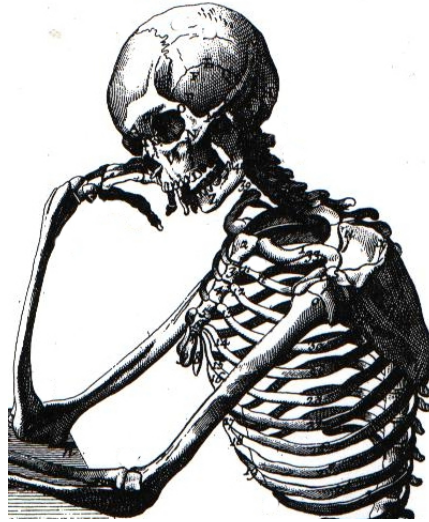


*Cognitio.uqam.ca/2005*



*Être ou ne pas être. Cognition et décision*

Actes de Cognitio 2005  
Colloque jeunes chercheurs en sciences cognitives

*To be or not to be. Cognition and decision*

Proceedings of Cognitio 2005  
Graduate students conference on cognitive science

Directeur de publication - Publication director  
Benoit Hardy-Vallée

**UQÀM**

Université du Québec à Montréal

En-ligne le 19 février 2006 | *Online February 19<sup>th</sup>, 2006*

<http://cognitio.uqam.ca/2005>

Page couverture | *Front page* :

*Le Squelette vu de côté (détail) – Diderot, L'Encyclopédie, Booking International, p. 291.*

Le colloque Cognitio s'est tenu les 2, 3 et 4 mars au département de philosophie de l'Université du Québec à Montréal (UQÀM)

*The Cognitio Conference took place on March 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 2005 at the philosophy department of the Université du Québec at Montreal (UQÀM)*

Organisation et édition | *Organization and edition* : Benoit Hardy-Vallée

Comité scientifique | *Scientific committee*:

- Pierre Poirier, philosophie, UQÀM
- Jude Leclerc, psychologie, Université de Montréal
- Jean-Frédéric de Pasquale, informatique cognitive, UQÀM
- Marie-Ève Bouchard, psychologie, UQÀM
- Isabelle Belzil, linguistique, Université de Toronto
- Dominic Beaulieu-Prévost, psychologie, Université de Montréal

Le colloque et ses actes ont vu le jour grâce au soutien financier et technique du département de philosophie, du bureau de l'enseignement et des programmes et le laboratoire d'analyse cognitive de l'information (LANCI) de l'UQÀM.

*The conference and its proceedings were made possible thanks to the financial and technical support of the UQÀM philosophy department, bureau de l'enseignement et des programmes and laboratoire d'analyse cognitive de l'information (LANCI).*

*Être ou ne pas être.  
Cognition et décision*

*To be or not to be.  
Cognition and decision*

## Table des matières - Table of content

The Neurophenomenological Illusion <i>Lana Kühle</i> .....	5
A Defence of Fodor's Informational Atomism <i>Ion Octavian</i> .....	16
Reconnaissance et sémantique des objets : approches comportementale et électrophysiologique de la modalité de présentation et de la catégorie sémantique <i>Karima Kahlaoui, Thierry Baccino, Yves Joanette, Marie-Noële Magnié</i> .....	23
How to place an adjective: semantic computation or lexical memory? The case of prenominal frequent adjectives in French <i>Frédérique Offredi</i> .....	33
Risky and Non-risky Decision making: The Role of Illusion and Uncertainty Revealed by fMRI and DCM <i>Ahmad Sohrabi, Andrea M. Smith, Shahin Fakhraei, Ian Cameron</i> .....	48

# The Neurophenomenological Illusion

Lana Kühle  
Doctoral Candidate  
Department of Philosophy  
University of Toronto  
[lane.k@sympatico.ca](mailto:lane.k@sympatico.ca)

Whenever faced with the prospect of conducting research, it is of utmost importance to ensure that a proper methodology is in place for such a project before it proceeds to the data collection stage. This is crucial because it is necessary that our methodology take into account as many, if not all possible angles of study. By analogy, to understand a sculpture it is not enough to understand the various chisels that are used in creating it. Undoubtedly, these chisels play a role in creating the piece; they each have specific ways that they can be used, and each produces its own specific effects. However, you nonetheless need to understand the sculpture in itself and what reactions it produces in you: you need to understand the very experience of the sculpture. These aspects of the sculpture cannot be seen or understood by simply studying the tools that are used to create it. Similarly, the body, and more specifically the brain, is in many respects a tool that we use in experiencing the world, and as such it is a part of the experiences and mental lives that we lead. However, it is becoming more and more apparent that the mental states of a subject cannot be completely explained in terms of strictly biological data. That is, the subjective cannot be reduced to, or eliminated in favor of, the objective.

This problem, which is referred to as the problem of the ‘explanatory gap’, is one that many cognitive scientists are coming to realize needs to be properly dealt with. In view of this, for many, the goal has been to find a way to bridge the gap by incorporating the subjective into objectively based research programs. One such attempt has recently been made by neuroscientist Francisco Varela. His project aims to naturalize the Husserlian phenomenological method such that it can be incorporated into a neuroscientific research methodology. Husserl’s transcendental phenomenology is a method by which a person can contemplate his/her acts of consciousness and their very essences from a privileged first person, or subjective point-of-view. However, as it stands this phenomenological method has hardly anything in common with biological sciences of the mind such as neuroscience. Therefore, if we are to make use of it, then we must find a way to use both methods such that each complements the other. This is precisely what Varela aims to accomplish with neurophenomenology.

Proponents of neurophenomenology are very aware of the theoretical and research benefits that follow from a consideration of Husserl’s phenomenology and an attempt to use it in conjunction with methods of neuroscience. By way of naturalization, that is, by finding a way to consider phenomenology within an objective framework, they hope to build a bridge that allows both methodologies to relate to each other and provide new ground for research. However, we must ask ourselves how successful this project has been so far, and what have been its problems and why?

As a method that can begin to build a bridge over the deep chasm of the explanatory gap, I hold that neurophenomenology has made a valiant effort, but as it

stands has nonetheless failed. I argue that in the process of naturalizing phenomenology, neurophenomenology has lost track of the very thing that it intended to naturalize, and in turn, ends up naturalizing an entirely different method than the Husserlian phenomenology it set out to work with. In order to show this, I will begin by explaining Husserl's views as they pertain to this project, which I will follow with a consideration of the neurophenomenological project in light of these views. I will then end with an evaluation of neurophenomenology's successes and failures thus far.

## 1. Husserl's Phenomenological Project

As mentioned above, Husserl's transcendental phenomenology aims at the very essence of a mental act. However, before we can understand how one gains access to such an essence, it is important to consider what Husserl understands by the essence of an act of consciousness. At the outset of his method, he distinguishes two aspects to any mode of consciousness that involves our embodied interaction with the world. If we consider experience, for example, then we can consider either the act of experiencing, or the object that forms the content of that experiencing act. The act is what he refers to as the subjective, and the content is what he refers to as the objective.

Every interaction that we have with the world is framed by some form of consciousness. Whether it be vision, listening to music, or any other sense perception, we always find that the object of such a sense perception is always subjectively framed. Because of this, one cannot experience the world in a purely objective way. As long as there is a person undergoing the experience, there will be a subjective aspect to that experience. Therefore, we can only know the objective through the subjective. Furthermore, one would not be able to reduce the very act of experiencing to the content of that act; and conversely, reducing the content to the act would be equally impossible. To get a complete understanding of these modes of consciousness, we must consider both their subjective and objective perspectives individually.

The question now becomes: how does one go about considering each perspective separately? Husserl's answer is as follows. When we perceive, it is not the case that we take a picture of an object and then re-build this picture in our heads. Rather, through our embodiment<sup>1</sup>, we directly experience the very object as it is in the world. Our experiences, in this regard, extend outside of us; they are located in the world that we live in. Therefore, if we want to study the object of our experiences, then we study the world outside of us. However, this only affords us an understanding of the objective. If we want to understand the act of experiencing itself, then we must turn inwards to consider it subjectively. This is where phenomenology finds its place.

For the most part, what we mean when we speak of turning inwards is a reflection on our consciousness. One looks inside to an act of consciousness in much the same way as one would look outside to an object in the world; that is, we use a similar method for each. We do this because the methods used in understanding the objective world have allowed us to form certain notions about the world that have, in

---

1. Here, embodiment refers to our bodily interactions with our environment such that these interactions and ensuing experiences take place directly in the environment. Consequently, there is no need to abstract our mental states of experience away from the world in which we live.

turn, proven to be useful in our everyday lives. This default way of looking at the world is what Husserl refers to as the 'natural attitude'.

This attitude is grounded in the natural sciences and our use of these to explain the world around us. As such, it is an attitude that we unconsciously take. It is like a pair of glasses that we do not realize we are always wearing. So, when we turn inwards to introspect or reflect on our thoughts without removing these glasses, we see things through this natural attitude. Further, because this attitude is based in the objective world and our understanding of it, when we reflect within this attitude, we conduct an objectively framed reflection. That is, we do not fully consider the subjective in itself. However, if we want to consider the essence of the act of experience, then we must temporarily remove this attitude so as to be able to see the subjective without this objective filter. This crucial step is what Husserl refers to as the *epoché*, or the bracketing of the natural attitude.

As Dan Zahavi explains in his book entitled *Husserl's phenomenology*, when you perform this bracketing, you do not alter your current view of reality, instead you simply put your view towards reality on hold in order to consider things phenomenologically. Therefore, the acts of consciousness become the objects of reflection. As Bernet, Kern, and Marbach quote: "bare reflection - however carefully it may observe and analyze, however truly it may be directed toward my pure psychical life, toward the pure inwardness of my soul - remains *natural, psychological reflection* as long as it is without such a method [*epoché*]." <sup>2</sup>

This *epoché* is the initial, and crucial step in the phenomenological reduction. By this reduction, Husserl does not intend an elimination of something into another; instead, he intends a distinction between the experience in itself, and the object that forms the content of that experience. Consequently, this reduction is one that proves to be very difficult as it involves turning away from what comes naturally. That is, we are so accustomed to working within the natural attitude that it becomes very counter-intuitive to bracket this attitude. However, the importance of such a step is obvious when we consider that what is being observed in the phenomenological reduction is something that lies outside the natural, and as such, cannot be understood by the natural or any other objective method.

In fact, Husserl believes that in the end, phenomenology brings back into the picture everything that it at first brackets for methodological reasons. Because both the phenomenological method and natural methods consider the same thing, simply from two different perspectives, it becomes apparent that they inevitably should be considered together in order to provide a complete understanding of the subject as both subject and object in the world. Once again, as Bernet, Kern, and Marbach point out from Husserl's work: "Thus, "*transcendental science*" has "a totally different theme from all the objective sciences; [it] is separated from them and yet related to all of them as a correlate."<sup>3</sup>

---

2. Edmund Husserl *Logical Investigations*, 2d ed. 2 vols. Translated by J.N. Findlay (London and New York: 1977), quoted in Rudolf Bernet, Iso Kern, and Eduard Marbach, *An Introduction to Husserlian Phenomenology* (Evanston, Illinois: Northwestern Press, 1993), 61.

3. Rudolf Bernet, Iso Kern, and Eduard Marbach *An Introduction to Husserlian Phenomenology* (Evanston, Illinois: Northwestern Press, 1993), 64.

At this point, it is important to mention that, within the methodological framework that he has created, Husserl is firm in his belief that the phenomenological reduction cannot be naturalized. For Husserl, it is absurd to think that a method that requires one to move away from the standard objective view of the world could be naturalized in such a way as to be incorporated within this type of view. However, this does not deny the possibility that some natural aspects of our experiences are part of both the objective and the subjective.

Firstly, we must remember that embodiment is a crucial aspect to our acts of consciousness. It is not something that can be separated from such things as experience. Even after having bracketed the natural attitude, we find that embodiment is part of the essence of the mental act considered. Consequently, we see that embodiment transcends the objective and forms part of the subjective as well. As such, it affords a window into how something that is directly linked to the objective, namely the body, can be inextricably linked to the subjective. In addition, insights and data that phenomenology provides can, it is assumed, be correlated to the data that are uncovered through neuroscience. This is precisely where the neurophenomenological project seeks to build a bridge between the methods of phenomenology that afford an unbiased consideration of the acts of consciousness and the methods of neuroscience that afford a method by which to study the brain and its activity while certain acts of consciousness are happening. Further, forming this type of bridge is the heart of the naturalization project.

## **2. Neurophenomenology and the Naturalization Project**

Until very recently, most of the work done in the cognitive sciences was focused primarily on the workings of the brain. This same trend was also the focus of most theoretical work being done in philosophy of mind. From early computationalism, to functionalism, to reductionism, to epiphenomenalism, and most other theoretical trends of the time, the main working assumption was that the key to understanding the mind lied in understanding the workings of the brain. The mind, the subject, the first-person point-of-view were all things that were either pushed aside, ignored, or thought to be reducible to the brain. Computationalists looked for ways to create various programs to re-create the workings of the brain. Functionalists turned to an understanding of the brain in terms of functional networks. But none looked at the subject as a subject in the world. So, in most every case, there was always something missing in the account.

The shift in this theoretical tradition came when the embodied/enactive approach to the brain was introduced. Here, it was no longer about simply studying the brain; it was now crucial to consider the entire organism. The brain is not what interacts directly with the world, rather, it is the body. Further, all of our experiences, perceptions, sensations, etc. are acquired through an embodied interaction with the world. Therefore, if we want to understand the brain, we must also consider the body and our environmental interactions. As such, notions of linear causality no longer hold and a more dynamical approach must be considered. More simply, the body is affected by the environment in such a way that is a direct result of how it itself affects the environment. There is a mutual interaction and causality between the two. So, if we are to understand the brain, and the brain is an embodied entity involved in a dynamical relation with the world, then we must consider all

aspects of this relation as well. This is the very project of the embodied/enactive approach.<sup>4</sup>

“Let us explain what we mean by this phrase *embodied action*. By using the term *embodied* we mean to highlight two points: first, that cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context.”<sup>5</sup>

Therefore, simply considering the physical brain is not enough; we must also consider everything else that plays a part in who we are. However, herein lies a deep problem.

Recall the explanatory gap problem that was raised in the introduction to this paper. If we restrict our notion of physical to what we can study using our available scientific methods, then the body is a physical thing. The same goes for the environment. As such, both can be considered using physical theories. But the mind, insofar as we consider this to mean our thoughts, experiences, emotions, dreams, etc., is not something that has been clearly identified as physical. So we have a gap. “... what advocates of the explanatory argument complain about is that Cognitive Science is a theory of the cognitive mind that leaves out phenomenality or subjectivity, either because it does not attempt to account for it or because its efforts to do so have failed.”<sup>6</sup>

However, before pushing to create a theory that includes phenomenological data<sup>7</sup>, we must first consider whether or not it is even possible for a scientific theory to be linked to or incorporate this type of data. According to neurophenomenologists, this possibility is made real by way of Husserlian phenomenology. What better way to incorporate phenomenality than by the very method that allows for a rigorous evaluation of subjective consciousness. However, once again the question remains: how do you integrate a subjective methodology into an objective one? If the answer is to naturalize this phenomenological method, then what does it mean to do such a naturalization?

“By “naturalized” we mean integrated into an explanatory framework where every acceptable property is made continuous with the properties admitted by the

---

4. It is important to clarify that we are still working under a materialist assumption with regards to the mind. However, this is not an eliminativist or reductionist approach. The mind is something that can be considered in its own respect, however, it is causally and explanatorily dependent on the brain.

5. Francisco J. Varela, Evan Thompson, and Eleanor Rosch *The Embodied Mind, Cognitive Science and Human Experience* (Cambridge and London: The MIT Press, 1993) 173.

6. Jean Petitot, et al. ed. *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science* (Stanford: Stanford University Press, 1999) 10.

7. Phenomenological data is used here in the same way as Petitot et al. use it in the introduction to *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science*. That is, it refers to the contents of consciousness and experience.

natural sciences.”<sup>8</sup> The naturalization project is about more than simply finding parallels between phenomenology and neuroscience, it is an attempt to translate phenomenology into our natural language and in so doing incorporate the phenomenological subjective into a natural explanatory framework.

“... the heart of the problem of naturalization is to make intelligible the fact that one entity can have both the properties characteristic of matter and those characteristic of mentality in spite of an apparent heterogeneity between them. This problem can only be answered by making this heterogeneity vanish, and thus transforming in one way or another the characterization of the mental properties.”<sup>9</sup>

More simply put, the sciences allow us to take a certain type of picture of a given object, let us say a black & white picture. Phenomenology allows us to take a different type of picture of the same given object, let us say a color picture. Naturalization is an attempt to try to make use of both pictures in order to explain the object that is depicted. The only problem lies in finding a way to see how black & white and color pictures can relate to each other and work together in an explanatory way seeing that they use different mediums to get at the object.

There are three proposed methods that I wish to consider here. I have chosen these for two reasons. Firstly, they exemplify the diversity with which one can go about conducting a naturalization. Secondly, they show how even given this diversity, they all suffer from the same underlying problems that plague the fundamentals of naturalization. These underlying issues will be addressed in the following section. For the moment, let us consider the various methods of application proposed.

The first consideration is to turn to mathematics for a link between neuroscience and phenomenology. Roy, Petitot, Pachoud, and Varela see a unique and potentially fruitful possibility in the mathematization of phenomenological data as a way to bridge across the explanatory gap. As they explain:

“ ... when provided with adequate characterizations such as those conducted along the lines of Husserlian phenomenology, phenomenological data can be adequately reconstructed on the basis of the main tenets of Cognitive Science, and then integrated into the natural sciences. Naturalization is thus seen as including the three following stages:

1. Phenomenological data ----- > Husserlian description ----- >
2. mathematization ----- > algorithms ----- >
3. naturalistic account. “<sup>10</sup>

According to Roy, Petitot, Pachoud, and Varela, mathematics is the only link to connecting phenomenological data to natural data. As they claim, “ ... mathematics [...] alone is seen as capable of generating naturalistic implementable reconstructions

---

8. Jean Petitot, et al. eds. *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science* (Stanford: Stanford University Press, 1999) 1.

9. *Ibid.*, 46.

10. *Ibid.*, 48.

of phenomenological data.”<sup>11</sup> This is evident from the move between step 1 and step 2 above.

Another way to get at the problem of applying naturalization is given by Daniel Dennett in his heterophenomenological approach. Here, phenomenologists collect various subjective reports that are directly given to them by subjects as they self-reflect. This data is then categorized and analyzed in light of other data given for similar circumstances. The phenomenologist looks for inconsistencies or contradictions. If any occur, the guilty reports are disregarded. Once a clear and precise set of data has been refined, it can then be used in connection with the neurosciences in an effort to incorporate both into an explanatory framework. This is very similar to the idea of incorporating a second-person point-of-view between the first-person and third-person point-of-view reports. This second person acts as a translator in order to create a bridge from the subjective to the objective.

The third method proposes that naturalization be seen as providing constraints. In attempting to draw parallels between the biological data and the phenomenological data by giving priority to embodiment as something that is manifest in both aspects, one looks to each as either a validation or contradiction of the other in specific circumstances. One can then consider the types of relations that hold between both approaches and use these in directing future research. Consequently, the naturalization lies in the mutual constraints that arise between the phenomenological and the neurological. “[T]he nature of the circulation one seeks is no less than one of mutual *constraints* between both accounts, including the potential bridges and contradictions between them.”<sup>12</sup> These are just a few ways that have been proposed for the naturalization project. Although they appear to provide interesting options for neurophenomenology, I still find that they contain many fundamental problems. I will now turn to a consideration of these problems.

### 3. Problems with the Project

Although I do agree that cognitive science is taking a large step forward by attempting to integrate the subjective into their research of the objective, I nonetheless believe that the project of naturalization as it has been offered so far fails at achieving this goal. This failure stems from a few major difficulties. Firstly, by framing the issue in a Cartesian manner, neurophenomenologists have set things up for failure right from the start. Secondly, naturalization does not employ the same phenomenological method in practice as was set out by Husserl, that is, the very one which neurophenomenologists intended to use. Let me elaborate.

The first difficulty stems from framing the issue in a Cartesian manner. By considering the mind and the brain as two separate items that are linked or correlated together, neurophenomenologists have created more than simply an explanatory gap. They speak as if they are dealing with two items that each must be considered on their own terms and of how a method must then be found to bring the resulting research data together so as to gain a better understanding of how these two items interrelate. However, this is problematic. Although they may not be considering the

---

11. Ibid., 49.

12. Ibid., 67.

mind and the brain as two different substances, they are nonetheless considering them as two separate items and this is a recipe for disaster. The first-person subjective and the third-person objective are not in any way separate items; rather they are merely two different ways for us to be in the world. If we want to consider the mind and the brain to be one and the same thing, then we cannot continue to separate them in our research if we intend to make any progress. “The empirical subject and the transcendental subject are not two different subjects, but rather two different ways of conceiving one and the same subject.”<sup>13</sup> Furthermore, if we look at how things are in the world and how they appear to us in the world, we realize that nothing appears as purely objective. We are always either looking at things from our first-person perspective, or from a third-person perspective: in neither can the subject be removed. For example, if I am sitting in front of you having a cup of coffee, I look at myself from a first-person point-of-view, but I look at you from a third-person point-of-view. It is impossible for me to consider myself from the same point-of-view as you consider me. We cannot separate the body in the world from the mind that experiences it. However, it appears as though in order to move forward this dichotomy has, so far, been necessary.

“... a splitting of the physical (brain) and mental (consciousness) is a methodologically necessary presupposition for cognitive neuroscience. In order to find correlations between two things, one is forced to make this kind of split. [...] The methods of cognitive neuroscience, or any given science, are in a specific way because they are construed to answer questions that have been posed in a specific way. Thus, even basic methodologies of cognitive neuroscience are influenced by a theoretical split between “two objects in the world”.”<sup>14</sup>

I agree that we are dealing with two different perspectives of one thing, namely the living, embodied subject as considered by the subject himself/herself or as considered by other subjects. However, it is important to be careful not to detach one from the other when considering them in terms of research, as the consequences of such a move will be to create yet another problem that will need to be dealt with. It is crucial to keep this view in mind when considering how to incorporate phenomenology into neuroscience. The mind and the brain are simply two ways of getting at the same thing.

My next criticism pertains to the naturalizing of phenomenology. In finding a way to make phenomenology and the data that can be drawn from its methods fit into a neuroscientific framework, the naturalization project is forced to turn a blind eye to the most important and characteristic aspect of the phenomenological method; namely, the bracketing of the natural attitude. I argue that the phenomenological method that ends up being naturalized is not the same method set out by Husserl, the one that initially attracted neuroscientists. Further, I do not believe it to be a coincidence that the part of the Husserlian method that ends up being forgotten is the very part that insists that one resist the natural categorization of consciousness. In

---

13. Dan Zahavi, “Phenomenology and the project of naturalization,” *Phenomenology and the Cognitive Sciences* 3.4 (2004): 335.

14. Morten, Overgaard, “On the naturalising of phenomenology,” *Phenomenology and the Cognitive Sciences* 3.4 (2004): 367-8.

short, in order for neurophenomenology to work in the way that has been set-up so far, the *epoché* must be dropped from the phenomenological method.

In addition, Husserl claims to set out a method by which a subject can conduct a transcendental reduction in order to gain access to his/her transcendental ego; that is, his/her pure, essential, subjective consciousness. However, if we look closely at Husserl's phenomenology, we notice that there are no explicit rules that one must follow in order to accomplish such a feat. That is, his methodology is one that sets out the broad lines necessary to achieve a transcendental phenomenology, but there are no details available as to how each step must proceed. Consequently, without a clear method of application available, how can neurophenomenologists claim to be making use of such a method in their studies?

The problem is the following: we can all reflect to ourselves and consider what we are experiencing from a subjective point-of view, we do not need a precise methodology for this type of basic phenomenological introspection. However, this type of consideration will then be framed within the natural attitude. What makes Husserl's transcendental phenomenology so interesting is that it allows us to gain access to pure subjective consciousness, as removed from the natural framework. Therefore, if we do not have a method by which we can apply the transcendental reduction of bracketing the natural attitude, then what neurophenomenologists are dealing with is not phenomenological data as obtained by a transcendental reduction, but instead data obtained by a merely rigorous report of introspection. What we find ourselves with is phenomenological psychology, not transcendental phenomenology. Further, if we take a clear and precise look at the distinction Husserl makes between phenomenological psychology and transcendental phenomenology we see that the distinguishing feature is the use of the *epoché* in the latter method. However, the *epoché* is what makes a naturalization of transcendental phenomenology problematic as it explicitly rejects the natural. Therefore, it must be swept aside, and by a very swift slight of hand, this is precisely what neurophenomenologists do. They do not explicitly claim to be turning a blind eye to the *epoché*, but by not acknowledging the distinction between phenomenological psychology and transcendental phenomenology that is precisely what they are doing. Therefore, neurophenomenologists are not naturalizing transcendental Husserlian phenomenology, they are simply working with phenomenological psychology. "To put it differently, by abandoning the transcendental element of phenomenology the editors [Roy, Petitot, Pachoud, and Varela] might ease its naturalization, but the kind of phenomenology they end up with is a psychological form of phenomenology, it is not, and let me emphasize this, it is not phenomenology understood as a philosophical discipline, tradition, or method."<sup>15</sup>

Interestingly enough, even Husserl makes the following comment regarding the naturalization of the transcendental reduction in his *Cartesian Meditations* §57: "Every analysis and every theory of transcendental phenomenology - [...] - can be developed at the natural level, by simply abandoning the transcendental attitude." Thereby turning the analysis into one that is not transcendental, but merely descriptive; and this could already be found in psychology, or introspection, or any other current form of scientifically framed consideration of consciousness. What is new about that?

---

15. Dan Zahavi, "Phenomenology and the project of naturalization," *Phenomenology and the Cognitive Sciences* 3.4 (2004): 340.

Given all this, however, I am still not ready to abandon the neurophenomenological project. I think it is a step in the right direction and if we were to work with the idea and flesh it out, we may come to something very fruitful. I do see two possible solutions to the aforementioned problems. Firstly, it is important to be clear on what aspects of phenomenology we are aiming to naturalize. We can either attempt to naturalize the method, or the data that the method provides after being applied. By naturalizing the method we found that we had to eliminate the most important part of it, namely the *epoché*. Therefore, we may want to try naturalizing the results of phenomenological research instead. What this means is that we allow a person to conduct a transcendental reduction and report what they encounter. We then take these reports and try to naturalize them in such a way as to make them compatible, in terms of language, with the data gained through neuroscientific research. The details of such a process remain to be developed, however, I suggest that the focus of naturalization be put on the data and not the method. Further, as mentioned earlier, we do not have any detailed methods that would allow us to perform the transcendental reduction. As such, it would be essential that such methods be developed so as to bring the methodological rigorosity that we see in neuroscience into phenomenological methodology and, in turn, facilitate the bridging of the resulting data from both sides. This methodological incompleteness is something that Roy, Petitot, Pachoud, and Varela acknowledge and I must credit them for their work to resolve it. They are involved in the much-needed development of a clearly elaborated method for the application of the *epoché* so as to be able to make use of it in the future. "... what is sorely needed is a method that receives both (1) a sustained effort to theorize it [*epoché*] and (2) an explicit prescription for its cultivation and training over time."<sup>16</sup>

Most fundamental, however, is the importance of not forgetting that we are dealing with one and the same thing when we try to reconcile phenomenology with neuroscience. We must look at the mind and the brain as two sides to a coin, the very link between them is the fact that together they make up the person.

#### 4. In Closing

The above considerations are merely the tip of an immense iceberg that has yet to even be categorized, let alone detailed. As such, we must continue to question and push these ideas in order to develop stronger research methodologies that will allow us to access parts of the mind and the brain that we have never been able to consider before. As I mentioned a few times throughout this paper, I truly believe that the neurophenomenological approach is one that opens many interesting new doors and that its invitation to find a way to include rigorous continental methodologies for considering phenomenological data is something that has been sorely missing in cognitive science up until today.

---

16. Jean Petitot, et al. eds. *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science* (Stanford: Stanford University Press, 1999) 74.

### ***Selected Bibliography***

- Bayne, Tim. "Closing the gap? Some questions for neurophenomenology." *Phenomenology and the Cognitive Sciences* 3.1 (2004): 1-16.
- Bernet, Rudolf, Iso Kern, and Eduard Marbach. *An Introduction to Husserlian Phenomenology*. Evanston, Illinois: Northwestern University Press, 1993.
- Dennett, Daniel C. *Brainstorms: Philosophical Essays on Mind and Psychology*. Cambridge and London: The MIT Press, 1981.
- Husserl, Edmund. *Cartesian Meditations: An Introduction to Phenomenology*. Translated by Dorion Cairns. The Hague M. Nijhoff, 1973.
- Legros, Robert. "La critique husserlienne des theories naturelles de la connaissance." In *L'intentionnalité en question: entre phénoménologie et recherches cognitives*, edited by Dominique Janichaud. Paris: Librairie Philosophique J. Vrin, 1995.
- Overgaard, Morten. "On the naturalising of phenomenology." *Phenomenology and the Cognitive Sciences* 3.4 (2004): 365-379.
- Petitot, Jean, et al. eds. *Naturalizing Phenomenology: Issues in Contemporary Phenomenology and Cognitive Science*. Stanford: Stanford University Press, 1999.
- Sartre, Jean-Paul. *The Imaginary, A phenomenological psychology of the imagination*. London and New York: Routledge Taylor and Francis Group, 2004.
- Varela, Francisco J., Evan Thompson, and Eleanor Rosch. *The Embodied Mind, Cognitive Science and Human Experience*. Cambridge and London: The MIT Press, 1993.
- Zahavi, Dan. *Husserl's phenomenology*. Stanford: Stanford University Press, 2003.
- Zahavi, Dan. "Phenomenology and the project of naturalization." *Phenomenology and the Cognitive Sciences* 3.4 (2004): 331-347.

# A Defence of Fodor's Informational Atomism

Octavian, Ion  
Concordia University, Montreal (Canada)

## Introduction

The purpose of this paper is to examine two foundational cognitive science issues, namely conceptual error and concept acquisition. Both of these issues need to be accounted for by any acceptable representational theory of cognition, which aims to explain behaviours such as inference, decision, etc. In the first part of the paper, we will describe two current theories of misrepresentation, Jerry Fodor's concept atomism account of error and Jesse Prinz's concept empiricism account. Both of these accounts are informational. Informational semantics is a theory according to which the relationship between a concept and what it picks out is best explained in terms of nomological covariance between the relata. It is argued that Fodor's account is the more favourable candidate of the two.

In the second part of the paper, we look at a puzzle which arises from Fodor's atomist account of concepts. According to the puzzle, Fodor's commitment to atomism also commits him to the implausible view that all concepts are innate. A solution to the nativism puzzle is put forward, which appeals to the evolutionary development of our cognitive capacities.

## 1. Misrepresentation

In order for a theory of concepts to explain how concepts manage to properly refer to their intentional objects, it must also provide an account of how mistakes are made in this process. Without such an account, there is no way to discriminate between proper and improper function of concepts. Outside of the informational semantics framework, for example in the definitionist conceptual model, misrepresentation can be explained simply in terms of failure to apply definitions correctly. However, on the informational semantics model, error cannot be explained in terms of a failure to meet necessary and sufficient conditions for concept application. This is because the relationship between a concept and its referent is wholly determined by the nomological covariance of the dyad. In this section we will examine Fodor's and Prinz's solutions to misrepresentation and evaluate them on the basis of some actual and possible counterarguments.

### 1.1. *Fodor's account:*

Fodor's solution to the problem of misrepresentation involves the use of counterfactuals. For Fodor, misrepresentation is asymmetrically dependent on accurate representation. To illustrate how this works, let us assume that someone has a concept *X* which reliably tracks the presence of instances of *x* in usual circumstances, but that this concept is erroneously tokened

on some occasions by instances of  $y$ , which are mistaken for  $x$ <sup>17</sup>. According to informational semantics, if  $y$  instances reliably cause the tokening of  $X$ , then such tokenings are not erroneous, since after all, informational semantics defines reference in terms of reliable correlations between concepts and events. The problem then, is that reliable correlations are not sufficient for establishing what is a correct tokening of a concept and what is a false tokening. Fodor's solution involves adding two extra conditions on correct tokening of a concept: Using the assumptions mentioned above, the difference between an accurate and an erroneous representation of the object  $x$  is that misrepresentation relies or depends on accurate representation of  $x$  and not vice versa. The following two counterfactuals ensure proper representation:

1. If  $x$ 's would not cause tokens of  $X$ , neither would  $y$ 's.
2. If  $y$ 's would not cause tokens of  $X$ ,  $x$ 's still would. (Fodor 1987, 109)

Having set up Fodor's theory of misrepresentation, we want to consider some of Prinz's arguments against his theory. Prinz believes that Fodor's asymmetric dependence account suffers from an incapacity to deal with error in the case of wild causes, Twin Earth causes, and Earth Bound Twin cases. (Prinz, 249) We will only consider the wild cause scenarios, pointing out the infelicity in Prinz's counterargument.

To begin with, let us consider wild causes. A wild cause refers to a situation where the error of misrepresenting an object is due to the fact that perception is impeded by sub-optimal conditions, and given optimal conditions, such an error would not occur. The problem Prinz finds in Fodor's account is that, following a standard policy in counterfactual analysis, the counterfactuals required to establish the asymmetric dependence relation are problematic. The problem is raised by the fact that the two clauses which together establish that dependence can contradict each other. To use an example, let us say that we make the mistake of taking an apple to be an orange. In order to establish the error, asymmetric dependence requires that the following two statements be true:

1. If apples did not cause tokens of the APPLE concept, oranges would not either.
2. If oranges did not cause tokens of the APPLE concept, apples still would.

The standard policy that Prinz alludes to requires that we consider the most proximate possible worlds in which the antecedents of these statements are true. According to Prinz, the first and second statements' antecedents come out true if either someone doesn't have the concept APPLE at all or if oranges did not resemble apples. Prinz believes that the first of these requires a smaller departure from the actual world than the second. The contradiction that is raised in such cases is that the proximate possible worlds in which the first statement's antecedent is true are also the proximate possible worlds in which the second statement is false. If this analysis of the two statements is viable then the asymmetric dependence relation breaks down and so does Fodor's solution to wild cause errors. (Prinz 274)

The problem with Prinz's argument is one that he himself considers in a footnote to his argument. There he admits that "some might think that worlds in which I have a different conceptual repertoire cannot be used to evaluate asymmetric dependence relations." (Prinz 323) It seems quite obvious that this is the case, after all, how can one's use of the concept ORANGE require for its analysis only worlds in which she doesn't have the concept? Nevertheless, Prinz believes that this critique can be accommodated if, instead of worlds where the person in question doesn't have the concept ORANGE, we consider worlds where the

---

<sup>17</sup> Lowercase variables refer to objects, while uppercase variables refer to concepts.

“psychophysical laws relating (oranges) to tokens of (ORANGE) are different.” (Prinz 323) But if this is done, then it is no longer obvious whether worlds in which psychophysical laws are different are closer to the actual world than worlds in which a mere fact (viz. the appearance of oranges) is different. Moreover, changing the psychophysical laws that exist between the person and the orange has an impact on their conceptual repertoire. If the psychophysical laws, which ensure that the person is reliably informed about the presence of oranges, are changed, then their conceptual repertoire is changed as well, since concepts result from psychophysical interactions with the things in the world. This entails that the move towards talking about changes in psychophysical laws is a red herring. Both of the options that Prinz considers involve making changes to the person’s conceptual repertoire, and that brings us right back to his initial implausible argument according to which a concept’s use must be analysed in terms of worlds where that concept is lacking from one’s repertoire. In its present forms at least, Prinz’s argument is not a convincing refutation of Fodor’s treatment of wild causes.

### 1.2. *Prinz’s account:*

For his account of misrepresentation, Prinz adopts a refined version of Dretske’s learning period approach. This approach considers accurate representation to consist in situations when the concepts people possess refer to things to which they referred during the learning period in which they were acquired. Misrepresentation takes place after the learning period is over, when the previously established correlations between the concepts and their referents break down. For Prinz, in contradistinction to Dretske, “the intentional content of a concept is the class of things to which the object(s) that caused the original creation of that concept belong.” (Prinz, 250) He calls the class of objects that caused the original creation of a concept its incipient cause. By defining misrepresentation as a tokening of a concept caused by something that is not the incipient cause of that concept, wild causes are precluded from being considered accurate representations.

Our criticism of this account of error is internal to Prinz’s conceptual empiricism. For Prinz, a concept is a stored perceptual representation composed of features (e.g. a particular type of flower has a particular colour, fragrance and shape). This perceptual representation is called a proxytype. The proxytype that is stored in memory upon an encounter with a particular kind becomes a detection mechanism for things of that kind, and Prinz equates concepts with detection mechanisms. Now, the criticism of wild causes that we want to offer is one that Prinz himself considers. He claims,

Suppose that I acquire a concept on the basis of experiences with Xs, and after that, I never apply it to Xs again, but only to Ys, which are superficially similar to Xs. The etiological constraint of my theory commits me to the claim that this concept refers to Xs and not Ys, despite the fact that I only apply it to Ys. To some ears, this sounds untenable. (Prinz 252)

The trouble with this type of situation is that incipient causes seem to do very little for a theory of concepts which holds concepts to be detection mechanisms. If it is true that the incipient cause is formative of the detection mechanism in the first place, it seems that errors at this level are also formative of failure to detect well. If the incipient cause of someone’s DOG concept is a poodle, then that presets the DOG concept as a poodle-detecting mechanism. If, afterwards, the person learns that Labradors and Chihuahuas are dogs too, then each of these becomes an incipient cause for the revised concept DOG. But if this is the case then the

extension of the concept DOG is not determined by the incipient cause but rather by all the previous, present and future incipient causes that the person encounters. A lot of concepts seem to be derived from multiple formative (or incipient) causes. If, looking at a magazine, we discover the concept CAR by seeing a variety of different ones, which one becomes the reference-determining one becomes arbitrary. The basic gist of the criticism we're putting forward is that concepts are too multifaceted to be determined merely by their incipient causes. An incipient cause is a stored representation that becomes a detection mechanism for things that are sufficiently similar to it. However, if this is the case, we don't have incipient causes as formative of concepts such as DOG or CAR, but only of 1967 Chevy Classic and Labrador. To go further, as Prinz seems to want to do, he needs to specify what the principle of individuation is by which sufficient similarity is established.

## 2. Acquisition

In *The Language of Thought*, Fodor famously argued for radical concept nativism by suggesting that all of our primitive lexical concepts are innate. The argument for his surprising conclusion might be termed the **Radical Concept Nativism Puzzle**. In what follows, we will offer an evolutionary solution to this puzzle.

In a recent paper, Laurence and Margolis argued that there is a genuine concept acquisition puzzle that drove Fodor to his conclusion. Here it is:

1. Apart from miracles of futuristic super-science all concepts are either learned or innate.
2. If they're learned, they are acquired by hypothesis testing.
3. If they're acquired by (non-trivial) hypothesis testing, they're structured.
2. Lexical concepts are not structured.
3. So lexical concepts aren't acquired by hypothesis testing.
4. So lexical concepts aren't learned.
5. Therefore, lexical concepts are innate.

The thought that lies behind the third premise is that in typical cases of concept learning, the experimenter has a concept in mind and the subject is asked to sort objects in terms of whether they exhibit the novel concept's name, say, a flurg. The subject subsequently frames inductive hypotheses concerning the objects and might decide that a flurg is a circle and only later discover that flurges possess the individuating conditions of objects that are, in fact, green. But if this is the case, Fodor notes, then the subject is not learning what a flurg is at all, since the subject already possesses the concept green. An alternative that Fodor points out is to conclude that concept learning involves complex concepts. The result is that genuine learning can take place since the complex concept was not represented in the evidential base, but assembled out of primitive constituent concepts. According to Fodor, the sort of structure found in such complex concepts is definitional structure. But the history of lexical concepts is that they are not characterizable in terms of necessary and sufficient conditions. That is, there are few, if any, definitions. Second,

non-definitional accounts of internal structure, such as Prototype Theory, fail because their constituents fail to compose. According to Prototype Theory, concepts have statistical structure. Hence, complex concept A has prototype structure if its constituents express properties that things that fall under A tend to have. Take the complex concept “Pet Fish,” say a goldfish. Its constituents, Pet and Fish have prototypes, dog and trout, that do not produce the goldfish prototype. Hence, a prototype theory of complex conceptual structure fails to satisfy the compositionality constraint, a constraint that Fodor has repeatedly, and - we think - persuasively, claimed is nonnegotiable for any adequate theory of concepts. It follows that lexical concepts are not learned by virtue of their structure because concepts have no structure. If that is so, then all lexical concepts are not acquired by hypothesis-testing and so they are not learned but innate. That is the concept acquisition puzzle that leads Fodor to conclude that all lexical concepts are innate. The argument is plausible, yet the conclusion is deeply counterintuitive. More recently, Fodor himself has backed off radical concept nativism in **Concepts**.

Adaptive courses of action can be neither deduced nor learned by general criteria, because they depend on statistical relationships between features of the environment, behavior, and fitness that emerge over many generations and are, therefore, not observable during a single lifetime. (Cosmides and Tooby 1994, 90)

For instance, determining that it is a good thing to hunt in the south valley because there is a statistically good chance that lots of prey will be there is a fact that evolution, but not learning, will respond to. Nevertheless, we acquire PERCEPTUAL KINDS in order that they will work alongside an evolutionarily selected for hunting module. We possess an innate predisposition to avoid snakes and the PERCEPTUAL KINDS, e.g., ‘long,’ that help us to identify snakes are made possible by the shape bias. The prototypical snake emerges as a generalization of the statistical data that our ancestors faced. Prototypes represent the results of categorization strategies developed to aid our ancestors in flight and fight. As such, these perceptual cues are acquired as perceptually primitive concepts necessary for the fulfillment of the proper function of our innate modules. But this story will not work since prototypes do not compose. Something else is needed; namely, natural kind terms, since they do compose. WHITE DOG is constructed out of the perceptual kind WHITE and the natural kind DOG. But why do humans possess an essentialist predisposition? It is a fact that young children expect objects to have insides that are constitutive of what that object is. Our suggestion is that such a disposition is an evolutionary adaptation that has a function, just as all naturally selected modules do. Acquiring good clean water and the natural kind term ‘water’ is a biological imperative where reproduction, the goal of natural selection, and its necessary precondition, survival, are at issue. Hence, while prototypes do not compose, natural kind terms succeed. On our view, Natural kind terms and Perceptual Kind Terms are acquired as the result of innate mechanisms. If that is true, we do not learn natural kind terms or Perceptual Kind Terms and so there is no inductivist circularity objection to face from Fodor. But such natural kind and perceptual kind terms are not “strictly speaking” innate either; rather, the concepts that natural kind terms token are acquired as a contingent consequence of innate predispositions, such as the essentialist and space bias. In this minimal sense, such terms are innate, call this “Minimal Nativism.” Secondly, there is no problem about

natural kind terms or perceptual kind terms being compositional as with other theories. Finally, it should say that we do not acquire natural kind terms or perceptual kind terms as such, i.e., only in a rich theoretical context, but only natural kind and perceptual kind terms. We do not require a sophisticated theoretical picture in order to grasp natural kind or perceptual kind terms. This view might be called “Place-Holder Essentialism” because natural kind terms have no structure, they are informationally atomic. That is why it is possible to track such kinds without benefit of theory, we lock to natural kinds by virtue of innate mechanisms and perceptual kinds. And, those perceptual kinds are themselves informationally atomic. If we are right, one can have one’s natural kinds ala Laurence and Margolis without learning (and its attendant Fodorian learning problem) and still retain informationally atomic natural kinds (contra Fodor). The real source of natural kind terms is the need to be sure that the object one sees is friend not foe, food not poison, and so forth. Hence, the snake response module, the natural kind term SNAKE, and perceptual kind terms used to identify snakes such as ‘long,’ ‘round,’ and ‘thin,’ developed to avoid the essential property POISONOUS that is partly constitutive of the snakes for which the snake response module was selected for. The search for natural kinds and perceptual kind terms is essential to the proper functioning of many modules because one needs to avoid predators. Laurence and Margolis are correct: one needs to avoid FAKES and the best way to ensure that is to be able to reliably identify natural kinds in one’s environment. Identification abilities are essential for all species.

### **References**

Adams, F. and Clarke, M. 2005. “Resurrecting the Tracking Theories,” **Australasian Journal of Philosophy**, 83 (2): 207-221.

Bekoff, M. and Lauder, G., editors. 1998. **Nature’s Purposes: Analyses of Function and Design in Biology**. Cambridge, Mass., The MIT Press.

Clarke, Murray. 2004. *Reconstructing Reason and Representation*. Cambridge, Mass.: The MIT Press.

Cosmides, L. and Tooby, J. 1994. “Origins of Domain-Specificity: The Evolution of Functional Organization.” In Hirshfield and Gelman(1994), 85-116.

----- 1995. Foreword to Baron-Cohen. 1995.

Dretske, F. 1986. “Misrepresentation,” in Bogdan, 1986, 17-36.

Fodor, Jerry. 1975. *The Language of Thought*. Cambridge, Mass.: The MIT Press.

----- 1987. *Psychosemantics*. Cambridge, Mass.: The MIT Press.

----- 1998. *Concepts: Where Cognitive Science Went Wrong*. New York: Oxford University Press.

Hirshfield,L., and Gelman, S., editors, 1994. *Mapping the Mind: Domain-Specificity in Cognition and Culture*. Cambridge: Cambridge University Press.

- Laurence, S. and Margolis, E. 2002. "Radical Concept Nativism," *Cognition* 86:25-55.
- LePore, E. and Pylyshyn, Z. 1998. *Rutgers Invitation to Cognitive Science*. Oxford: Blackwell.
- Margolis, E. 1999. "How to Acquire a Concept," in *Concepts: Core Readings*, edited by Margolis E. and Laurence, S., 549-568.
- Margolis, E. and Laurence, S, editors. 1999. *Concepts: Core Readings*. Cambridge, Mass.: The MIT Press.
- Prinz, J. 2002. *Furnishing the Mind*. Cambridge, Mass: The MIT Press.
- Samuels, R., Stich, S., and Tremoulet, P. 1998. "Rethinking Rationality: From Bleak Implications to Darwinian Modules." In LePore and Pylyshyn, 1998, 130-160.
- Wright, L. 1998. "Functions." In M.Bekoff and G.Lauder, eds., *Nature's Purposes: Analyses of Function and Design in Biology*. Cambridge, Mass.: The MIT Press.

# Reconnaissance et sémantique des objets : approches comportementale et électrophysiologique de la modalité de présentation et de la catégorie sémantique

Karima Kahlaoui<sup>1,3</sup>, Thierry Baccino<sup>2</sup>, Yves Joanette<sup>1,3</sup>, & Marie-Noële Magnié<sup>4</sup>

<sup>1</sup>Centre de Recherche, Institut universitaire de gériatrie de Montréal, Canada

<sup>2</sup>Laboratoire de Psychologie Expérimentale, Université de Nice-Sophia Antipolis, France

<sup>3</sup>Faculté de Médecine, Université de Montréal, Canada

<sup>4</sup>Laboratoire de Physiologie, Université de Nice-Sophia Antipolis, France

## I. Problématique

### I.1. Introduction

L'étude des processus cognitifs impliqués dans la reconnaissance visuelle des objets a suscité un intérêt considérable ces dix dernières années. Ces processus ont un impact important sur notre vie quotidienne puisque nombre des interactions avec l'environnement impliquent des objets. Face aux signes de l'environnement, l'être humain a développé ses propres systèmes de signe : le symbolisme imagé et le langage. Ces représentations externes sont à la base de nos apprentissages à la fois en tant qu'objet (i.e., il faut apprendre à les identifier) et en tant que médiateurs (i.e., ils véhiculent du sens). Nos connaissances sur l'objet doivent donc pouvoir être évoquées que l'objet soit présenté physiquement ou que son nom soit évoqué. Mais comment ces connaissances sont-elles stockées et organisées ? Prenons quelques exemples : que représente pour vous l'image d'une pomme ? Que représente l'image d'une girafe ? Quelle est la date de Noël ? Quelle est la capitale de la France ? Sans doute pouvez-vous répondre assez rapidement à la plupart des ces questions qui représentent une petite quantité seulement de l'énorme masse d'informations que nous possédons tous et dont une grande partie nous est accessible rapidement et sans effort. Tout comme il existe une diversité de langues et d'individus, il existe également différentes mémoires et cette connaissance que nous avons sur le monde est stockée dans une partie de notre mémoire : la « mémoire sémantique ».

## I.2. La mémoire sémantique

C'est Tulving qui, en 1972, définit pour la première fois la mémoire sémantique en l'opposant à la mémoire épisodique. Contrairement à la mémoire épisodique qui stocke des informations portant sur des événements dans un contexte spatio-temporel donné, la mémoire sémantique contient des informations indépendamment de leur contexte d'acquisition. Selon cet auteur, la mémoire sémantique est un *thesaurus mental* contenant le savoir organisé qu'un individu possède pour les mots, les autres symboles verbaux, leurs significations et leurs référents, leurs relations et les règles, formules, algorithmes pour la manipulation de ces symboles. C'est un système mnésique qui n'enregistre pas les propriétés perceptives des stimuli mais plutôt les référents cognitifs des signaux d'entrée. Très vite cette définition est contestée par Warrington (1975) qui estime que le concept de mémoire sémantique doit s'appliquer à l'objet lui-même. Contrairement à Tulving, elle considère que la mémoire sémantique comporte un double *thesaurus* : un *thesaurus verbal* qui contient l'information sémantique concernant l'objet et son nom et un *thesaurus visuel* qui contient l'information sémantique concernant l'objet et son image. Ces deux conceptions illustrent l'opposition toujours actuelle entre une mémoire sémantique composée de multiples systèmes et une mémoire sémantique unique et amodale.

## I.3. La catégorisation sémantique

A cette controverse concernant l'organisation des représentations sémantiques en mémoire vient s'ajouter un autre débat, étroitement lié au précédent, concernant cette fois-ci l'accès et/ou l'organisation des connaissances sémantiques sur les objets en fonction de leur catégorie sémantique (i.e., objets biologiques : animaux, fruits et légumes, etc. *versus* objets manufacturés : instruments de musique, outils, etc.). Depuis l'Antiquité, l'organisation des connaissances sémantiques fait l'objet de nombreuses hypothèses. Les recherches entreprises jusqu'à présent ont essayé de déterminer, en particulier, comment les informations sont stockées les unes par rapport aux autres.

L'organisation des connaissances en mémoire sémantique implique un processus de « catégorisation » permettant de faire émerger les concepts et de regrouper les exemplaires en catégories. Selon Collins et Loftus (1975), les connaissances sémantiques sont organisées en un ensemble de concepts liés les uns aux autres pour former un maillage ou réseau sémantique. Les auteurs ont développé un modèle de la propagation automatique de l'activation sémantique correspondant à un réseau complexe de nœuds conceptuels connectés les uns aux autres via des liens de forces et de distances variables. Les concepts seraient susceptibles de s'activer réciproquement en fonction de l'étroitesse de leurs liens, c'est-à-dire de leur proximité sémantique qui se caractérise principalement par le nombre de traits sémantiques partagés et qui permet ainsi le groupement en catégories.

Les catégories sont organisées hiérarchiquement de façon paradigmatique et définies par les traits sémantiques les plus généraux partagés par ses exemplaires (par exemple, « animal » est la catégorie super-ordonnée de la hiérarchie Mammifère -

Félin - Chat - Siamois). Rosch (1975) propose d'organiser les catégories en trois niveaux : niveau super-ordonné, niveau de base et niveau subordonné. Par exemple, pour le niveau de base fauteuil, meuble représente le niveau super-ordonné et fauteuil Louis Philippe le niveau subordonné. Le niveau de base est le niveau privilégié car il n'est ni trop spécifique, ni trop général. Il correspond à la quantité optimale d'informations permettant la discrimination entre les items. Certains d'entre eux ayant une grande accessibilité, ces « meilleurs représentants » de la catégorie sont dits prototypes. Les autres items entretiennent avec le prototype des relations de ressemblance qualifiées par le terme de typicalité. En d'autres termes, lorsque l'on demande à une personne de produire le plus grand nombre de noms de fruits, les fruits les plus souvent cités en début de séquence sont « pomme » et « poire » qui apparaissent dès lors comme des prototypes de la catégorie fruit. Parmi les fruits, « pêche », « banane » et « cerise » sont considérés comme typiques comparés à « jujube », « nêfle » ou « arbouze ».

#### **1.4. Les catégories sémantiques**

Les études de cas en neuropsychologie clinique ont apporté des arguments en faveur de dichotomies au sein des catégories sémantiques. En particulier, les auteurs ont observé des atteintes sélectives de la reconnaissance d'objets appartenant à certaines catégories sémantiques chez des patients présentant une encéphalite herpétique ou une anoxie cérébrale. Classiquement, ces déficits spécifiques se manifestent par une atteinte de la reconnaissance des objets biologiques (e.g., animaux, fruits, légumes) alors que celle des objets manufacturés (e.g., outils, meubles, ustensiles de cuisine) est relativement préservée (pour une revue, voir Shelton & Caramazza, 1999). La dissociation inverse est plus rare mais il est néanmoins important de souligner que cette double dissociation existe. Chez ces patients, la reconnaissance des objets manufacturés est sélectivement déficitaire alors que celle des objets biologiques est relativement préservée (Cappa et coll., 1998; Hillis & Caramazza, 1991).

Ces dichotomies rapportées dans la littérature ont donné lieu à plusieurs interprétations. Selon Warrington et McCarthy (1987), les attributs perceptifs sont critiques pour la reconnaissance des objets biologiques alors que les attributs fonctionnels sont prépondérants pour reconnaître les objets manufacturés. Pour Humphreys, Riddoch et Quilan (1988), un déficit sélectif de la reconnaissance des objets biologiques peut être attribué à l'effet de similarité structurale intra-catégorielle plus importante pour les objets biologiques que pour les objets manufacturés. De ce fait, un déficit de la reconnaissance des objets biologiques semble résulter d'une difficulté variable du traitement perceptif selon la catégorie sémantique. Vitkovitch, Humphreys et Llyold-Jones (1993) ont réalisé une expérience de dénomination d'objets sous contrainte de temps dans le but de favoriser les erreurs. Les auteurs constatent une prédominance des erreurs de dénomination pour les objets provenant de catégories ayant un degré élevé de similarité structurale intracatégorielle (e.g., les animaux) par rapport aux catégories dans lesquelles les objets sont peu similaires entre eux (e.g., les moyens de transports). Ces résultats suggèrent qu'un objet, appartenant à une catégorie dans laquelle la similarité entre les objets est élevée, active sa propre représentation structurale ainsi que celle des objets structurellement similaires. D'autres études, réalisées en mesurant le temps de

réaction, ont montré qu'il est plus difficile de décider que deux objets appartiennent à des catégories sémantiques différentes lorsqu'ils sont structurellement similaires que lorsqu'ils sont structurellement différents (Job, Rumiatti & Lotto, 1992; Snodgrass & McCullough, 1986). De façon similaire, le temps pour décider que deux objets appartiennent à la même catégorie sémantique est plus court si les objets sont similaires par leur forme (pomme et orange) que s'ils ont une forme différente (pomme et banane) (Walls & Siples, 1987).

En résumé, l'organisation des connaissances sémantiques en mémoire a fait l'objet d'un nombre considérable de travaux. Les recherches en neuropsychologie clinique ont mis en évidence une dichotomie de spécificité catégorielle (objet biologique *versus* objet manufacturé) soulignant ainsi l'importance d'étudier l'accès aux connaissances sur l'objet en fonction de la catégorie sémantique.

### 1.5. Modalité de présentation

Comme nous l'avons souligné pour introduire cet article, nos connaissances sur l'objet doivent pouvoir être évoqués que l'objet soit présenté sous la forme d'un dessin ou d'un mot. Cependant l'accès aux connaissances sur l'objet est-il similaire lorsque celui-ci est présenté sous la forme d'une image et/ou d'un mot ? Où vont se loger l'image et le mot dans le cerveau ? Comment une image et un mot sont-ils traités dans le cerveau ? Il est important de répondre à ces questions car face à l'essor du multimédia, de l'Internet et de l'audiovisuel, nous nous trouvons confrontés chaque jour à une multitude de perceptions rapides qu'il nous faut comprendre dans l'instant.

On sait depuis longtemps qu'il existe un effet de la modalité de présentation<sup>18</sup>. Dès 1886, Cattell a mis en évidence un effet de la modalité de présentation. Il a montré que la lecture du nom d'un objet est toujours plus rapide que sa dénomination à partir d'une image. A l'inverse, le temps de réponse est plus rapide pour une image que pour un mot lors d'une tâche de catégorisation sémantique (e.g., Riddoch & Humphreys, 1987).

Pour appréhender l'organisation du système sémantique, un nombre considérable d'études a porté sur la comparaison entre le traitement des images et des mots soulignant à la fois les similitudes et les différences entre ces deux types de modalité. Nombreuses sont les études qui ont été réalisées par l'intermédiaire du paradigme d'amorçage sémantique. Plus précisément, ce paradigme expérimental permet d'étudier l'organisation des informations en mémoire sémantique. Pour ce type de paradigme, un essai est basé sur la succession de deux événements : la présentation d'un item amorce qui définit un contexte sémantique et pour lequel aucune réponse n'est fournie, suivie par la présentation d'un second item, la cible, sur laquelle il est demandé au sujet de donner une réponse. L'effet d'amorçage sémantique peut être mesuré dans différentes tâches expérimentales. En règle générale, le traitement d'un mot cible est facilité par la présentation préalable d'un

---

<sup>18</sup> La modalité de présentation renvoie ici soit à une image d'objet, soit à un mot écrit.

mot amorce qui lui est sémantiquement lié : les sujets sont plus rapides à décider que la suite de caractères « beurre » forme un mot lorsque celle-ci est précédée du mot « pain » que du mot « bois ». Les effets d'amorçage entre mots écrits ont fait l'objet de nombreuses publications (pour une revue, voir Neely, 1991).

## **1.6. Méthodes d'études de la mémoire et des représentations sémantiques**

L'approche expérimentale en psychologie fait appel à diverses méthodes pour explorer le fonctionnement cognitif des sujets neurologiquement sains. Dans le cadre de nos recherches, nous avons choisi d'utiliser deux approches complémentaires pour explorer les processus sous-jacents à la reconnaissance visuelle des objets : l'approche comportementale et l'approche électrophysiologique.

### **1.6.1. L'approche comportementale**

De manière générale, les expériences comportementales classiques mesurent un temps de réaction (TR). Cette technique de chronométrie mentale permet d'appréhender la durée d'une opération mentale. Plus précisément, le TR correspond à la durée de l'ensemble des étapes de traitement mis en jeu dans une tâche donnée depuis l'étape perceptrice la plus précoce jusqu'à l'étape motrice finale.

De manière générale, les études comportementales, réalisées avec un paradigme d'amorçage sémantique, ont été entreprises selon deux axes : d'une part, en condition intra-modale, les auteurs ne s'intéressant qu'à une seule modalité de présentation (i.e., image-image versus mot-mot) et d'autre part, en condition inter-modale, les auteurs étudiant simultanément l'effet des deux types de modalité (image-mot versus mot-image). En condition intra-modale, le temps de lecture du mot est plus court que celui de dénomination de l'image alors que le temps de catégorisation de l'image est plus court que celui du mot (Glaser, 1992 ; Seifert, 1997). Cette asymétrie de performance peut s'expliquer par la différence de similarité structurale intra-catégorielle entre les images et les mots. La similarité intra-catégorielle, plus importante pour les images que pour les mots, facilite la catégorisation sémantique et, au contraire, ralentit la dénomination (Glaser & Glaser, 1989). En condition inter-modale, la présentation d'une amorce verbale améliore le temps de dénomination et de catégorisation de l'image tandis qu'une amorce imagée ne modifie pas de façon significative le temps de lecture et de catégorisation du mot (Durso & Johnson, 1979). D'autres travaux ont comparé la mémorisation des images et des mots. Ces derniers sont en faveur d'un accès sémantique plus rapide à partir des images que des mots. Pour rendre compte de la supériorité de l'image sur le mot, Paivio (1991) a élaboré la théorie du double codage : les images impliqueraient systématiquement un codage imagé et verbal ; le double codage étant possible pour les mots concrets alors que les mots abstraits ne bénéficieraient que d'un codage verbal.

## I.6.2. L'approche électrophysiologique

Cette approche fait appel à la méthode des Potentiels Evoqués (PE). Par définition, cette méthode est un examen destiné à enregistrer l'activité électrique cérébrale en réponse à un stimulus externe spécifique. On peut proposer des potentiels évoqués auditifs, visuels ou tactiles par exemple. Cette technique, qui constitue un perfectionnement de l'électroencéphalographie, apporte des réponses de plus en plus fines et permet d'explorer le fonctionnement cognitif des sujets. Quelle que soit la tâche cognitive que le sujet est en train de réaliser (e.g., une tâche de décision lexicale, une tâche de catégorisation), son cerveau génère des ondes qui sont le reflet de l'activité électrique des neurones et qui se propagent vers la surface du scalp où elles peuvent être enregistrées sans traumatisme pour le sujet. L'étude de ces activations est essentielle à la compréhension du fonctionnement cérébral car elles traduisent la transmission de l'information entre les neurones.

Peu de travaux électrophysiologiques ont directement comparé l'accès aux connaissances sur l'objet à partir des images et des mots. Ces études ont été principalement réalisées dans un contexte phrastique et ont comparé les conditions intra-modale (i.e., la phrase se terminant par un mot) et inter-modale (i.e., la phrase se terminant par une image ; Federmeier & Kutas, 1999, 2001 ; Ganis et coll., 1996 ; Nigam et coll., 1992). Elles apportent des résultats contradictoires : pour certains auteurs, leurs données sont compatibles avec l'accès à un système sémantique unique indépendant de la modalité de présentation (Nigam et coll., 1992), tandis que d'autres considèrent qu'elles sont en faveur de l'existence de systèmes multiples (Federmeier & Kutas, 1999, 2001 ; Ganis et coll., 1996). Des travaux ont étudié les effets de l'amorçage sémantique en condition intra-modale soit dans une tâche de décision lexicale (e.g., Bentin et coll., 1985 ; Holcomb & Neville, 1990), soit dans une tâche de décision d'objet réalisée avec des images (Holcomb & McPherson, 1994). L'effet d'amorçage se traduit par l'occurrence d'une composante N400 en décision lexicale et d'une composante N300<sup>19</sup> associée à une N400<sup>20</sup> en décision d'objet. Récemment, McPherson & Holcomb (1999) ont étudié l'effet d'amorçage sémantique dans une tâche d'association sémantique et dans une tâche de décision d'objet avec des photographies en couleur d'objets réels. Un effet d'amorçage survient que le sujet soit encouragé (i.e., en association sémantique) ou non (i.e., en décision d'objet) à prendre en considération la relation entre l'amorce et la cible. Ces auteurs retrouvent à la fois une composante N300 et une N400 pour les objets sémantiquement non reliés dans les deux tâches. L'association des deux composantes plaide en faveur d'un double codage spontané des images.

---

<sup>19</sup> La composante N300 serait spécifique au traitement sémantique des stimuli imagés.

<sup>20</sup> La composante N400 serait spécifique au traitement sémantique des stimuli imagés et verbaux.

En résumé, les travaux comportementaux et électrophysiologiques montrent des résultats contradictoires concernant l'accès aux connaissances sur l'objet en fonction de la modalité et également de la catégorie sémantique. Il semble que la diversité de ces résultats soit liée à la nature de la tâche expérimentale réalisée par le sujet. Le choix de la tâche s'avère donc critique dans la mesure où elle correspond à un niveau spécifique de traitement cognitif.

## II. Travaux de recherche

### II.1. Objectifs

Nous nous proposons d'étudier l'influence de la modalité de présentation et de la catégorie sémantique sur l'accès aux connaissances sur l'objet. Notre but est d'apporter des éléments de réponse aux deux questions suivantes : (i) La modalité de présentation joue-t-elle un rôle différent sur l'accès aux connaissances stockées en fonction du niveau du traitement cognitif réalisé sur l'objet, selon que le traitement est perceptif ou sémantique ? (ii) De la même façon, la catégorie sémantique des objets (biologique *versus* manufacturée) influence-t-elle différemment l'accès au savoir en fonction du niveau du traitement cognitif ?

Pour ce faire, nous comparons l'accès aux connaissances sur l'objet à partir de son image et de son nom dans 3 conditions expérimentales (uni, intra et inter-modales) et dans plusieurs tâches (décisions de réalité sans et avec amorçage sémantique, association sémantique) pour différentes catégories sémantiques (biologiques *versus* manufacturées). La tâche de décision de réalité est une tâche originale qui permet d'étudier les mécanismes impliqués à la fois dans la décision d'objet et dans la décision lexicale. Elle peut être réalisée sans ou avec amorçage sémantique. La tâche de décision de réalité impliquerait un accès aux représentations structurales, qu'elle soit réalisée sans ou avec amorçage. La présence d'une amorce pourrait permettre d'accéder également aux représentations sémantiques des objets, et ce de façon implicite. A l'inverse, la tâche d'association sémantique nécessite un accès explicite aux représentations sémantiques.

### II. 2. Principaux résultats

L'approche comportementale a consisté à mesurer le TR dans trois expériences utilisant différents paradigmes : décisions de réalité avec et sans amorçage sémantique, association sémantique. Cette première étude suggère que la modalité critique est celle de la cible dans une tâche de décision de réalité et celle de l'amorce dans une tâche d'association sémantique. Nos données sont en faveur d'un effet de supériorité du mot en décision de réalité et d'une supériorité de l'image en association sémantique. En outre, nous mettons en évidence une asymétrie de performances pour la catégorie sémantique : le traitement des objets biologiques paraît plus long que celui des objets manufacturés en décision de réalité mais serait plus rapide dans la tâche d'association sémantique. Tandis que ce patron n'est

observé qu'en modalité imagée dans la tâche de décision de réalité sans amorçage, il est retrouvé dans les deux modalités pour les deux tâches comportant un paradigme d'amorçage sémantique. Ces résultats plaident en faveur de l'hypothèse selon laquelle l'effet de catégorie est lié à quatre facteurs : complexité visuelle, similarité structurale et sémantique, manipulabilité des objets. Nous ne mettons pas en évidence d'effet d'amorçage en décision de réalité grâce à la technique des TR.

L'approche électrophysiologique nous a permis, grâce à l'enregistrement des PE, d'étudier les corrélats neurophysiologiques des processus de traitement perceptifs et sémantiques sous-jacents à l'image et au nom de l'objet. Cette série d'expériences a permis d'apporter des arguments supplémentaires grâce à l'utilisation des mêmes paradigmes que dans la série comportementale. Nos données ont montré que la décision de réalité avec amorçage sémantique implique un accès implicite au système sémantique aussi bien en condition intra-modale qu'en condition inter-modale. Nos résultats sont en accord avec la littérature qui montre que les images accèdent plus rapidement au système sémantique que les mots et également avec les travaux en neuroimagerie fonctionnelle qui suggèrent que le traitement des objets biologiques et manufacturés impliquerait des régions cérébrales différentes. En outre, notre étude est en faveur de la spécificité de la composante N300 pour le traitement sémantique des informations imagées alors que la composante N400 refléterait l'accès à un système sémantique amodal.

### **III. Conclusion**

Dans le débat toujours d'actualité sur l'influence de la modalité de présentation sur l'accès aux connaissances sur l'objet, Nos travaux sont compatibles avec l'existence d'un système sémantique unique mais avec un codage spécifique en fonction de la modalité de présentation, selon la théorie du double codage de Paivio (1991).

## Références

- Bentin, S., McCarthy, G., & Wood, C.C. (1985). Event-related potentials, lexical decision and semantic priming. *Electroencephalography and Clinical Neurophysiology*, 60, 343-355.
- Cappa, S.F., Frugoni, M., Pasquali, P., Perani, D., & Zorati, F. (1998). Category-specific naming impairment for artefacts : A new case. *Neurocase*, 4, 391-397.
- Cattell, J.M. (1886). The time it takes to see and name objects. *Mind*, 11, 63-5.
- Collins, A.M., & Loftus, E.F. (1975). A spreading activation theory of semantic processing. *Psychological Review*, 82, 407-428.
- Durso, F.T., & Johnson, M.K. (1979). Facilitation in naming and categorizing repeated pictures and words. *Journal of Experimental Psychology : Human, Learning and Memory*, 5, 449-459.
- Federmeier, K.D., & Kutas, M. (1999). A rose by any other name : long-term memory structure and sentence processing. *Journal of Memory and Language*, 41, 469-495.
- Federmeier, K.D., & Kutas, M. (2001). Meaning and modality : influence of context, semantic memory organization, and perceptual predictability on picture processing. *Journal of Experimental Psychology : Learning, Memory, and Cognition*, 27, 202-224.
- Ganis, G., Kutas, M., & Sereno, M.I. (1996). The search for 'common sense': An electrophysiological study of the comprehension of words and pictures in reading. *Journal of Cognitive Neuroscience*, 8, 89-106.
- Glaser, W.R. (1992). Picture naming. *Cognition*, 42, 61-105.
- Glaser, W.R., & Glaser, M.O. (1989). Context effects in Stroop-like word and picture processing. *Journal of Experimental Psychology : General*, 118, 13-42.
- Hillis, A.E., & Caramazza, A. (1991). Category-specific naming and comprehension impairment : A double dissociation. *Brain*, 114, 2081-2094.
- Holcomb, P.J., & McPherson, W.B. (1994). Event-related potentials reflect semantic priming in an object decision task. *Brain and Cognition*, 24, 257-276.
- Holcomb, P.J., & Neville, H.J. (1990). Auditory and visual semantic priming in lexical decision : a comparison using event-related brain potentials. *Language and Cognitive Processes*, 5, 281-312.
- Humphreys, G.W., Riddoch, M.J., & Quinlan, P.T. (1988). Cascade processes in picture identification. *Cognitive Neuropsychology*, 5, 67-103.
- Job, R., Rumiati, R., & Lotto, L. (1992). The picture superiority effect in categorization : visual or semantic ? *Journal of Experimental Psychology : Learning, Memory, and Cognition*, 18, 1019-1028.
- McPherson, W.B., & Holcomb, P.J. (1999). An electrophysiological investigation of semantic priming with pictures of real objects. *Psychophysiology*, 36, 53-65.
- Neely, J.H. (1991). Semantic priming effects in visual word recognition. In D. Besner, & G. Humphreys, (Eds.), *Basic processes in reading : Visual word recognition*. Hillsdale, NJ : Erlbaum. p. 264-336.
- Nigam, A. Hoffman, J.E., Simons, R.F. (1992). N400 to semantically anomalous pictures and words. *Journal of Cognitive Neuroscience*, 4, 15-22.
- Paivio, A. (1991). Dual coding theory : retrospect and current status. *Canadian Journal of Psychology*, 45, 255-87.

- Riddoch, M. J., & Humphreys, G.W. (1987). Visual object processing in optic aphasia : a case of semantic access agnosia. *Cognitive Neuropsychology*, 4, 131-85.
- Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology : Human, Perception, and Performance*, 1, 305-322.
- Seifert, L.S. (1997). Activating representations in Permanent memory : different benefits for pictures and words. *Journal of Experimental Psychology : Learning, Memory, and Cognition*, 23 (5), 1106-1121.
- Sheldon, J.R., & Caramazza, A. (1999). Deficits in lexical and semantic processing : Implications for models of normal language. *Psychonomic Bulletin & Review*, 6, 5-25.
- Snodgrass, J.G., & McCullough, B. (1986). The role of visual similarity in picture categorization. *Journal of Experimental Psychology : Learning, Memory, and Cognition*, 12, 147-54.
- Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory*. New York : Academic Press, p. 382-403.
- Vitkovitch, M, Humphreys, G.W., & Lloyd-Jones, T.J. (1993). On naming a giraffe a zebra : picture naming errors accross different object categories. *Journal of Experimental Psychology : Learning, Memory, and Cognition*, 19, 243-259.
- Walls, W.F., & Siples.P. (1987). Similarity effects on semantic activation by pictures and words. Abstract presented at the second annual meeting of Psychonomic Society, Seattle, USA.
- Warrington, E.K. (1975). The selective impairment of semantic memory. *Quarterly Journal of Experimental Psychology*, 27, 635-657.
- Warrington, E.K., & McCarthy, R. (1987). Categories of knowledge. Futher fractionations and an attempted integration. *Brain*, 106, 859-878.

# How to place an adjective: semantic computation or lexical memory? The case of prenominal frequent adjectives in French

Frédérique Offredi  
Queen's University - Kingston (Canada)  
Département d'études françaises  
Maîtrise en linguistique

## Introduction

In French adjectives can be placed before or after the noun. As a consequence, when speakers produce an adjectival modification, they have to choose between these two possible positions. Bouchard (2002) showed that each position encodes a specific type of semantics: the postnominal positioning is associated with a restrictive adjectival modification, while the prenominal positioning carries a combinatory adjectival modification. In other words, the adjective placement is governed by a semantic rule. However, we will show in this paper that a dozen of very frequent adjectives do not behave according to the rule, and seem to have inherited their predominantly prenominal placement from a previous state of the French language, in which the prenominal position was dominant. This entails that for these exception adjectives speakers have to decide on their position in a context of competing instructions: the semantic rule on the one hand, and the lexical content on the other hand. Therefore some questions arise about how the speakers deal with this situation, first at the time of acquisition, and second at the moment of speech production. In particular we will look into the sequencing of instructions and the semantic conflict resulting from the coexistence of two decision-making mechanisms.

## I. Presentation of the context

### 1. The data

In French adjectives used as an epithet<sup>21</sup> are mostly found after the noun, but four situations are actually possible:

- 1) In some cases the adjective must be placed before the noun:

---

<sup>21</sup> Marc Wilmet (1980, 1981) studied the frequency and position of epithets in a corpus of 4 000 pages (taken from 80 contemporary French novels). He found that 66% of the epithets were postnominal, whereas 34 % were prenominal.

(1) le beau ballon \* le ballon beau  
 the nice ball the ball nice  
 "the nice ball"

2) In other cases the adjective must be placed after the noun:

(2) le ballon rouge \* le rouge ballon  
 the ball red the red ball  
 "the red ball"

3) In some cases the adjective can be placed before or after the noun, with a change of meaning:

(3) une certaine nouvelle une nouvelle certaine  
 a certain piece of news a piece of news sure  
 "a certain piece of news" "a sure piece of news"

This situation is actually similar to situations 1) and 2), because the adjective must be placed before or after the noun to express a given meaning.

4) Finally, in some cases the adjective can be placed before or after the noun, without involving a change in the property expressed by the adjective. The choice of the less common position of the adjective is generally said to place emphasis on the property expressed, by creating a stylistic effect:

(4) une voix splendide une splendide voix  
 a voice splendid a splendid voice  
 "a splendid voice" "a *splendid* voice"

## 2. Traditional grammar and linguistic analyses

Grammarians identified a number of factors correlated to the position of the epithet<sup>22</sup>. For instance, they mention that in French longer words are generally placed after shorter ones:

(5) un bel appartement  
 a nice apartment  
 "a nice apartment"

(6) un vers harmonieux  
 a verse harmonious  
 "a harmonious verse"

The morphology of the adjective is also relevant to its placement, as show the postposition of participial adjectives:

<sup>22</sup> Information in this section comes from Le Bon usage by Grevisse et Goose (DeBoeck Duculot 1993).

- (7) un directeur redouté  
 a director dreaded  
 "a dreaded director"
- (8) un démenti cinglant  
 a refutation scathing  
 "a scathing refutation"

And the grammarians point out that a combination Adj-N constitutes a whole and expresses a banal quality of the noun, while a combination N-Adj does not create a unity and expresses new information about the noun.

However, these descriptions do not provide a reliable tool to predict the position of epithets, since exceptions to these "rules" are numerous.

Linguists offered a number of models to account for adjective placement. It has been proposed that when an adjective can be found before or after the noun, with a change of meaning, there were in fact two different lexical entries, one for each meaning. Another approach suggested that adjectives can be classified in various subclasses (for instance, intentional or restrictive, categorematic or syncategorematic) and that each subclass imposes on its member a feature [prenominal] or [postnominal]. Others proposed that adjectives are always postnominal in deep structure and they may move before the noun to reach their pronominal position in surface structure. But again, these models seem to achieve more description than prediction.

### 3. A unified analysis: Bouchard (2002)

In reply to these propositions, Bouchard (2002) presents a convincing semantic analysis: according to Bouchard, speech constitutes a one-dimension encoding system based on the axis of time. Therefore the sequencing of words encodes meaning, and an inversion in word order always corresponds to a regular and predictable change in the meaning encoded. In the case of the French adjectives the semantic code is the following:

- Postnominal adjectives = restrictive adjectival modification

The adjective restricts the set of entities denoted by the noun (intersection of the N-set with the Adj-set): a *vélo* (bicycle) *rouge* (red) is bicycle that is red; a *église* (church) *ancienne* (old) is a church that is old.

- Prenominal adjectives = combinatory adjectival modification

The adjective participates to the very definition of the set of entities denoted: a *futur* (future) *président* (president) is not a president, but a person who will be a president in the future; an *ancienne* (former) *église* (church) is something that used to be a church but could now have a totally different function.

A number of arguments militate for this analysis. First and foremost, it is widely supported by the data<sup>23</sup>. The difference of meaning encoded by a difference in placement can be witnessed when a particular adjective is found in pre and postnominal position:

(9)	un	enfant	curieux	un	curieux	enfant
	a	child	inquisitive	a	strange	child
	"an inquisitive child"			"a strange child"		

Second, this minimalist model does not introduce any feature or move ad hoc, which, according to Bouchard, often merely reformulate the phenomena observed but do not provide a satisfactory explanation. Finally, it accounts for the exclusive postnominal positioning of participles: these adjectives express processes, which are highly connected to a context; as a result the property they carry can not be seen as "banal", or inherent to the noun, and accordingly they are not found in prenominal position.

As we have seen, Bouchard provided a valid explanatory and predictive model. However, a small group of adjectives still does not seem to follow this semantic rule, thus raising questions about the mechanisms by which a speaker chooses the position of adjectives used.

## II. Exceptions to the model

Nine very frequent adjectives (*beau* (nice), *bon* (good), *grand* (big), *gros* (large), *jeune* (young), *joli* (cute), *mauvais* (bad), *petit* (small) and *vieux* (old)) are found almost exclusively in prenominal position<sup>24</sup>, although most often leading to a restrictive interpretation. We do not deny that these adjectives, when placed before the noun, can involve a combinatory modification, as described in Bouchard's model (this is why it is not relevant for us to study the cases in which these adjectives, combined with some specific nouns, typically contribute to the definition of the entities denoted: *un grand homme* (a great man), *une petite vie* (a modest life) etc.). But we will show that in most cases a prenominal placement of these adjectives actually goes with a restrictive interpretation, which should have normally been encoded by a postnominal placement. Our point is that these adjectives do not always behave according to the implication:

Prenominal epithets => combinatory adjectival modification

In fact, most of the time they do not.

---

<sup>23</sup> For numerous examples of the semantic interpretation of pre and postnominal epithets, see Bouchard (2002: 73-85).

<sup>24</sup> Marc Wilmet's findings showed that, among the 3 875 different adjectives found in his corpus, seven of the adjectives mentioned above were among the ten first with regard to the number of occurrences found in the corpus (the other two ranking in position 17 and 31). More than 90% of the time, the nine of them were found in prenominal position. From now on, these nine adjectives may therefore be referred to as "FP adjectives".

In the following section we will present tests that show whether an adjectival modification is restrictive or combinatory.

### 1. Attributive paraphrase

A restrictive adjectival modification can always be paraphrased by an attributive structure:

- (10) Je lui ai montré la maison bleue.  
I her/him have showed the house blue  
"I showed her/him the blue house."  
Je lui ai montré la maison qui est bleue.  
I her/him have showed the house that is blue  
"I showed her/him the blue house."

But, on the other hand, with a combinatory adjectival modification the transformation into an attributive structure involves a change of meaning, and thus does not constitute a paraphrase. In some cases, the attributive structure is even ungrammatical:

- (11) Ce musée est situé dans un ancien monastère.  
This museum is located in a former monastery  
"This museum is located in a former monastery."  
≠<sup>25</sup> Ce musée est situé dans un monastère qui est ancien.  
This museum is located in a monastery which is old  
"This museum is located in an old monastery."  
(12) Ils ont acclamé le futur président.  
they have cheered the future president  
"They cheered for the future president."  
\* Ils ont acclamé le président qui est futur.  
they have cheered the president which is future

When applying this test to the adjectives FP, it turns out that an attributive paraphrase is possible when these adjectives are in prenominal position:

- (13) Il a choisi un grand arbre.  
He has chosen a big tree  
"He chose a big tree."

---

<sup>25</sup> We use the symbol ≠ to indicate that the following structure is grammatical but does not carry the same meaning than the first sentence in the example.

Il a choisi un arbre qui est grand.

He has chosen a tree which is big.

"He chose a big tree."

(14) Elle écrit toujours dans un petit cahier.

She writes always in a small notebook

"She always writes in a small notebook."

Elle écrit toujours dans un cahier qui est petit.

She writes always in a notebook which is small

"She always writes in a small notebook."

The test also shows that it is the nature of the adjectival modification, and not some particularity of these adjectives, that allow the attributive paraphrase. For when these adjectives actually carry a combinatory modification, the attributive paraphrase is not possible:

(15) Ils ont ruiné les petits actionnaires.

They have ruined the little shareholders

"They ruined the little shareholders."

≠ Ils ont ruiné les actionnaires qui sont petits.

They have ruined the shareholders who are short

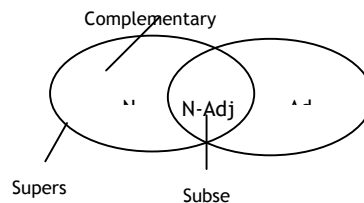
"They ruined the short shareholders."

The next three tests are proposed by Bouchard (2002: 95) and are based on the fact that a restrictive interpretation is associated with two implicit sets of entities (the superset denoted by N and the subset denoted by N-Adj), whereas a combinatory interpretation involves only one set, denoted by the complex property Adj-N:

#### Prenominal positioning



#### Postnominal positioning



## 2. Comparison

When faced with a superset denoted by N and a subset denoted by N-Adj, a comparative structure is possible because the subset is implicitly compared to its complement in the superset:

- (16) Les églises anciennes attirent plus de visiteurs. (que les récentes)  
the churches old attract more of visitors  
"The old churches attract more visitors." (than the new ones)

On the other hand, when faced with a single set (denoted by Adj-N), a comparative structure is strange because there is no complement set to compare it to:

- (17) #<sup>26</sup> Les anciennes églises attirent plus de visiteurs. (que quoi ?)  
the former churches attract more of visitors  
"The former churches attract more visitors." (than what?)

But adjectives FP can enter a comparative structure even when they are in prenominal position:

- (18) Une bonne eau est plus chère. (qu' une mauvaise)  
a good water is more expensive  
"A good water is more expensive." (than a bad one)

## 3. Questions *quelle/quel*

Likewise, when a complementary set has been ruled out, a structure can be the answer to a *lequel* (which one) question:

- (19) Il aime visiter les églises anciennes. (Lesquelles aime-t-il visiter ?)  
he likes to visit the churches old  
"He likes to visit old churches." (Which ones does he like to visit?)

Conversely, when implying a single set, a structure can only be the answer to a *quel* (which) question:

- (20) Il aime visiter les anciennes églises. (Qu'aime-t-il visiter ? /  
# Lesquelles aime-t-il visiter ?)  
he likes to visit the former churches  
"He likes to visit former churches." (What does he like to visit ? /  
# Which ones does he like to visit?)

---

<sup>26</sup> We use the symbol # to indicate that a structure is grammatical, but does not make sense.

Again, even when prenominal, adjectives FP can enter into a structure which can be the answer to a *lequel* question:

- (21) Nous avons interviewé le gros monsieur. (Lequel avez-vous interviewé ?)  
 we have interviewed the fat man
- "We interviewed the fat man." (Which one did you interview?)

#### 4. Negation

Negations can also reveal the type of adjectival modification encoded in a structure. When the negation applies to the subset of a superset, it can be supposed that the complementary set satisfies the proposition:

- (22) Il n' a pas visité d' église ancienne. (Mais il en a peut-être visité une moderne)
- he NEG has NEG visited of church old
- "He did not visit an old church." (But maybe he visited a recent one.)

But a combinatory interpretation, with which no complementary set is implied, does not suggest that other objects could satisfy the proposition:

- (23) Il n' a pas visité d' ancienne église. (Ne suggère pas qu'il a visité autre chose.)
- he NEG has NEG visited of former church
- "He did not visit a former church." (Does not suggest that he visited something else)

With adjectives FP, negations tend to imply that the proposition could be satisfied with objects which do not have the property expressed by the adjective:

- (24) Elle n' achète pas de petits cahiers. (Mais elle en achète peut-être des grands.)
- she NEG buys NEG of smallnotebooks
- "She does not buy small notebooks." (But maybe she buys large ones)

The previous tests objectively confirm the intuitive sensation that adjectives FP can be found in prenominal position without intimately combining with the noun, as is normally the case with a prenominal adjective. As pointed out by Bouchard, to speak about the *flegmatiques* (phlegmatic) *Britanniques* (British) gives the impression that one cannot be British without being phlegmatic; but to speak about a *petit* (small) *cahier* (notebook) or a *belle* (nice) *maison* (house) does not imply that every notebook is small or every house is nice. In these cases the understanding is restrictive: the expression refers to the note books which are small or the houses that are nice.

We therefore conclude that, for the nine FP adjectives, Bouchard's analysis - i.e., the position of the adjective is determined by the semantics of the adjectival modification - does not explain every case of prenominal positioning. Consequently,

we must look for another cause, to account for the cases of prenominal positioning that go against the predictions made by Bouchard's semantic rule.

### III. The proposal

We propose that, for the FP adjectives, the prenominal positioning comes from a previous state of French, in which the preposition of adjectives was the dominant position. Because of their high frequency, these adjectives resisted the syntactic change which led to the dominance of adjectival postposition in Modern French. As a result, while a semantic rule currently dictates the positioning of adjectives in Modern French, FP adjectives behave according to a "prenominal positioning" requirement encoded in their lexical content.

The corollary of this is that a speaker is faced with two mechanisms when he has to choose the positioning of these adjectives: on the one hand, a rule tells him to place the adjective according to the semantic content of the adjectival modification; on the other hand lexical information tells him to place these adjectives before the noun, regardless of the semantics.

In section 3.1 we will present linguistic data which support our proposal; in section 3.2 we will focus on how speakers might deal with the duality created by the coexistence of two competing mechanisms in a decision-making process.

#### 1. Linguistic support to the proposal

##### *i. Diachronic data*

It is well established that in Old French the adjective was placed before the noun more often than is the case in Modern French. In a corpus research we found that in *La Mort le Roi Artu*<sup>27</sup>, an anonymous text from the 13<sup>th</sup> century (99 195 words), 85% of the adjectives are placed before N, and 15% after.

Works on historical grammar and linguistics (Marchello-Nizia (1995, 1997, 1999), Buridant (2000), Moignet (1976), Perret (2001)) show that some adjectives which must be placed after N in Modern French are found before N in Old French. Typically, in Modern French colour adjectives are found before N only in highly stylistically marked contexts or in figurative expressions (*de noirs desseins*: evil plans), but they are no longer productive. On the other hand, colour adjectives were commonly placed before N in Old French. In a corpus of four texts from the 13<sup>th</sup>

---

<sup>27</sup> *La Mort le Roi Artu*, edited by Jean Frappier, Droz (TLF), Geneva, 1954.

century<sup>28</sup>, we found the adjective *blanc* ("white") in prenominal position in 45% of the cases.

These data confirm that adjectives were dominantly found before N in Old French. They also indicate that a change occurred in the syntax of the nominal phrase: the behavior of colour adjectives in Old French shows that the placement of the adjective did not follow the semantic rule depicted by Bouchard for Modern French. These conclusions support the proposal that the dominant prenominal position of adjectives FP could be inherited from Old French, and be independent of the semantic rule which normally applies in Modern French.

## ii. *The effects of high frequency*

In our list, six adjectives out of nine are monosyllabic (*beau, bon, grand, gros, jeune, and vieux*), and the other three are bisyllabic (*joli, mauvais and petit*). This is in line with the fact that these adjectives are frequent, since frequent words are the most exposed to phonological erosion (Zipf (1929,1932), Ziff (1960)). On the other hand, frequent words manifest a greater resistance to analogical changes, as can be seen from the persistence of irregular past tense in frequent verbs like "to be", "to do" or "to go" (Corbett and al. (2001)). From the phonological behavior of frequent structures, we can suggest that such a resistance to regularization could also take place at the syntactic level, thus preventing speakers to place these adjectives according to the semantic rule, and perpetuating their prenominal positioning.

## 2. Implications for the speakers

To suggest that rules have exceptions entails that speakers have to deal with such dualities. In particular, at the time of acquisition they have to make out the rule while perpetuating the exceptions; at the time of production they have to choose the position of FP adjectives in a context of competing instructions.

### i. *Acquisition*

The theory of "emergence" offers interesting prospects about the way children could both figure out the general rule governing adjective positions and retain the specific behavior of FP adjectives. Taking some distance from the view that grammar is totally pre-existing in the cognitive architecture, this model points out the role played by the exposition to forms in the structuring of language: the "emerging

---

<sup>28</sup> - *La Mort le Roi Artu*, edited by Jean Frappier, Droz (TLF), Geneva, 1954.

- Robert de Clari, *La Conquête de Constantinople*, edited by Philippe Lauer, Champion (CFMA 40), Paris.

- *La Queste del Saint Graal*, edited by A. Pauphilet, Champion (CFMA 33), Paris, 1923.

- *Tristan en prose* (vol.1), edited by Philippe Ménard, Droz (TLF 353), Geneva, 1987.

grammar" progressively takes shape through the interaction with actual speech forms (Bybee (1998, 2001), Hopper (1988, 1998), Givón (1979), Hopper et Thompson (1984)). From this point of view, forms showing a high frequency turn out to be of a particular interest.

Hallan (2001) shows that children begin to use forms like *on* or *over* in specific and frequent structures (*come on, all over, over there*), and not as spatial prepositions, even though this usage is traditionally described as the basic function for these forms, from which the other usages are supposed to later derive. Children would then seem to first acquire very specific structures, which become productive (that is, governed by grammatical principles) only later on. Transposing such a sequence to adjectival modification acquisition, we suggest that children acquire the adjective placement first through exposure to the structures, before they derive the general rule which links pre and postnominal placement with a specific semantic reading. Because of their high frequency of use, FP adjectives would then resist the rule and keep their prenominal position.

The fact that children disentangle which forms are productive and which forms constitute "exceptions" - in a context where "exceptions" happen to be the more frequent forms - suggests that productivity is linked to the number of adjectives showing a given position, and not to the number of tokens of a given adjective. Smith (2001) points out a similar distinction ("type frequency" versus "token frequency") with regard to the disappearance of the structures *be* + past participial (PP) in favour of *have* + PP in English. According to Smith, when two structures are in competition, it is the "type frequency", and not the "token frequency", which predicts which one will eventually prevail. Thus the structure *have* + PP finally gained over *be* + PP, not because the number of tokens of *have* + PP was greater than the number of tokens of *be* + PP, but because more verbs were conjugated with *have* than with *be*. On the other hand, the ability to resist a regularization depends on its token frequency: therefore, among the verbs which were conjugated with *be* in Old English, the ones with the highest token frequency were the latest to switch to the *have* construction.

Turning to the adjectival modification, a handful of very frequent adjectives is found in prenominal position, regardless of the semantics. But most adjectives do behave according to the semantic rule; therefore the rule can be inferred by children, because the adjectives behaving according to it largely outnumber the FP adjectives.

## ii. Production

At the production level once acquisition has taken place, the presence of both a rule and exceptions suggests that two mechanisms are competing when a speaker chooses the position of an adjective: a rule (or computing mechanism), which determines the position of the adjective according to the semantics to be encoded, and an information retrieval mechanism, which extract from the lexical content of FP adjectives their prenominal position. Such a coexistence leads to two questions: first, in which order should these mechanisms be activated? Second, a semantic conflict occurs in the case of FP adjectives: how can it be tolerated?

- Order of activation of the two mechanisms

For the semantic rule to be bypassed, the lexical content reading must occur before the computing mechanism. This is in line with the fact that a memorised answer is generally produced quicker than a computerised answer (as can for instance be observed by comparing the time needed to come up with the result of a multiplication, when obtained by calculation on the one hand, and when retrieved from memory on the other hand), as long as the access to the memorized information is frequent enough to ensure a quick answer.

It is noticeable that the sequencing taking place in the case of adjective placement differs from the one producing an irregular morphology. According to Pinker (1999), to produce an irregular preterit in English the search for an irregular form in memory does not precede the application of the "Add-ed" rule. If this were the case, the production of any irregular preterit would be quicker than the production of any regular one; on the contrary, tests in laboratory settings show that irregular forms are produced more slowly than regular ones. We haven't compared the time needed to produce structures containing a FP adjective versus structures containing a "regular" adjective, but it is likely that FP adjective structures would not take longer to produce, and would probably actually be produced quicker. The difference comes from the fact that with irregular verbs the speaker has to go through a list of irregular forms to select the appropriate one; but with FP adjectives the information is immediately accessible, since it is part of the lexical content of the adjective. Moreover, the rule application takes place at two different times of speech production: at the time of morphological construction for irregular verbs; at the time of syntactic construction for FP adjectives. For these two reasons we argue that in the case of FP adjectives placement the retrieval mechanism actually precedes the computing mechanism.

- The semantic conflict is tolerated

With irregular verbs, a morphological rule is "simply" blocked; but with FP adjectives, not only is the semantic rule blocked, but a violation of the rule also occurs (unlike an *ancienne* (former) *église* (church), a *vieille* (old) *église* (church) is still a church and could not be something else.)

According to Wilmet (1981: 34), such a conflict should have prevented the perpetuation of prenominal placement for FP adjectives: "an archaism is likely to survive only if it does not violate any grammatical constraint" (translation from the author). However, despite the semantic conflict, the prenominal placement of FP adjectives did survive. It then seems that the linguistic community agrees to give a restrictive adjectival modification reading, even when these adjectives are placed before the noun. We argue that such an agreement is possible only if there is a mechanism that reduces the semantic clash that should occur when the semantic rule is violated. Dahl's (2001) findings suggest a possible working: he points out that a phenomenon of semantic erosion takes place when structures are frequently used. This phenomenon can be compared to the habituation that occurs when organisms cease to react to a repeated stimulus (to reactivate an answer the intensity of the stimulus must be increased).

According to the semantic rule, the prenominal placement encodes the marked (versus unmarked) case of adjectival modification (the restrictive reading, encoded by a postnominal placement constitutes the unmarked case, whereas the combinatory reading constitutes the marked case). An erosion phenomenon acting on prenominal FP adjectives would attenuate the "markedness" of the modification, and could therefore permit a restrictive reading. Furthermore, the following fact support this analysis: if a sentence has to unambiguously convey a restrictive reading, then the rule takes over: to give the meaning that "he likes ONLY *little* dogs" (and not little dogs among others), a speaker will use the structure (25):

(25) J' aime les chiens petits.

I like the dogs small

"I like dogs that are small."

and not the more ambiguous wording in (26):

(26) J' aime les petits chiens.

I like the small dogs

"I like small dogs."

A semantic erosion allows us to interpret a "weak" restrictive reading despite a prenominal placement, but not a "strong" restrictive reading (when the emphasis is put on the restrictive meaning). This draws the line of where the retrieval mechanism has to yield to the computing mechanism.

## Conclusion

To sum up, it appears that the choice of FP adjectives placement is based on the coexistence of two cognitive systems: memorized information retrieval on the one hand, and semantic computing on the other hand. The fact that exceptions to the semantic rule survive over time implies that the adjectives concerned used to show and continue to show a high frequency of use. It is this high frequency that enables children to acquire their irregular placement. And it is also this high frequency that accounts for the survival of their dominant prenominal positioning: first by ensuring a frequent exposition to speakers, which regularly reinforces the lexical information they keep in memory; second by provoking a semantic erosion of the adjectival modification, which attenuates the semantic conflict that goes with their prenominal placement. In most cases, the placement choice is dictated by the retrieval mechanism, which comes up with a "prenominal placement instruction" before any semantic computing takes place; but if a restrictive reading has to be unambiguously conveyed, the computing system then takes over and places the FP adjective postnominally, according to the semantic rule.

## References

Bouchard, Denis (2002). *Adjectives, number and interfaces - Why languages vary*. NH Elsevier, Oxford.

Buridant, Claude (2000). *Grammaire nouvelle de l'ancien français*. Sedes, Paris.

Bybee, Joan (1998). The emergent lexicon. *CLS 34.2: The Panels*, 421-435.

Bybee, Joan (2001). Frequency effect on French liaison. In *Frequency and the Emergence of Linguistic Structure. Typological Studies in Language*, 45, 201-226. John Benjamins, Amsterdam/Philadelphia.

Corbett, Greville, Andrew Hippisley and Dunstan Brown (2001). Frequency, regularity and the paradigm: A perspective from Russian on a complex relation. In *Frequency and the Emergence of Linguistic Structure. Typological Studies in Language*, 45, 337-360. John Benjamins, Amsterdam/Philadelphia.

Dahl, Östen (2001). Inflationary effects in language and elsewhere. In *Frequency and the Emergence of Linguistic Structure. Typological Studies in Language*, 45, 471-480. John Benjamins, Amsterdam/Philadelphia.

Givón, T. (1979). *On Understanding Grammar*. Academic Press, New-York.

Grevisse, Maurice and André Goose (1993). *Le bon usage*. Duculot, Paris.

Hallan, Naomi (2001). Paths to Prepositions? A Corpus-based Study of the Acquisition of a Lexico-grammatical Category. In *Frequency and the Emergence of Linguistic Structure. Typological Studies in Language*, 45, 91-120. John Benjamins, Amsterdam/Philadelphia.

Hopper, Paul (1988). Emergent Grammar and the A Priori Grammar Postulate. In *Linguistics in Context*, 117-134. D. Tannen. (Collected General Lectures from 1985 LSA Linguistics Institute, Georgetown University.).

Hopper, Paul (1998). Emergent Grammar. In *The New Psychology of Language: Cognitive and Functional Approaches to Language Structures*, 155-175. Michael Tomasello, Mahwah, NJ/London.

Hopper, Paul and Sandra A. Thompson (1984). The discourse basis for lexical categories in universal grammar. *Language*, 60, 703-752.

Marchello-Nizia, Christiane (1995). *L'Évolution du français - Ordre des mots, démonstratifs, accent tonique*. Armand Colin, Paris.

Marchello-Nizia, Christiane (1997). *La langue française aux XIVe et XVe siècles*. Nathan, Paris.

Marchello-Nizia, Christiane (1999). *Le français en diachronie : douze siècles d'évolution*. Ophrys, Paris.

Moignet, Gérard (1976). *Grammaire de l'ancien français*. Klincksieck, Paris.

Perret, Michèle (2001). *Introduction à l'histoire de la langue française*. Armand Colin, Paris.

Pinker, Steven (1999). *Words and Rules -The Ingredients of Language*. HarperCollins, New York.

Smith, Aaron (2001). The role of frequency in the specialization of the English anterior. In *Frequency and the Emergence of Linguistic Structure. Typological Studies in Language*, 45, 361-382. John Benjamins, Amsterdam/Philadelphia.

Wilmet, Marc (1980). Antéposition et postposition de l'épithète qualificative en français moderne. *Travaux de Linguistique*, 7, 179-201.

Wilmet, Marc (1981). La place de l'épithète qualificative en français contemporain - Étude grammaticale et stylistique. *Revue de Linguistique Romane*, 45, 17-73.

Ziff, Paul (1960). *Semantic analysis*. Cornell University Press, Ithaca.

Zipf, George K. (1929). Relative frequency as a determinant of phonetic change. *Harvard Studies in Classical Philology*, 15, 1-95.

Zipf, George K. (1932). *Selected Studies of the Principle of Relative Frequency in Language*. Harvard University Press, Massachusetts.

# Risky and Non-risky Decision making: The Role of Illusion and Uncertainty Revealed by fMRI and DCM

Ahmad Sohrabi<sup>1,2,9</sup>; Andra M., Smith<sup>2</sup>,  
Shahin Fakhraei<sup>2</sup>; Ian Cameron<sup>2</sup>

<sup>1</sup>Carleton University

<sup>2</sup>University of Ottawa

## Abstract

The current study aimed to elucidate the role of a distributed brain network including striatal, frontal, and ACC areas in reward-based and perceptual decision making. Using fMRI and a task with different conditions, the illusory chance of winning or losing (risky) and the non-illusory equal chance (non-risky or perceptual), we showed the neural correlates of these types of decision making. The Dynamic Causal Modeling (DCM) was employed to assess the functional connectivity between brain locations in both risky and perceptual decision processes. The results showed that the reward system helps to anticipate the outcome automatically but is controlled by conflict monitoring areas. In addition, it showed that the integration of information in regular (certain) perceptual domain activates a region of prefrontal cortex known to integrate explicit information.

## Introduction

The relationship between brain and psychological states has been assessed using neuroimaging in the recent years. One area of research has been reward-based Risky Decision Making (RDM) and the other, Perceptual Decision Making (PDM). We use RDM to refer to cognitive processes in ambiguous, uncertain, and risky domains, involving the selection between different options that leads to different outcomes. The RDM depends on the estimation of the outcome and the differential processing of gains and losses. According to Kahneman and Tversky (1984), subjective value is different from normative value as is clear from phenomena such as risk aversion. Here is an example of risky decision:

Option 1: A 50% chance to win \$200

(50% chance to win nothing)

OR

Option 2: Receiving \$100 for sure

---

<sup>29</sup> Send correspondence to: [asohrabi@connect.carleton.ca](mailto:asohrabi@connect.carleton.ca)

This is called a gain domain because the decision maker could win for sure if she/he picks option 2. Most people choose this option and because of risk aversion do not pick option 1 in most cases. Another example of risky decision is as follows:

Option 1: A 50% chance to lose \$200

(50% chance at nothing)

OR

Option 2: Losing \$100 for sure

In this case, most people pick option 1, because it's a loss domain where people prefer risk seeking, as they lose any ways. On the other hand, PDM does not involve different amount of reward or punishment, if any. Information usually is available in the stimuli and if enough information is available it can be processed successfully. It has been shown that when information is available explicitly and completely, it can reach Pre-Frontal Cortex (PFC) and its processing is straight forward (Heekeren et al., 2004). In the current study we employed functional Magnetic Resonance Imaging (fMRI) to elucidate the neural bases of RDM and PDM and to compare them together. The PDM here was a condition where the chance to win or lose was equal, thus involved no risk or preferences. In the RDM condition the chance to win was sometimes higher and sometimes lower than the chance to lose. However, the chance was illusory, and in fact, a here again the chance of winning and losing was equal (50/50).

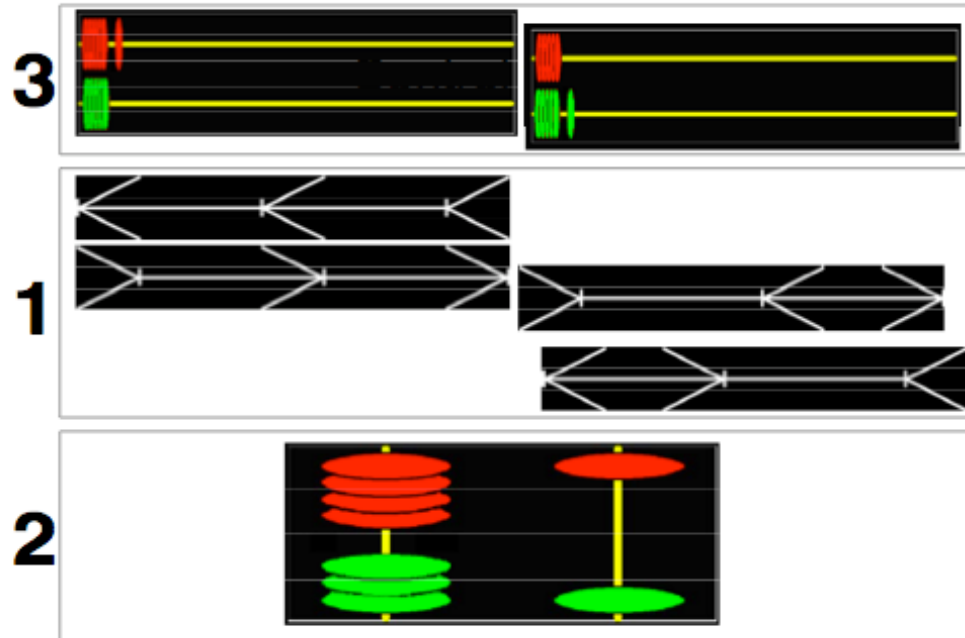
We used a recent statistical method called Dynamic Causal Modeling (DCM; Friston et al., 2003) to reveal the involvement of different parts of brain and their interactions in the RDM and PDM. This DCM method goes beyond simple subtraction method and looks for "how", not just "where", the cognitive functions are processed in the brain dynamically (see Sohrabi and Brook, 2005). Specifically, we were interested in showing the interactions between the dorsal Anterior Cingulate Cortex (dACC), PFC, and the main part of striatum (caudate). We hypothesized that caudate is involved in prediction of reward and punishment and activating of the PFC, but is modulated by dACC. Also, we predicted that doro-lateral Pre-Frontal Cortex (dl-PFC) is involved in the PDM, and that the involvement of the dACC, Orbito-Frontal Cortex (OFC), and striatum is lower compared to the RDM. Other results including Fixed effect (i.e., first level) analyses (FFX) and Random effect (i.e., second level) analyses (RFX) of the RDM are reported elsewhere (Sohrabi et al., forthcoming).

## 1. Method

### *Material and Procedure*

The procedure and material are shown in Figure 1. The task had two phases, of 3 sec each. In each trial, the first phase was a gamble followed by an outcome (feedback) phase. In the gamble phase, a line with two parts was presented briefly (150 ms) followed by a gamble abacus. The left part of the line (compared to the right part) represented the participant's chance to win in the gamble (see below). The

line's parts had arrows (wings) at their both sides. If all arrows were in the same direction (left or right), the line was non-illusory and its two parts were equal, otherwise it was illusory (Müller-Lyer) and one of its parts seemed longer than another. In fact the line parts in all conditions had equal length, and the chance to win and lose was the same (50/50, randomly) throughout the task.



*Figure 1.* This diagram illustrates one trial; 1 (briefly presented chance), left (for PDM): two lines with non-illusory wings as Non-Illusory Equal Chance 2, right (for RDM): a Müller-Lyer line as Illusory Higher Chance and another Müller-Lyer line as Illusory Lower Chance; 2: Gamble phase; 3 (feedback phase), left: when the participant loses one point; right: when the participant loses one point In 2 and 3, the upper disks are red and the lower ones are green, representing losses and gains, respectively.

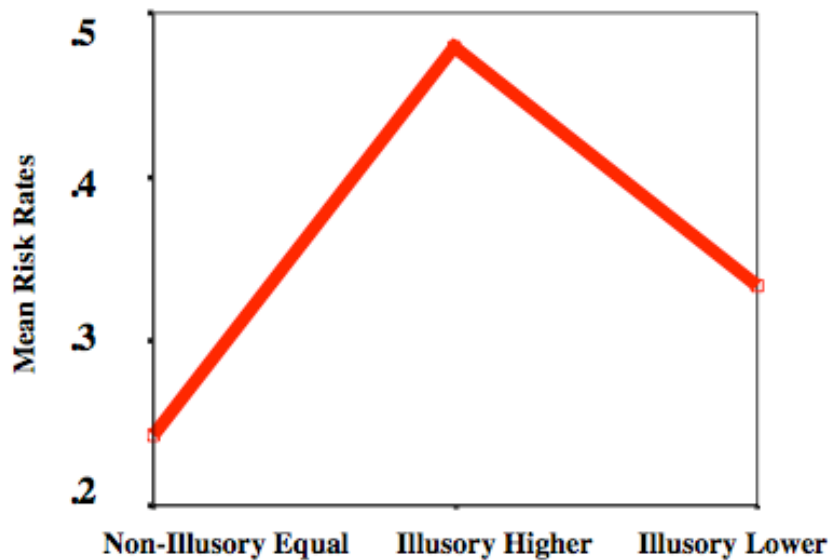


Figure 2. Means of risk rates are depicted for the three chance conditions.

However, because of the illusion, in the Müller-Lyer line with outgoing wings on the left side, the left part seemed longer thus indicated a higher chance of winning. On the other hand, in the Müller-Lyer line with ingoing wings on the left side, the left part seemed shorter thus indicated a lower chance of winning. The gamble abacus had two columns with green (lower) and red (upper) disks. The columns had different ratios of green to red disks, making a risky (3 to 4) and a safe (1 to 1) option (see Figure 1). The options were randomly presented at the left and right sides. The gamble remained on the screen until a response was made, and then the selected column was illuminated briefly in the rest of the 3 sec. After the 3 sec, the gamble abacus was removed, followed by the outcome phase in form of a horizontal abacus at the top of the screen. This abacus showed the related number of disks (i.e., points) being added to the related column.

The lower column had green disks and the upper column had red disks, showing the gains and losses, respectively. In this stage the exact number of gained or lost disks first appeared on the right side of the current disks for 1500 ms then moved left to join the total disks (pile) on the related column (Figure 1). If no responses were made, the gamble would disappear without any feedback. All participants were instructed through a practice version of the task before going into the scanner. As a part of the instruction, participants were asked to try to win points as much as they can. They were also reminded of the instruction, briefly before the task in the scanner, using a special headset, and were asked to not move their head throughout the experiment.

The experiment had 54 trials, 6 seconds each, (and two extra initial trials, see below), making 3 repetitions of 18 sec blocks for each one of the three conditions. The first one was a condition where the non-illusory lines (with all wings directed to left or right, randomly, to control the effect of wing direction) were presented as the chance (henceforth, Non-Illusory Equal Chance). The second one was a condition where an illusory line whose left part seemed longer, representing illusory higher chance to win (henceforth, Illusory Higher Chance). And finally, the third one was a condition where

an illusory line whose left part seemed shorter, representing illusory lower chance to win (henceforth, Illusory Lower Chance).

Participants were eight right-handed normal volunteers with normal or corrected to normal vision (using contact lenses). They all signed informed consent and MRI safety forms at the Ottawa Hospital. The Müller-Lyer line illusion (e.g., Moore and Egeth 1997) was employed to study its automatic effects on risk taking in decision making. At the time of instruction only one example of the two non-illusory lines (i.e., no one of the illusory lines) was presented to participants (to decrease the effect of illusion awareness), but they were told that they may see other patterns of the arrow direction in the real experiment.

They were also found to the illusion when they were asked after the experiment, except one participant whose result did not cause any significant changes to the overall result. The task was programmed in Visual Basic 6 (Microsoft Corp.) with millisecond time precision using Class and Thread Priority (e.g., Chambers and Brown, 2003). The stimuli were back projected onto a screen to be viewed through a mirror attached to the standard coil of the MRI machine. Participants responded using the index or middle finger of their right hand on a fiber optic response device.

#### *DCM and fMRI design*

The imaging was performed using a 1.5-T Siemens Magnetom Symphony MR scanner. Whole brain echo planar fMRI, based on the Blood Oxygen Level-Dependent (BOLD) signal, was performed using a gradient echo pulse sequence (TR/TE 3000/40 ms). The fMRI data were analyzed with Statistical Parametric Mapping analytic package (SPM2, Wellcome Department of Cognitive Neurology). For each participant, the images were realigned (with re-slicing and co-registering), normalized, and finally spatially smoothed with 10 mm FWHM isotropic Gaussian kernel. Then, all data were analyzed (except the first four images of the two initial extra trials included for hemodynamic equilibration purpose), taking into account the hemodynamic response and the global effect using a block design. Trials were blocked based on the three mentioned conditions: Non-Illusory Equal Chance, Illusory Lower Chance, and Illusory Higher Chance. All coordinates are in MNI atlas (Cocosco et al. 1997). Fixed effect (i.e., first level) analysis (FFX) was performed, and then it was used in the DCM analysis. Although using more locations in DCM decreases the power of the analysis, we included areas around the brain. Five locations were used in the DCM analysis: occipital ( $x = -45, y = -84, z = 0$ ), parietal ( $x = 33, y = -45, z = 35$ ), striatum ( $x = 15, y = 6, z = -5$ ), OFC ( $x = -24, y = 57, z = -10$ ), and dACC ( $x = 0, y = 27, z = 25$ ). All the three mentioned conditions were included in this analysis. As shown in the figures, the bidirectional relations between the adjacent locations were estimated.

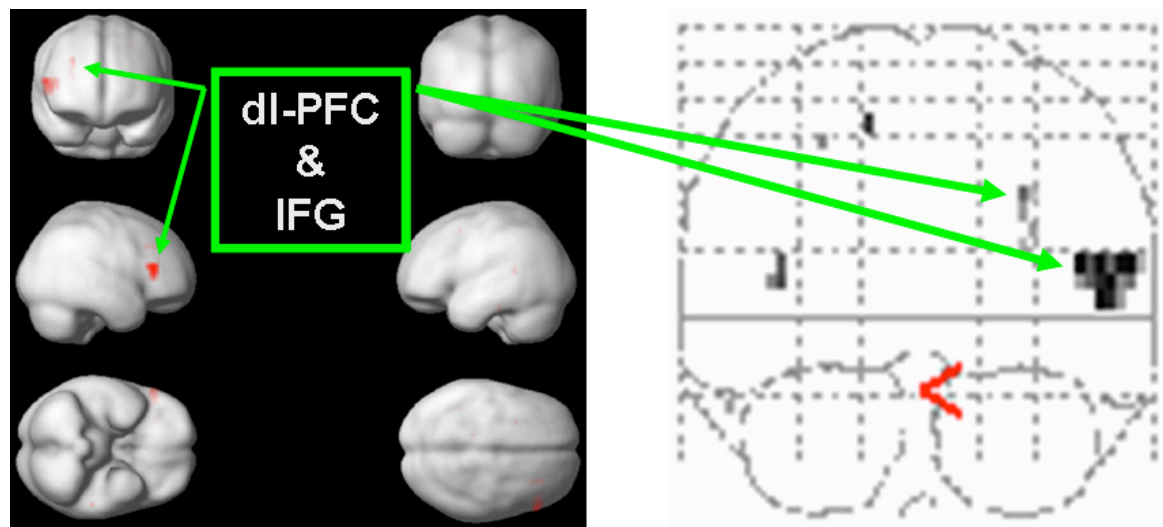
## 2. Results

### *Behavioral results*

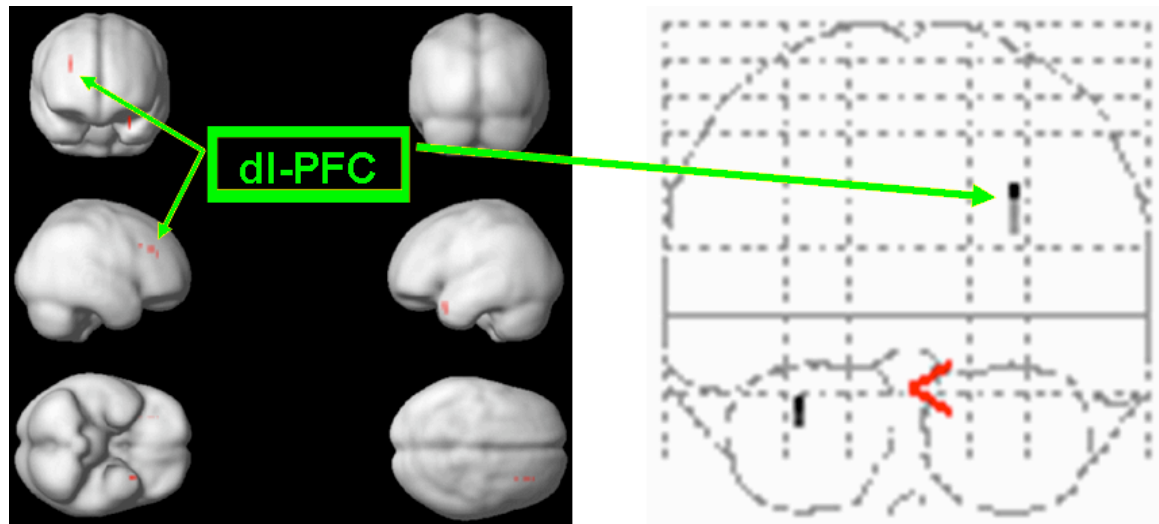
The mean RTs for the three conditions, Non-Illusory Equal Chance, Illusory Lower Chance, and Illusory Higher Chance were 1186, 1091, and 1082 milliseconds, respectively, and their differences were not significant. The means of risk rates for the three conditions are illustrated in Figure 2. The ANOVA item analysis showed significant differences for the risk rates between Illusory Higher Chance and Non-Illusory Equal Chance ( $F = .236, p < .001$ ) and between Illusory Higher Chance and Illusory Lower Chance, ( $F = .146, p < .025$ ). The difference between Illusory Lower Chance and Non-Illusory Equal Chance was not significant. In the subject analysis only the first comparison was significant.

### *Imaging Results*

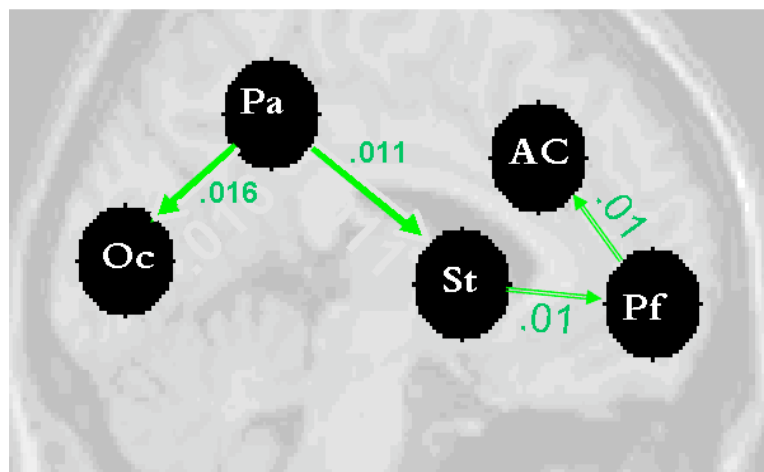
As mentioned above, the three conditions including Non-Illusory Equal Chance, Illusory Lower Chance, and Illusory Higher Chance were first analyzed using subtraction method (t-test contrasts) with FFX. The highly activated areas ( $p .005$ , uncorrected) for the PDM condition are shown in figures 3-4. There was significant activation in dl-PFC and Inferior Frontal Gyros (IFG) as effect of PDM (Non-Illusory Equal Chance), using the contrasts Non-Illusory Equal Chance - Illusory Higher Chance as well as Non-Illusory Equal Chance - Illusory Higher Chance. The effect of this condition and other condition are shown using DCM for the group (Figure 5) and two single participants (Figures 6-7). Only coefficients equal to or greater than .01 are shown in the DCM results.

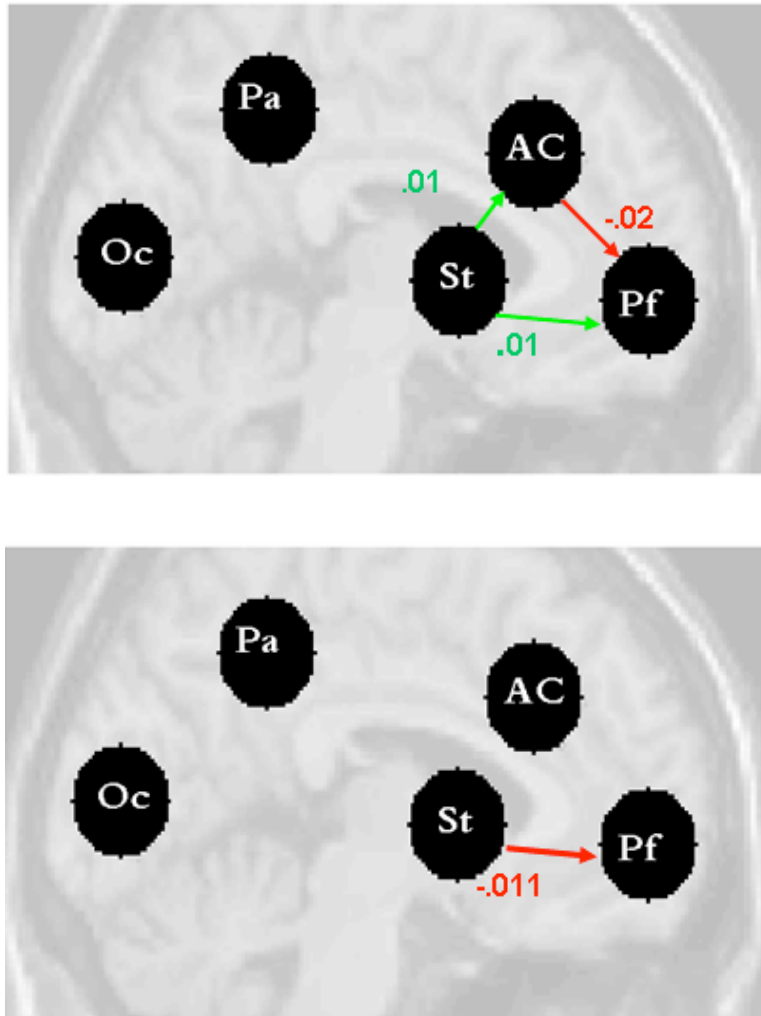


*Figure 3.* The effects of PDM (NO-LOW) in IFG and dl-PFC is shown ( $p$  .005, uncorrected). NO = Non-Illusory Equal Chance; HI = Illusory Higher Chance; LOW = Illusory Lower Chance.



*Figure 4.* The effects of PDM (NO-HI) in dl-PFC and a small area in temporal lobe is shown ( $p$  .005, uncorrected). NO = Non-Illusory Equal Chance; HI = Illusory Higher Chance; LOW = Illusory Lower Chance.





*Figure 5.* The result of DCM for all participants. Upper: The effect of HI. Middle: The effect of LOW. Lower: The effect of NO. HI = Illusory Higher Chance; LOW = Illusory Lower Chance; NO = Non-Illusory Equal Chance. Oc = Occipital; Pa = Parietal; St = Striatum; Ac= dACC; Pf = OFC. Green arrows and positive numbers indicate excitatory and red arrows and negative numbers indicate inhibitory connection.

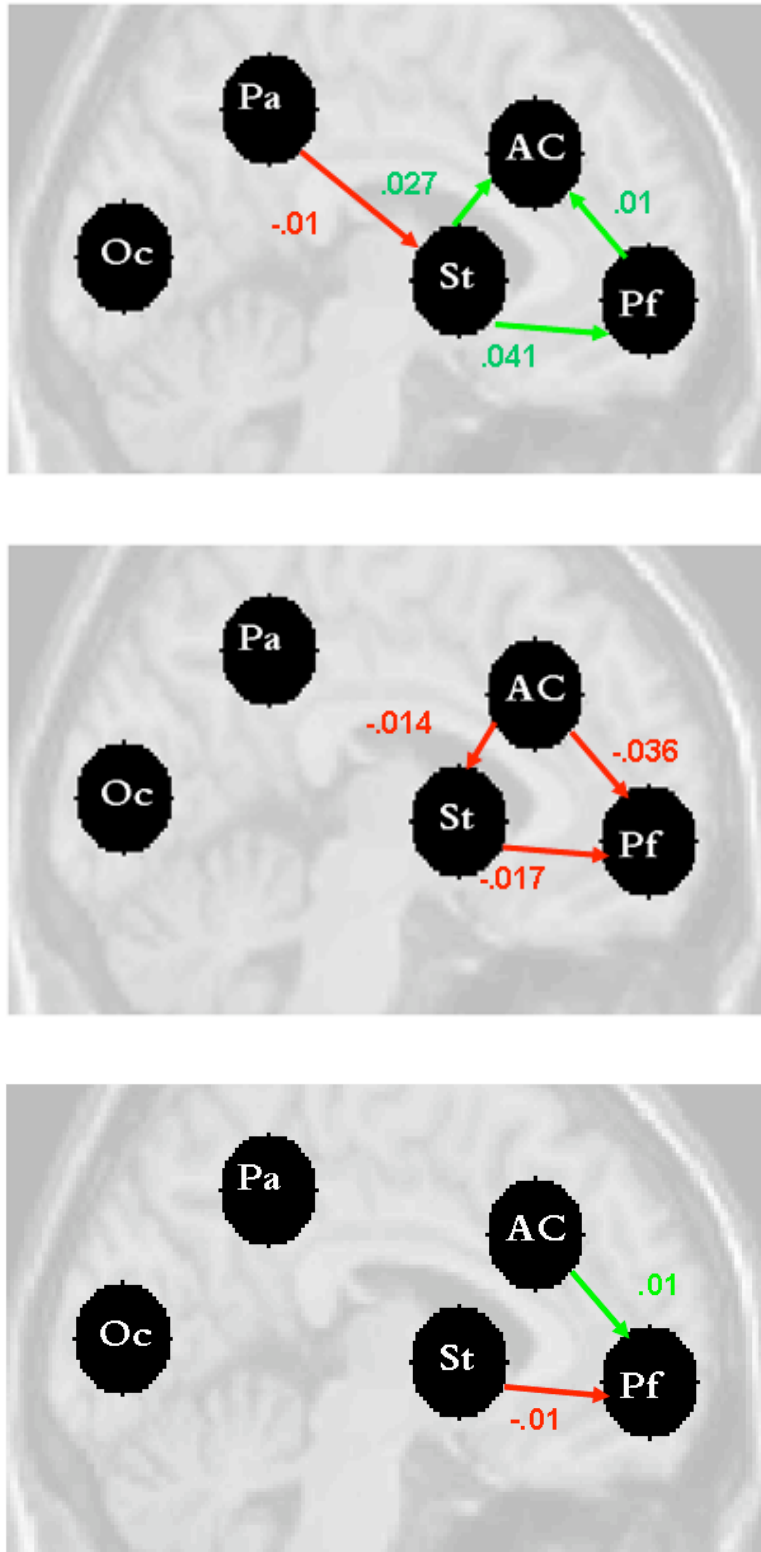
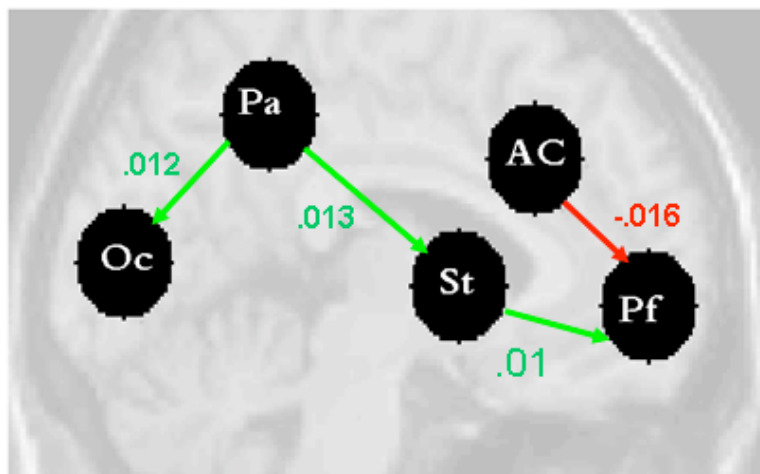
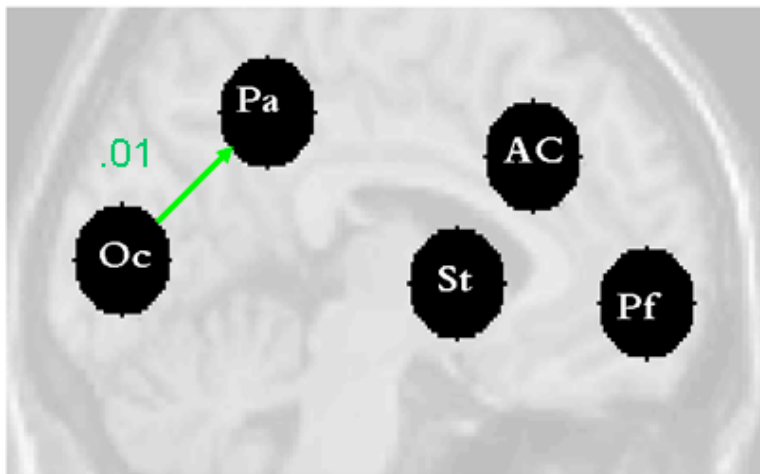
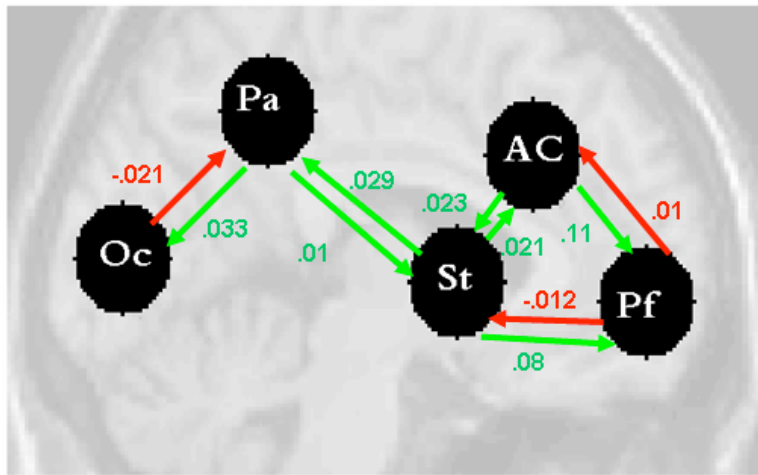


Figure 6. The result of DCM for a typical participant. Upper: The effect of HI. Middle: The effect of LOW. Lower: The effect of NO. HI = Illusory Higher Chance; LOW = Illusory Lower Chance; NO = Non-Illusory Equal Chance. Oc = Occipital; Pa =

Parietal; St = Striatum; Ac= dACC; Pf = OFC. Green arrows and positive numbers indicate excitatory and red arrows and negative numbers indicate inhibitory connection.



*Figure 7.* The result of DCM for another participant. Upper: The effect of HI. Middle: The effect of LOW. Lower: The effect of NO. HI = Illusory Higher Chance; LOW = Illusory Lower Chance; NO = Non-Illusory Equal Chance. Oc = Occipital; Pa = Parietal; St = Striatum; Ac= dACC; Pf = OFC. Green arrows and positive numbers indicate excitatory and red arrows and negative numbers indicate inhibitory connection.

As can be seen in the figures, the DCM result shows that in the HI condition, the striatum has a stronger positive (i.e., excitatory) connections with OFC and dACC. These connections are weaker or negative (i.e., inhibitory) in other NO and, especially, LOW conditions. In this case, the negative connection from dACC to OFC and/or striatum indicates the modulatory effect, especially in the LOW condition.

### 3. Discussion

This study revealed the neural correlates of reward and punishment anticipation in the gain and loss domains, respectively. It also showed the difference between reward-based decision and perceptual decisions. The prediction of gain (by more than 50% chance of winning) and loss (by less than 50% chance of winning) was illusory because in fact the likelihood of reward and punishment was the same. The prediction of reward (Illusory Higher Chance) activated the reward system in the brain and was characterized behaviorally by picking the risky option that had more gains and even more losses compared to the safe option with equal but fewer gains and losses. The prediction of punishment (Illusory Lower Chance) caused conflict, indexed by activations of conflict-related brain areas and was characterized behaviorally by less risk taking compared to Illusory Higher Chance and more risk taking compared to Non-Illusory Equal Chance. In the anticipation of gains, the striatum, OFC, and ACC were highly activated. In the anticipation of losses, striatum was activated but was modulated by ACC and OFC. The role of OFC and striatum in decision making and reward prediction has long been shown (e.g., Bechara et al. 1998, Rogers et al. 1999, 2004, O'Doherty et al. 2003, Paulus et al. 2002, McClure et al. 2003). Also, Rogers et al. (2004) showed that the upper part of PFC and ACC in decision and OFC and subgenual ACC in gain or loss feedback. Other brain areas that were activated commonly in both illusory conditions included the parietal and occipital lobes. Activation of IFG shows the need to response inhibition in the illusory conditions (e.g., Aron et al. 2004). The parietal lobe is involved in spatial attention (e.g., LaBar et al. 1999) and quantity estimation (e.g., Dehaene 2001).

People take risk in the loss domain more than in the gain domain when the winning is unlikely (e.g., Kahneman and Tversky 1984). This happened in the Illusory Lower Chance. Perhaps participants would like to get more gains in the less likely case of winning in the risky option. Participants took slightly higher risks in the Illusory Lower Chance condition compared to Non-Illusory Equal Chance condition. This indicates that they assessed that condition as a loss domain. Despite appreciating higher probability of losses, they picked the risky option more frequently (but not as much as Illusory Higher Chance condition that is more like a gain domain). The conflict and uncertainty resulted from this risky decision was indexed by activation of dACC, an area well known to be activated in conflict (e.g., Carter et al. 1998; Sohrabi et al. 2005) and uncertainty (Keri et al. 2004). But if participants knew that they had a

higher chance to win, they could exert more cognitive effort in their decision. This could decrease their conflict, as happened in Illusory Higher Chance.

Very recent studies using different methodologies have shown the involvement of the dACC in conflict monitoring (Walton et al. 2004), value (e.g., gain/loss) processing (William et al. 2004), and mental effort awareness (Naccache et al. 2005). Walton et al. (2004) found that the dACC is activated in conflict monitoring of voluntary actions, not in externally directed ones. William et al. (2004) were able to measure the activity of the human dACC, before and after its ablation, when they opened the participants' skull for surgical cingulotomy. They showed the role of the dACC in monitoring of the task set and especially in the monitoring of the reward reduction. By comparing a new three-phase gambling task with a two-phase task, we showed that dACC was activated when participants had time to memorize their chance in the gamble in the first phase, especially in the loss domain (Sohrabi et al. 2005). In the lesion study of Naccache et al. (2005), a patient with dACC lesion had problems reporting mental effort in a cognitive control task, but had normal performance in doing the task. The normal performance of patients with dACC in non value-based (non-monetary) tasks such as Stroop and Go-No go has also been shown in other lesion studies (e.g., Fellows and Farah 2005). We have shown that the dACC, especially toward its rostral, and mPFC are mainly activated when an explicit value of the stimuli is available which occurs especially in the conscious appraisal of a conflicting situation (Sohrabi et al. forthcoming). However, the activation of a given area(s) implies necessity, but not sufficiency for a function (see Sohrabi and Brook 2005), and the area(s) must be considered only as a part of a distributed network of brain areas involved in the related process.

This study supported the recent studies that have shown the role of striatum, OFC and dACC in reward processing. Using a gambling task, Delgado et al. (2000) have shown the involvement of ventral and dorsal striatum in reward and punishment during the guessing and outcome phases. Knutson et al. (2001) have shown the role of striatum in anticipation of reward and the role of medial PFC in experiencing the reward (i.e. outcome phase). Breiter et al. (2001) used a game of chance with two phases, prospect and outcome, and showed the role of striatum in predicting reward. Tricomi et al. (2004) showed that the activation of caudate nucleus is not because of experiencing reward *per se*, but because of action-reward contingency i.e., doing an action that is a predictor of an outcome. In addition, Bush et al. (2002) based on previous neurophysiological finding on the heterogeneity of dACC showed a specific role of dACC and subgenual ACC in human reward-based decision making. Moreover, Dickhaut et al. (2003) showed that OFC is highly activated during RDM. The involvement of all these areas, as well as their interactions, was shown by the current DCM analysis.

In the PDM, the reward and punishment were equal. This happened because participants had equal chance to win or lose, therefore they frequently picked from the safe option with equal number of gain and loss. However, this was not completely a perceptual domain, as was indexed by activation in striatum that was modulated by dACC and OFC. In another study (Sohrabi et al., 2004; Sohrabi et al., forthcoming), we have shown the involvement of dl-PFC using a PDM task with no reward or punishment at all. These results support Heekeren et al. (2004) assuming that dl-PFC integrates sensory evidence to support PDM. According to them, the dl-PFC activity is correlated with the output of sensory areas of the occipital cortex and its activity is greater on trials for which the sensory evidence is strong than on trials whose sensory evidence is

weak. In the current study, when the evidence for decision making was obviously equal, the decision making could be performed with certainty. On the other hand, the uncertainty of gain and loss made a risky decision and caused a complex interaction between different brain areas in RDM compared with PDM.

Overall, the current study supported the previous empirical findings, using a new approach and analysis, showing the role of a large neural circuit including striatal, frontal, and ACC areas in reward-based decision making. By using illusory chance of winning or losing and comparing it to non-illusory equal chance, we were able to show the neural basis of illusory gain or loss prediction as well as that of simple perceptual decision making. It seems that the reward system helps to anticipate the outcome by a predictive process, automatically, to help the evaluation of action outcomes. Also, the integration of information in regular perceptual domain is less involved in this system, instead it is greatly involved in dl-PFC. More investigations are needed to study the role of implicit processes and reward prediction in risky decision making and the role of explicit process in perceptual decision making.

### **References**

Aron, A. R. Robbins, T. W. and R. A. Poldrack. 2004. Inhibition and the right inferior frontal cortex. *Trends in Cognitive Sciences* 8 4: 170-177.

Bechara, A. Damasio, H. Tranel, D. and S. W. Anderson. 1998. Dissociation of working memory from decision making within the human prefrontal cortex. *The Journal of Neuroscience* 18: 428-437.

Bush, G. Vogt, B. A. Holmes, J. Dale, A. M. Greve, D. and M. A. Jenike et al. 2002. Dorsal anterior cingulate cortex: A role in rewardbased decision making. *Proceedings of National Academy of Science of the United States of America* 99: 523-528.

Carter, C. S. Braver, T. S. Barch, D. Botvinick, M. M. Noll, D. and J. D. Cohen. 1998. Anterior cingulate cortex error detection and the on-line monitoring of performance *Science* 280: 747-749.

Chambers, C. D. and M. Brown. 2003. Timing accuracy under Microsoft Windows revealed through external chronometry, *Behavior Research Methods, Instruments, and Computers* (35) 1: 96-108.

Cocosco, C. A. Kollokian, V. Kwan, R. K. S. and A. C. Evans. 1997. Brainweb: Online interface to a 3D MRI simulated brain database. *Neuroimage* 5: 425.

Dehaene, S. and L. Naccache. 2001. Towards a cognitive neuroscience of consciousness: basic evidence and a workspace framework, *Cognition* 79: 1-37.

Delgado, M. R. Nystrom, L. E. Fissell, C. Noll, D. C. and J.A. Fiez. 2000. Tracking the hemodynamic responses to reward and punishment in the striatum. *Journal of Neurophysiology* 84: 3072-3077.

- Dickhaut, J. McCabe, K. Nagode, J. C. Russtichini, A. Smith, K. J. and V. Pardo. 2003. The impact of the certainty context on the process of choice. *Proceedings of the National Academy of Science* 100: 3536-3541.
- Fellows, L. K. and M. J. Farah. 2005. Is anterior cingulate cortex necessary for cognitive control? *Brain* 128: 788-796.
- Friston, K. J., Harrison, L., & Penny, W. (2003). Dynamic causal modelling. *Neuroimage*, 19, 1273-1302.
- Heekeren, H. R., Marrett, S., Bandettini, P. A., & Ungerleider, L. G.. (2004) A general mechanism for perceptual decision-making in the human brain. *Nature* 431, 859-862.
- Kahneman, D. and A. Tversky. 1984. Choices, values, and frames. *American Psychology* 39: 341-350.
- Keri, S. Decety, J. Roland, P. E. and B. Gulyas. 2004. Feature Uncertainty Activates Anterior Cingulate Cortex. *Human Brain Mapping* 21: 26-33.
- Knutson, B. Fong, G. W. Adams, C. M. Varner, J. L. and D. Hommer. 2001. Dissociation of reward anticipation and outcome with event-related fMRI. *NeuroReport* 12: 3683-3687.
- LaBar, K. S. Gitelman, D. R. Parrish, T. B. and D. Mesulam. 1999. Neuroanatomic overlap of working memory and spatial attention networks: a functional MRI comparison within subjects. *Neuroimage* 10: 695-704.
- McClure S. M. Berns G. S. and R. Montague. 2003. Temporal prediction errors in passive learning task activate human striatum. *Neuron*, 38, 339-346.
- Moore, C. M and H. Egeth. 1997. Perception Without Attention: Evidence of Grouping Under Conditions of Inattention. *Journal of Experimental Psychology: Human Perception and Performance* (23) 2: 339-352.
- Naccache, L. Dehaene, S. Cohen, L. Habert, M. Guichart-Gomez, E. Galanaud, D. and J. Willer. 2005. Effortless control: executive attention and conscious feeling of mental effort are dissociable, *Neuropsychologia* (43) 9: 1318-1328.
- O'Doherty J. P. Dayan P. Friston K. M. Critchley H. and R. J. Dolan. 2003. Temporal difference models and reward-related learning in the human brain, *Neuron* 38: 329-337.
- Paulus, M. P. Hozack, N. Frank, L. and G. G. Brown. 2002. Error rate and outcome predictability affect neural activation in prefrontal cortex and anterior cingulate during decision-making. *Neuroimage* 154: 836 -846.
- Rogers, R. D. Owen, A. M. Middleton, H. C. Pickard, J. and T. W. Robbins. 1999. Choosing between small, likely rewards and large, unlikely rewards activates inferior and orbital prefrontal cortex. *Journal of Neuroscience* 20: 9029 -9038.
- Rogers, R. D. Ramnani, N. Mackay, C. Wilson, J. L. Jezzard, P. Carter, C. S. and S. M. Smith. 2004. Distinct Portions of Anterior Cingulate Cortex and Medial Prefrontal Cortex Are Activated by Reward Processing in Separable Phases of Decision-Making Cognition. *Biological Psychiatry* 55: 594-602.
- Sohrabi, A. and A. Brook. 2005. *Functional Neuroimaging and its Implications for Cognitive Science: Beyond Phrenology and Localization*. Proceedings of the twenty seventh annual meeting of the Cognitive Science Society, Stresa, Italy, 2244-2249.

Sohrabi, A. West, R. L. and A. M. Smith. 2005. *An fMRI study of the effects of memory and goal setting in a risk taking task*. Proceedings of the twenty seventh annual meeting of the Cognitive Science Society, Stresa, Italy, 2005.

Sohrabi, A., Smith, A. M., & Logan, J. 2004. An fMRI study of gambling-like decision making: Attention, risk, and reward prediction, The 14<sup>th</sup> Annual Meeting of the Canadian Society for Brain, Behaviour and Cognitive Science, St. John's, NF, Canada.

Tricomi, E. M. Delgado, M. R. and J. A. Fiez. 2004. Modulation of caudate activity by action contingency. *Neuron* 41: 281-292.

Walton M. E. Devlin J. T. and M. F. S. Rushworth. 2004. Interactions between decision making and performance monitoring within prefrontal cortex, *Nature Neuroscience* (7) 11: 1259-1265.

Whalen, P. J. Bush, G. McNally, R. J. Wilhelm, S. McInerney, S. C. Jenike, M. A. and S. L. Rauch. 1998. The emotional counting Stroop paradigm: A functional magnetic resonance imaging probe of the anterior cingulate affective division. *Biological Psychiatry* 44: 1219-1228.

Williams, Z. M. Bush, G. Rauch, S. L. Cosgrove, G. R. and E. N. Eskandar. 2004. Human anterior cingulate neurons and the integration of monetary reward with motor responses. *Nature Neuroscience* 7: 1370-1375.