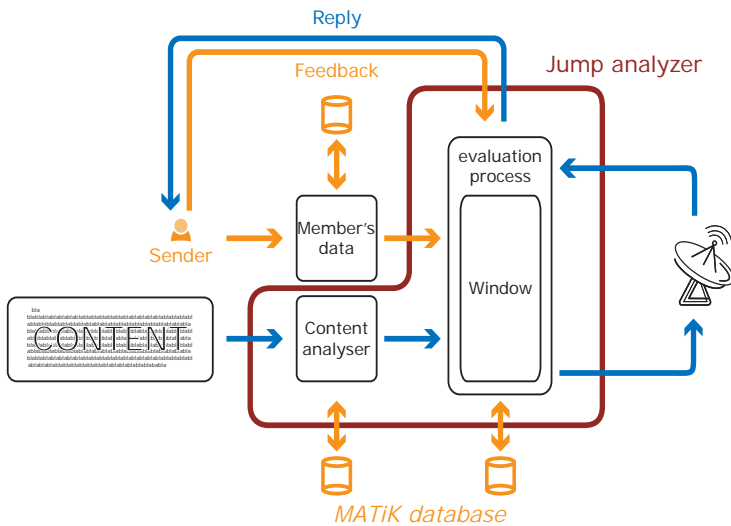
esting postings on the board. Then relevant postings are sent to the requester, who can provide a feedback to *MATiK* for further improvements of this service.

**10.2.4.2 The ancestor**

To search in the archives of *MATiK*, a member sends a request (with content) to the ancestor (the only one listed in the expected receiver area). The content and the member’s data are analyzed for the ancestor to provide the most relevant information to the member. A feedback procedure is also possible, for further improvements of this service.

**10.2.4.3 The window**

The window system works basically the same way as the ancestor. The difference is that the window searches information on the Internet, whereas the ancestor searches on the archive of *MATiK*. The information provided to the



**Figure 10.13** | The window usage process

requester is then different. That also changes various things on a technical point of view.

### 10.3 Quantitative functional data: the cocktail party phenomenon experiment

Following the interdisciplinary design methodology, using the *Loft as Evoked Metaphor*, the conversation system had been explained based on a cognitive consideration in the context of communication. Nevertheless, some elements of this description needs to be specified more precisely for the design of *MATiK*. The quantification of some aspects of the cocktail party phenomenon for direct application in *MATiK* design is proposed in this part.

#### 10.3.1 Problem

As described in the section 10.2.2.3, jump analyzer needs to weight quantitatively some criteria, used for the evaluation of the level of the message interest for an individual. For example, an obvious criteria is the “individual relevancy” of some of the words included in the message.

When considering the cocktail party phenomenon in the *Loft*, it is obvious that switches are due to some characteristics related to the content of the message and the context (including the sender and the receiver). The content of the message itself is not the only characteristic that has an influence on the switching process. For example, if somebody hears a voice he knows in a crowded area, or if a tourist hears unexpectedly some sentences in her/his own language in a foreign country, then the brain may switch and focus on the unattended channel.

To integrate the cocktail party phenomenon process in *MATiK*, it is important to evaluate, i.e. to quantify the weighting of these characteristics, and to define their equivalences in *MATiK*. The weighting of these characteristics would permit to approach quantitatively the cocktail party phenomenon, and thereafter to instruct the content analyzer process of *MATiK*.

### 10.3.2 Hypotheses

The aim is to specify by quantification of the reaction of the brain concerning different factors resulting on the switch to unattended channel. The switch reaction in the cocktail party phenomenon is activated based on some criteria which are reminded here [35]:

- *The spatial position of the source* — This includes not only the distance between the subject and the source (interpersonal distance [153]), but also the spatial position of the source (related with the concept of personal space [169] [94, p. 206-210]). These two criteria induce the use of a polar coordinates system (centered on the subject). The radial coordinate  $r=0$  is the subject, and the polar angle  $\theta=0$  is what the subject is facing. The hypothesis related to the spatial position of the source is that the greater  $\theta$  is (for  $\theta \in [0;\pi]$ )<sup>12</sup>, the less strong is the brain reaction. In other words, the reaction should be greater for front events and lower for back ones.
- *The volume of the message received by the subject* — This volume is related with the volume of emission of the source, the importance of the background noises, and the distance between the source and the receiver. The hypothesis is that the louder is the stimulus, the greater will be the reaction.
- *The content of the message* — This is probably one of the most fundamental criteria launching cocktail party phenomenon . The subject's name, or place he/she lives... may be contents being keyword hits for the subject's reaction. The hypothesis is that the greater is the 'self-relevance' of the content<sup>13</sup>, the greater is the cognitive reaction [87].
- *Recognizing source voice* — The more the source's voice is familiar, the more the subject's reaction would be high. This aspect of the stimulus is related with the notion of 'auditory face': Voice can also be viewed as an 'auditory face', that allows us to recognize individuals and emotional states. Voices, as faces,

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12 It is admitted here that the side from where the stimulus comes from does not have any influence in this experiment.

13 The term of 'self-relevance' is defined as the level of relation to the one receiving the stimulus.

are characterized by a unique combination of physical features related to the unique configuration of the human vocal apparatus [7]. Therefore, the hypothesis is that the voice pattern would create a brain reaction, stronger if the voice is already known (i.e. the speaker is known by the subject).

- *Familiar way of speaking* — This criteria is kind of wild, but we will limit here to the language pattern (way of speaking, accent, intonation... ). It is expected that, even if the subject understands a foreign language, a word said in the subject's native language (by a compatriot) would have more impact than the same word said in a foreign language (by a foreigner).

Cherry proposed some other criteria that are not listed because they don't correspond with the objective of this experiment (such as grouping processes, and continuities, visual or timing aspects) [35].

<i>Loft</i>		<i>MATiK</i>
Spatial position	↔	Close activity
Volume	↔	Message importance
Spoken content	↔	Written content
Source voice recognition	↔	History of closeness
Familiar way of speaking	↔	Discipline level of the content

**Figure 10.14** | Equivalences between criteria of flow jumps in *MATiK* and in the *Loft*

### 10.3.3 Equivalences with *MATiK*

The question this experiment intends to answer is: Is there any pattern defining the influence of the selected factors structuring the switching ability on the brain reaction? By weighting each of these criteria, we expect to be able to build a structure which contribute to the evaluation of the impact that could have a message for each user of *MATiK*.

To be able to answer completely to the question, the equivalences between the cocktail party phenomenon's characteristics and the *MATiK*'s ones need to be precised (cf. the illustration by Figure 10.14):

- *The spatial position of the source* — Distance in the *Loft* reflect on the difference of activity between the speaker and the unattended listener. On one hand, if both are far from each other, it means that they are in different parts of the *Loft*, doing different things. On the other hand, if both are close, they may be in the same area of the *Loft*, doing together a task related to this area (e.g. cooking if they are in the kitchen). Then, the distance can be associated with the activity. In *MATiK*, the activity is related to the sub-project. People being in the same sub-project are highly expected to interact and to share activities. The distance between such two people is small. Yet, two members being part of two different projects in the interdisciplinary group are far in the *Loft*.
- *The volume of the message received by the subject* — When the emitter of a message raised the volume of her/his own voice, it has a purpose. That can aim at accessing people which are away in the *Loft*, or at accentuating the importance of the message. Then, in *MATiK*, the equivalence of the volume would be the importance of the sent message (importance decided by the sender).
- *The content of the message* — The equivalence between the content of the explicit spoken message, in the *Loft*, and the one of the written messages, in *MATiK*, is immediate.
- Recognizing source voice — The capability of recognition of the voice is mainly depending on the relationship between the speaker and the listener. The temporal dimension and the "closeness" are two important aspects which

determine this capability. However, it is possible to characterize this criterion by the “long-term” relationship between the two persons. Note that the idea of “long-term” evoked here is opposed to the idea of “short-term” intrinsically included in the criterion spatial position of the source which may vary greatly at anytime. Therefore, the equivalence in *MATiK* is immediate. The quantity and the quality of communication between the two protagonists modify this criterion, which should be considered by the jumper analyzer during the switch evaluation process.

- *Familiar way of speaking* — As seen before, this criterion is related to the way the speaker expresses her/himself (language, intention, expressions, etc... ), and the closeness with the listener’s expressing way. In the interdisciplinary group, this corresponds to the disciplinary aspect of each message. If a message is highly-discipline related, then the more an individual is disciplinary close to the one used in the message, the more she/he would be sensitive to this message. That is because of the familiarity with the content of the message. Therefore, the disciplinary level of the message in *MATiK* is equivalent to the familiar way of speaking in the *Loft*.

### 10.3.4 Expectation

The expectation is to find a good correlation between the relative reactions of the subjects on each of these criteria. This experiment intends to compare the different kinds of criteria, not to provide it any absolute value, since it is firstly impossible to provide by nature of the experiment, and secondly wouldn’t bring any extra information. Regarding the six factors listed previously, we expect that the content of the message has the highest weighting on the switch process. On the other hand, the expectation for a familiar way of speaking is a low weighting.

### 10.3.5 Method

To do so, the experimental protocol is described, involving surround system inside laboratory environment (in order to control and limit other parameters, such as lights or parasite sounds). Brain wave measurement system (ERP) is used so that brain reaction level is evaluated for each event.



### 10.3.5.1 Material

#### Environment

In order to control a maximum of parameters, it was decided that the experiment will be done in a laboratory environment. As this experiment itself was supposed to stick the maximum to the *Loft*, a real situation (it means here a social environment that can occur in an actual life, such as a real cocktail party) was first wished, but the quantity of noises brought by an uncontrollable environment obliged to reject this possibility. The aim is to prevent from any other cocktail party effect, which could occur in a real situation, from electro-magnetic waves, which could interfere with the electroencephalogram (EEG) system, and to limit other environment parameters (such as visual channels influence or third party movements).

#### Sound

Since we want to examine cocktail party sound effect on the subject reaction, the design of the sound environment is very important for the success of this experiment. It is important to recreate a virtual real-like sound environment, in order to be able to get realistic results. Also a virtual sound environment will make possible the control of the source position compared to the subject's one. That requires the use of a surround technology, supported by a 6.1 channel system.

Two different systems exist currently supporting surround technology: home theater speaker systems, and surround headphones. Findings by Kallinen and Ravaja convinced to prefer the use of headphones to the use of speakers. Even though speakers are able to recreate a more realistic situation, isolating the subject from the outside world using head-phones may increase the sense of presence (thus pleasuring more the listening experience), would elicit a more intense and immerse listening experience (better arousal and attention) than using speaker systems [125].

Material:

- Sony Infrared Cordless Digital Surround Headphone System MDR-DS8000.
- M-AUDIO Transit USB Audio Device.
- Adobe Audition 1.5 (for sound edition).

The fact that the cordless headphones would not have any impact on the EEG measurements was checked and validated.

### 10.3.5.2 Brain wave measurement

#### Description of the ERP

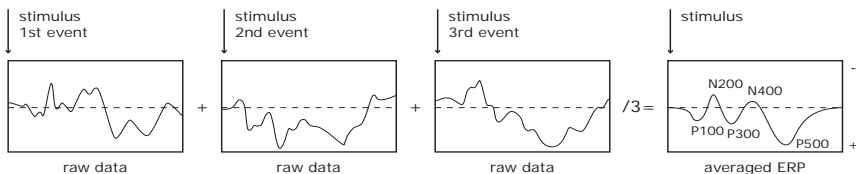
Measuring the brain reaction to the cocktail party phenomenon events can be done with event-related potential (ERP) techniques. ERP techniques are based on the classical paradigm ‘stimulation-response’. The stimulation can be electric or natural (in the current paper, the sound as a natural one) and the response is the brain reaction seen by electrodes (difference of voltage between the electrode and a reference site — here, the left and right hemispheres of the brain use the left and the right mastoids, respectively, as reference site). Two data can be observed: the latency (in milliseconds) and the amplitude (in microvolts) of response [171]. The aim here is to collect the level of response of the brain following sound stimuli in case of cocktail party phenomenon.

As the aim is to measure the reaction of the brain on auditory information, the interest for the auditory cortex is immediate. The main risk of measuring at the part of the scalp is the presence of hair. As proposed by Goff [84, p. 111], vicious electrode cream can be used to use disk electrodes on hairy areas. This technique has the advantage for ease and speed, but is not very secure, mainly if the experiment lasts.

To synchronize the sound player and the ERP measurement system, a trigger system is used. This trigger is activated once, when the sound starts to

be played. Then it is possible to know when the sound is played while checking the raw data output from the ERP.

As the brain does not deal only with the activity measured during the experiment, numerous noises appears on the EEG results. To emphasize the investigated signal and minimize other ones, a technique to ‘time-lock’ and ‘average’ the signal is required. The ‘time-lock’ technique consists in marking the time when the stimulus is sent. Then it is possible to point out each stimulus entrance on the raw data. The ‘average’ technique consists in doing the same trial (i.e. sending the same stimulus) for many times (about a hundred times) and to average them aligned in the time-lock, so that events happening at the same time relative to the stimulus input are averaged. For example, the hundred values which occur 50ms post-stimulus are averaged together. This averaging process has the characteristic to filter the brain activity not related with the reaction to the stimulus. Any brain activity not related to the stimulus does not occur at a consistent time relative to the stimulus. Then, it would be averaged out thanks to the numerous trials. Yet, as the brain activity related to the stimulus occurs with the same regularity as the stimulus input frequency, it stays visible on the output data (cf. Figure 10.15).



**Figure 10.15** | ERP average technique

When using ERP average technique, temporal information becomes crucial, as it attests of the brain reaction to the stimulus. In the Figure 10.15, key temporal information are noted P100, N200, P300, N400, P500 (conventionally, N stand for negative voltage in the output of the EEG, P for positive, and the following number for the post-stimulus length of time in milliseconds).

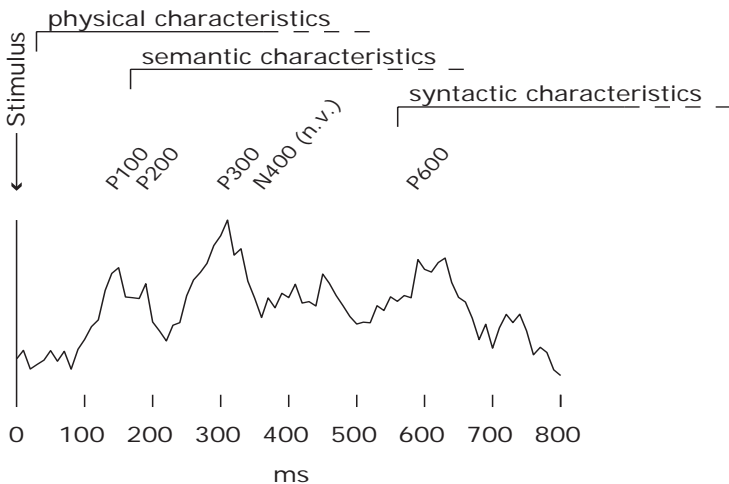
Material: Nihon Kohden Neurofax EEG 1100

### **Literature study on the auditory-related ERPs**

In the literature, numerous studies can be found which explain the reason of peaks found by ERP techniques. However, as the brain can process a few functions in the meantime, at the same latency, different explanations about the on-going function are sometimes possible. I propose here to explain some of them (related to the present study) briefly:

- from 10 to 100ms — These potentials are endogenous, i.e. related to the physical characteristics of the stimulus [171, p. 105]. Woldorff [251] demonstrates that an “early selective control” over sensory attention can start, at the earliest, 20ms post-stimulus: an earlier positive wave in the interval 20-50ms is related to attention [251, 252].
- N100 — The N100 component, or ‘N1’, is described as the reflecting peak related with the obligatory sensory analysis of acoustic stimuli in auditory cortex. Giard suggests that the related activity is a filtering or gain mechanism capable of inhibiting or gating unattended stimuli, relative to attended, at an early stage of sensory analysis (about 100ms). This model represents a physiological version of the original psychological filtering or attenuation models (cf. [20, 238]) – [77]. Citing Hillyard’s research ([95, 104]), Teder-Sälejärvi noticed that the N1 and the P300 are indices of two hierarchically ordered levels of stimulus selection, with the N1 reflecting an early sensory selection based on easily discriminable channel cues (such as location) and the P3 reflecting a subsequent within-channel target selection based on a more detailed processing of the relevant stimulus properties [236].

- P200 — The P200 component is described as the latency at which congruous and incongruous words, in their semantic aspect, are detected. This process peaks at 400ms (cf. N400) [135, p.102].
- P300 — The P300 component is probably the most studied in the literature (cf. [53, 54, 121, 201] as basic description literature). It is known to be influenced by the task relevance of the stimuli presented to the subject. But it appears too that P300 can be enhanced, not if the task relevance of the stimuli is not explicit, but if the stimuli itself is relevant [65]. As a selective attention behavior (as reviewed in [105]), the name effect was shown: subjects can notice their own name even if it is an unattended auditory element [173]. Therefore, the subject's name holds an innate relevance to the subject that influence the P300 [11]. This aspect, which is important for the present study, is confirmed by Gray, who shows that the P300 component is elicited by the attention to self-relevant stimuli, such as subject's own name.
- N400 — The N400 component may reflect processes of semantic priming or activation [134]. It is sensitive to semantic violations in the sentence: if unex-



**Figure 10.16** | The ERP components

pected words are semantically expected in the sentence, i.e. related semantically to highly expected words, then the N400 amplitudes are lower. N400 seems then to be associated with the lexical/semantic processing [93, 228, 231]. This component is broadly distributed across the scalp, but is larger over parietal, posterior temporal, and occipital sites, than frontal sites [135, p. 105].

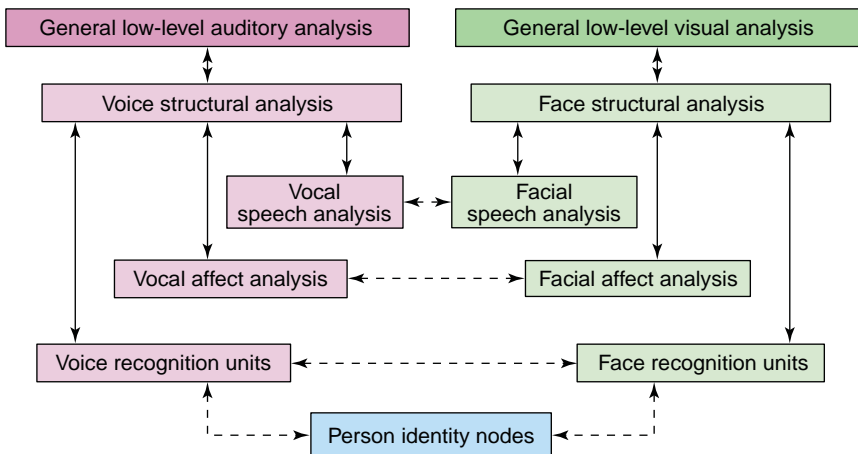
- P600 — As said by van Herten [243], the P600 effect occurs to sentences that contain a syntactic violation, have a non-preferred syntactic structure, or have a complex syntactic structure. The P600 has been claimed accordingly to reflect various kinds of syntactic processing difficulties, such as the inability of the parser to assign the preferred structure to the incoming words, syntactic reanalysis, or syntactic integration difficulty. P600 seems then to be associated with the syntactic processing.
- Further peaks exist, mainly when decisions and motor behaviors are the reaction of the stimuli. However, as the current research focus on the cocktail party phenomenon, this range is not of our interest.

### Literature analysis on the hypothesis

The literature suggests that two selection processes occur and are elicited by the N100 and the P300 [95, 104, 105, 106, 236, 244]. The earlier reflecting an initial selection between channels based on easily discriminable cues (endogenous criteria). The later indexing a subsequent target selection within each channel following a more elaborated and detailed processing of the relevant stimulus properties (exogenous criteria). To link the literature analysis, done in the previous paragraph, and the hypothesis, here will be detailed a state of the literature concerning the five hypotheses:

- *The spatial position of the source* — Mondor [172] showed that auditory spatial attention was distributed as a gradient model in which attentional resources decline gradually with distance from an attended location. A negative ERP elicited in the auditory cortex starting 60-70ms post-stimulus provides strong evidence of spatial selective attention. This attention-related peak overlaps with the N100 and is enhanced in amplitude in response to attended vs. unattended stimuli [104, 176].

- *The volume of the message received by the subject* — In the literature, no information concerning the potential influence of the auditory volume on the cocktail party phenomenon was found. Therefore, this literature analysis cannot help on building assertions concerning this point. However, as the volume of the stimulus is endogenous, it is suggested that if the volume has an impact on the selection process, it would occur for the events corresponding to the ERP of 100ms as latency.
- *The content of the message* — This topic is the most present in the literature. The semantic analysis concerns all the semantic dimension of the content, and are described by the P200, the P300, and the N400 described previously.
- *Recognizing source voice* — The Voice-Sensitive Response (VSR), peaking at around 320ms, is defined as reflecting the process of distinction between human voice and other sounds [145, 146]. Also, voice-selective areas are localized in the in the upper bank of the central part of the superior temporal sulcus (STS) [8]. Several studies separated and described the middle STS



**Figure 10.17** | A model of voice perception [7]

regions, more responsive for the determination of speech presence, and the anterior regions of the left STS/superior temporal plane, involved in the comprehension of the speech [13, 46, 214, 218, 219, 259]. Belin proposes the voice perception model in a similar way as the face perception (cf. Figure 10.17):

*We propose to use Bruce and Young's model of face perception [25] as a framework for understanding the perceptual and cognitive processes involved in voice perception. After low-level analysis in subcortical nuclei and regions of primary auditory cortex (A1), vocal stimuli are further processed in a stage of 'structural encoding' – probably involving bilateral regions of the middle STS close to A1. Vocal information processing might then be dissociated in three functionally independent systems: (i) analysis of speech information, involving anterior and posterior STS as well as inferior prefrontal regions predominantly in the left hemisphere; (ii) analysis of vocal affective information, involving temporo-medial regions, anterior insula, and amygdala and inferior prefrontal regions predominantly in the right hemisphere; (iii) analysis of vocal identity, involving 'voice recognition units' probably instantiated in regions of the right anterior STS each activated by one of the voices known to the person, and a subsequent supra-modal stage of person recognition ('person identity nodes'). These three processing pathways are proposed to interact with homologous pathways in the face processing architecture, in a supra-modal stage of information processing. [...]*

*Despite the proposed functional dissociation, the three pathways are clearly not wholly independent. During the normal processing of vocal information, cortical regions involved in processing the different types of vocal information are likely to interact to build increasingly abstract representations. It is only at the highest levels of the architecture that representations for one type of information would become independent of sources of variability related to other types of information. For example, the 'voice recognition units' are supposed to be activated by the voice of one individual*



*regard less of the speech content or the emotional tone of the vocal input.*

- *Familiar way of speaking*— Jacobsen [116] found that language-familiar words are processed differently from language-unfamiliar words and pseudowords<sup>14</sup>, even when subjects have no task related to them. In an ERP study, this difference is perceived by a modification of the amplitude of the Mismatch Negativity (MMN) wave [176, p.136]. Findings shown two MMN components: the early MMN wave (peaking at 150-200ms), elicited by the acoustical (i.e. physical) features of the stimuli, and the later MMN (peaking at 350-500ms), connected with automatic detection of lexical differences [132]. The MMN seems then to react to deviant (unattended) auditory stimuli, and this reaction is different for familiar and unfamiliar words (difference of amplitude of the MMN).

Firstly, this analysis can be concluded by noticing that most of the hypothesis had been already discussed in the literature, besides the volume hypothesis. This hypothesis, being endogenous, should still be noticed in a ERP with a latency close to 100ms. However, all the hypotheses should be observed, and then validated or undermined, by the ERP analysis. Two great groups of latency should catch the attention during the analysis: before 100ms for the endogenous-related hypotheses, and around 300ms for the exogenous-related ones.

Secondly, the analysis points out that the amplitude of the ERP peaks are hardly, if ever, communicated or used as a quantitative information in ERP analysis. However, a few techniques were proposed to work on this unused source of information [28, 30], and their usage seems nonexistent in the literature.

### **10.3.5.3 Building the auditory sets**

The design of the auditory sets (i.e. what subjects hear during the experiment) is very important. In the first time, the setting up of a synopsis for the experiment is important and as to be precisely defined. Then, according to this synopsis, sounds need to be recorded. Finally, the auditory set can be built on the computer.

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14 A pseudoword is a phonotactical legal non-word of a given language.

### The auditory synopsis

Firstly, the background sound needs to be defined. To stay close from the *Loft* environment, the decision to create a mix of conversations as a background sound has been taken. That is all the more relevant that it is necessary to recreate a cocktail party phenomenon environment, asking the brain to segregate the incoming sound in different channels. For this purpose, five radio conversation shows had been recorded on the Internet radio, and included in the audio-editing software.

Secondly, regarding the criteria defined in the part 10.3.2, which needs to be weighted, an experiment gathering ten sequences have been set up (cf. Table 10.1):

- *Sequence 1: The benchmark* — This sequence in the benchmark one, which most of the other sequences are compared with. The source of the sound capable to create the switch is on the head of the subject and the volume is normal (not louder than background sound). The content is a known name (i.e. a name of a close person) said by an unknown foreigner (relatively to the subject's nationality).
- *Sequence 2: Front source* — This sequence is equivalent to the sequence 1 except that the source location is in front of the subject ( $r=1$  and  $\theta=0$ ). Comparing this sequence with the sequence 1 will make it possible to evaluate the impact of the distance between the source and the listener when the source is in front. This evaluation is a partial response to the criteria 'the spatial position of the source'.
- *Sequence 3: Side source* — This sequence is equivalent to the sequence 1 except that the source location is on the left side of the subject ( $r=1$  and  $\theta=\pi/2$ ). Comparing this sequence with the sequence 1 will make it possible to evaluate the impact of the distance between the source and the listener when the source is on the side. This evaluation is a partial response to the criteria 'the spatial position of the source'.
- *Sequence 4: Back source* — This sequence is equivalent to the sequence 1 except that the source location is in the back of the subject ( $r=1$  and  $\theta=\pi$ ).

**Table 10.1** | The cocktail party phenomenon auditory synopsis

time	length	topic	distance	angle	volume	content	voice	language
0	30	intro	fade in of background in 10s					
30	200	Seq.1	0	0	1	Known name	Unknown	Foreign
230	15	pause						
245	200	Seq.2	1	0	1	Known name	Unknown	Foreign
445	15	pause						
460	200	Seq.3	1	$\pi/2$	1	Known name	Unknown	Foreign
660	15	pause						
675	200	Seq.4	1	$\pi$	1	Known name	Unknown	Foreign
875	15	pause						
890	200	Seq.5	0	0	10	Known name	Unknown	Foreign
1090	15	pause						
1105	200	Seq.6	0	0	1	Unknown name	Unknown	Foreign
1305	15	pause						
1320	200	Seq.7	0	0	1	Own name	Unknown	Foreign
1520	15	pause						
1535	200	Seq.8	0	0	1	Own country	Unknown	Foreign
1735	15	pause						
1750	200	Seq.9	0	0	1	Known name	Known	Foreign
1950	15	pause						
1965	200	Seq.10	0	0	1	Own country	Unknown	Native
2165	20	end	fade out of background in 10s					

Comparing this sequence with the sequence 1 will make it possible to evaluate the impact of the distance between the source and the listener when the sources is in the back. This evaluation is a partial response to the criteria ‘the spatial position of the source’.

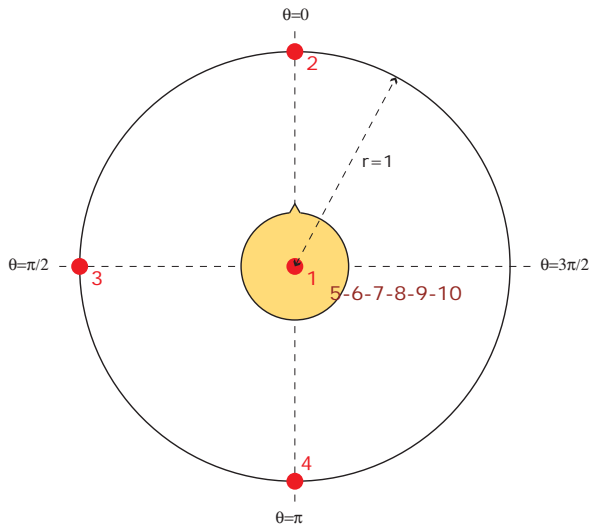
- *Sequence 5: Loudness* — This sequence is equivalent to the sequence 1 except that the source volume is 10dB higher. Comparing this sequence with the sequence 1 will make it possible to evaluate the impact of the volume. This evaluation is a response to the criteria ‘the volume of the message received by the subject’.
- *Sequence 6: Unknown name* — This sequence is equivalent to the sequence 1 except that the content is an unknown name for the listener (the voice is similar). Comparing this sequence with the sequence 1 will make it possible to evaluate the difference of impact between a known name and an unknown name. This evaluation is a partial response to the criteria ‘the content of the message’.
- *Sequence 7: Own name* — This sequence is equivalent to the sequence 1 except that the content is the listener’s name. Comparing this sequence with the sequence 1 will make it possible to evaluate the difference of impact between a known name and the listener’s name. This evaluation is a partial response to the criteria ‘the content of the message’.
- *Sequence 8: Own country* — This sequence is equivalent to the sequence 1 except that the content is not a name anymore, but a country. Comparing this sequence with the sequence 1 will it make it possible to evaluate difference of content for two elements close to the listener. This evaluation is a partial response to the criteria ‘the content of the message’.
- *Sequence 9: Known voice* — This sequence is equivalent to the sequence 1 except that the voice of the speaker is known by the listener (the speaker is still foreigner relatively to the subject’s nationality). Comparing this sequence with the sequence 1 will make possible it to evaluate the difference of impact between a known voice and an unknown one. This evaluation is a response to the criteria ‘recognizing the voice’.

- *Sequence 10: Native language* — This sequence is equivalent to the sequence 8 except that the speaker's native language is the similar to the listener one's. Comparing this sequence with the sequence 1 will make possible it to evaluate the impact of language. This evaluation is a response to the criteria 'familiar way of speaking'.

### From the auditory set to the hypothesis

These ten sequences are necessary and sufficient to check all the hypothesis:

- *The spatial position of the source* — There are two elements that should be checked for this hypothesis: the distance ( $r$ ) and the polar angle ( $\theta$ ) between the source and the receptor. The first four sequences are used for this aim. The comparison 1, between the sequences 1 and 2, measures a difference of distance. Thus, the distance  $r$  can be checked. The set of the comparisons 1, 2, and 3 (between the sequences 1 and 2, 1 and 3, 1 and 4, respectively) can be used to evaluate the impact of  $\theta$ .



**Figure 10.18** | Localization of the sources

- *The volume of the message received by the subject* — This hypothesis can be checked thanks to the comparison 4 (between the sequences 1 and 5). Indeed, the difference between the sequences 1 and 5 concerns only the volume of the stimulus.
- *The content of the message* — The content of the message is probably the most important hypothesis to be checked in this experiment. Four different contents are evaluated: a ‘known name’ (sequence 1), an ‘unknown name’ (sequence 6), the ‘subject’s own name’ (sequence 7), and the subject’s country (sequence 8). These three contents have a different self-relevancy. This self-relevancy is used to evaluate the importance of the content of the message thanks to the comparisons 5, 6, and 7 (between the sequences 1 and 6, 1 and 7, 1 and 8, respectively).
- *Recognizing source voice* — This hypothesis can be easily checked by the same content told by two different persons: one known by the subject, and the other one unknown by the subject. The comparison 8 (between the sequences 1 and 5) would check the relevancy of this hypothesis.
- *Familiar way of speaking* — The last hypothesis required the same content to be said by two unknown persons, but one being a compatriot of the subject and the other one a foreigner. That is what is proposed by the comparison 9 (between the sequences 8 and 10), in which only the speaker changes.

### **The sound elements**

As each member switches on different contents (a person may switch on one’s name, more hardly on somebody else’s name), the experiment has to be prepared with a prior brief investigation on the subject. For each potential subject, here are the information requested (in English, in Japanese and in their own native language): their own name, the name of their country, their own native language, the name of their own mother (to be used as the ‘known name’ in the experiment). Out of thirty persons, four refused to provide these information, canceling their potential participation to the experiment.

Then according to the requirement of ‘known’ and ‘unknown’ speakers, 11 persons read the information previously gathered while being recorded.



Figure 10.19 | Building the auditory sets

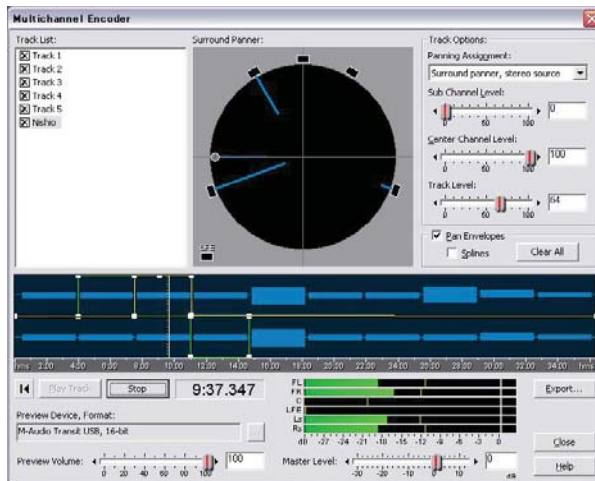


Figure 10.20 | The surround

### **Building the auditory sets**

Using the Adobe Audition software, the recordings were gathered and edited. Then each sound was normalized in terms of volume, and the blank parts on the beginning and the end of the sound were trimmed.

Then the files were organized on the multitrack board following the experimental synopsis (cf. Table 10.1). The Figure 10.19 is a screen shot of the setting up for one subject. On the right side of the screen, the first five lines are the five conversations used as background sounds. The last line, composed of ten blocks, is the track for the ten sequences. After all the sounds are placed, their volume is checked in monophony to valid the normalization of the volume.

Finally the sounds are brought in a surround console (6.1 channels) (cf. Figure 10.20). The sources are spatially placed to create a real-like auditory environment. The auditory set is then ready for a 36:25' long experiment.

#### **10.3.5.4 Experiment organization**

##### **Introduction speech**

On a cognitive point of view, cocktail party phenomenon is preceded by an unconscious monitoring of blocked-out stimuli [199]. In order to observe the phenomenon in the most probable situation, the minimum information is told to the subject: She/he is asked to listen carefully to what is output from the headphone. More information could provide her/him clues about the experiment, which is not wished.

##### **Personality inventory questionnaire**

A questionnaire is submitted to the subject after the auditory experiment (see appendix B). This questionnaire is a personality inventory. Its goal is to evaluate subject's personality thanks to a small number of independent dimensions, called traits. Traits have the following three main properties: stability across different domains, stability over time, and stability across cultures.



**Table 10.2** | OCEAN factors

<b>Characteristics if high scorers</b>	<b>Nature of factor</b>	<b>Characteristics of low scorer</b>
<b>Neuroticism (N)</b>		
Worrying, insecure, high anxiety, easily tempted	Emotional stability, proneness to distress, excessive cravings or urges, unrealistic ideas	Calm, secure relaxed, stable
<b>Extraversion (E)</b>		
Talkative, optimistic, sociable, affectionate	Capacity for joy, need for stimulation, interest in other people and external events	Reserved, comfortable being alone, stays in the background
<b>Agreeableness (A)</b>		
Good-natured, trusting, helpful	One's orientation along a continuum from compassion to antagonism in thoughts, feelings, and actions.	Rude, uncooperative, irritable, aggressive, competitive
<b>Conscientiousness (C)</b>		
Organized, reliable, neat, ambitious	Degree of organization, persistence, and motivation in goal-directed behavior	Unreliable, lazy, careless, negligent, spontaneous
<b>Openness (O)</b>		
Creative, artistic, curious, imaginative, nonconformist	Tolerance for an exploration of the unfamiliar	Conventional, down-to-earth, preserving the status quo

The Five Factor Model, also called OCEAN model of personality, is currently the most widely accepted trait theory and has been independently arrived at by many different studies. The five factors are best summarized in the table 10.2. The Five-Factor Model is different to the Big Five Model. The differences between these two empirically related yet conceptually distinct models are such:

- *Major proponents* - B5: Goldberg; FFM: McCrae and Costa.
- *Theoretical basis* - B5: Lexical hypothesis, those individual differences that are most salient and socially relevant will come to be encoded as terms in the natural language; FFM: Theoretical contexts, traits are situated in a comprehensive model of genetic and environmental causes and contexts.
- *Position on causation* - B5: Phenotypic, no stance on causation; FFM: Biosocial. Genetic as well as environmental.
- *Naming of factors* - B5: Surgency, Agreeableness, Conscientiousness, Emotional stability, and Intellect; FFM: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to experience.
- *Measurement Model* - B5: Circular, many items have non-zero correlations (loadings) on two factors rather than just one; FFM: Hierarchical, lower-level facets combine to form higher-level domains.
- *Questionnaires* - B5: Big Five Makers (recently International Personality Item Pool); FFM: Revised neuroticism, Extraversion, Openness Personality Inventory (NEO PI-R).
- *Type of questionnaire items* - B5: Adjectives (recently, sentence stems); FFM: Sentences.

Saucier and Goldberg [217] presented evidence that nearly all clusters of personality-relevant adjectives can be subsumed under the Big Five. Paunonen and Jackson [195], however, argued that this study used too loose a criterion for inclusion in the Big Five, namely that the Big Five account for at least 9% of the variance in the adjective cluster. Reanalyzing the same data using a stricter criterion of 20% explained variance resulted in nine clusters of traits that fell

outside of the Big Five: Religiosity, Honesty, Deceptiveness, Conservativeness, Conceit, Thrift, Humorousness, Sensuality, and Masculinity-Femininity. These analysis do not imply that the clusters are unrelated; for example, Honesty and Deceptiveness may be highly (negatively) related as opposite sides of the same dimension. Nevertheless, these results suggest that several important personality traits lie beyond the Big Five. In addition, theoretical reasons suggest the importance of other personality traits that are poorly captured by terms in the natural language, such as impulsive sensation-seeking [195].

From these considerations, the NEO PI-R (revisited) is selected as the personality questionnaire for the current experiment. The NEO PI-R is a copyrighted instrument; however, we decided to use the IPIP-NEO, a similar public-domain questionnaire developed by Lewis Goldberg.

To measure these five personality traits, Costa and McCrae developed the NEOPI (Neuroticism Extraversion Openness Personality Inventory). This is known as one of the most reliable personality questionnaires. Its reliability had been documented across several different cultures and languages, and the scores have been shown to be stable over time. To measure the factors more accurately, they subdivided each into six scales, each of which is covered by several items in the NEO PI. To help clarify what each factor represents, the subscales are presented in the table 10.3.

The IPIP-Neo comes in two versions: the original inventory (300 items) and the short inventory (120 items). Although the original inventory is more reliable than the short one, the short one still meets professional standards of reliability and is much less forcing than the original one for the subject. The task is already heavy enough not to impose a 300-item inventory. Thus we propose the usage of the short IPIP-NEO personality inventory for the present experiment. It is composed of 120 items that the subject has to auto-evaluate according to a 5-degree scale: very inaccurate (xx), moderately inaccurate (x), neither accurate nor inaccurate (xo), moderately accurate (o), very accurate (oo) (cf. Appendix B.2).

**Table 10.3** | Factors and subfactors of the NEO PI

<b>Neuroticism</b>	<b>Extraversion</b>	<b>Conscientiousness</b>	<b>Agreeableness</b>	<b>Openness to experience</b>
Anxiety	Friendliness	Self-efficacy	Trust	Imagination
Hostility	Gregariousness	Orderliness	Straight-forwardness	Artistic interests
Depression	Assertiveness	Dutifulness	Altruism	Emotionality
Self-consciousness	Activity level	Achievement-striving	Compliance	Adventurousness
Impulsiveness	Excitement seeking	Self-discipline	Modesty	Intellect
Vulnerability	Cheerfulness	Cautiousness	Tender-mindedness	Liberalism

### 10.3.6 Data analysis

In this experiment, the data analysis is probably one of the most difficult and dangerous steps. As it will be shown here, it is a difficult part because the numerous parameters in this experiment make the analysis complex. And it is dangerous because mistakes can easily drive to wrong conclusions. To prevent these mistakes, the parameters will be first recalled, and the analysis process will be precised. After then, the analysis will be described, and conclusions will be drawn up in the next paragraph.

#### 10.3.6.1 Experiment parameters

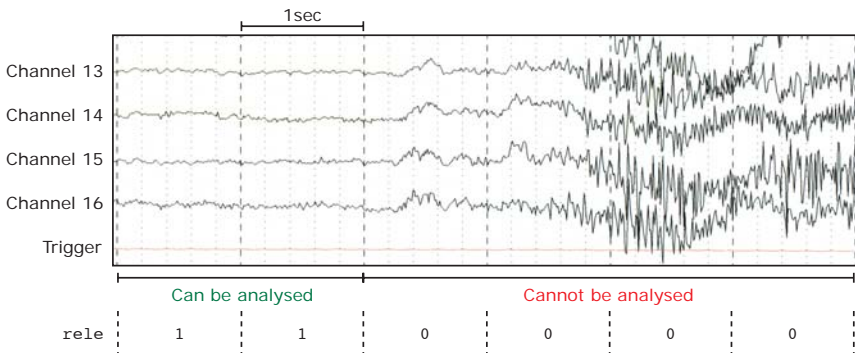
The basic difference between a classic laboratory experiment and this one is closeness with the practical problem (cf. page 116). The aim of this experiment is to stay the closer possible to the practical problem and its complexity, and to limit the theoretical approach constraints.

This is a key point of the experiment structure and analysis. Considering the objective of this experiment, it is very important to stay the closest of the actual practical problem. But for the feasibility of the experiment, and the relevancy of its analysis, it is also required to follow experimental constraints. This difficulty can be seen as a characteristic of interdisciplinary experiments: Trying to solve the same problem, different disciplines may have a different approaches. Therefore, they would do differently, with different requirements and rigor at each step of the problem solving process. In the interdisciplinary workgroup, these differences have to be confronted and discussed, in order to find balance and agreement for the experiment process.

This experiment aims at simulating the cocktail party phenomenon in a social environment. The ERP measurement aims at detecting brain's reaction to the phenomenon, and at determining difference tendencies between the factors introduced in the paragraph 10.3.2. Therefore, the auditory environment should be similar to a classic social environment. The background is a mix of five discussions recorded on Internet radios, and edited in order to prevent any auditory perturbation during the experiment. Auditory perturbations are events such as discontinuities or irregularities in the speech, the volume or the tone. Discus-

sions are also normalized in volume to prevent any dominant discussion. Finally, these discussions are dispatched in the space, thanks to the surround edition system, to prevent any spatial dominance. Periodic events (stimuli used for the experiment) are added as a supplementary auditory channel of this background. These stimuli are also edited to become part of the background. Indeed, as the cocktail party phenomenon suggests that background sounds are also analyzed by the brain, the aim of this experiment is to create an auditory environment in which cocktail party phenomenon occurs with an unattended stimulus.

This approach had been criticized several times, because the complexity of the auditory environment makes uncertain the occurrence of the cocktail party phenomenon, which may distort partially the results. However, this social auditory environment had been designed with great rigor, to minimized the best possible the risk of backgrounds discussion distortions. Creating a more 'laboratory' background environment (with a write sound) would have been to far from the practical problem, and thus would have reduced the relevancy of this experiment: it's aim is to evaluate the cocktail party phenomenon in the *Loft*. Both of the phenomenon and the environment have to be included.



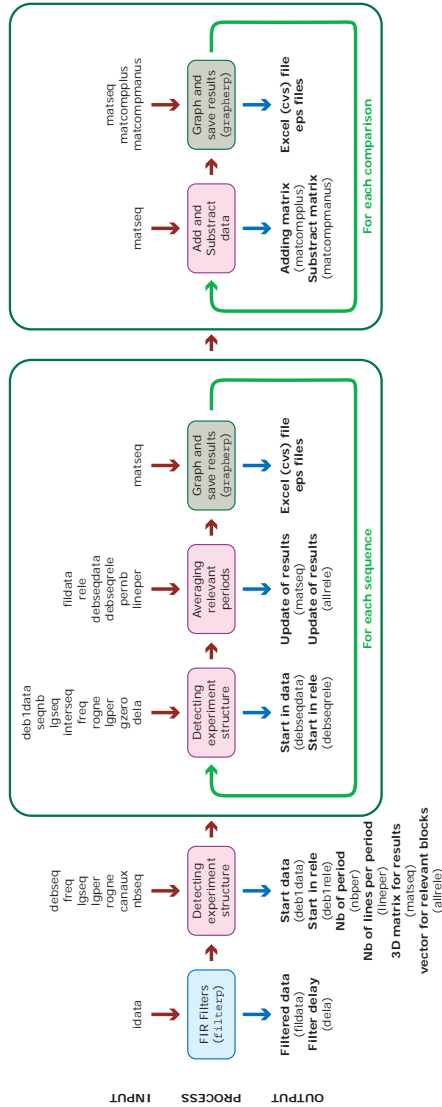
**Figure 10.21** | Example of selection on the raw data

### 10.3.6.2 Analysis process description

After the experiment is conducted, the first step is to determine the usable and usable parts of the data. Head movements, falling asleep, eye movements, eye blinks, heartbeat, and so on are perturbations which can greatly affect and distort EEG results [135, p. 98]. To prevent their impact, they shouldn't be considered in the analysis. As raw data were printed with a grid (one second per vertical grid), it was decided to select relevancy blocks (i.e. per portion of one second). To record the selection, a vector called *rele* was created (cf. the third input element in the function *erp*, paragraph B.1.1). The quantity of elements of *rele* is the quantity of seconds of the raw data. The value 1 means that the related block can be used for the ERP analysis; The value 0 disqualifies the related block (cf. Figure 10.21).

To output ERP data, I programmed functions on matlab, especially adapted to this experiment (cf. paragraph B.1):

- The main input data are the raw data *idata* (a matrix of 20 columns — the sixteen channels plus four for other functions, such as the trigger — and one line per 10ms), the nickname of the subject *nam* (*sub1*, *sub2*, *sub3*, etc...), the vector *rele*, and the vector *syn* gathering the length of the stimuli for each sequence. Other input data are related to the structured of the experiment (*nbseq*: Quantity of sequences; *debseq*: The length of time between the beginning of the experiment sound and the beginning of the first sequence (in seconds); *lgseq*: The length of time of a sequence (in seconds); *interseq*: The length of time between two sequences (in seconds); *lgper*: The length of time of a period (in seconds); *freq*: The data collection frequency (in Hertz); *canaux*: The quantity of channels; *rogne*: The quantity of period to cut of at the beginning and the end of each sequence; *gzero*: The length of time to see before the stimulus on the graph (in seconds)).
- The first function, *erp*, makes the ERP analysis by average technique and output all the information (graphs and tables) which will be used for the analysis (cf. B.1.1). Its process is explained by the Figure 10.22.
- The second function, *filterp*, is used by the function *erp* to filter the raw data (cf. B.1.2). The filter used in this experiment is a discrete-time finite impulse



**Figure 10.22** | Process of the function `erp`



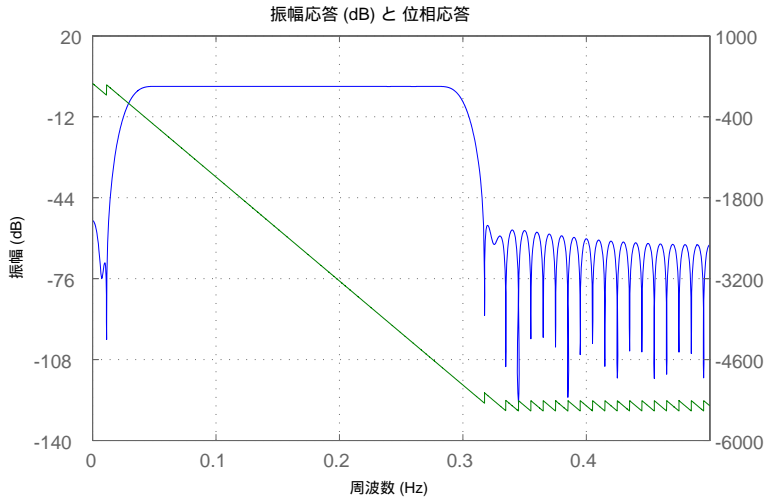


Figure 10.23 | Bandpass FIR Filter used in filterfp

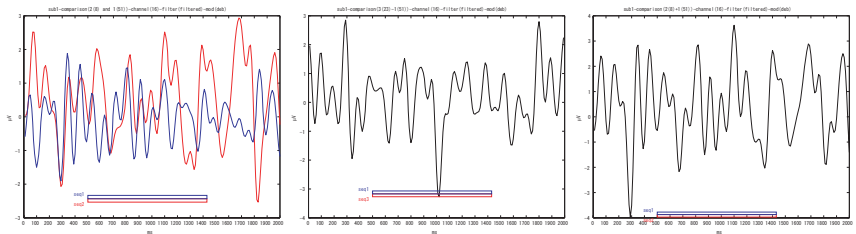


Figure 10.24 | Example of ERP graph result

response (FIR) passband (0.03-0.3)<sup>15</sup>, order 100, linear phase (type1), stable. The delay of this filter is 50. Its confidence level is 95%. This filter is used to erase the frequencies which the EEG could have recorded but considered as noises (e.g. electric noises, eyes and head movements, etc... ). The brain waves considered in this experiment are from 3Hz to 30Hz, i.e. theta (3-8 Hz), alpha (8-12Hz), and beta (12-30Hz) waves. The high order of the filter is to have a good cut at the border frequencies. The Figure 10.23 show the magnitude response (in dB), and the phase response.

- The third function, grapherp, is used by the function erp to draw and save the graphs (cf. B.1.3).
- As shown on the figure 10.24, from left to right, three different graphs are output from experiment: The first one gathers the graphs of the two sequences; The second one is the difference of the two graphs; And the third one is the sum of the two graphs. These three graphs are used for the analysis.

### 10.3.6.3 Analysis criteria

Because of the original aspect of this experiment (cf. paragraph 10.3.6.1), the criteria and tolerances used for this analysis have to be described precisely. To analysis the graphs, three criteria have to be taken into account: the temporal criteria, the amplitude criteria, and the phenomenon repeating criteria.

#### Temporal criteria

One of the most important criteria of ERP analysis is the time. For a specific channel, an event is localized and characterized thanks to its temporal position. As viewed previously, a event is named by its concavity/convexity<sup>16</sup> (P/N, respectively) and its temporal position after the beginning of the stimulus (in millisecond). For example, a concave event occurring 300 seconds after the stimulus would be named P300. It is certain that, on a specific channel, P300 and P400 are different events, i.e. correspond to different process, or function, of the brain.

---

15 Normalized frequencies

16 There is an inflexion point of a continuous function  $f$  at the point  $x_0$  if  $f'(x_0)=0$  and  $f''(x_0)\neq 0$ . Around the inflexion point  $x_0$ ,  $f$  is concave if  $f''(x_0)<0$  and convex if  $f''(x_0)>0$ .

However, the temporal precision of the analysis has to be precised. How long can be a delay between two peaks of respectively two different sequences for these two to be considered related to the same event?

Three different factors are bringing temporal imprecisions: the ERP machine, the filter, the variation of stimulus length, and the results reading method:

- The ERP measurement system used has a reading frequency of 100Hz. Then, its imprecision is of a minimum of 5ms.
- Based on the Figure 10.25, the delay of the filter varies between 103.6404rad/Hz and 293.257rad/Hz, i.e. between approximately 16.5ms (at the extreme low frequencies) and 46.85ms (on most of the frequencies). As the order of the filter is 100, the programs filtertp and erp established a linear delay of 50ms [165]. For the waves that will be analyzed in the analysis, the delay will be hardly inferior to 30ms. We consider then a temporal imprecision due to the filter to between 20ms and 30ms.

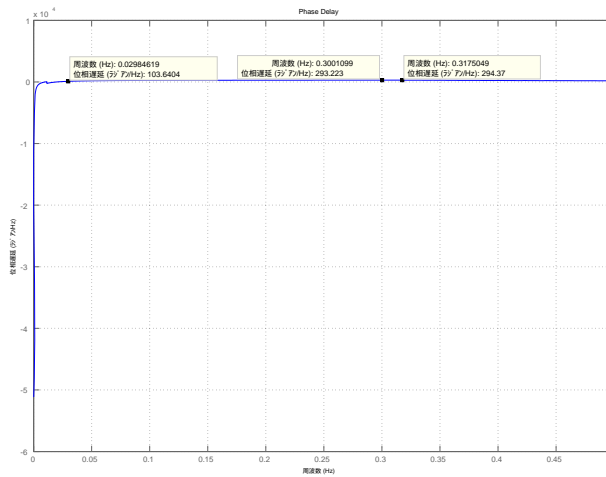


Figure 10.25 | Filter delay

- For the analysis, all the graphs output from the program *erp* are printed out. The graphics are vectorized and saved in Encapsulated PostScript (*eps*) format, insuring a good precision when printed out. However, as the graphs were numerous, I decided to check that a reduced size for graphs to be printed (on a minimum of pages) would not increase the imprecision of the time and amplitude dimensions. Four graphs on one page seems to be a good number. In such a situation, 1sec corresponds to 56mm. When using a ruler, the imprecision is about 0.5mm. Then the imprecision would be 9ms, which is acceptable for the present study.

Considering these three factors, we considering that an approximation of 20-30ms is acceptable for the present study.

### **Relevant period minimum**

The average technique is used to point out events sought by the ERP. The averaging required a minimum of relevant periods to be itself relevant. Indeed, a fewer number of trials does not provide a good signal-to-noise ratio. The minimum of relevant periods is fixed to 25 [135].

### **Amplitude criteria**

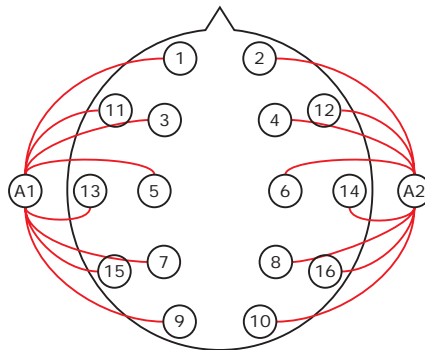
Events are detected due to peaks appearing on the ERP graphs. The amplitude of the peak shows the 'stress' of the brain. Figuring out the relative amplitude of these peaks is the objective of this experiment. The average technique is used to emphasis peaks related with the periodical event (the object of the study), and to fade down other peaks. However, as mentioned previously, the performance of this technique depends on the number of relevant periods used. Yet, when comparing two sequences, the difference of the quantity of relevant periods used for each sequences is important to be considered. Indeed, if the difference is too important, then amplitudes between the two compared sequences may vary. Then, when comparing two different sequences, the difference of relevant periods should be noticed. If the difference is to great, the comparison should not be considered.

### Phenomenon repeating criteria

The last criteria to be taken into account is the repetition of the peaks across the sequences at the same latency for a similar channel. If the peak is missing for one sequence, that means that the considered peak is not related to the event the experiment is focusing on.

### Considered channels

The Figure 10.26 shows the position of the captors on the scalp of the subject with the channel connected to it. The equivalences with the electrode names: Channel 1:Fp1 ('Frontopolar 1'); Channel 2:Fp2; Channel 3:F3 ('Frontal 3'); Channel 4:F4; Channel 5:C3 ('Central 3'); Channel 6:C4; Channel 7:P3 ('Parietal 3'); Channel 8:P4; Channel 9:O1 ('Occipital 1'); Channel 10:O2; Channel 11:F7; Channel 12:F8; Channel 13:T3 ('Temporal 3'); Channel 14:T4; Channel 15:T5; Channel 16:T6. All odd-numbered channels and are odd-numbered channels



**Figure 10.26** | Placements of captors on the scalp (with channel number)

linked to the left earlobe (A1) and to the right earlobe (A2), respectively, for potential reference [135, p. 89].

This experiment focus on auditory-related activities of the brain. Thus, to concentrate the investigation on the parts of the brain concerned with these activities (explained in the paragraph 10.1.1.1). The considered channels will then be limited to the 13,14,15,16 ones.

### **10.3.7 Results**

#### **10.3.7.1 Auditory sets**

With 153 sounds recorded by 13 persons, the auditory set for 33 different persons had been created. It was not planned that all these sets were to be used, but for better flexibility and smooth operation during the experiment time, all these sets were prepared and ready to be used.

#### **10.3.7.2 Brain wave measurements**

Three subjects participated to the experiment (N=3), one female and two males. Each subjects listened to ten sequences (a total length of 36min 30s). Raw data were analyzed to determinate relevant 1-second blocks. The vector rele was created, and all necessary data were input into erp to obtain the ERP data to analyze.

All the graphs were analyzed to determine relevant peaks, according to the analysis criteria. Few peaks have been found for the graphs: P210, P300, N400, P610 (approximate latencies). Based on the literature analysis presented in the section 10.3.5.2 (p.168), and according to the peaks found during the experiment analysis, the analysis will thereafter focus on the 'P300-like peak', that will be noted P300\* . The term . This peak is actually highly related to the semantic self-relevancy of the stimulus, and consequently to the cocktail party phenomenon. However, the relevancy of the P300\* for the endogenous criteria (space location and volume of the stimuli) is doubtful as the P300\* concerns the semantic (exogenous) aspects of the stimulus.

### 10.3.7.3 P300\* analysis

The P300\* component amplitudes were peaked from all subjects, for all sequences at the points T3, T4, T5, and T6. Then, they were average to obtain a unique value (cf. Table 10.4). Finally, the results were compared (by subtraction) for each subject (cf. Figure 10.27).

Major comments can be output from the analysis of these data:

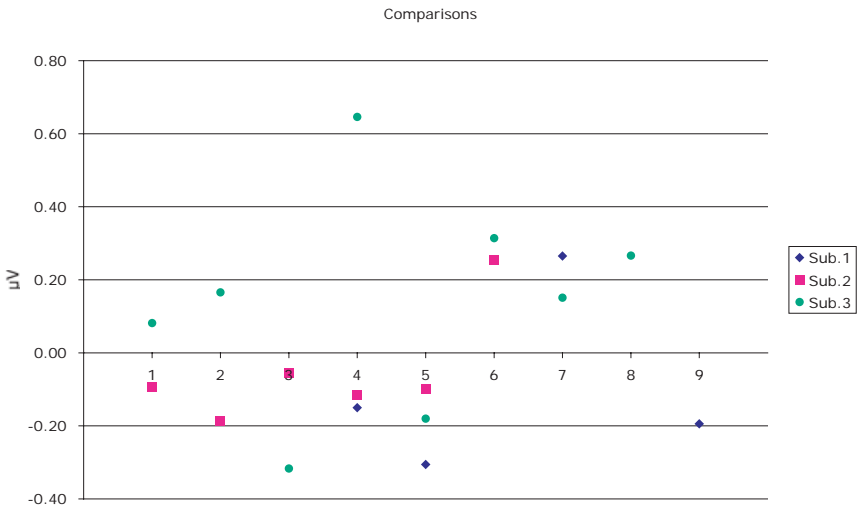
- The lack of relevant data, mainly due to the too few numbers of relevant blocks, prevent to prove any hypothesis of this experiment. It will be possible to show tendencies which go for or against the hypothesis. This point will be developed in the discussion part, in order to find a method to obtain more relevant results.
- The comparisons 5,6,7,8 are supporting the hypothesis:
  - The comparison 5 (subtraction between the sequences 6 and 1) aims at determining the impact of the variation of the content (between an 'unknown name' and a 'known name'). The hypothesis, related to the self-relevant word [87], expected that the more the word has a self-relevancy (as a 'known name' compared to an 'unknown name'), the more the brain reacts. This comparison should be negative. As it is the case for the three subjects, a good tendency of confirmation can be pointed out.
  - The comparison 6 (subtraction between the sequences 7 and 1) aims at determining the impact of the variation of the content (between 'my own name' and a 'known name'). The hypothesis is based on the same approach as the comparison 5. However, the stimulus 'my own name' should supposedly have a strong self-relevance. Therefore, this should result in positive comparison. As it is the case for the subjects 2 and 3 (not calculable for the subject 1), a tendency of confirmation can be pointed out.
  - The comparison 7 (subtraction between the sequences 8 and 1) aims at determining the impact of the variation of the nature of content (between a 'known name' and a 'known country'). The hypothesis, also related to the high self-relevance word, expected the same tendencies as the compar-

**Table 10.4** | Peaks at the P300\* component

	Seq.1	Seq.2	Seq.3	Seq.4	Seq.5	Seq.6	Seq.7	Seq.8	Seq.9	Seq.10
rele.	51	8	23	5	44	53	17	33	18	27
T3	1.112				0.354	0.807		1.485		0.964
T4	0.848				1.017	0.206		0.906		0.839
T5	0.717				0.466	0.906		1.108		1.199
T6	1.235				1.474	0.773		1.475		1.194
ave.	0.98				0.83	0.67		1.24		1.05
rele.	77	88	80	67	84	84	52	15	22	9
T3	0.555	0.500	0.397	0.388	0.445	0.560	0.547			
T4	0.675	0.421	0.506	0.607	0.568	0.460	0.695			
T5	0.727	0.459	0.389	0.927	1.007	0.820	1.277			
T6	0.972	1.176	0.892	0.784	0.449	0.695	1.428			
ave.	0.73	0.64	0.55	0.68	0.62	0.63	0.99			
rele.	82	62	73	78	56	35	29	33	31	18
T3	0.775	0.767	0.595	0.570	0.902	0.833	0.927	0.798	0.731	
T4	0.650	0.740	1.180	0.147	1.040	1.019	1.019	0.421	1.159	
T5	0.628	0.415	0.839	0.216	1.826	0.325	0.589	1.019	1.850	
T6	0.493	0.949	0.595	0.346	1.362	-0.352	1.266	0.913	-0.129	
ave.	0.64	0.72	0.80	0.32	1.28	0.46	0.95	0.79	0.90	



Comparison	Sub.1	Sub.2	Sub.3
1 (2-1)		-0.09	0.08
2 (3-1)		-0.19	0.17
3 (4-1)		-0.06	-0.32
4 (5-1)	-0.15	-0.11	0.65
5 (6-1)	-0.31	-0.10	-0.18
6 (7-1)		0.25	0.31
7 (8-1)	0.27		0.15
8 (9-1)			0.27
9 (10-8)	-0.19		



**Figure 10.27** | Comparisons at P300\*  
(by subtraction between the sequences)

ison 6, but with a smaller result, as 'my own name' has a higher self-relevance than 'my own country'. This should result in positive comparison (confirmed by the subjects 1 and 3), but smaller than the comparison 6 (confirmed by the subject 3, the only subject to have the sequences 7 and 8 relevant). The tendency remains weak, but still in accordance with the hypothesis.

- The comparison 8 (subtraction between the sequences 9 and 1) aims at determining the impact of the voice (between a known voice and an unknown one). The hypothesis expected that a known voice to provoke a greater reaction in the brain than an unknown voice. Then, the comparison should be positive, which is supported by the subject 3. The tendency remains weak, but still in accordance with the hypothesis.
- The comparison 9 (subtraction between the sequences 10 and 8) aims at determining the impact of the language (between a foreign language and the native one). The hypothesis expected that the stimulus in one's native language should have a greater impact than an unknown voice. Then, the comparison should be positive, which is in contrast with the result found on the subject 1.
- The comparisons 1,2,3,4, are also contrasting (at least partially) with the hypotheses:
  - The comparison 1 (subtraction between the sequences 2 and 1) aims at determining the impact of the source-receptor distance. The two obtained results are contrasting each other. Therefore, it is impossible to conclude whether this comparison is supporting or not the hypothesis.
  - The comparison 2 (subtraction between the sequences 3 and 1) aims at determining the impact position of the source (lateral position). The result is qualitatively similar to the comparison 1, and so its support to the hypothesis cannot be suggested. Moreover, since a front source hypothetically has a greater impact than a lateral one, the amplitude of this comparison should be less high than the one of the comparison 1. This is also contrasted by the results.

- The comparison 3 (subtraction between the sequences 4 and 1) aims at determining the impact position of the source (back position). It is expected that a back position source has less impact than a lateral or even more a front position source. This cannot not be supported by the results of this comparison. However, the confusion is already high because of the non-conclusion of the two precedent comparison results.
- The comparison 4 (subtraction between the sequences 5 and 1) aims at determining the impact of the volume of the stimulus. It is expected that the volume has a positive impact on the amplitude of the result. Thus, the comparison 4 should be positive. This is validated only for the subject 3, but not for the two others. No conclusion can be established for this comparison.

However, these four comparisons are focusing on physical (endogenous) characteristics of the stimuli. According to Meunier [171, p. 105] and to the literature analysis conducted in the section 10.3.5.2, these characteristics are seen in the ERP by endogenous potentials, for which latencies are before 100ms. Therefore, the P300\* is not a relevant component for the study of these sequences.

#### 10.3.7.4 P300\* analysis

Following the same process as described for the P300\* component, a study had been done, for the first four comparisons, on an endogenous component: the P30\*<sup>17</sup>. The method is similar to what has been done for the P300\*. The results are shown by the Table 10.5 and the Figure 10.28.

These comparisons bring new results which should be analyzed:

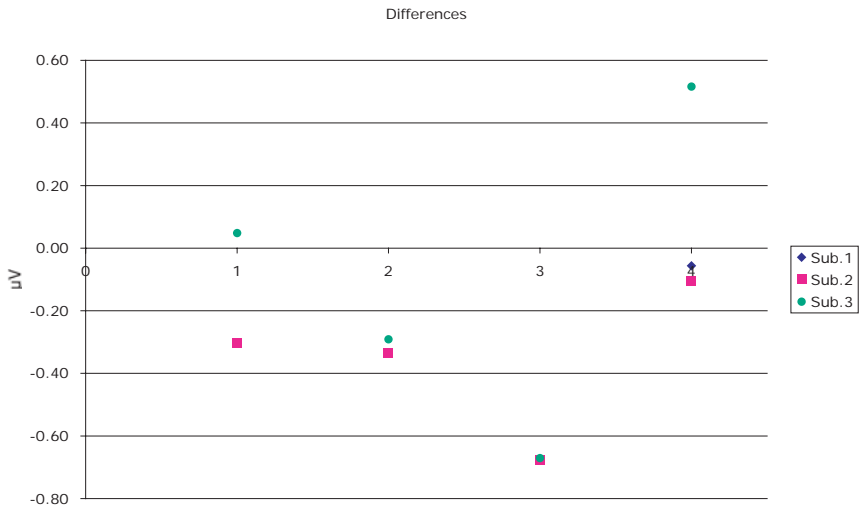
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<sup>17</sup> The latency denomination of this component cannot be done perfectly because of the imprecision of the measure. However, measurements were done close to this latency, and this denomination is supported by Deouell who is defining it as a primary auditory response [49, p. 341].

**Table 10.5** | Peaks at the P30\* component

		Seq.1	Seq.2	Seq.3	Seq.4	Seq.5
Sub.1	rele.	51	8	23	5	44
	T3	0.880				1.115
	T4	0.261				0.398
	T5	0.435				0.532
	T6	1.067				0.372
	ave.	0.66				0.60
Sub.2	rele.	77	88	80	67	84
	T3	0.817	0.421	0.534	0.377	0.307
	T4	0.136	0.371	0.222	-0.185	0.498
	T5	1.047	0.410	0.450	0.360	1.435
	T6	0.825	0.416	0.276	-0.433	0.170
	ave.	0.71	0.40	0.37	0.03	0.60
Sub.3	rele.	82	62	73	78	56
	T3	0.608	0.846	0.155	0.383	0.759
	T4	0.475	0.065	0.411	-0.283	1.022
	T5	0.308	0.551	-0.058	-0.334	0.694
	T6	0.569	0.691	0.288	-0.482	1.549
	ave.	0.49	0.54	0.20	-0.18	1.01

Comparison	Sub.1	Sub.2	Sub.3
1 (2-1)		-0.30	0.05
2 (3-1)		-0.34	-0.29
3 (4-1)		-0.68	-0.67
4 (5-1)	-0.06	-0.10	0.52



**Figure 10.28** | Comparisons at P30\*  
(by subtraction between the sequences)

- The comparison 1 (subtraction between the sequences 2 and 1) is still contrasting between the subjects 2 and 3. Therefore, no conclusion can be output concerning the impact of the distance.
- The comparisons 2 and 3 (subtraction between the sequences 3 and 1) are supporting the hypothesis since there are both inferior to the comparison 1, and the comparison 3 is also inferior to the comparison 2. This result support the idea that a frontal position of the source ( $\theta=0$ ) has a greater impact on the brain activity than a lateral position ( $\theta=\pi/2$ ), and even greater on a back position ( $\theta=\pi$ ). The hypothesis of the source position is thus supported by the experiment analysis.
- The comparison 4 (subtraction between the sequences 5 and 1) is greatly supported by the results of the subject 3, but slightly contrasting the results of the subjects 1 and 2. Then, no conclusion can be emitted concerning this hypothesis.

The study of the P30\* has brought better qualitative results than the P300\* for the first four comparisons. That is explained by the fact that these comparisons are related to physical characteristics of the stimulus. However, this analysis still cannot bring any prove, but tendencies. A deeper analysis is required to obtain more relevant results.

## 10.3.8 Discussion

### 10.3.8.1 Conclusion

At the current state of the investigation, no relevant conclusion can be done concerning the validation of the hypothesis. This point will be discussed in the paragraph 10.3.8.2.

There are two kinds of aspects of the message (stimulus) to consider separately during the analysis: the physical characteristics and the semantic ones. The physical characteristics, affecting the endogenous potentials, can be seen in the earlier latencies (Between 10 and 100ms). The semantic characteristics, affecting the exogenous potentials, can be seen in the later latencies

(after 100ms). This experiment required then to be split on (at least) two different ERP window analysis. The first window concerns the endogenous potentials (the entire length 10-100ms can be recorded), and the second window concerns the exogenous potentials around 300ms (about 200-500ms). During a further analysis on the filter of *MATiK*, if the syntactic characteristic of the message has to be taken into account, then later latencies (600ms post-stimulus) should be taken into consideration.

Based on the data analysis, the current conclusions are:

- *The spatial position of the source (comparisons 1, 2, and 3)* — The results from this experiment could neither support or undermine the impact of the distance between the source of the stimulus and the receptor (the variation of  $r$ ). As for the angle position of the source, a tendency to confirm the hypothesis was shown: the greater is  $\theta$  ( $\theta \in [0; \pi]$ ), the lower is the brain reaction (as seen at the P30). Then, the spatial position of the source relatively to the receptor seems to be an aspect of the communication that should be considered as influencing the brain activity, in thus indirectly the cocktail party phenomenon.
- *The volume of the message received by the subject (comparison 4)* — This physical aspect of the stimulus seems to be undermined by the analysis. The comparison could be done on the three subjects, but the results where contrasting each other. A first approach would be to undermine its influence on the cocktail party phenomenon. However, in a further experiment, this hypothesis should be tested again, as the validity of this hypothesis cannot be definitely concluded thanks to the present analysis.
- *The content of the message (comparisons 5, 6, and 7)* — The influence of the content of the message was confirmed by the three comparisons. The self-relevancy of the content of the stimulus appears to be one of the most important aspects of the stimulus when considering the influence of the content of the brain activity. As it is also very important in the cocktail party phenomenon, it is now obvious that the self-relevancy of the elements in the message is an important aspect of analysis system of *MATiK*.

**Table 10.6 |** Personality inventory questionnaire results

<b>Subject</b>	<b>EXTRAVERSION</b>	52	74	29	54	49	36	66	25	79	19	33	26	18	31
	<b>FRIENDLINESS</b>	54	47	64	44	60	36	66	43	61	19	57	54	65	21
	<b>AGREEABLENESS</b>	60	85	50	47	63	14	80	34	34	76	32	52	16	40
<b>Subject</b>	<b>CONSCIENTIOUSNESS</b>	38	13	49	54	46	47	38	47	55	52	46	22	28	85
	<b>SELF-EFFICACY</b>	3	1	18	8	4	4	56	54	45	43	79	48	48	48
	<b>NEUROTICISM</b>	24	9	36	19	26	54	33	34	68	19	26	82	1	53
<b>Subject</b>	<b>CONSCIOUSNESS</b>	38	13	49	54	46	47	38	47	55	52	46	22	28	85
	<b>ACHIEVEMENT-STRIVING</b>	3	1	18	8	4	4	56	54	45	43	79	48	48	48
	<b>SELF-DISCIPLINE</b>	24	9	36	19	26	54	33	34	68	19	26	82	1	53
<b>Subject</b>	<b>IMMERSION</b>	38	13	49	54	46	47	38	47	55	52	46	22	28	85
	<b>ORDERLINESS</b>	3	1	18	8	4	4	56	54	45	43	79	48	48	48
	<b>CAUTIONSNESS</b>	24	9	36	19	26	54	33	34	68	19	26	82	1	53
<b>Subject</b>	<b>IMAGINATION</b>	38	13	49	54	46	47	38	47	55	52	46	22	28	85
	<b>ARTISTIC INTERESTS</b>	3	1	18	8	4	4	56	54	45	43	79	48	48	48
	<b>EMOTIONALITY</b>	24	9	36	19	26	54	33	34	68	19	26	82	1	53
<b>Subject</b>	<b>ADVENTUROUSNESS</b>	38	13	49	54	46	47	38	47	55	52	46	22	28	85
	<b>INTELLECT</b>	3	1	18	8	4	4	56	54	45	43	79	48	48	48
	<b>LIBERALISM</b>	24	9	36	19	26	54	33	34	68	19	26	82	1	53



- *Recognizing source voice (comparison 8)* — The hypothesis has been supported by the analysis. The ‘auditory face’ has an influence on the brain activity and should be considered by *MATiK*.
- *Familiar way of speaking (comparison 9)* — This hypothesis is weakly undermined by the analysis. It could be checked again by a further experiment, but however seems to be less important than the other hypotheses.

A presentation had been done about the personality inventory questionnaire, and about the way it could be use for *MATiK*. However, even if the data had been collected (cf. Table 10.6), it is not yet possible to use it. Indeed, it is first required to obtain pertinent conclusions from the ERP analysis before trying to correlate them with subject’s personality. Each comparison should be validated statistically before any correlation is possible, which means that the number of subjects should be increased to at least ten persons.

The evaluation of the time and amplitude precision of the material used for the experiment (electroencephalogram and filter) shown the lack of precision for a relevant ERP analysis. In a further analysis, it would advised to use a material especially dedicated to ERP measurement (such as the Nihon Kohden Neuropack MEB-2200).

#### **10.3.8.2 For more relevant results**

Several times, it had been said that a further experiment should be necessary. Indeed, three objectives should be reached: more relevant results to validate the hypothesis (they have been, for most of them, supported by the analysis but not scientifically validated), more data to correlate the amplitude extracted during the experiment, and more subjects to expect some correlation with subject’s personality. Even if this new experiment is not presented in this present dissertation, some impositions are discussed here:

- A measuring system (machine for measuring ERP and adapted filter) should be preferred to the material that have been used. The precision was not good enough to obtain satisfying output.

- The words, used as stimuli during the experiment, should be standardized in term of time length: they should all be the same length. A difference of time length may provoked a difference of latencies for similar cognitive function. Their determination and comparison is then harder to be done, and the risk of errors are higher.
- Finally, to prevent fatigue and cognitive tiredness during the experiment (the present experiment requires the subject to sit down and listen to a set of speeches for more than 36 minutes), the auditory sets should be done for only one comparison (i.e. two sequences). Also, each sequence should contain more periods, to ensure that a sufficient number of relevant periods could be used for the data analysis.

### 10.3.8.3 Results for *MATiK*

This experiment was originally proposed to quantify some functional requirements of *MATiK*. The design of *MATiK* used an *Evoked Metaphor*, the *Loft*, to defined qualitatively the functional requirement. But some of these functions need to be quantify. A psycholinguistic approach, using ERP techniques, was to be used for their quantification in the *Loft* environment.

The current state of the experiment does not provide yet definite results which can be used in the design of *MATiK*. Yet, the use of personality information to 'customize' weightings of cocktail party phenomenon criteria remains possible. To obtain a statistically sufficient quantity of information, the number of subject should increase: to consider the 35 personality criteria and to correlate them with the 9 comparisons, then at least 45 subjects are required (at least one more subjects than the number of criteria to correlate).

However, from the tendencies described in the conclusion (cf. section 10.3.8.1), it is possible to transfer back the results found for the *Loft* to the validation of *MATiK*'s criteria. This transfer can be simply done following the equivalences illustrated by Figure 10.14, page 218:

- The spatial position of the source has the close activity as equivalence in *MATiK*. A tendency to confirm this criterion was slightly shown in the experiment.

- The volume of the message received by the subject has the message importance as equivalence in *MATiK*. The validity of this criterion was undetermined by the experiment. At the current state, if a level of importance for e message (as it currently exists for emails) is created and controlled by the sender, then it should not be taken into consideration by the jump analyzer at any moment.
- The content of the message has the written content as equivalence in *MATiK*. All the aspects related to this criterion were confirmed. Therefore, the jump analyzer has to consider fully the content of the message to evaluate the opportunity of information flow jump.
- Recognizing source voice has the history of closeness as equivalence in *MATiK*. This criterion was supported by the result of the experiment. *MATiK* should have then the capability to record people's relationship evolution in order to inform the jump analyzer about the history of closeness between all the members. That is one of the capital function of *MATiK*'s database system.
- Familiar way of speaking has the disciplinary level of the content as equivalence in *MATiK*. This criterion could not be validated by the experiment, and further experimental investigations are required. However, if this criterion is validated and thus, then it should be taken into consideration by the jump analyzer. Thus, a selective process, aiming at determining the disciplinary level and the concerned discipline, could be created based on the proposition by Sakurai [213].

#### 10.3.8.4 Reflection on this experiment

This experiment took a long time, about one year and a half, to obtain these first results. Numerous problems have been met, challenged and solved. These results are not definitive but yet, they bring some answers, especially concerning the method used for this interdisciplinary experiment. I wish to develop here different aspects related with these issues.

This experiment is indeed interdisciplinary because the relation between the problem and the method is itself interdisciplinary. The problem emerged from a design approach on communication in social context: the communication

process in the *Loft*. The aim is to quantify factors that provoke the cocktail party phenomenon in the *Loft*. The environment is very important and the phenomenon cannot be disconnected from its environment. The experiment is based on a psycho-cognitive approach, and requires specific experiment constraints which have to be followed rigorously. This approach requires the experiment to be done in a laboratory environment, with very strict rules in order to limit and to control the best possible the variables of the experiment. Therefore, there is a priori a conflict on the (auditory) environment to be built for the experiment, and a balance (that would satisfy all involved disciplines) should be found.

Actually, the 'interdisciplinary' experiment issue concerned not only the way the environment of the experiment is built, but also which material should be used. During the first pilot experiment, a wireless IBVA (Interactive Brain wave Visual Interactive) system. The great advantages of this system are its ease of use and its wireless transmission system. It is based on a two channel system recording voltage on the frontal cortex (F3 and F4). The raw data (120 sampling per second for each channel) are recorded by a computer distant from the subject. Then, the subject can be relatively (to classic EEG systems) separate from the tools which are usually disturbing for the subject. Moreover the only two points of measure ease considerably the analysis. But issues were also numerous, and finally disqualified the IBVA for this experiment. The two main issues were:

- The system requires a measurement on the front of the subject, where there is no hair. But the psycholinguistic method prefers greatly measures on the auditory cortex. Thus there is an incompatibility between the IBVA and the method concerning the place of the measurement on the scalp.
- Electro-magnetic noises were too numerous to output correct results. Classic EEG systems are already disturbed by electro-magnetic noises, but the wireless system made it even more sensitive.

The results output from the first pilot experiment were not relevant, and the main reason was because of the unreliable data output with the IBVA system. So another machine was tested and finally used for the experiment: the Neurofax 1100. This system has also drawbacks, such as the heavy preparation before experiment, a sampling frequency of 100Hz, the huge quantity of data (not

always easy to manage), the wire system, which constraint to a laboratory environment.

To solve all these issues, the wise behavior is not to work on each of them as distinctive experimental design issues, but to gather them in a set and to consider it as an issue originating from the interdisciplinary quality of the experiment. Then following the methodology presented in the chapter 6, solutions satisfying all specialists could be found.

I could list the three main points that helped to find systematic solution for the design of the experiment as follow:

- A clear knowledge and understanding of the problem and the objective of the experiment for each of the members.
- A permanent and open-minded dialogue between the members concerning the proposition made to progress on the experiment design.
- A systemic reflection on each decision, in order to ensure to reach the best compromise between the involved disciplines without distorting the issue, the method, and the objective of the experiment.

These three points seem actually obvious, but the experimenters have to have them clearly and permanently in mind to succeed the entire realization of an interdisciplinary experiment. Thus, the success of such experiment cannot be reach only by application of methods, brought out by disciplines, but also by acceptance of wise compromises, brought out by human beings.



# ***Chapter 11***

## **Technical requirements**

### **Introduction**

As the functional requirements have been defined in the previous chapter, suitable technical requirements have to be set up. In the manner of the functional requirements, it will also be presented in this chapter how the interdisciplinary design methodology can be applied on the technical requirement. It will be shown how the *Evoked Metaphor*, i.e. the *Loft*, can help the basic technical choices, can explain the way they work, and can assist the members of the workgroup during the whole technical step.

As it will be highly involved in this chapter, an introduction to multiagent system technology will be presented first.

### **11.1 Agent and Multiagent systems**

Different definitions concerning the term of 'agent' exist, causing difficulties to specify this term and a necessity to define it again before using it in a new context. The notion of agent is not only reserved to data processing sciences, but can be expanded to various fields.

Research in the field of distributed artificial intelligence (DAI) started in the beginning of Seventies. It had been involved in various fields of research, such as robotics, natural language studies, and also in psychology, sociology or ecology [17]. Nowadays, the research in this field has reached a mature stage bringing the possibility to propose specific and relevant tools to various fields. The increasing interest for new functionalities concerning the usage of the Internet, possibly thanks to multiagent system, brought the need of new techniques and methodologies by which agents help users to interact in a dynamic environment [222].

## 11.1.1 Agent

### 11.1.1.1 Definition

Various literatures offer different definition on the term ‘agent’ The definitions mostly depends on the field of study they originate from. Nevertheless, Ishida [113] and Ferber [67] defined the term of ‘agent’ in a comprehensive way and their definitions are widely used as a reference:

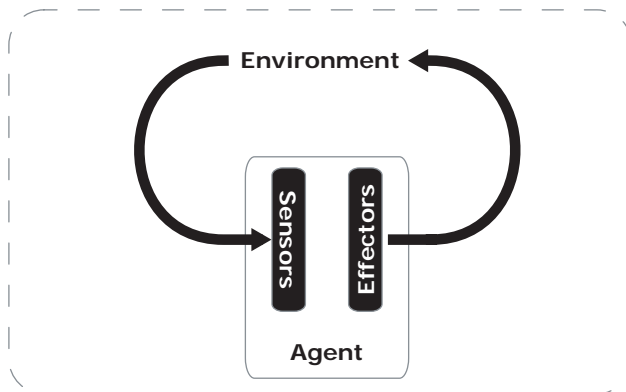
- *An agent is an autonomous entity which pursues an individual goal, which is ready to act on the environment of the system to which it belongs and/or to interact with the other agents, which has only one evolutionary representation of this environment and which can perceive the other agents thanks to the communication or the observation.* — [113]
- *An agent can be a physical or virtual entity that can act, perceive its environment (in a partial way) and communicate with others, is autonomous and has skills to achieve its goals and tendencies. It is in a multi-agent system (MAS) that contains an environment, objects and agents (the agents being the only ones to act), relations between all the entities, a set of operations that can be performed by the entities and the changes of the universe in time and due to these actions.* — [67]

Jennings and Wooldridge [120] have made a research on the definition of agent that is widely quoted in the literature. Starting from their propositions, we define an agent as an entity with the following characteristics:

- *autonomous* - An agent is able to act on itself and to control its inner states without the intervention of any outer entity. Thus, an agent can take its own decision and realize a set of goals or tasks for which they are designed without the intervention of any other external entity [162];
- *real or abstract* - This clause expresses that an agent’s nature is not limited to a software, but can be generalized to many other natures. From this point of view, even human kind can be considered as a multiagent system;



- *being in an open environment* - An agent is able to perceive its own environment through sensors and to act upon its environment through effectors [212];
- *enabling to communicate with other agents* - When an agent is in contact with other agents, it can interact with them via an agent-communication language [76]. Interaction can be done possibly with agents of other nature. When the agent's environment includes of three or more agents, it is called multiagent system (the term of multiagent system is detailed in the paragraph 11.1.2.1);
- *aiming based on proper objectives* - An agent has its own objectives and acts usually for the benefit of it (altruist agents do exist too). An agent can refuse to act if it doesn't bring any profit, i.e. if it doesn't help to reach one of its objective;
- *possessing its own resources* - An agent owns elements considered as resources: knowledge and methods, and possibilities to move in the multiagent system;

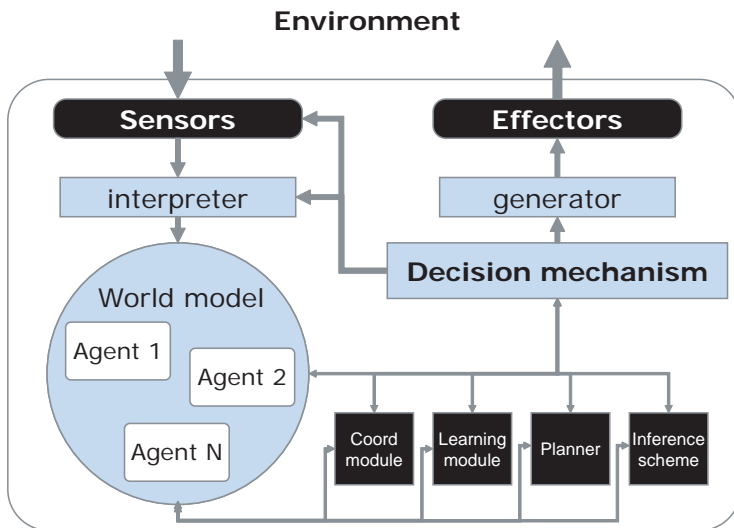


**Figure 11.1** | Agent interaction with its environment

- *having a partial representation of other agents* - An agent can engage in dialogs, and negotiate or coordinate transfer of information;
- *possessing skills (or services) which can be offered to other agents* - Thanks to its own resources and to its ability to communicate with other agents, an agent can help others or be helped by others. Nevertheless, as agents act mainly for their own benefit, team work is foregone usually by a negotiation process;
- *reactive and behaving in order to satisfy its objectives, taking into account not only its own resources and skills, but also its own representations and communications.*

Considering these descriptions, the notion of agent will be used in the present manuscript as:

*An agent is an autonomous, skillful, and situated entity (virtual or not) that can perceive its environment partially and act on it.*



**Figure 11.2** | Basic structure of an agent

*It is able to interact with other agents and to participate to team activity, and of which main concern is to achieve its predetermined goal(s).*

#### **11.1.1.2 Agents and objects**

In the case of information science, although objects and agents are very close and possess many similarities, they are not the same and it is important to understand the differences.

The first difference concerns the autonomy. If an object owns a public method, it doesn't have any control on the execution of it. Other objects can appeal it anytime without permission from the object. As for agents, they address requests for the usage of the method instead of appealing a method directly, and the owner of the method may decide whether to execute the method or not. Thus the execution of the method would occur if it is also profitable to the owner (or at least not detrimental to its own goals). As Wooldridge [255] sums up, objects do it for free; agents do it for money .

The second main difference concerns the goals. In an object-oriented system (OOS), the system as a global has a thread, whereas in the case of multiagent systems, each single agent has a thread. Newer OOSs possess parallelism ability, enabling various threads to coexist. A new kind of object, called active agents, are defined as objects having their own thread. Thus Odell & al. [188] introduce agents as a variety of active objects having their own initiative and free will, and enabling themselves to communicate with their environment.

#### **11.1.1.3 Topology of agents**

To understand the great variety of agents currently exists, and to position ourselves in this world, various topologies had been set up and a few of them will be introduced here.

Franklin and Graesser [72] propose a clear and interesting taxonomy of agents (cf. Figure 11.3). This taxonomy is based on a very comprehensive point of view and is a good starting point to investigate on agent topology.

In this study, the aim is to detail better agents based on information treatment methods and objectives. On this point, Jacques Ferber [66] proposes a classification contingent on cognitive<sup>18</sup> and reactive<sup>19</sup> characteristics, and on teleonomic<sup>20</sup> and reflex<sup>21</sup> behaviors. The main difference between a cognitive agent and a reactive one is that the first one can anticipate actions whereas the second one cannot. To understand this difference, Ferber proposes the following example illustrating the behavior differences:

A cognitive agent can build such a plan:

Plan to open the door

Go to the place where the key is

Take the key

Go to the door

Open the door with the key

A reactive agent can build such a plan:

R1: If I am in front of the door and I have a key, then open it.

R2: If I am in front of the door but with no key, then try to open it.

R3: If the door cannot be opened and I have no key, then go and look for the key.

R4: If I am looking a key and there is a key in front of me, than take it and go open the door.

This approach is very interesting since it already proposes a simple categorization of agents, according to their main characteristics and basic behaviors. But it appears that this topology does not bring enough practical usage possibilities. Thus, this topology is less preferred to the one proposed by Nwana and Azarmi [187], based on the following criteria:

- Mobility: static or mobile;
- Presence of symbolic reasoning model: deliberative or reactive;

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18 Each agent owns a knowledge base

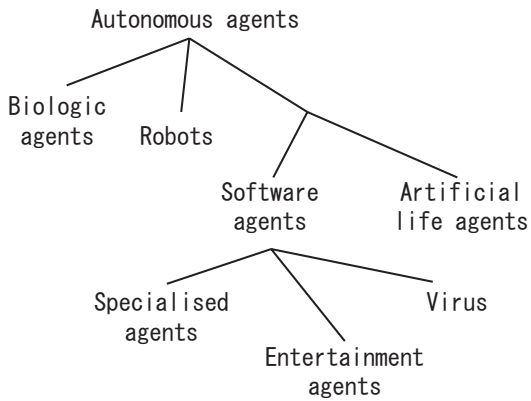
19 Each agent owns reacting mechanisms to events

20 Explicit goals oriented

21 Governed by perceptions

**Table 11.1** | Agent classification proposed by Ferber [66]

RELATIONSHIP WITH THE WORLD		
BEHAVIOR	<b>Cognitive agents</b>	<b>Reactive agents</b>
<b>Teleonomic</b>	Intentional agents	Impulsive agent
<b>Reflex</b>	Modular agents	Agents



**Figure 11.3** | Taxonomy of agents proposed by Franklin et Graesser [72]

- Presence of a goal and initial properties such as autonomy, cooperation and learning.

From these criteria, Nwana and Azarmi propose six categories of agents: collaborative agents, interface agents, mobile agents, informational agents, reactive agents, intelligent agents and hybrid agents (any designed agent is most of the time a mix of these categories).

### **Collaborative agents**

Collaborative agents are both autonomous and able to cooperate with other agents to reach their goals. They have to be able to negotiate in order to find acceptable agreements. The ability to learn is another possibility, but it is not essential. The main reason for which a collaborative agent would be used are the following ones:

- solving an issue which is too big for one agent only because of limited resources and risks related to centralized systems;
- enabling interconnections between legacy systems such as expert systems, decision systems... ;
- solving issues distributed by nature, such as traffic control;
- solving issues for which available expertness is distributed;
- stimulate modularity, execution speed and flexibility.

### **Interface agents**

These agents are autonomous and have the ability to learn. Pattie Maes [162] describes them as personal assistant collaborating with the user. The difference with the collaborative agents is that the entity the interface agent is not another agent but a user, i.e. a human being. Interface agents learn users' preferences by observing and imitating users, receiving their action's feed-backs from users, receiving users' instructions, and being advised by other agents. Intra-agent communication is limited to advise which is different in many points

from collaborative agents. Interface agents have a minimum of knowledge on the beginning and gain it progressively. The main reason to use interface agents is to discharge repetitive or irksome tasks.

### **Mobile agents**

Mobile agents are processes able to array themselves in great networks such as the Internet, interacting with various hosts, gathering information for the users and fulfilling required tasks. These agents are not really mobile, but their mobile characteristic come from the fact that they are very autonomous and cooperative. A mobile agent can communicate or cooperate with another agent in charge of informing other agents about the localization of its attributes and methods in order to limit the publication of too much personal information. Some of the main reasons to use mobile agents are the limitation of communication costs, insufficiency of local resources, an easier coordination between requests, an asynchronous treatment and a more flexible distributed architecture. The application of these agents can vary from plane ticket reservation systems to telecommunication network administration.

### **Information agents**

Information agents' tasks are to administrate, manipulate and collect information coming from various distributed information sources. They seem to be very close to the interface or collaborative agents (all are manipulating information), but they are actually different because of the way they are defined. Information agents are defined by what they are doing, whereas collaborative or interface agents are defined by what they are (properties and attributes are specified). The main reason of using information agents is because of the explosion of the number of information sources (Internet): there is a large necessity to find solutions similar to search engines for multiagent systems, and they may become much more efficient than the current search engines.

### **Reactive agents**

Reactive agents have the specificity not to possess inner and symbolic model of their environment: they are just reacting to stimuli coming from outside. They

are relatively simple agents and interact with other agents relatively simply. They can actually be considered as a group of autonomous modules being in charge of a single task for each of them. They are mainly used when one wishes to take into consideration only hypothesis based on the physical environment. They are supposed to be more robust and tolerant to break-down than other agents.

### **Hybrid agents**

The choice between such and such agent is actually theoretical and not very useful for multiagent system design. Because each agent possesses assets and drawbacks, the actual approach is to design hybrid agents. Hybrid agent characteristic is a combination of different agent characteristics (mobility, collaboration, autonomy, capability to learn... ) in a single agent. The design of a hybrid agent is always guided by the aim to minimize weakness and maximize serenities of the agent in the scope of the desired multiagent system.

#### **11.1.1.4 Communication**

The communication is one of the most important activities and abilities of agents. The interest one can have for agent systems is because they can communicate and interact. These two abilities of agents are the base of the multiagent system which will be introduced in the paragraph 11.1.2. For an agent, interacting with other agents is in the meantime the best and the worst ability: Thanks to communication, it can act in a group and the group can achieve more than the sum of each; Because of communication, it has to deal with issues of group coordination, conflicts, negotiations, and so on.

### **Communication paradigm**

The theory that supports the communication between agents is the Language Act Theory, originated by Austin [3] and developed further by Searle [220]. According to Austin, language is not used only to describe reality (idea that he calls the descriptive illusion : talks are only assertions which can be true of false). It can also act on reality [3]. For example, when considering the two following sentences:



- It rains.
- I bet you a hundred yens it will rain tomorrow.

The former sentence is constative, whereas the later one is performative<sup>22</sup>. Constative sentences can be true or false (it is a state of the weather, and it is true if it actually rains); Performative can succeed or fail. Austin also uses the terms happy or unhappy. A performative is successful if it respects the following rules (called satisfaction conditions):

- *Non-plays* — There must exist an accepted conventional procedure having a certain conventional effect, the procedure to include the uttering of certain words by certain persons in certain circumstances [3, p. 26]. In other words, the utterance had to be acceptable in the environment it is said, by whom it is said, and to whom it is said.
- *Misplays* — The particular persons and circumstances in a given case must be appropriate for the invocation of the particular procedure invoked. [3, p. 34]. For example, 'I give it to you', when 'it' is not mine, is unsuccessful.
- *Non-executions* — The procedure must be executed by all participants correctly [3, p. 36]. Examples are numerous in the law.
- *Misexecutions* — The procedure must be executed by all participants completely [3, p. 36]. This is about the abortion of the action. For example, being casual and proposing a coffee time to somebody by saying 'I will bring you to a nice coffee place' and being replied 'I don't drink coffee.' is entering this category.
- *Dissimulations* — The procedure is designed for use by persons having certain thoughts, feelings, or intentions, or for the inauguration of certain consequential conduct on the part of any participant, then a person participating in and so invoking the procedure must in fact have those thoughts, feelings or intentions, and the participants must intend so to conduct themselves ;

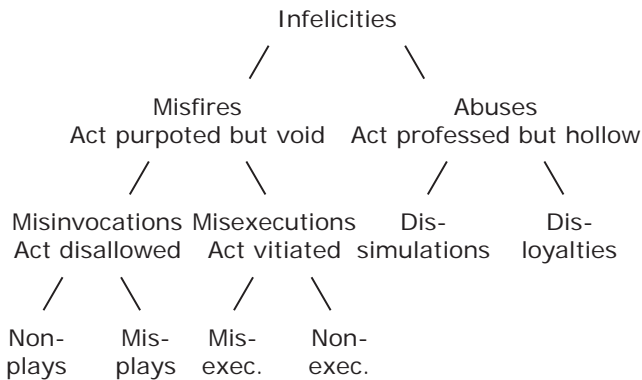
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<sup>22</sup> Austin proposes the term 'performative', derived from 'perform', indicating that the issuing of the utterance is the performing of an action [3, p. 6].

- *Disloyalties* — The participants must so conduct themselves subsequently. If this rule is not respected, the action is void still, but unhappy. It may happen when the procedure is invoked in inappropriate circumstances. Advising somebody without experience or skill on the topic, congratulating somebody without thinking her/him to deserve it, and betting without intention to pay are three examples of dissimulation on thoughts, feelings, and intentions.

Some performatives (such as ‘I should be there’) have the same form as constatives. Then, he introduces a differentiation between primary (or implicit) performatives and explicit ones. Formers are ambiguous. Only linguistics or paralinguistic elements (imperative grammar form, voice intonation, gesture, etc... ) can help to understand if an utterance is a primary performative or a constative.

Finally, Austin proposes a topology of the language acts based on three categories:



**Figure 11.4** | Classes of the act of language [3, p.18]

- *Locutionary acts* correspond to the performance of an act of saying something (asking or answering a question, advising or warning, giving a description, etc...). For example, saying “My friend told me: ‘There is a salsa party on Friday.’” is a locutionary act.
- *Illocutionary acts* correspond to the performance of an act in saying something. For example, saying “My friend made me notice that there would be a salsa party on Friday.” is an illocutionary act.
- *Perlocutionary acts* correspond to the performance of an act by saying something. For example, saying “I am convinced there will be a salsa party on Friday.” is a perlocutionary act.

More details about the theory of the language acts can be seen at [88, 36]. The theory of the language acts is interesting for the interaction between agents. As said previously, an agent is able to interact with other agents and acts mainly to attain a goal. An agent is not only able to communicate information to other agents, but also able to induce reactions and behaviors. Therefore, communication between agents is an act of modification of another agent’s states. That means that agent communications are composed of performatives.

### **Agent communication languages (ACL)**

Cohen and Levesque applied the theory of the language acts on multiagent system in 1990 [38]. A communication between two agents is noted as follow:

$$e:d \ll F(a) \tag{11.1}$$

where *e* and *d* are respectively the emitting agent and the receiving one, *F* is the performative describing the type of message, and *a* the message content. The KQML (Knowledge Query and Manipulation Language) is an ACL based on the theory of language acts [69]. The KQML is conceived as both a message format and a message-handling protocol. KQML consists in three layers. The content layer bears the content of the message, encoding in any representation language (for example, ASCII or binary based languages). The communication layer encodes a set of message features (identity the sender and receiver, language, etc...). The message layer encodes a message that an agent would

like to transfer to another agent. I propose here to explain the three layers with an example:

```
(ask-one
:sender zatoichi
:content (PRICE GLASSES ?price)
:receiver meganeya
:reply-with megane-price
:language LPROLOG
:ontology NYSE-TICKS)
```

The example provided here could be translated as follow: Mr. Zatoichi is asking Mr. Meganeya the price of glasses. The syntax of the KQML is based on balanced parenthesis list. The initial element (ask-one) is a performative. The content of the message is PRICE GLASSES ?Price, the ontology assumed by the query is identified by the token nyse-ticks. The query is written in a language caller LPROLOG. The value of the :content is the content level. The values of the :reply-with, :sender, and :receiver form the communication layer, and the performative name ( ask-one), with the values of :language and :ontology form the message layer. In due time, Mr. Meganeya may send to Mr. Zatoichi the following KQML message as an answer:

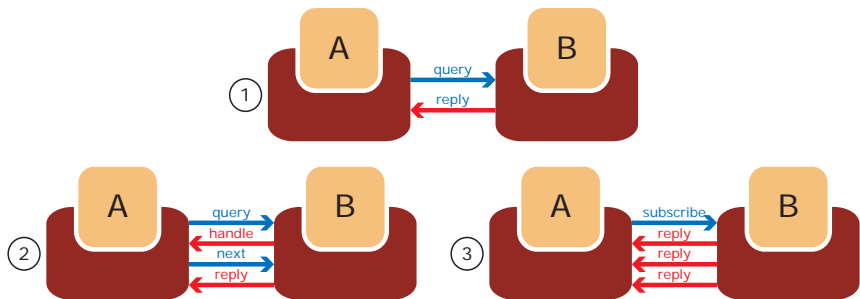
```
(tell
:sender meganeya
213
:content (PRICE GLASSES 3000)
:receiver zatoichi
:in-reply-to megane-price
:language LPROLOG
:ontology NYSE-TICKS)
```

Most of the reserved performatives, i.e. standardly recognized ones, are listed in the Table 11.2 [68]. Nevertheless, this list is not exhaustive in the sense that additional performatives can be set if their interpretation and the protocol associated with is accepted by the community of agents.

There is a variety of information exchange protocol in KQML. In the simplest, one agent acts as a client, sends a query to another agent acting as a server,

**Table 11.2** | The reserved performatives in KQML (version 1997)

Category	Name
Basic informative	tell, deny, untell
Database	insert, delete, delete-one, delete-all
Basic responses	error, sorry
Basic query	evaluate, reply, ask-if, ask-about, ask-one, ask-all
Multi-response query	stream-about, stream-all, eos
Basic effector	acheive, unacheive
Generator	standby, ready, next, rest, discard, generator
Capability-definition	advertise
Notification	subscribe, monitor,
Networking	register, unregister, forward, broadcast, pipe, break, transport-address
Facilitation	broker-one, broker-all, recommend-one, recommend-all, recruit-one, recruit-all



**Figure 11.5** | Basic communication protocols in KQML [69]

and waits for the answer. In this pattern, three main processes exist (cf. Figure 11.5). The pattern is the most basic one and has been explained previously. If the server's answer consists in a set of replies, it sends to the client a handle that allows the client to ask for the components of reply one at a time (cf. pattern similar to the one in the pattern between the agents. In the third pattern ( subscribes to the server's output in order to receive an indefinite number of asynchronous answer at irregular intervals. An example of KQML usage with agents can be seen at [85].

The KQML became a standard ACL in the Nineties, but it is not the only existing:

- The FIPA-ACL was developed because of several critics on KQML, because of lacks of semantic aspects at the content level, because KQML does not handle any performative about promises, and because performatives are too numerous and redundant. The FIPA-ACL and KQML are using a similar performative syntax but FIPA-ACL uses another language at the content level called the SL (Semantic Level). The SL integrates the semantic of the language act and can describe the feasibility as condition (necessary condition for the sender) and the rational effect (the effect expected by the sender as a result of performing the action). Also the number of performatives in the FIPA-AC is reduced to 22 only [216].
- The KQML Lite is an attempt to merge KQML and FIPA-ACL [159].

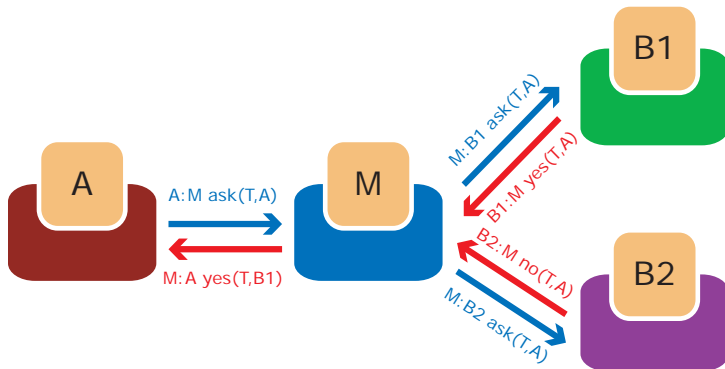
In this presentation of the notion of 'agent', it is obvious that the strength of an agent is its capability to communicate with others. An agent does not have much interest by itself. Thus, one of the most important abilities of an agent is its sociability. The social environment in which an agent behaves and communicates is called a multiagent system.

## 11.1.2 Multiagent systems

### 11.1.2.1 Definition

A multiagent system is an environment in which three or more agents coexist, behave and interact in order to achieve a common goal. The main characteristics of a multiagent system are [33]:

- A partial view of the environment for each agent;
- limited skills for each agent so that none of them can achieve the multiagent system mission by itself;
- absence of global control system;
- decentralized data;



**Figure 11.6** | The use of a mediator for coordination

- synchronous system.

The strength in using multiagent system is because of their sturdiness and efficiency, abilities to interconnect existing systems and to solve issues for which data, expertness and/or controls are distributed. Also, multiagent systems are very suitable to represent problems with multiple solving methods, multiples perspectives, and/or multiple solvers. These systems have the advantages of both distributed systems (such as modularity, speed, reliability) and artificial intelligence such as knowledge symbolic treatment, ease of maintenance, portability, and most of all the use of sophisticate schemes of interaction [119]. The types of interaction include:

- *Cooperation* — The aim of the cooperation is to work together in order to solve a common objective. It is the most studied process for multiagent systems. Simply, the problem of cooperation is to determine who does what, when, with which tools, how, and with whom.
- *Coordination* — The aim of the coordination is to organize the solving process to solve existing issues, using at the most beneficial interactions, and preventing damaging ones. A classic system of coordination uses the mediation: A mediator is managing the allocation of tasks among agents, function of bid and call (cf. Figure 11.6).
- *Negotiation* — The aim of the negotiation is to reach a compromise that all agents can accept. This interaction is important since agents may have different personal objectives, which could be harmful for the global objective.

In order to define multiagent systems, Ferber [66] breaks them down into following elements:

- an environment  $E$  (a metric space);
- a set of objects  $O$  - These object are situated (at anytime it is possible to associate to each object in a position in  $E$ ) and passive (they can be perceived, created, destroyed, or modified by the agents);
- a set of agents  $A$  - They are specific objects, the active entity of the system;



- a set of relations  $R$  which are linking objects to each other;
- a set of operations  $Op$  allowing agents ( $A$ ) to perceive, produce, consume, transform and manipulate objects of  $O$ ;
- operators in charge of representing the application of these operations and the reaction of the environment to the attempts of modification, which are called the laws of universe.

In this dissertation, the term of multiagent system by an environment in which agents are working together for the profit of each and the whole.

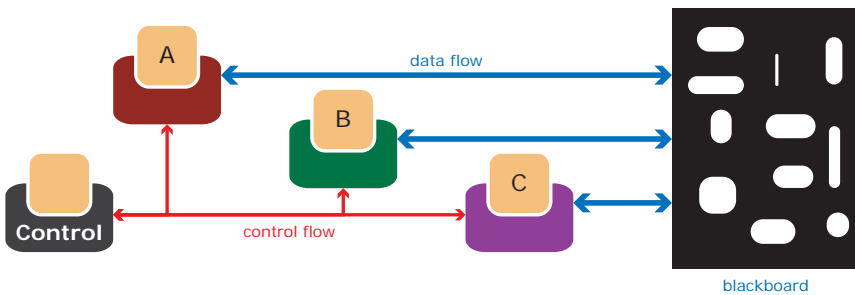
#### 11.1.2.2 Multiagent system architecture

Multiagent systems are complex and their architecture gathers concepts developed in the fields of distributed systems and artificial intelligence. Jacques Ferber proposes a structure based on four layers (cf. Figure 11.3):

- The level 0 gathers a set of available resources such as communication mechanisms on low level (UNIX sockets, TCP/IP or http, . . . ) and parallel execution mechanisms such as threads. It is on top of this layer that the strictly speaking multiagent system is built in.
- The level 1 describes the low level layers of a multiagent system: communication primitive between distant agents (KQML-type primitive), name server (allowing agents to enter and exit the system by check-in check-out process), as well as engines which are implementing the agent operating basic cycle. This cycle based on the BDI architecture (Belief, Desire, Intention), based on practical reasoning [18, 206, 226]. According to the BDI architecture, agents are represented thanks to 'mental states' described as follow (let's take as an example of the soccer player agent, based on Burkhard [27]):
  - *Belief* - It is what the agent knows about its own environment (*The soccer server sends only a partial noisy picture in relative coordinates of the other agents to the agent, which leads to an individual belief of the world in every agents. The agent cannot rely on the accuracy of the received and interpolated data; Therefore, it is belief, not knowledge.*)

**Table 11.3** | Architecture by layers of a multiagent system, by Ferber [66]

Level 3	Specific protocols	Assistant agents	Ontologies	Application agents
Level 2	Generic protocols	Administrative and contact agents	Language of description	Generic behavior
Level 1	Primitive communication/language act		Name server	Engines
Level 0	Low level communication		Threads	



**Figure 11.7** | The 'blackboard' architecture [69]

- *Desire* - The possible states in which the agent may wish to engage himself into (Different (even opposite) goals can be achieved, but the agent selects only one of them. The component planning embeds the planning process that can be initiated each time a new piece of sensor information has arrived. A new situation is classified as follows: If the ball is under control, the agent is able to pass the ball or dribble. If the player has no control of the ball, it can decide whether to intercept it, watch the game, or run to a certain position. This goal (target) finding is done by a usual decision tree. Some of the decisions are trivial ("Is the ball in the kick range or not?"), but some are really tricky ("Should I run to the ball, or should my teammate do it?"). The latter decision is done by using a distance measure: If the agent supposes to be the first of its team to reach the ball, it will run. If not, it relies on its teammates and runs back to its home position.).
- *Intention* - The states in which the agent engaged itself and its resources (There are two major cases to cope with: The agent is out of the kick range, or it can control the ball (that is, has ball possession). In the first case, the player calculates an optimal interception position, if it has decided to get the ball.[...] If the player controls the ball, it has to decide whether to pass the ball or dribble. Furthermore, it has to decide in which direction to kick or dribble, respectively. It should prefer a direction with the best chances to score or pass the ball to a teammate. At the same time, it should prefer directions that promote an offensive play style.[...] These planning procedures have a certain overlapping with the finding procedure for desires. This overlapping is necessary because the decision process has to look for achievable desires, and the realization of the intentions relies on the capabilities of the agent).
- The level 2 gathers the set of generic mechanisms that are carried out in a multiagent system. Here are the generic protocols of communication; Here are described the administrative agents and connective ones (which are connecting service requesting agents and service offering agents); The description of general content language, generic behavior of agents...
- The level 3 deals with specific applications and particular domains which are dedicated to a specific multiagent system is also shown here.

### 11.1.3 Multiagent system mechanism

Reasoning in multiagent system consists in taking decisions concerning the way agents will be selected and organized, the way the tasks will be delegated, and the way information will be treated. It depends on:

- the assignation of tasks and skills - a task or a skill can be assigned to one or more agents. In the case two or more agents are sharing the task or the skill, a mechanism (set of elements pt R and O) is required to process the competition/cooperation state;
- the type of communication protocol - the information exchange can be of agent-to-agent type, or with the intermediate of a blackboard. The blackboard architecture is widely used for symbolic cognitive multiagent systems. The principle is that agents (called in this model Knowledge Sources (KS)) do not communicate directly between each other, but indirectly by sharing information in a database called the 'blackboard' that can be checked and updated at anytime. The system is also equipped with a control module to manage access conflicts between KS.

The assignation of tasks and skills in a multiagent system is very important. It is structured on two main points: the list of skills each agent owns, and the unity of each skill. The quantity of skills an agent owns conditions the behavior of agents and their collaboration.

## 11.2 Multiagent system and *Kansei* Information

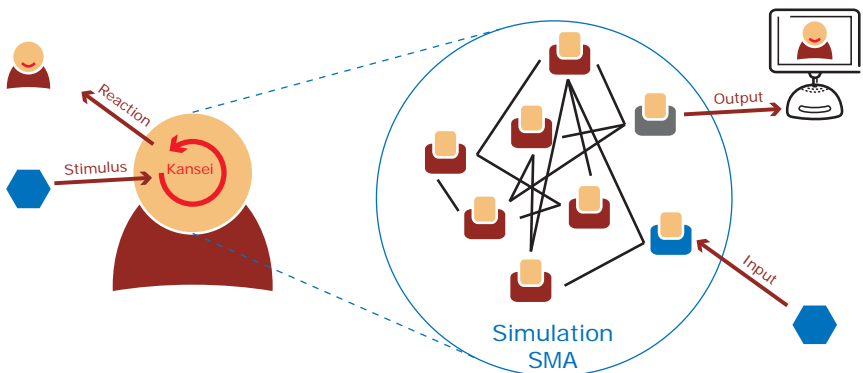
As multiagent systems have been described, it is appropriate now to focus on the interest they could have for both *Kansei* Information and interdisciplinary group communication. On the first point, concerning multiagent systems and *Kansei* Information, the problem can be seen as bilateral: How can multiagent systems participate to the development of *Kansei* Information as a tool for simulation and system design? How *Kansei* Information can participate to multiagent system design and understanding? On the second point, rich in the literature, will lead to consider how can multiagent systems be seen through the *Loft*, and finally how can multiagent systems be used to simulate the *Loft*. That

is important as by being able to simulate the *Loft*, it will be shown that multiagent systems are the most suitable technology for *MATiK*.

### 11.2.1 Multiagent systems for *Kansei* Information simulation

When considering the definition of a multiagent system (cf. paragraph 11.1.2.1), the Collective Intelligence Society could be described actually as a multiagent system: The environment is of course the entire society; Each agent (each individual) works (creates knowledge through learning and experience) for the profit of each and the whole (collective intelligence); Tools, such as computers (objects of O) are being part of a network (the set of elements of R); The Cyberspace is a consequence of R's activity.

It is actually very interesting to notice that human being can themselves be considered as agents. Human and social life simulation is actually one of the most popular simulation topics, and sociology is one of the disciplines that is interesting in the potential application of multiagent systems ([64, 152, 221, 235, 193] as examples). However, still the way this technology, based on descriptive



**Figure 11.8** | Multiagent systems to simulate *Kansei* Information

information system (data processing), is able to simulate subjective aspects of behavior, and information communication should be cleared.

The reason why a multiagent system can simulate outwardly subjective matters is mainly because of structural aspects and the way agents can interact. The layer based structure (cf. Table 11.3) enables various levels for information treatment, decision making (or reasoning) and action. Each of these steps can be launched and performed at different levels, in a parallel way, and with inter-level and intra-level links, influences, or interactions. The information treatment process and the resultant behavior are still intrinsically explicit, but their complexity can be raised to such a level that it is not possible anymore to describe the entire process. However, the output of the process can be perceived and understood intuitively, which lets some subjective aspects to appear within the intuitive interpretation. The uncertainty, the complexity and the performance of the system can get to such a high level of appearance abstraction that the user perceives as a partially subjective process. Also, Bianchi Berthouze proposes a network representation, based on layered abstraction levels, in which agents establish relations both within and across abstraction levels. These relations, who give to the system a graph structure, allow the definition of higher level perception, i.e. lead to the possible emergence of subjective impression definition [12].

A system that lets a subjective behavior to emerge is not necessarily complicated, but complex<sup>23</sup>. As described previously, the multiagent system designer describes an environment (E) and some objects involved (O,A,R and Op). Thanks to this description of rules and objects, a dynamic is created revealing phenomenons seemingly subjective. The difficulty for the designer is to create sagely rules and objects so that this set operates the expected behavior.

From a *Kansei* Information standpoint, the laws of the universe (i.e. external to the agent) refer mainly to already known models, or the ones to evaluate, representing the way information is transferred from the sources to the human captor(s). The laws related to the agents (the operation rules of agents and of

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23 It is necessary here to make the difference between the terms 'complex' and 'complicate'. A 'complex' system is composed of an interconnected set of 'subsystem', whereas a 'complicate' system is combined especially in an inextricable manner. The 'complexity' of a system describes then its structure. The 'complication' of a system qualifies the difficulty to describe and understand it.

their interaction with external world) refer to the way human beings perceive and interpret information. Biology, Cognitive sciences and psychology are probably the main protractor of knowledge in this field. Mechanisms discovered in these fields should be the inspiration for the determination of agent related laws.

Non-agent objects would simulate information transmitter and non-human information modifiers which interact in the environment (for example, sound source or reverberation system). As for the agents, they can be used for the simulation of two different kinds of elements: Firstly, they can be used for the simulation of the human being, in most of the case, this is the center of interest for the investigation; Secondly, they can be used for other 'intelligent' elements acting in the environment (such as robots for example).

It is to be noticed, here, that this model's main objective is to simulate, within the framework of *Kansei* Information, the human behavior, but not the inner states (such as emotions or mood). However, it would be possible to include in each agent a module enabled to collect and send information of the agent's inner state to the experimenter. Yet, it is important that these information may not have any direct influence on the multiagent system process. In the real world, inner state of a person doesn't have any direct influence on the environment. However, they do have indirect influence only when this person expresses something influenced by inner states.

### **11.2.2 *Kansei* Information for multiagent systems**

On the other hand, it is also interesting to note that the relation between *Kansei* Information and multiagent systems can be considered the other way around, for *Kansei* Information to participate to multiagent systems design. Indeed, *Kansei* Information can bring knowledge or methods useful in the design of any system simulating or serving people and human behaviors.

With *Kansei* Information methods and knowledge, it is possible to figure out and to quantify some aspects of human perception and behavior. Thus, these information can be input during a multiagent system design aiming at simulating social phenomenon. An example is of course the design of *MATiK*. Brain wave analysis (cf. paragraph 10.3) had been used to quantify various factors involved in the cocktail party phenomenon. These data are input in the design of the

multiagent system included in *MATiK* (that will be developed in the paragraph 11.3.3).

### **11.2.3 Multiagent systems as an information technology for *Kansei* Information**

This paragraph initializes a thought-worthy aspect for the development of *Kansei* Information. As *Kansei* Information is still relatively a new field of research, it is obvious that *Kansei* Information still needs to find or develop tools and methods. In the matter of social or behavior simulations, it was shown here that artificial intelligence and distributed systems (at which multiagent systems are part of ) are or will be a wellhead for *Kansei* Information tool elaboration. It is not the point of this thesis to develop this point, but this output can be explained by the point of this chapter.

As an example, the following paragraph will explain the way a multiagent system can be set up for *MATiK*, following the interdisciplinary design method developed in chapter 6.

## **11.3 Multiagent system and *MATiK***

### **11.3.1 A multiagent system in the *Loft***

To explain how a multiagent system could be used for the design of *MATiK*, and to validate the technical choice of the multiagent system technology for *MATiK* requirements, multiagent system has to be explained in the scope of the *Evoked Metaphor* point of view (cf. chapter 9).

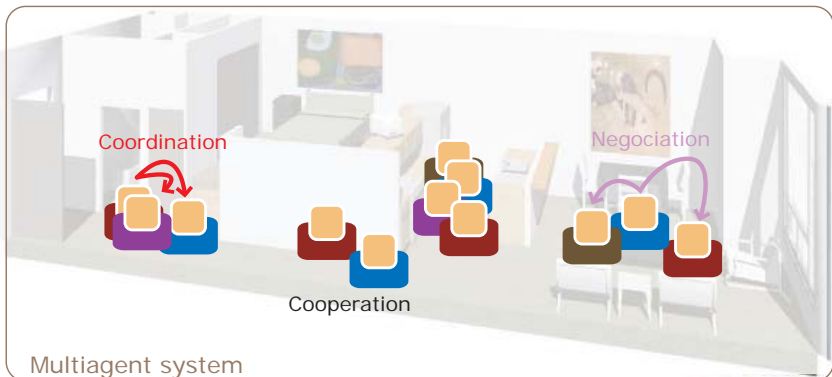
### **11.3.2 Multiagent system technology and the *Loft***

It was suggested previously that agents are not necessarily data processing objects, e.g. human beings can be considered as agents. I propose here to show that the *Loft* can be seen as a multiagent system:



- People in the *Loft* are humans. They are autonomous and skillful. They have personal objectives, which are the activities they are on and probably to feel good in the *Loft*. They are able to interact with each other.
- Their environment is the *Loft*, of which they only have a partial view (They perceive their surrounding but cannot perceive so clearly what is far from them. Same thing can be said about auditory perception). There is now global control system. As people live together, at the same time, the system is perfectly synchronous. According to the definitions of agent and multiagent system (cf. parts 11.1.1.1 and 11.1.2.1), the first point shows that people in the *Loft* as agents, and the second point concludes that the *Loft* is a multiagent system for people in it. It is now necessary, to follow the interdisciplinary design methodology, to explain the multiagent system through the scope of the *Evoked Metaphor*, the *Loft*.

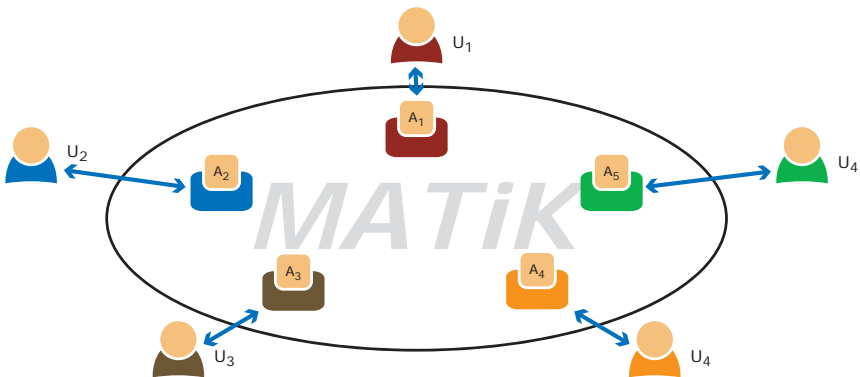
Let's describe a multiagent system once again, but this time as a *Loft*. The multiagent system could be defined as an environment (unity of space) in which individuals, called agents, live. The environment is closed in the way



**Figure 11.9** | Multiagent system described by the *Loft*

individuals cannot leave or enter whenever they want. However, contacts are still possible with the ‘outside world’, thanks to the window (the Internet or other server connection). In this environment, individuals are having different activities, sometimes in group, sometimes individually (multiplicity of tasks). When they have common activities, it is because their wishes, or objectives, can be reached if they work together (cooperation). Then, they need to communicate in order to coordinate their actions (coordination). Since their objectives or the way they wish to proceed may be contradictory, they have to discuss and find an agreement (negotiation).

In the *Loft*, the cocktail party phenomenon occurs, and is not included in a multiagent system as native function. Therefore, in order to reach the analogy between the *Loft* and the multiagent systems, this function needs to be created. Such a function, linking agents thanks to the cocktail party phenomenon, is the specificity of this multiagent system. This function will be described in the next paragraph (paragraph 11.3.3) as a function of a multiagent system for MATiK.



**Figure 11.10** | Each user has an associated agent

Yet, it is possible now to propose and justify the use of multiagent system as a technical choice for the design of *MATiK*. The characteristics of multiagent systems such as parallelism, absence of global control, and decentralized data suit greatly with the characteristics of the *Loft*. As shown before, the same comparison could be made between agents and individuals in the *Loft*. Multiagent system technology is then suitable to *MATiK*'s requirements, and expectation of efficiency and smoothness may be high. Another technology, such as centralized operating filter, intervening on each message to modify the list of receivers, could have been proposed too. However, the non-parallelism of the task process with such a great amount and variety of information would have limit considerably in the smooth operation, as one can tell by experience, and the reliability of the *MATiK*. Yet, Multiagent system technology is a suitable and judicious choice for the design of *MATiK*.

### 11.3.3 Description of a multiagent system for *MATiK*

The main function to be designed in the multiagent system for *MATiK* is the cocktail party function. As said in the beginning of the part C, the aim of this dissertation is limited to the determination and the description of the technical choices. The actual design of the script of the multiagent system for *MATiK* will not be presented here. However, here is proposed a descriptive solution of the multiagent system for *MATiK*.

#### **User representation of the users in *MATiK***

A user is defined here as a actual human being, taking part in an interdisciplinary workgroup using *MATiK* as a communication tool. To contact other users of the group, one user writes and sends the message as explained in the paragraph 10.2.1. The message and the sender's receiver proposition are received by an interface agent. This agent is working only for this user and represent her/him in the multiagent system. Then, from now on, as a nomenclature of users and interface agents and as , the user n will be noticed  $U_n$  , and the associated agent n will be noticed  $A_n$  (e.g. The user 1 is  $U_1$  , and her/his associated agent 1 is  $A_1$ , cf. Figure 11.10).

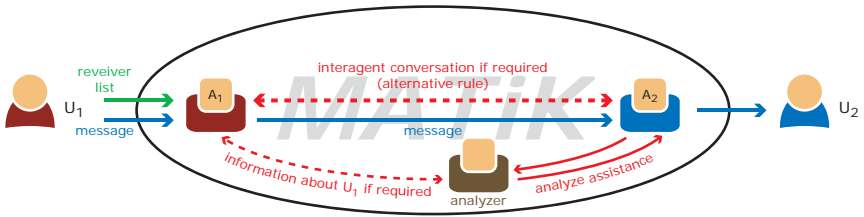


Figure 11.11 | Analyze assistance for attended messages

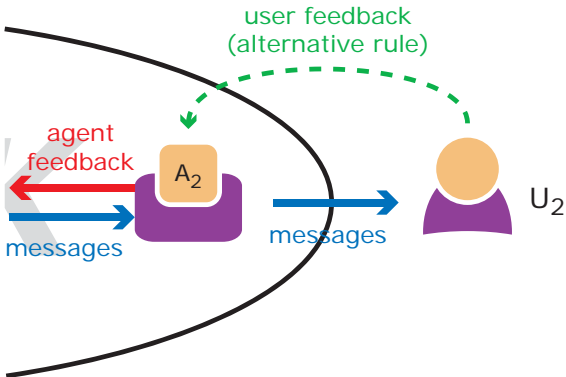


Figure 11.12 | Receiving a message

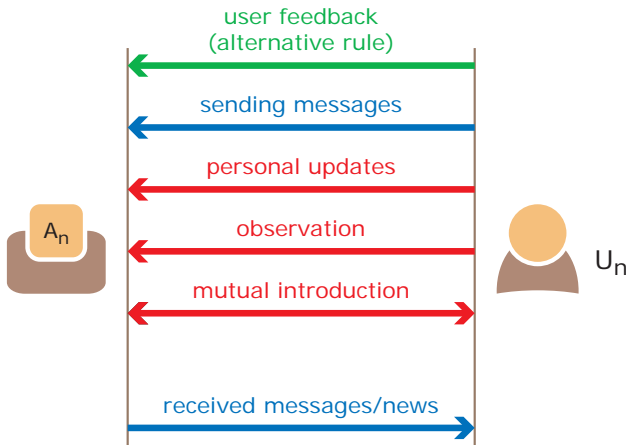
### Emitting a message

The sender agent (i.e. associated with the user sending the message) contacts agents associated with the members listed in the receiver area (cf. Figure 10.8). Then, there are two alternative rules<sup>24</sup>, whether the receiving agent decides the interest of the message for its associate user by itself (with the help of an analyzing agent, called ‘analyzer’), or a conversation between the two agents is launched to evaluate this interest. Finally, the receiving agent sends the message (the interesting part) to its associate user (cf. Figure 11.11).

### Receiving a message

In the step of receiving the message, the receiving agent sends the filtered message to its associated user. The message is also included in the list of

<sup>24</sup> The notion of ‘alternative rule’ expresses the idea that it may have two different ways to process the task, and the selection is not done yet. This notion will be developed more in detail later in this paragraph and in the section 11.3.3.



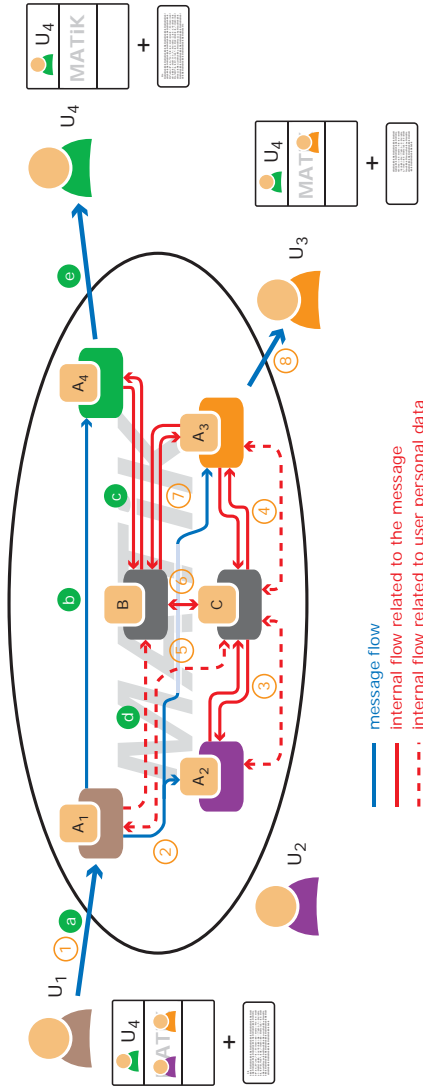
**Figure 11.13** | Relationship user-agent

attended receivers. The receiving agent also informs the sending agent what has been sent to the user (complete message, partial message, nothing, etc...). An alternative rule consists in providing the user or not the ability to send optionally a feedback to the agent. That would help the agent to learn more about its associate user, but would also complicate the process (cf. Figure 11.12). My comment on it is that this function should not be included in the first version of *MATiK*, but added in further development. It is important here to notice that the function of the interface agent is not only to maintain the information flow between *MATiK* and the user (sending/receiving messages only), but it has to get information about the user and to learn continuously from her/him in order to improve the efficiency of the filter.

### **The relationship user-agent**

Indeed the relationship between the agent and its associate user is not trivial. To operate the filter suitably, the agent has to know what was previously called the personal characteristics of the user. Then as the user starts to use *MATiK*, a mutual introduction is required for the agent to know about the user, and the user to understand how *MATiK* works (cf. Figure 11.13). However, this learning about the user for the agent does not stop at this step. Continuously, the agent observes the way the user works and interprets it in order to improve the message filter. As presented before, the feedbacks are precious information for the improvement of the filter. The user and the agent also provide each other information called news. User's news are about new projects or any other professional modification. They are obviously important information for the agent to know the user better and to improve criteria of the filter. Agent's news are about *MATiK*'s evolutions or other information collected by *MATiK* and likely to interest the user (like a statistical overview of the group communication). Since I propose that these news are provided to the user as a message, I gathered in the Figure 11.13 the receiving messages and the news in the same flow.

As the interface agent has to take care of all this input and output information (plus the one related to the internal function of *MATiK*), its structure may not be simple. However, it is one of the key element of *MATiK* since it has to carry out all the interaction between the user and *MATiK*. As described previously, the information about the user helps *MATiK* to improve the filter used not only to



**Figure 11.14** | Cocktail party phenomenon in the multiagent system

bring interesting information to the user, but also to operate the cocktail party phenomenon when required.

### **The cocktail party phenomenon in the multiagent system**

When the sender sends a message, she/he selects a few persons to whom she/he wants to send the message (he places them in the receiver area, cf. Figure 10.8) and the ones she/he does not want to send the message (placed in the excluded area). The other members of the group are automatically placed in the *MATiK* area and are likely to receive the message (or a part of it) thanks to the cocktail party function. The Figure 11.14 illustrates the proposed process for the cocktail party function to be operated in the multiagent system:

- The flow a-b-c-d-e corresponds to the one for attended receiver (users in the receiver area) and was explained previously.

- The flow 1-2-3-4-5-6-7-8 corresponds to the one for attended receiver (users in the *MATiK* area), receiving the message thanks to the cocktail party function. In the first place, the sender writes the message, selects people to be placed into the selected and excluded area, and sends the message to its associated agents (1). As two members of the group (U2 and U3) are in the *MATiK* area, the message is forwarded to them with the notice that U2 and U3 are in the *MATiK* area (2) message, A2 and A3 request the help of the agent C, in charge of the cocktail party function in the multiagent system (3 and 4) the agent C needs the message and the personal information about the receivers (3 and 4), the personal information about the sender (5), and the help of the agent B for the content analysis<sup>25</sup> (6). As the result from the cocktail party function are output, the receiving agent decides which part of the information is sent to the user. In the case of U2, the information doesn't seem to be interesting enough. Nothing is sent to U2. In the case of U3, a part of the information included in the message is interesting enough. Then, A3 requests to the agent B the analysis

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<sup>25</sup> The message analysis asked by U4 in the attended message flow may be different from the one required by the agent B. The former request is for U4 to get better understanding of the associate user activities and to improve dynamically the filter. The later one is for the agent C to evaluate the interest of the message according to the content of the message, the sender personal characteristics, and the receiver ones (including the filter data).



of the interesting part of the message (7) (as U4 does it during the step 3) and finally sends it to (8).

The data output from the cocktail party phenomenon experiment presented in the chapter 10.3 are used by the agent C to process the cocktail party function. Indeed, weighted criteria can be adapted for the analysis of *MATiK*:

- *The spatial position of the source* is translated in *MATiK* by what is called 'conversational distance' between people. As an example, people of ten working together in the workgroup are intensively conversing, and thus are 'conversationally' close. However, if two persons are working on two totally distinctive topics, then they have few chances to converse with each other. Thus they are conversationally distant. It is obvious that this value may change in time. This dynamic value still has an initial value based on the organization of the group.
- *The volume of the message* is translated in *MATiK* by the number of attended persons in a conversation. If the attended persons become numerous, then the speaker has to be louder. According to the cocktail party phenomenon experiment, increasing the volume of the message (which means increasing the number of attended receivers in *MATiK*) increase the chance of cocktail party phenomenon. An alternative translation could be the importance of the message, if a system of importance level is defined in *MATiK*.
- *The content of the message* is probably one of the most important aspects of the message analysis.
- Recognizing voice source — Whereas the spatial position of the source can change quickly, the voice recognition is a longer term data. People may have been working together a lot in the past and then after became distant. In this situation, the spatial distance between the two persons may be great, but still both of them are able to recognize each other's voice.
- The familiar way of speaking is translated in *MATiK* considering a categorization of messages. As explained by Sakurai [213], a message can be analyzed and put into a category in which users are associated with (e.g. categorized

messages by discipline). The switch should be eased if the message is put in a category where the potential unattended receiver is associated with.

### Conclusion

The aim of this description is to propose a global structure of the multiagent system and its operation in *MATiK*. This would provide starting requirement sheet for the information engineering development. The aim of such sheet is a frame for the design of the multiagent system in accordance with the way *MATiK* has been thought thanks to the *Loft*. The actual design of the multiagent system may require modification of the description previously make, but still the global idea should remain.

A few time in the description, the term of 'alternative rule', that was briefly described in the footnote page 295, has been used. It is impossible, a priori, to know which rule would be the most suitable for the operation of *MATiK*. There are two ways to choose before the actual design of the multiagent system: using a computer-powered simulation or a human-powered simulation. The creation of basic computer simulators using multiagent systems to compare different rules quantitatively would provide objective results. Nevertheless, the use of computer simulators to evaluate social behavior simulators does not seem the most appropriate. Why not checking social behavior thanks to direct observation of actual human groups? My proposition is to propose an original experiment, called the 'Human-Powered Computer Experiment for the Multiagent system' Experiment (HPMASSE), aiming at simulating *MATiK* with actual human beings as agent simulators.

## ***Chapter 12***

### **Reflections on *MATiK***

As I have been presented *MATiK* and its concepts to lots of people, numerous questions have been asked, and some of them have pushed the discussion to a deeper reflection or forecast on *MATiK*. I want to present here these reflections. They are essentials because they answer points that are not explicitly expressed previously. It should help the reader to understand better what *MATiK* is, where it goes, and why it is here.

#### **12.1 Questions**

##### **12.1.1 Can *MATiK* replace all other computer-mediated communication (CMC) systems?**

This is not the purpose of *MATiK*. As shown in the paragraph 8.2.1, *MATiK* is different from the other existing tools but it does not replace them. It is a proposition for a new kind of CMC missing in wide workgroups. Emails, forums, chat systems, and so on have their own specificities and suit to specific situations. *MATiK* does not intend to replace them but to operate in situations in which other software do not suit correctly.

##### **12.1.2 What are the constraints for a group to use *MATiK* ?**

I think the main constraint of a group is to be well delimited. From the beginning, people have a common project which is the reason why they are in this group. There is technically no constraint of size, as *MATiK* is based on a decentralized system.

##### **12.1.3 What is the next step in this research?**

The next step is definitely the actual design of a first version of *MATiK*. From now, it is important to make an attempt. This will reveal supplementary issues related to the design. Some aspects of *MATiK* will require more preci-

sions. Globally, *MATiK* will benefit from a design by a better understanding of its operative structure and the way people would use and appreciate it.

## 12.2 Considerations

### 12.2.1 The effect of *MATiK*

The jump analyzer is at the origin of the main effect of *MATiK* on the workgroup knowledge-sharing process. Its aim is to determine the relevancy of a message for each member of the workgroup being in the *MATiK* area, to continuously understand the relationship between members. The operative process of the jump analyzer, based on the cocktail party phenomenon, is not hidden: the sender knows it and uses *MATiK* contingent on it. This is a fundamental difference with most of the currently existing communication systems: the sender is assisted by an information flow management system, and has to be confident in it.

Then, *MATiK* cooperates with the sender to manage, in an optimized way, the sent message. The consequence of this cooperation is double:

- The sender can manage her/his contacts more intuitively: she/he selects only the members participating directly to the conversation (People doing the same task together in the *Loft* ). The link with other members are managed by *MATiK*. This cooperation, between the sender and *MATiK*, by sharing the levels of communication flow management, brings the sender a more intuitive relation with potential receivers.
- Concerning these potential receivers, the main consequence was presented in the introduction of *MATiK* (cf. 8.1, p. 157). If the sender concentrates on the sub-group which she/he is working on the sub-objective with, then certainly the members of the sub-group would receive the message. The other members, the ones who are in the *MATiK* area, may receive the message if the jump analyzer evaluate a high enough relevancy. The usage of *MATiK* would then provide two kinds of messages: the attended ones, directly in relation with the current sub-task, and the unattended ones, supposedly interesting.

The consequence of such system is to ‘clean up’ the information flow inside the workgroup. Indeed, *MATiK* offers a solution that reduces considerably the informational pollution (i.e. uninteresting messages for the receiver), and that revitalizes the social quality of the workgroup thanks to the creation of unattended, but however relevant, links between the members.

### 12.2.2 Two examples of *MATiK*

In order to illustrate *MATiK*, I propose here to provide two examples showing the benefit *MATiK* could bring to organizations such as companies or research institutes.

#### 12.2.2.1 Case 1: design department in a company

##### Scenario

Two members (persons A and B on Figure 12.1) of the design department of a big company face a problem that they cannot solve by themselves. Therefore, they request assistance from other departments of the company, such as R&D or production departments, looking for somebody who could help. It happens that somebody (for example, person D on Figure 12.1, member of R&D) knows the type of problem and offers her/his assistance.

Each department is composed of five persons. One of them is the manager (the five managers are in the dot circle of Figure 12.1).

##### Using email

Steps are as follow (cf. the left part of Figure 12.1):

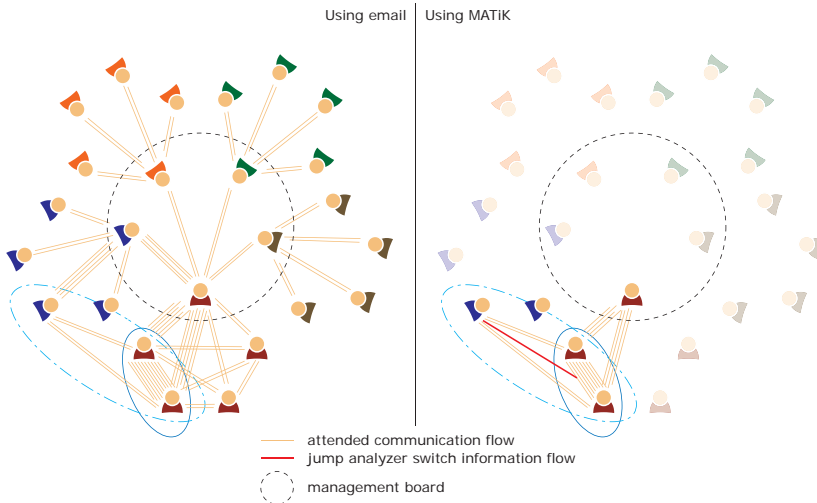
- *Problem statement* – Both designers notice the problem and the lack of solution.
- *Necessity of an outside help* – Both designers talk with all the members of the design department, without success.

- *Call for assistance* – The design manager (C on Figure 12.1) talks with other managers about the problem.
- *Department check* – In each department, the manager interviews members to look for somebody who can help.
- *Feedback* – The manager who found somebody in the department recontacts the design manager and propose the help.
- The helper is contacted by the two designers, the new team is created. The problem can be solved.

This system requires 88 emails.

### Using MATiK

Steps are as follow (cf. the right part of Figure 12.1):



**Figure 12.1** | Example 1: Using MATiK in a company

- *Problem statement* – Both designers notice the problem, provoking an automatic switch of *MATiK*.
- *Inter-department contact* – The unattended receiver proposes assistance to the two designers.
- The problem can be solved.

This system requires 20 attended messages and 1 unattended message. All other information transfers are managed automatically and in real-time by the agents in *MATiK*, in a digital layer invisible by users.

### Conclusion

The information flow savings gained by using *MATiK* are obvious. Therefore, using *MATiK* is effective because:

- 67 units of information flow are saved (more than 75%), even though the content of the result is the same or better;
- For 21 persons out of 25 (84%) have more free time and less stress;
- The social link creation is more fluid and natural inside the company;
- The idea of group is stronger concerning the entire company, not only concerning the department.

#### 12.2.2.2 Case 2: team in a research institute

##### Scenario

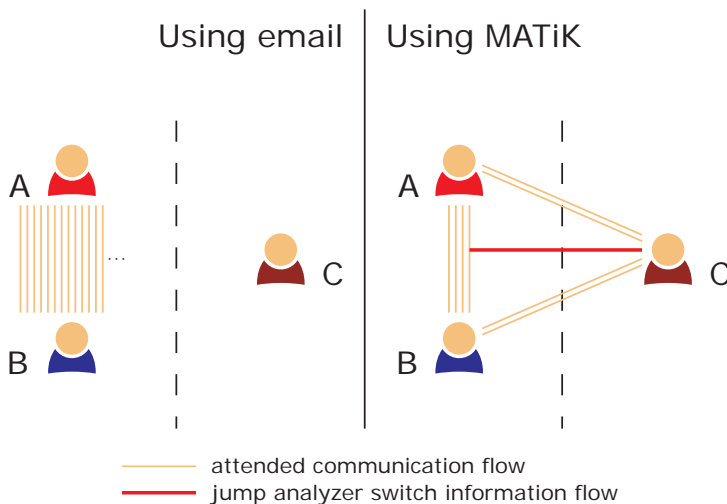
Two researchers (A and B on Figure 12.2) are working on a new project about which they do not know well the theoretical base. A long investigation will be required, probably punctuated with wonders, discussions, unsuccessful path, and so on. . . It happens that in the institute these two researchers are working

in, a third researcher (C on Figure 12.2) has a background that could help them. Unfortunately, they don't know each other.

### Using classic systems

Different cases are possible (cf. the left part of Figure 2):

- The use of email only cannot connect A and B to C.
- Another member of the institute could fortunately link these people, which would be only by chance.
- The use of other classic tools, such as a forum or a mailing list, could be used. However, these systems create lots of information pollution in the institute, and the yield is fairly low. Moreover, these researchers should participate to the same forum and subscribe to the same mailing-list, which is reducing even more the chance of connection and the yield of these systems.



**Figure 12.2** | Example 2: Using *MATiK* in a research institute



- The combination of the two latest cases (somebody in the mailing-list or in the forum knows are searcher who could help) adds drawbacks.

### Using *MATiK*

When working on the basis of the problem, the two researchers will compulsory state keywords that will be related to the interest of C. *MATiK* will then connect the three researchers thanks to an automatic switch on C. By joining the research team, C will greatly help A and B to solve the problem.

### Conclusion

In this case, no quantitative data are provided. However, it is obvious that *MATiK* can help A and B to solve the problem better by improving considerably the information flow in the institute. The advantages are:

- A better use of the institute capabilities;
- A better organization of research teams;
- A socially better environment in the institute;
- Opportunities of new links between researchers, i.e. between disciplines. The consequences could be the creation of new research projects in the future.

#### 12.2.3 The disappearance of the receiver and excluded areas

What if the sender does not put any member in the selected area? Or what if this receiver selection process (selected and excluded area) is voluntary turned off? Let's call *MATiK<sub>2</sub>* this new version of *MATiK*. Then *MATiK<sub>2</sub>* as to guess by itself who should be receiver and who should be excluded. That is a possible evolution of *MATiK*, proposing an entirely new way to communicate through computers.

The mission of *MATiK<sub>2</sub>* is not anymore to modify 'cleverly' the information flow in the workgroup, but to create it. Technically, no major modification is required to

support this variation: *MATiK* is able to determine if the information is interesting or not for each member of the group. Then *MATiK<sub>2</sub>* can determine, according to the content of the message, the personal data of each member of the group (including the sender), to who the message should be sent, completely or partially.

Nevertheless, two aspects of *MATiK* have to be improved, or at least modified, for *MATiK<sub>2</sub>* to work efficiently:

- The first aspect concerns the ‘human continuity’ of conversations. A conversation can be interesting and productive only if participants are permanently active, or at least present. In the *Loft*, if a person leaves regularly a conversation and come back after, its participation is at least minimized, if not counterproductive. This should be avoid in *MATiK<sub>2</sub>*. To prevent this, *MATiK<sub>2</sub>* has to determine if the analyzed message is part of a going-on conversation or if it starts a new one. That is requiring a pragmatics approach on conversation analysis<sup>26</sup> [131].
- The second aspect, for which I don’t have a definite answer, concerns the replacement in *MATiK<sub>2</sub>* of the ‘excluded area’ of *MATiK*. This area is used to select people which would be prevented from receiving the message. As *MATiK<sub>2</sub>* does not propose this area, how can it be replaced? I suggest for now that this function may disappear from *MATiK<sub>2</sub>*, as it is not a necessarily wished function for the workgroups (cf. paragraph 8.3.3).

### 12.2.4 Human-powered experiment proposal for multiagent system design

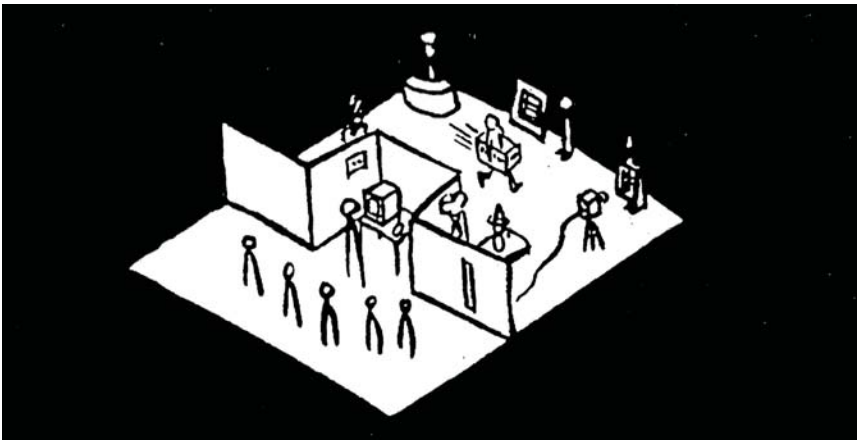
The conception of the multiagent system of *MATiK* necessarily involves trials and simulations to help to evaluate possibilities and then to take decisions all along the design process. Simulations can be done thanks to computer programing, while programing *MATiK*. However, as the actual implementation of

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<sup>26</sup> Conversation analysis (CA) is a sociolinguistic approach that is largely concerned with the analysis of the verbal communication that people routinely use when they interact with one another. It originated in the 1960’s, primarily due to the work of the American sociologist Harvey Sacks, and draws on ethnomethodological and interactional traditions of naturalistic observation [34].

the multiagent system for *MATiK* is not planned within this dissertation framework, computer implementation is not judicious neither. In the early steps of the design of *MATiK*, I suggest to consider the experiment called Human-Powered Computing Experiment (HPCE), as introduced by Maeda [161, p. 50], and to propose an adaptation for the multiagent systems.

Based on the proposal from Laurel [138] who presents Computers as Theatre, he reverses the words around. From Theatre as Computer, Maeda introduces the HPCE. The stage is separated in two parts: the user side and the computer one (cf. Figure 12.3). On the user side, the user interacts with the computer thanks to a video screen and a information transmitting system (keyboard, puck...). On the computer side, actors play different parts of the computer. They interact with the user by sending information to the display, and by receiving information sent by the user. According to user's actions, the computer displays to the monitor thanks to a video camera the output of script of the play. The synopsis proposed by Maeda aims at simulating the operational structure of the computer on the stage of a play.

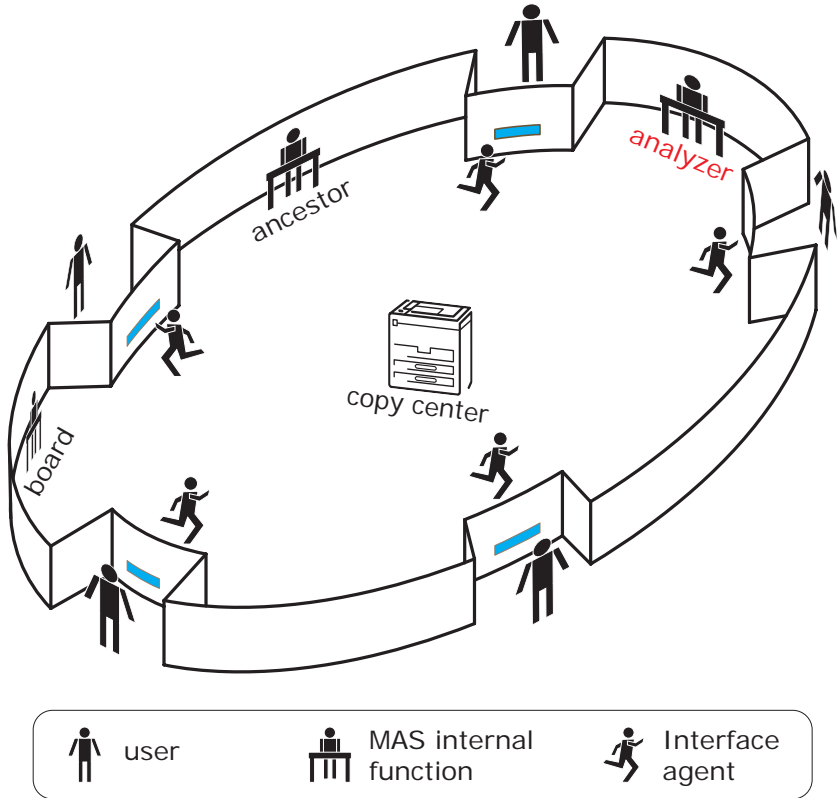


**Figure 12.3** | Human-Powered Computing Experiment  
(from [161, p. 51])

The purpose of the HPMASSE (Human-Powered MultiAgent System Simulation Experiment) is to apply the same idea of experiment, but to a multi-agent system. Instead of proposing computer actors to act as a component of the computer, they would be proposed to act as an object of the multiagent system. As in the proposition from Maeda, there are two kinds of actors: the ones playing a real person (user), and the ones playing an element of the multiagent system (an agent or another object of O – cf. p. 284). Each user receives a role that has to be reviewed and well known before the experiment. This role has to be precised enough for the actor to figure out correctly her/his situation in the group and his/her project and responsibilities. Each agent receives the same kind of information as the one input in the design of an agent (skills - what the actor is authorized to do - and objectives). Other actors, playing non-agent elements of the multiagent system, receive script describing the process of their activity. The interface between users and agents should stay simple and uniform. In the Figure 12.4, illustrating a multiagent system simulating play, the interface is materialized by a slit in the wall separating the multiagent system world with the real one. I propose here to introduce briefly how this experiment could be apply to *MATiK*.

Simulating the operation process of *MATiK* thanks to the HPMASSE may provide a clearer visualization of macro-processes of *MATiK* (behaviors and decisions of agents, introduced by Figure 11.14) and a comparison of some rules of operation. Therefore, it is first important to define correctly the rules of the universe (which govern in the present case both the real world and the cyberspace) and the attributes of each character (for both individuals of the real world and agents of the cyberspace). In this purpose, we pitch on an authorization law system (the laws are not restricting the activity of people, but are providing them possibility to act, which is more restricting).

This experiment can be compared to a role game in which two worlds are rubbing elbows with each other: the ‘real world’, in which isolated human beings can communicate only by the intermediate of the second world; the ‘cyberspace’, which is mainly composed of agents aiming at creating and managing with efficiency the communicating link between the individuals of the real world. The term of efficiency point out the idea that the cyberspace elements have to manage these links such as each individual of the real world receive an information considered interesting to her/his own point of view (cf. the definition of



**Figure 12.4** | Human-Powered Multiagent System Simulation Experiment

*MATiK*, in chapter 8). The objective of this experiment would be thus to modify some of the characteristics influencing this efficiency and to evaluate their impact.



## **Part D | Conclusions and further considerations**



This part gathers findings and implications found in this dissertation in order to draw conclusions and further considerations. The first chapter, overall conclusions and reflections are drawn as a summarization of this dissertation. Then, in the second chapter, further consideration is proposed for the continuation and the improvement of this study.



# ***Chapter 13***

## **Conclusions**

### **13.1 Objectives**

The overall objective of this study was to understand how *Kansei* Information can contribute to the creation of a design method for Collective Intelligence (and therefore intrinsically of an interdisciplinary nature), and thus to the improvement of communication structures of interdisciplinary groups (cf. p.29). However, before concluding on this objective, the background of this study should be recalled, the two sub-objectives should be analyzed, and their achievement evaluated. Then after, as a global evaluation of the study carried in this dissertation, the overall objective will be discussed.

#### **13.1.1 Background**

*Kansei* was defined as the mental sense of subjectivity. Thus, its influence on the communication behavior of a human being is not immediate. Determining the three types of knowledge (descriptive, prescriptive, and tacit) and their relation to *Kansei*, it was possible to show how *Kansei* participates to the subjective information processing. Tacit knowledge and partially prescriptive knowledge are dependent on one's experience when they are gained or retrieved. *Kansei*, fundamentally related to experience, affects the information processing when the transmitter s/his message, and when the receiver perceives and conceptualizes the message. Therefore, *Kansei* is not implicated directly in the communication process, but on the way messages are formulated and understood.

Considering the indirect influence of *Kansei* on the process of interpersonal communication, considering its ability to integrate its approach to human subjectivity, and finally considering the necessity of integrating such a human dimension for the design of Collective Intelligence tools, it is suggested to use *Kansei* Information as an approach for the design of tools dedicated for the Collective Intelligence.

### 13.1.2 First sub-objective

The first sub-objective of the study was to understand how design, thanks to an interdisciplinary approach, can participate to the development of the Collective Intelligence. This objective had been actually split into two parts, and analyzed here:

- *To understand not only the strength and the originalities, but also the issues and the dangers, of an interdisciplinary design approach* — At the beginning, design was defined as conscious and intuitive activity to create and organize the artificial world. Design can be seen from a disciplinary point of view, having its own knowledge, its own teachings, and its own research themes. A reflection, based on the observation of the multi-dimensions of artifacts, shows the interest that design should have for interdisciplinary approach: it should adopt a interdisciplinary behavior in order to embrace the problems and the complexity of artifact creation in the practical world completely. Therefore, the strength of an interdisciplinary behavior for design is to enable designers to manage the creation and the organization of artifacts and of the artificial world more fully and more efficiently, by considering more globally the dimensions of the artifact and of their environment to propose better artifacts, i.e. more adapted for the humanity.

However, interdisciplinary activities clash to problems, which design has to face (notably concerning knowledge sharing):

- The transfer of implicit knowledge meets issues permanently in interpersonal communication. These are due to the peculiarity of personal experiences and human subjectivity.
  - The transfer of explicit knowledge meets issues in the interdisciplinary context: involved disciplinary ontologies may contradict with each other (i.e. being incompatible) or may create gaps between disciplines, so then understanding may be almost impossible, or at least knotty, between disciplines.
- *To propose an interdisciplinary design methodology in the context of Collective Intelligence* — Starting from the consideration of knowledge sharing strengths

and issues in interdisciplinary context, the objective is to understand how design can solve these issues in order to profit fully from these strengths.

Therefore, the first step was to find a communication process able to minimize both implicit and explicit knowledge sharing issues. Intuition was pointed out as a mental process able to solve this double issue and able to create an operable communication process in the context of interdisciplinary design.

Using intuition as a process of perception, of conceptualization, of understanding, of communication, and thus of exchange, a proposal for an interdisciplinary design methodology is possible. For this purpose, to the theory of *ba* and the SECI model (already recognized as a well-working set for knowledge sharing in social context) were added to the knowledge set, named the *Evoked Metaphor*. The *Evoked Metaphor* was defined as a set of intuitively transferable successful information and operating laws. Finally, to reach the second part of this objective, the *Evoked Metaphor* was analyzed in order to point out that it can profit to the interdisciplinary group concerning knowledge exchange, and how it fits both into the SECI model (to be in adequacy with the knowledge sharing process) and into the design process (to be in adequacy with the project the interdisciplinary design group is working on).

These two steps point out, in the first time, the strengths and the issues raised by the inclusion of an interdisciplinary behavior in the design process and propose, in the second time, a methodology to profit fully to the strengths while solving the issues. The use of the methodology for interdisciplinary design enables then the design process to take into consideration a maximum of dimensions of the artifact and of its context. As this consideration is a mandatory path for Collective Intelligence, now interdisciplinary design can fully and efficiently participate to the development of the Collective Intelligence and of its tools.

### 13.1.3 Second sub-objective

The second sub-objective of the study was to develop a tool to communicate in an interdisciplinary workgroup, i.e. to bring to a more concrete level than the previous findings. In order to extend the reflection concerning Collective Intelligence and concerning the issues on communication in interdisciplinary workgroups (but more concretely this time), and to apply the previously created

methodology, a project for the design of an interdisciplinary group communication tool was launched. This tool, called *MATiK*, possesses an original function inspired from the cocktail party phenomenon: the jump analyzer. This function enable the automatic modification of the information flow inside the group when a message is likely to interest greatly a member, even if she/he was not selected by the sender of the message as a receiver. This function, taking into consideration the content of the message and some personal information related to each member of the group, aims at recreating the cocktail party phenomenon, seen as an information flow optimizer. *MATiK* is pointed out as original and as being part of the emergence of the Collective Intelligence.

To design *MATiK*, an *Evoked Metaphor* is created and used: the *Loft*. The *Loft* will not only be used to explain intuitively *MATiK* and its operating structure, but also to go through the whole design process, up to the definition and the characterization of the functional and technical requirements.

The design of *MATiK* satisfies two important aspects of the current study:

- It proposes a communication tool for the interdisciplinary group (and by this, reach the second sub-objective);
- It provides an illustrative explanation of the interdisciplinary design methodology.

#### **13.1.4 Overall objective**

The success of the two sub-objectives reaches two important aspects:

- Finding a solution for the issues related to communication in an interdisciplinary context;
- Proposing an original communication tool dedicated to this context.

Firstly, this study showed how *Kansei* Information can contribute to the development of the Collective Intelligence. Secondly, it proposed, thanks to an approach based on *Kansei* Information, and more precisely on intuition, a methodology for interdisciplinary groups to work with the benefit of Collective

Intelligence. Lastly, it was concluded on the design, up to the functional and technical requirements, of a communication tool aiming at creating a Collective Intelligence dynamism in the interdisciplinary workgroup. Thus, the overall objective is reached: The *Kansei* Information can permit to take into consideration human subjectivity, in order to create a design process able to provide artifacts for the Collective Intelligence, and thus able to improve communication structures of interdisciplinary workgroups.

### 13.2 Other reflections

The *Evoked Metaphor* was introduced as a set of successful knowledge, fitted up with operating laws, that represents by analogy the object of the design project, and allows knowledge exchange and sharing based on intuition. The strength of this proposition is related to the fact that the *Evoked Metaphor* is used during the whole time of the project, whatever the advancement of the project, whatever the kind of problem, and whoever is communicating. Then, the entire group can participate to the whole project, from its beginning to its end, while understanding each point and eventually participating to it.

This process is possible because the *Evoked Metaphor* acts directly to the three main levels of the design process (cf. Figure 13.1) and links them. These three levels are:

- In the *conceptual level*, there are the ideas and concepts which inspire or are created by the industrial design process. The *Evoked Metaphor* is included in this level. It is both the creator and the organizer of the conceptual level.
- The *reality level* is actually the real world in which practical issues exist and are solved thanks to design. The practical issues are 'translated' in the conceptual level at the beginning of the design process. Thus, the real world is represented in the conceptual level, in which it can be understood intuitively even if it stays complex.
- The technical level gathers all the technical solutions used to solve practical issues revealed by the conceptual level. The *Evoked Metaphor* can define the technical requirements, and analyze them in order to determine solutions that can be finally validated and used in the design. Therefore, the *Evoked*

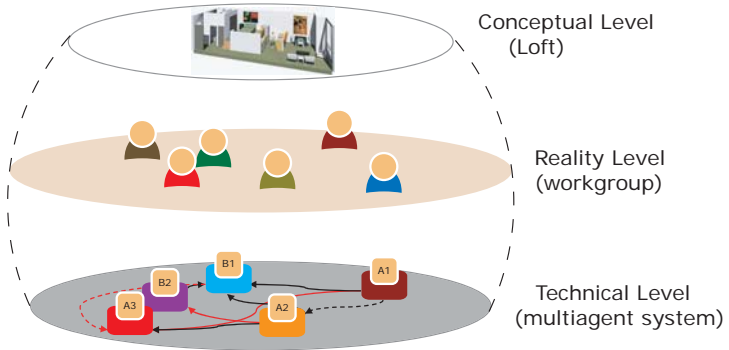
*Metaphor* links the technical and the conceptual levels since concepts structure technical needs and valid their choice. Also, it links the technical and the real levels since it allows to understand the practical problems and to propose a technology which is able to participate to the problem resolution.

Therefore, the *Evoked Metaphor* is permanently present in the design process. This permanence has a few but strong consequences on the process (cf. Figure 13.2):

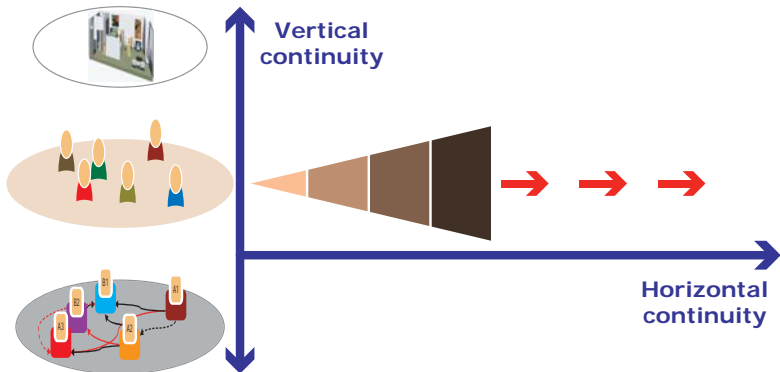
- It allows to preserve a continuity throughout the process, at all the steps. This conceptual continuance, called horizontal continuity, permits to follow continuously the evolution of the project, which makes sense from the beginning to the end.
- It allows an intuitive and continuous between the three levels, which enable anybody to understand the conceptual and technological implications of the project on the practical problem. This vertical continuity allows all the group to understand intuitively the evolution of the project and to valid its progression.

These two continuances enable the set of disciplines to understand, eventually to participate, and to validate each step, from the beginning to the end of the project. The keypoint expressed here is that the *Evoked Metaphor* has the role of cement for the entire project. This cement makes the horizontal and vertical continuities. And thanks to this double continuity, the process is of interdisciplinary nature: each discipline can follow continuously the progression of the design process (horizontal continuity) while understanding and validating the conceptual and technical implications and consequences (vertical continuity).





**Figure 13.1** | The levels of the design process



**Figure 13.2** | The horizontal and vertical continuity



## ***Chapter 14***

### **Further considerations**

*The virility of the idea lies not less in its power of breaking through contemporary thought than in its capacity for dominating subsequent movements.* — Kakuzo Okakura [189]

#### **14.1 Methodology**

The interdisciplinary design methodology, based on the use of the *Evoked Metaphor*, is on the important point of this dissertation. Its adequacy with the SECI Model, for knowledge information processing, and with the design process were shown. An application was presented and tested with the design project of *MATiK*. However, more trials are required to evaluate its relevancy, and to improve if necessary. That is to say the this methodology needs to gain maturity. It is especially necessary to test it with a product design project. Trails and experience are required for the *Evoked Metaphor* to gain enough strength to be recognized as being successful.

#### **14.2 Design of *MATiK***

In this study, the interest to design *MATiK* was double. Firstly, it was launched as an application of the interdisciplinary design methodology presented in this dissertation. Secondly, its aim was also to propose a new-generation communication tools for the operation of the Collective Intelligence.

However, in the scope of the dissertation, the process was interrupted at the level of the functional and technical requirement step. The reason to stop at this point is that the implication of the *Evoked Metaphor* in the interdisciplinary design process is most important and the most active up to this point. In the project realization steps, the *Evoked Metaphor* has a minor role since the realization is systematically disciplinary driven (engineering, finance, architecture, etc. . . ). However, it can still intervene as a major element during communication periods (to the outside of the workgroup) of the project and of its resulting design. During

these periods, the *Evoked Metaphor* is able to make people understanding intuitively not only the created artifact, but also about the design process used, which has the double advantage to justifying the choices made in the design project.

But the interest of the *MATiK* design is not only for the use of the methodology itself: *MATiK* is by itself interesting since it is a new kind of communication tools for workgroups. *MATiK* is then interesting by itself, independently from the methodology, and deserves to be created. However, its realization will not be proceeded without difficulties, because of the technology to use and because of the complexity of its context. Numerous trial, fixings will be required using computer trials or simulations, and using the HPMASSE (cf. p.239).



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# Appendix

# Appendix A

## The *Kansei* mapping experiment

### A.1. Keywords

Table A.1: Keywords

English	Japanese (日本語)	Definition (when required)
Acceptance	受け入れ	お客が商品の使用を受け入れること。
Accessibility	近づきやすさ	商品が身近に存在し、手に入れやすいこと。
Adaptability	適用性	様々な状況に商品が適合できること。
Added Value	付加価値	付加的な価値。
Advertisement	広告宣伝	
Aesthetic	美学	自然・芸術における美の本質や構造を解明する学問。美的現象一般を対象として、その内的・外的条件と基礎とを解明規定する。
Age	年齢	
Anthropometric	人体測定学	人体を比較的計測する学問。
Availability	入手容易性	プロダクトを買い時あるかどうか。
Benchmarking	ベンチマーキング	他社の様々なプロセスを分析して、自社の弱点を改善すること。
Biodegradation	生物分解	プロダクトが自然分解により消滅すること。
Brand positioning	ブランドの位置づけ	ブランドを相対的に位置づけすること。
Color	色	
Compactability	小さくしやすさ	プロダクトを収納や携帯のために小さくするしやすさ。
Context	状況	自分が置かれている状況。
Creativity	創造性	
Culture	文化	
Customization	カスタム	プロダクトを人に合わせられること。
Disposability	使い捨て	使い捨てできる可能性。
Durability	耐久性	プロダクトが長年使用できる可能性。
Efficiency	効率	プロダクトの目的達成のための効率。

English	Japanese (日本語)	Definition (when required)
Energy Consumption	エネルギー消費	
Environment integration	環境統合	自分の環境にプロダクトを取り入れること。
Exhibition	展示	
Exotic	異国風	
Experience	経験	
Fashion	流行	
Friendliness	友情	プロダクトへの愛着。
Gender	性別	
Group	belonging	グループへの帰属意識 プロダクトを入手することによって生じる、あるグ
グループへの帰属意識。		
Innovation	新機軸	
Interpersonal communication	人と人とのコミュニケーション	
Law	法律	
Made in	Made in	生産国へのこだわり。
Morality	道徳性	社会生活を営む上で、ひとりひとりが守るべき行為
の規準。		
New functions	新機能	
Nostalgia	郷愁	故郷を離れている人が故郷をなつかしく感じる気持ち。ノスタルジア。「一を覚える」。古いものをなつかしむ気持ち。
Packaging	パッケージ	プロダクトの包装方法。
Patent	特許	
Price	値段	
Product family	プロダクトファミリー	ある統一感を持ったプロダクト群。
Promotion	販売促進	
Promotional items	おまけ	
Quality	品質	
Recycle	リサイクル	
Regulation	規則	生産や販売をする上での規則。

English	Japanese (日本語)	Definition (when required)
Religion	宗教	
Repairability	修理のしやすさ	
Reuse	再利用	本来の利用目的で使用した後、違った目的で利用すること。
Security	安全性	
Selling human relation	セールスマンと客の関係	
Service After Sale	アフターケア	
Shape	形	プロダクトの形。
Size	サイズ	プロダクトのサイズ。
Social status	社会的地位	
Standard	スタンダード	法律上ではなく、事実上の標準。
Stockability	収納性	収納や整理のしやすさ。
Structure	構造	プロダクトの構造。
Style	スタイル	プロダクトの外見。
Technology	技術	
Texture	表面の肌合い	
Top of mind	トップ・オブ・マインド	あるプロダクトを考えた時、一番早く思い出せるブランド。
Updatability	拡張性	プロダクトの拡張のしやすさ。
Usability	使いやすさ	
Value	価値	物もっている、何らかの目的実現に役立つ性質や程度。値打ち。有用性。
Warranty	保証	プロダクトの品質を保証すること。
Weight	重さ	

Table A.2: Distance between the keywords



# Appendix B

## The cocktail party phenomenon experiment

### B.1. Matlab functions

#### B.1.1 ERP Analysis

Purpose — ERP analysis and graph output from the raw data function `erp(nam,i data, rele, syn, nbseq, debseq, lgseq, interseq, lgper, freq, canaux, rogne, gzero)`

```

% By Pierre Levy, 2005
% To calculate the ERP after selection by hand of data relevances
%
% nam=name of the person, string
% idata=data to work on, table
% rele=relevance data, vector
% syn=length of the sounds, vector
% nbseq=number of sequences
% debseq=start of the first sequence, seconds
% lgseq=length of each sequence, seconds
% interseq=length between two sequences, secondes
% lgper=length of a period, seconds
% freq=data collect frequency
% canaux=nd of channels
% rogne=start and end cut
% gzero=what time before should start the graph, seconds
% filtering raw data
[filldata dela] = filtirerp(idata,16);
filtmod='filtered';
filttitr='filt';
% Starting point of experiemet in data, when the canal 20 come back to
values<11000
startdata=2;
while (idata(startdata,20)>11000
|| idata(startdata-1,20)<11000)
startdata=startdata+1;
end
startdata=startdata+1;
287
% Beginning of the first sequence in both data and rele
debldata=debseq * freq + startdata;
deblrele=debseq+1;
% Number of period to consider
nbper=fix(lgseq/lgper)-(rogne*2);
% Number of lines in the matrice per period

```

```

lineper=lgper*freq-1;
% Blank 3Dmatrice to gather results
matseq=repmat(0, [lineper+1,canaux,nbseq]);
% Vector to gather the number of relevant blocks
allrele=zeros(nbseq);
% For each sequence
for seqnb=1:nbseq
% Number of period considered by relevancy
relnb=0;
% Start of the first period to consider in the sequence
debseqdata=debl1data+(seqnb-1)*(lgseq+interseq)*freq+rogne*lgper*freq-
gzero*freq+dela;
debseqrele=debl1rele+(seqnb-1)*(lgseq+interseq)+rogne*lgper;
% For each period
for pernb=1:nbper
% Relevancy of the block
rel1=rele(debseqrele+(pernb-1)*2);
rel2=rele(debseqrele+(pernb-1)*2+1);
if ((rele(debseqrele+(pernb-1)*2)==1) & & (rele(debseqrele+(pernb-
1)*2+1)==1))
relnb=relnb+1;
% Determine the first line and the last line of the block to add
fline=debseqdata+(pernb-1)*(lineper+1);
lline=fline+lineper;
% Add the block
matseq(:, :, seqnb)=matseq(:, :, seqnb) + fildata(fline:lline,1:canaux);
end
end
% Division for average
matseq(:, :, seqnb)=matseq(:, :, seqnb)/relnb;
allrele(seqnb)=relnb;
% Save results
xlswrite(strcat(nam,'
\',filttitr,'-', 'seq-', num2str(seqnb), '-mod-', align, '.xls'), matseq(:, :, seqnb));
% Graph for each channel
for cana=1:canaux
titltop=strcat(nam,'-', 'sequence(', num2str(seqnb), ') -channel(', num2str(cana)
,') -filter(', filtmod, ') ...
-mod(', align, ') -retained(', num2str(relnb), ')');
titlfil=strcat(filttitr,'-', align, '-', num2str(seqnb), '-', num2str(cana));
grapherp(matseq(:, cana, seqnb), 0, nam, titltop, titlfil, gzero*freq, 1, syn(seqnb)
*freq, 2, strcat('seq', num2str(seqnb)), 'courb2');
end
end

```

```

% Evaluation graphs
matcompplus=repmat(0, [lineper+1 canaux nbseq-1]);
matcompmanus=repmat(0, [lineper+1 canaux nbseq-1]);
for comp=1:nbseq-2
matcompplus(:, :, comp)=matseq(:, :, comp+1)+matseq(:, :, 1);
matcompmanus(:, :, comp)=matseq(:, :, comp+1)-matseq(:, :, 1);
xlswrite(strcat(nam, '
\ ', filttitr, '- ', 'comp-', num2str(comp+1), '+1 -mod-', align, '.
xls'), matcompplus(:, :, comp));
xlswrite(strcat(nam, '
\ ', filttitr, '- ', 'comp-', num2str(comp+1), '-1 -mod-', align, '.
xls'), matcompmanus(:, :, comp));
% Graphs
for gcana=1:canaux
titltop=strcat(nam, '-', 'comparison(', num2str(comp+1), '(', num2str(allrele(com
p+1)), ')'+1('num2str(allrele(1)), ')')...
-channel('num2str(gcana),')-filter('filtmod,')-mod('align,')');
titlfil=strcat(filttitr, '- ', 'comp-', align, '- (+)', num2str(comp), '-
', num2str(gcana));
grapherp(matcompplus(:, gcana, comp), 0, nam, titltop, titlfil, gzero*freq, 2, syn(c
omp+1)*freq, syn(1)*freq, ...
strcat('seq', num2str(comp+1)), strcat('seq', num2str(1)));
titltop=strcat(nam, '-', 'comparison(', num2str(comp+1), '(', num2str(allrele(com
p+1)), ')'-1('num2str(allrele(1)), ')')...
-channel('num2str(gcana),')-filter('filtmod,')-mod('align,')');
titlfil=strcat(filttitr, '- ', 'comp-', align, '- (-)', num2str(comp), '-
', num2str(gcana));
grapherp(matcompmanus(:, gcana, comp), 0, nam, titltop, titlfil, gzero*freq, 2, syn(
comp+1)*freq, syn(1)*freq, ...
strcat('seq', num2str(comp+1)), strcat('seq', num2str(1)));
titltop=strcat(nam, '-', 'comparison(', num2str(comp+1), '(', num2str(allrele(com
p+1)), ') and ...
1('num2str(allrele(1)), ')'-channel('num2str(gcana),')-filter('filtmod,')-
mod('align,')');
titlfil=strcat(filttitr, '- ', 'comp-', align, '- (and)', num2str(comp), '-
', num2str(gcana));
grapherp(matseq(:, gcana, comp+1), matseq(:, gcana, 1), nam, titltop, titlfil, gzero*
freq, 3, syn(comp+1)*freq, syn(1)*freq, ...
strcat('seq', num2str(comp+1)), strcat('seq', num2str(1)));
end
end
% Last comparison
matcompplus(:, :, nbseq-1)=matseq(:, :, 10)+matseq(:, :, 8);
matcompmanus(:, :, nbseq-1)=matseq(:, :, 10)-matseq(:, :, 8);
xlswrite(strcat(nam, '
\ ', filttitr, '- ', 'comp-(10+8)-mod-', align, '.xls'), matcompplus(:, :, nbseq-1));
xlswrite(strcat(nam, '
\ ', filttitr, '- ', 'comp-(10-8)-mod-', align, '.xls'), matcompmanus(:, :, nbseq-1));
% Graphs
for gcana=1:canaux
titltop=strcat(nam, '-', 'comparison(', num2str(10), '(', num2str(allrele(10)), ')'+
8('num2str(allrele(8)), ')')...

```

```

-channel('num2str(gcana),'-filter('filtmod,'-mod('align,')'));
titlfil=strcat(filttitr,'-', 'comp-', align,'-(+)', num2str(nbseq-1),'-
', num2str(gcana));
grapherp(matcompplus(:,gcana,nbseq-1),0,nam,titltop,titlfil,gzero*freq,2,sy
n(10)*freq,syn(8)*freq,...
strcat('seq',num2str(10)),strcat('seq',num2str(8)));
titltop=strcat(nam,'-', 'comparison(', num2str(10),'(', num2str(allrele(10)),')-
8(', num2str(allrele(8)),')')...
-channel('num2str(gcana),'-filter('filtmod,'-mod('align,')'));
titlfil=strcat(filttitr,'-', 'comp-', align,'-(-)', num2str(nbseq-1),'-
', num2str(gcana));
grapherp(matcompmanus(:,gcana,nbseq-1),0,nam,titltop,titlfil,gzero*freq,2,s
yn(10)*freq,syn(8)*freq,...
strcat('seq',num2str(10)),strcat('seq',num2str(8)));
titltop=strcat(nam,'-', 'comparison(', num2str(10),'(', num2str(allrele(10)),')
and ...
8(', num2str(allrele(8)),')-channel('num2str(gcana),'-filter('filtmod,'-
mod('align,')'));
titlfil=strcat(filttitr,'-', 'comp-', align,'-(and)', num2str(nbseq-1),'-
', num2str(gcana));
grapherp(matseq(:,gcana,10),matseq(:,gcana,8),nam,titltop,titlfil,gzero*freq
,3,syn(10)*freq,syn(8)*freq,...
strcat('seq',num2str(10)),strcat('seq',num2str(8)));
end

```

## B.1.2 Filter

function [filtfirdata,dela]=filtfirerp(idata,canaux)

```

% By Pierre Levy, 2005
% Filter FIR passband
% Normalized frequencies: 0.03 < ω < 0.3
% Filter order: 100
% filtfirdata=filtered data
% dela=filter delay
% idata=data to filter
% canaux=nb af channels to filter
ord=100;
h=fir1(ord,[0.06 0.6])
for canal=1:canaux
y=conv(h,idata(:,canal));
filtfirdata(:,canal)=y(1:length(idata(:,canal)));
end
dela=ord/2;

```

### B.1.3 Graph

Purpose — Draw the graphs and save them as jpeg function grapherp(output,nam,titltop,titlfil,stimu,nbrect,slong1,slong2)

```

% By Pierre Levy, 2005
% To graph the ERP
% output=data to graph
% nam=name of the person, string
% titltop=title to put at the top of the graph
% titlfil=file name
% stimu=time of the stimulus
% nbrect=number of stimuli
% slong1=time length of the stimulus 1
% slong2=time length of the stimulus 2
vrect=min(min(output));
plot(output)
title(titltop)
xlabel('ms')
ylabel('\muV')
set(gca,'XTick',0:10:200)
set(gca,'XTickLabel',{'0','100','200','300','400','500','600','700','800','900','1000',
',...
'1100','1200','1300','1400','1500','1600','1700','1800','1900','2000'})
rectangle('Position',[stimu vrect slong1 0.1])
if nbrect==2
rectangle('Position',[stimu vrect+0.1 slong2 0.1])
end
plotWindow = findobj(gcf,'Type','axes');
newFig = figure;
copyobj(plotWindow,newFig);
saveas(newFig, strcat(nam,
\',titlfil, '.jpg'), 'jpg')
close

```

## **B.2 Personality inventory questionnaire**

On the following pages, there are phrases describing people's behaviors. Please use the rating scale below to describe how accurately each statement describes you. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Please read each statement carefully, and then fill in the bubble that corresponds to the number on the scale.

- Date of the experiment:
- Gender:
- Age:
- Country:

*Note for this edition: the questionnaire can be found in [61].*



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