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RESEARCH

Deciding Where to Live

An Interdisciplinary Approach to Residential Choice in its Social Context

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(Eds.)

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With a Preface by Lena Sanders

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Preface

Lena Sanders

Deciding where to live—this is a fundamental issue for individuals and society alike, and it is also a great subject for interdisciplinary research because of the many complex aspects to this seemingly straightforward question. What makes this book original and rich is primarily that it looks at this issue from so many sides, with intersecting angles of approach and an interdisciplinary grounding. Rather than being a series of chapters in which each discipline sets out its point of view, with its questions and methods, one of the features of great interest in this book is that all the chapters are written by several hands, most of them involving three or four separate disciplines. This approach implies forms of "negotiation" among the authors, who have managed to put across didactically what each discipline has to contribute to the question of deciding to move and choosing where to live. Almost all the chapters are co-signed by geographers and psychologists, reflecting the backgrounds of the two editors of the book. This underlying interdisciplinarity is enhanced by the outlooks of economists (also associated with very many chapters), neurologists, sociologists, linguists, and a physicist (one of the editors began his academic career in theoretical physics). Each of these outlooks illuminates the others. Three aspects of the work seem to me worth highlighting:

– the approach is resolutely *multiscalar* and *multidimensional*: on an individual level consideration is given to individuals' neurological and psychological workings, their inheritance and past experience, their mode of evaluation and rationality; the effects of context influencing their decision-making process are contemplated in all their dimensions (family, environment); lastly, the dynamics of residential spaces and planning strategies are addressed on the collective level of society and territory. Each level is addressed per se and in terms of its mutual interactions with the others.

– The approach is a *systemic* one and the concept of system, which is a pre-eminently cross-disciplinary one, is mobilized in several chapters. The systems and interactions at work in deciding where to live are highly diverse, some being intra-individual, with the various components of emotion (physiological, behavioural, and cognitive) and the executive cerebral system (emotional, cognitive, and motivational processes); some inter-individual and inter-locational, with the spatial system bringing into play interactions among places, accessibility, migratory flows, and more generally among individuals, groups, and the environment with respect to the system of relations between the residential setting, the way inhabitants perceive it, and their satisfaction with it. The concepts relating to the systemic approach such as feedback (e.g. between individual behaviour and collective references), emergence (especially urban patterns, segregation patterns), and self-organization (e.g. in the phenomenon of periurbanization) are explained from the point of view of theory and are mobilized in several chapters on varied topics.

– The *theoretical underpinnings* of the book are robust and manifest themselves in two ways: (1) within each chapter, with theory serving a line of argument that is followed through to the end, for example, that of evaluation of an environment or the psychological context of residential choice; (2) in a more transversal approach that consists in explaining and comparing theoretical frameworks through which to describe and model complex systems, account for a decision-making process, examine the objects of observation, or juggle with the questions of uncertainty and imprecision. Accordingly, the interest of this book extends beyond the theme of deciding where to live, and the conceptual thinking proposed here could readily be extended to other topics.

The introduction to the book presents the chapters in the logical sequence chosen by the authors. However, it seems to me that the various chapters can stand alone while at the same time contributing to the collective work and can be read in other orders, depending on the reader's own interests. This approach is facilitated by the frequent cross-references that make it easy to navigate among the chapters.

Contents

Introduction

Pierre Frankhauser and Dominique Ansel

Choosing where to live has certainly been a fundamental act in human society ever since people became sedentary. This choice is largely determined by the cultural, historical, social, and spatial context in which people live. However, the place where an individual, household, or group settles contributes greatly to their well-being or uneasiness and may prompt them to move, within the bounds of their possibilities.

In evaluating a place to live, account is taken not just of the housing but also the environment in which it is located and more generally the places that are regularly frequented. The image associated with such spaces is an essential component in appraising the residential environment and the degree of satisfaction of the resident population.

In developed countries, the spectacular improvement of means of travel has facilitated the appropriation of places within an ever increasing radius and so modified the relationship between the individual and the space experienced, which now covers a vaster area and more diversified usages. Growing mobility has also increased the potential for choice and decision-making and contributed to making the relation with space more complex.

Recurrent spatial practices and residential choice act directly on anthropized space by transforming it and generating daily travel flows. Such flows are an important issue in territorial dynamics. But these transformations also modify the space experienced and the way users perceive it. What are the factors that push individuals to move home and how do they reach that decision? That is the general question we address in this multi-authored book. The individual who chooses a place to live acts by integrating factors relating to her personal history in conjunction with her spatial experiences but also aspects pertaining to the perception of her social and spatial environment that are socially constructed and contribute to the implementation of multiple individual and collective facets of identity.

The complex interactions between space and user that condition the processes of choice in question provide a priori an incentive to develop an approach combining different disciplines (geography, psychology, economics, sociology, linguistics, medicine) that attempt to understand, explain, and model these processes of choice and decision-making. However, we observe a certain shortfall in communication among disciplines that contribute in a complementary way to furthering knowledge in this domain.

To develop such a cross-disciplinary approach is the main objective of this book, which has been written as part of the ECDESUP project (l'évaluation, le choix et la décision dans l'usage des espaces urbains et périurbains) financed by France's Agence nationale de la Recherche (ANR). The book associates three main inputs with this approach:

– allowance for geographical space through the reading of theoretical and quantitative geography;

– consideration of humans in constant interaction with their environment through the social psychology and environmental social psychology approach;

– focus on choice by means of a more individual-centred contribution as proposed by economic theory.

In keeping with the objective of developing intersecting views from the various disciplines, we have associated representatives of various disciplines in each of the chapters. Special attention is given to clarifying the concepts developed in the various disciplines in order to agree on their meaning in the given context. It has thus been possible to avoid a juxtaposition of disciplinary approaches and to develop a synthetic view instead. This orientation of the work is far from anecdotal. It is the manifestation of an intention to think of human activity in its totality and to contemplate the research process directed at complex phenomena.

As we emphasize the decisions involved in moving home, we consider de facto in this book the description and modelling of the choice and decision-making process, which seems to give precedence to that part of the population in a position to make such choices. It is obvious that growing mobility has excluded some people who are restricted in their daily travel patterns as in their residential choices. Even so, albeit with reduced margins of freedom, in particular in economic terms, the aspirations of anyone with respect to a place to live remain strong. Thus, although most moves are dictated by budget constraints, this aspect will be only marginal in this book.

The book is for post-graduates and experienced researchers alike. While it follows the rationale of a handbook, it is neither the intention nor is it possible to give a complete overview of the approaches developed in the associated disciplines. The concepts and approaches are dealt with here with a specific purpose in mind. The aim is to consider residential choice and the decisions associated with it from the perspective of possible formal modelling of the decision-making processes associated with residential choice. Notice that such modelling has not been achieved either in psychology or in economics or quantitative geography, even if various inroads have been made. However, the value of such modelling is manifold. In terms of academic research, it compels us to clarify the features that condition decision-making and to account for the factors that help or on the contrary hinder decision-making. It thus enables us to enhance the theoretical concepts in question. From a perspective of more applied research, it is possible to integrate such modelling into the design of models for simulating territorial dynamics. Although the objective is not, then, to present any particular model to satisfy the objectives of modelling, we do wish to contribute to scientific debate in this domain.

These objectives have oriented the plan of the work which is structured into two main parts. The first considers the residential choice context from various angles (first five chapters) and the second looks more especially at modelling the decision-making process by taking account of the individual's position in the societal context (last five chapters).

Chapter 1 looks at how individuals create and modify their spatial references over the course of their lifetime. Self-awareness relative to their environment and the way individuals appropriate and feel that environment comes in later in their evaluations. Thus it is likely that we tend to seek out the ambience of a setting we experienced as reassuring or pleasant and avoid atmospheres that recall unpleasant memories. But beyond individual experiences we are also conditioned by the references of our environment and therefore the cultural context but also by certain universal symbols. This aspect is taken up again in chapter 2, which develops dialectic linkages between individual position and collective references in the decision-making process.

Chapters 3 and 4 look at aspects that may condition the actual decision-making process. Thus on the subject of geographical mobility, whether daily or not, the concept of accessibility is central in human geography. Accessibility is also used in other disciplines such as sociology when examining social mobility or psychology when investigating the level of awareness of a form of behaviour, knowledge, or emotion. Accessibility studied in terms of disability is also a useful "detour" for addressing the socio-cognitive dimension. Chapter 4 also develops the way theories have progressively taken account of subjectivity and the affective dimensions in modelling the decision-making process. Running through this just below the surface we can read the development of the idea of rationality. Accordingly we thought it worth including in our considerations recent results of work in neuroscience that have made it possible to clarify in this perspective the role of cognitive and affective factors that may modulate choice (chapter 5).

Our individual spatial behaviours are guided by collective references. The purpose of chapter 6 is to discuss the role of such references in choices concerning spatial mobility in light of the different social sciences. Chapter 7 looks more specifically at the concepts used for modelling interaction between individuals and the societal context within the context of residential choice. Emphasis is on the approaches used for modelling self-organizing phenomena and the emergence of spatial and societal structures. First we consider models that highlight "macroscopic" structures, that is, the distribution of population on the aggregate scale of a city or region. Then we consider models that are directed more at modelling the behaviour of individuals and their interactions.

The scientific study of any phenomenon requires some reflection on the methods most suitable for acquiring such knowledge. This aspect is broached in chapter 8. It should be recalled that one objective in our approach is to obtain such information in a form that can be integrated into a mathematical or computer model. This is therefore a complex observational context that requires in-depth reflection on suitable methods for obtaining the desired information. This leads us to epistemological considerations on scientific observation which is addressed through a cross-disciplinary interpretation and enables us to specify requirements of the observational methods to be used.

Chapter 9 shows how the notions of preferences, utility, choice, and attractiveness are interdependent. We examine the process of choice leading to a decision and an action with spatial consequences, essentially from the point of view of residential mobility even if elements relating to local daily mobility such as choice of mode of transport, destination, or path are evoked.

The final chapter examines how this decision-making can be formalized. This question is seldom considered, at least in the research context in question. With this in mind, the various concepts of modelling decision-making are recalled. Beginning with the classical probabilistic approach traditionally used in decision-making in economics, the criticism levelled at this approach is presented and the more recent development of the probabilistic concept that stems from it. The next section is a reflection on the contribution from thinking developed in quantum mechanics and overall the generalization of the probabilistic approach that makes it possible to address the question of choice from a particular angle. A relation is established with fuzzy set theory which invites us as our final step to rethink decision-making mechanisms.

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Individuals in Their Spatial and Social Environments

Sophie Mariani-Rousset, Anne Griffond-Boitier, Andrée Chauvin-Vileno, Jérôme Valentin, and Victor Alexandre

1. Introduction

This chapter presents the psychological context in which individuals find themselves when they have to choose a place to live (to rent or buy) in a given setting. The act of living in a particular place and type of dwelling arises out of a specific process. It is this decision mechanism that we wish to account for here. Most studies provide figures, percentages, and economic references but very little information about the details of the human dimension of residential choice. The basis for the decision is usually ignored. Yet, an individual's well-being does not come down just to the price of land, number of rooms, or the image projected by living in such or such a place. We must also consider the mental construction of the living space. This fresh viewpoint broadly takes into account family, social, and cultural references but also criteria concerning each individual's personality. What matters here is an understanding of the mental phenomena that determine, condition, and induce our choices and decisions, often without our knowing it.

Urban space is therefore thought of as human space in which everyone explores their person/space relationships in terms of representations and interactions in the world. Our aim is to show how the various approaches and disciplines of the human and social sciences (psychology, human geography, language sciences, sociology, and so on) are mutually enhancing. We shall be dealing, then, with appropriating space in its personal and interactive dimensions. Human development is a fundamental given in our approach to space.

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From it will develop a knowledge of intimacy and the social realm, the differentiation between public and private spheres, and integration within urban space depending on how that space is shared. Once human competency is acquired in a relative way, next comes urban competency.

Residential mobility implies movement in space, relocation, moving home, settling somewhere new and perhaps a total change of scenery. That involves a cognitive and affective process developed since infancy that has enabled us to acquire certain aptitudes: the possibility of moving around in space physically and mentally, while being firmly grounded, so as to be able to form relationships with other individuals. Residential choices are the outcome of a set of skills acquired over the course of time. The appropriation of individual space arises out of humankind's appropriation of space in general. Two time scales are therefore involved.

– The *individual* time scale concerns whatever provides access to space and time, to the ability to settle and to up-and-go (nomadism), which occurs over the course of the child's development through their upbringing in a particular family and a particular cultural and sociological environment. We shall therefore address what it is that determines human beings over the course of their development, in their relations with others and the environment, including their choice of living place, since childhood references greatly influence what becomes of us.

– The *anthropological* time scale flows from human evolution, which is itself related to the appropriation of geographical space, to exploring and discovering the world and the way it has been signified.

The way in which human offspring grow and forge themselves is the outcome of the evolution of the species itself and certain behaviour cannot be understood without the accompanying historical context. Gregariousness or sociability, it matters little which. We observe that humankind has clustered for specific purposes: for survival, for effective self-protection, for trust-building (towards the environment and other humans), to the point of creating a dynamic of exchange and positive or negative interactions. Over the course of time, this clustering has continued unabated, but safety and communication are still aspects of it.

After elaborating on these aspects, we shall turn to the traces left by our personal and universal history, in western society, and more especially through language and interactions. We shall see how humankind has experienced space, named it and represented it; how, by defining themselves in a personal space, people have come to live increasingly in interaction with their environment, by learning to observe distances and boundaries with others.

Accordingly—this is our postulate—an individual's historical (social, family, etc.) circumstances within a given culture (landscape, climate, lifestyle, rites of interaction, language, etc.) influence or even determine residential choices and spatial practices.

2. Constructing one's place in the world

"Finding one's place" is essential in the life of every individual. The body in space calls for a delimitation of a personal space allowing for the boundaries between self and non-self. This apprenticeship of inside/outside, within/without will have repercussions on the ability to set limits and to endure the limits of others. Individuation makes it possible to differentiate oneself from others, initially, but also to accede to others. All the stages of self-construction and encountering others will then make it possible to set about living in society.

2.1 Towards individuation

Individuation[1] (Simondon 1989) is the process which, by integrating unconscious contents, allows the individual personality to develop, to be specified as a full-fledged being, separate from any filial dependency. "Being in the world" is not innate. Proving oneself as a subject involves this capacity to stand apart from others and from the surrounding space.

The appropriation of space during infancy

"Attachment theory" was developed between the 1940s and 1970s by Bowlby (1978) from work in psychoanalysis by Harlow and Winnicott (1957) and Ainsworth et al. (1978)[2] and by the ethnologists Lorenz (1970) and Hinde (1982). Bowlby showed that the infant's prime need is to feel attached, bound, in relation with a "good-enough" mother who provides care and affection coherently and continuously while gradually fading out. If she is "containing", she enables the child to feel supported (what Winnicott calls "holding"[3]). This is the first anchor point, the first landmark. Is not talk of an attachment to place (Fleury-Bahi 2000, Altman et al. 1992) tied in with this cognitive-affective process?[4] This justifies place-related identity described by Proshansky et al. (1983) and even urban-related identity described by Lalli (1992). There is a feeling of belonging to the place where we grew up that influences our later choice of where to live.[5]

1 A concept devised by Jung (1990), Piaget (1937), Winnicott (1957a) and others, and taken up by Gilbert Simondon in 1989.

2 Ainsworth et al. conducted a test (the strange situation) evaluating the "how" of early attachment, showing that the attachment figure provides a safe base at the time the child is opening up to the physical and social world.

3 Holding corresponds to a stable environment, with the mother capable enough of physically and mentally bearing her child.

4 This may seem metaphorical, but metaphor is the basis of the construction of meaning, language and human evolution.

5 Guérin-Pace (2006) observes that roots are sometimes expressed more in terms of family and friends than geography.

So the child, once reassured about this safe landmark, may move away from it without feeling lost. The child's construction of its identity involves it becoming separated from the undifferentiated world. It is the separation from the (reassuring) mother that gives the child to understand that the world exists. That is when the child gradually moves into its space. The "skin-ego" concept described by Anzieu (1985) refers to the relationship with the world and states that the difference between the real exterior and the exterior as perceived depends on the individual's construction. Just as the skin encloses the body, there is a protection around the mind serving as a container, a boundary with the outside, and which marks the line of demarcation between inside and outside.

Attachment theory shows that once they become adults, sufficiently "reassured" children engage in independent exploratory behaviour and maintain the same behaviour under stressful circumstances. But it is not all plain sailing, as Freud (1938), Klein (1957), and Winnicott (1975) all showed. Differentiating the self from the world is no easy matter. What psychoanalysis and child psychology teach is that the very young child does not differentiate itself from its mother or its surroundings. It "is" the world. Little by little, the child discovers that it does not remotely control its surroundings when it wants and as it wants. It takes its "first steps" in the world as a living and thinking being. In classical Freudian theory, the father or a third party brings the child to differentiate itself and to grow aware of the interior and exterior of its body and the environment, in a painful but foundational moment. *The other is the very first environment*, which influences us as much as we would like to influence it. That environment is both protective and potentially dangerous whether because of external physical aggression or because it fails to leave the other room to grow (intrusion, lack of intimacy, incest, etc.). The child learns to tame this environment and negotiate with it. Paradoxically, it is the ability to be alone that makes it possible to enter into relations with others later on (Winnicott 1958).

The body is the fundamental component in appropriating space. It is a sensory conveyance moving from one place to another, transmitting information about what is happening in the environment. It is the body that constructs the city in occupying and moving through space. Goffman (1973b) spoke of "vehicular unit" attesting to the appropriation of shifting territory. The "mirror stage" described by Lacan (1949)[6] brings the child an awareness of its bodily unity. It gives the child the pleasure of looking at itself while feeling differentiated from its image. The encounter between the child and its mirror image confronts it with the first function of the image of its body, enabling it to acquire a "bodily schema". This is the initial stage that is to lead to mental development, symbolization, identification of itself: the being takes shape, recognizes itself, becomes distinct from its environment. Its movements in space provide

6 The initial concept, taken up by René Zazzo, is from Henri Wallon. The stage between 6 and 8 months of age.

different sensations. Walking, which is acquired by the age of about one year, is the vehicle of this appropriation of space and relations. This transition from the body as felt to the body as experienced may be set in parallel with space perceived and space experienced.

Autonomy in the service of identity

With the concept of "fort-da" or the reel game, Freud (in *Beyond the Pleasure Principle*) shows that the game involving an object that appears and disappears in succession allows the child to experiment with and surmount his mother's absence. For Winnicott, the child's first "non-me" possessions, such as a blanket, are objects that are created at the same time as they are found. They stand out from external objects because the child "recognizes" itself in them. The blanket, which is significant of childhood attachment, creates in the child's mental experience an intermediate zone between the ego and external objects, a "potential space" that remains active life long. It is this that makes the idea of separation possible for the child: the other still exists even far from its field of view; separation is not permanent (Winnicott 1958, 1957b).

This "extending of territory" involves sight. Initially, before looking, the eye is used for direction finding. The view of the landscape is an important component. Is it better to live in an unprepossessing dwelling overlooking a forest or in a fine house beside a busy road? Is the sense of direction related to difficulties in moving around in space and creating ties? Is "not finding your way around" not recognizing yourself in space? Does catching a look of space enable spatial appropriation, the ability to find one's marks. This is related to what Piaget (1937) called the "permanence object": what vanishes from sight continues to exist. Taking up the concept later, Winnicott spoke of the permanence of the "continuing feeling of being" (1957b). It is the time when the child feels that the objects around it exist outside of it, but above all continue to exist even when it cannot see them. This mental image is the basis of the capacity for *representation*. The child sees the image of its bodily envelope appear, which then becomes symbolic of its self. This bodily limit, by providing a frame, enables the child to come to an understanding of its own existence.

Depending on all these stages, the simplicity or complexity of the city is appreciated in different ways—in the complexity of its geographical landmarks, but also in its acceptance of other individuals. Here there forms the importance accorded or not to the crowd, noise, promiscuity, and to what Chombart de Lauwe (1965) named "crowding": the impression of being closed-in or of stifling that is felt in an urban setting.

There is a space of the self that structures one's identity, a zone that is both mobile and bounded depending on the person and the situation. Whoever the authors, the construction of mental space is likened to a subjective zone.

Personal space structures our personal identity. It forms a system of defence and protection of intimacy, by regulating interactions with the social environment. Freud (1923), Klein (1957), and Anzieu (1987) spoke of psychic envelopes, Bion (1983) of *psychic space, mental space, emotional space, thinking apparatus*, Hall (1971) of *bubbles*, Sommer (1973) of *portable territories*, Moles (1968, 1972) of *concentric* shells, Goffman (1973b) of territories of the self, Horowitz of a *body-buffer zone* like a boundary between the self and others, Anzieu (1985) of *skin-ego*, Sloterdijk (2006) of *spheres* and *foam.*

Before being able to take on the world, the child learns the ropes with the family environment and its living space, the home. The child occupies the space making it its own via the object but also via language: its room, its toys, its bike, etc. In terms of ontogenesis, the psycholinguistic study of the representation of space in the child's language (in the wake of Piaget) shows universal regularities in the development stages but also important differences from one language to another, especially in the rhythm of acquisition. Hill (2003) argues that children lexicalize their changes of place in line with the typological properties of their language.

From the time the child takes its first steps, it "bumps into" the real world in bumping into the objects around it. But the more it occupies space, the more it delimits itself; the more it finds its marks in space, the more it founds itself as a full-blown individual and can begin to take its place among its family. The child must therefore at one and the same time individualize itself, protect itself from others, and be capable of living with them.

Inner and outer space are very much interlinked. "Internal psychic space, as a place in which the individual constructs himself and his relationship with the world, is not unrelated to the day-to-day experience of the surrounding space" (Fourment-Aptekman 2004:8). Space is mobile and is both what surrounds us (the environment) and what moves around with us: bodily limits but also (family, social, and cultural) history—history that permeates us.

Historical, social and family effects on residential choice

Time is important, too. Our upbringing but also the places in which we have grown up and the time spent there have all shaped us in a particular way. Piaget (1946) showed that logical relationships became established between time, space, and speed. It is the idea of duration that interests us here: when it comes to going to live somewhere new, we project ourselves in this future place both spatially (by imagining the place) and temporally. The affective aspect of a place where we lived in childhood is found again in the choice of or inability to choose a place to live. If the affect is positive, the choices may be about a "paradise lost" forever or endlessly sought out, with respect to the loss of place being the loss of childhood. In contradistinction, a type of place to live in may be shunned if the feelings and recollections are too painful. For Peytard (1993:167), "Choosing implies excluding (…). The things excluded are not erased, though. They remain in the memory, as waste or as loss, but held in reserve, as it were, always available".

Settling somewhere is much like saying, "This is where I am from". Our choices tell of our origins… whether we accept them or reject them. The child begins to create landmarks, schemas based on what it sees and what surrounds it. From these "models", thought of perhaps either as paragons or as things to be fled, will flow the child's expectations, future choices, and preferences as to residential environment. In their discourse, parents provide a model with the need to comply or on the contrary to change. Residential choices are induced by this sociological aspect: for an entire generation of parents, urging children to "get on in the world" by getting an education, a good job, and money has been essential. The type and place of home then changed, sometimes painfully as it meant denying what had been given until then. There is a family loyalty not to do better than one's parents, complicated by the fact that parents themselves ask their children to do so. This is what de Gaulejac (1987) says in speaking of "class neurosis". He was the first to show that social climbing could be experienced as suffering. Some people cannot live in the city centre or in an upmarket district without feeling like impostors. And vice-versa, some "sensitive" districts will frighten residents used to greater comfort and/or less promiscuity. All of this causes internal conflict. Currently, social conditions suggest that children will not live as well as their parents and will not necessarily be able to buy their own homes (or at least not under the same circumstances), or even live in their parents' house if they cannot pay the inheritance tax.

Access to ownership has historically been an essential turning point. But the psychological cost (of owning space) is sometimes greater than the financial cost. It may be that the place where one lives and the type of housing make reference to *social representations*. When one moves to settle in a new city, the house fronts provide information of which we may not be aware. One imagines oneself living there… or not. And those same façades also give an image of those who live there to outsiders.[7] Some will prefer to skimp to live in what looks a fine building (façade, district, historical aspect) rather than a more spacious outlying district[8] because it is what they have known to date.

The new place to live may also be chosen because it is reminiscent of one's place of origin (country, region, district, housing type, etc.). The concept of mobility, highly fashionable as it is, uproots people as much as it broadens their minds. Short of being able to stay in a place to which one has attachments, it may be possible to remain close to it symbolically.

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7 The word façade comes from the Italian *faccia*: face.
8 This may be associated with an impression of safety or insecurity.

Capacity for mobility

On can *imagine* living somewhere depending on one's childhood, depending on what is assumed to be pleasant or dangerous, adapted or not to one's standing. The construction of the dangerous character of a place would here be the expression of a representation based on presuppositions that are not necessarily materially expressed or on material signs with specific meaning for each individual depending on their past experience. Initially, towns formed around "natural" points of attraction: rivers, quarries, crops, strongholds, etc. The history of the place where one grew up (metropolis, village, market town, hamlet, city or countryside, house or flat) and one's life history in that place determine subsequent choices. Everything will therefore depend on the size of the accommodation, the housing type, its location in the city and the neighbourhood (different demands for social contacts), on the location of the city itself, social and cultural origins, etc., but also on one's status as owner or tenant. Does the idea of well-being depend on this? Here we find the importance of *being* and *having*: is the feeling of being "at home" stronger if one is the home owner? Is it not also a way of rationalizing things? After such an expensive investment, is it conceivable that one might not feel at home?

What Moscovici (1984) calls *anchoring* or grounding refers to the social rooting of representation, which is done by incorporating new factors added and attached to others, in reference to beliefs, values, and pre-existing knowledge of the culture to which the subject belongs. This makes it possible to make the environment familiar, to regulate behaviour, to ensure a communication function, and therefore to enable interactions and provide a consensus basis for sharing the same value systems. It is also what promotes a degree of capacity for mobility.[9]

The reasons for residential choice take up much of the space in the place ultimately chosen. There is a need to meet a demand or requirement. The "choice" made is that of a place to reside, but not necessarily to have to leave the place where one lives. It is possible to study through "the idea of 'residential choice' [the] forms of social construction and [the] socio-economic and territorial effects" (Authier et al. 2010:9). Is there a question of bringing the family together, psychological aspects (blended families), or economic aspects (house-sharing by young adult workers)? Redundancy, for example, means one can no longer stay in a flat for which the rent has become too expensive, hence a move towards an outlying place or a smaller place. The answer will be different depending on age and family status (alone, with one's own children or step children?). Modern lifestyles and occupational mobility induce original and sometimes non-rational behaviour. Couples do not always live together if the two work in

9 Mobility, which Simmel (1908) speaks of in Grafmeyer and Joseph (1990), in the case of a stranger in a city, both fixed in a point in space and detached from that same point.

different cities. Some families see one of the parents leave the home during the week and then come back to base at the weekend; others are required to move for their work (members of the armed forces, government employees, etc.). All of this entails economic but also psychological and organizational constraints.

So, contrary to what might be thought, a removal (like a birth or a promotion) may induce depression. In appearance, there is nothing to explain the sense of ill-being. The problem arises from the weak ability to have created bonds as a child. The initial up-anchoring is revived and the removal distances one from a geographical zone that represents stability and safety. Now, as we have just seen, safety is the fundamental parameter for any individual; sometimes their survival depends on it. "Urban space and experience of it may be considered as a metaphor for psychic space" (Fourment-Aptekman, 2004). It is a matter, then, of finding the words to express what one feels.

2.2 Naming space

Anchoring is therefore physical (it is the body that is at issue), but it is also a question of representing the self in its environment (imagining oneself somewhere) and a question of *language*. We express our feelings as a function of our personal history and of human history. We name the space around us and the actions that take place there so situating ourselves in that space. Not all cultures have this anthropocentric approach and not all symbolize space by placing mankind in the midst of it all. Yet this is the vision of our western world and the residential choices made fit in with this representation.

Constructing oneself as an individual in the space-world already involves being able to describe it and name it. Language reflects the relationship with the geographical and physical environment. How can one find one's bearings in space and what effect does it have? How is residential urban space named, represented via language and concepts, and how do some scientific disciplines make of it a specific subject of analysis? This is what interests us here.

From language to languages: spatial usage

The relationship of language with space in general and urban space in particular is part of a mental and social process of appropriation by the individual, community, and culture. The production of meaning operates at all physical and mental levels, but it counts with respect to subjectivity and identity for all users of urban space. Culture is subject to the city, which also builds it, and there is a specific urban culture.

Even before language constructed humankind and marked our evolution, place names marked out space and its inhabitants. People were from the "Wood", "Lake", or "Ford"; they were endowed with some feature whether physical (Long, Short, Large, Redhead), historical (family origins or trade), or geographical (from the village of…, from the place where there are frogs, orchards, a stream, etc.). Places are identified verbally, indicating who lives there and how. People "belong" to a place of origin. Surnames are also a form of appropriation since they refer to a geographical origin. Even a name derived from a trade can be identified by the local region and dialect. Names give an idea of the regional experience and even contribute to learning about space—from which strategies of spatial practices derive, which depend, it will be recalled, on the culture in which we live. "To delimit is to give meaning to spatial extension, and that could only be done once people had managed to handle the symbolic dimension, that is, with the advent of language as a tool with which to communicate" (Segaud 2007:126).

Language is a material held in common and available to speakers with a meaning to transmit, that can be understood by all. It makes it possible to *re-present* an object that is absent, thereby making it possible to "transport" one's environment with one. It also enables exchange among individuals and contributes to the evolution of humankind and the dynamics of groups formed in socialized spaces. *Language* is a universal faculty just as time and space are universals of experience. But it is important not to overlook the diversity of *languages*.

An investigation of spatial and temporal deixis[10] in various parts of the world (Africa, North America, and East Asia) of speakers of different languages living in different environments and speakers living in the same environment reveals two types of "cognitive models": one type is "globalized because based on constants of human experience" (Hill, 2003:161), and the other "localized" being related more to cultural givens (writing, religious practices, history of relations among peoples). Chinese, for example, gives "priority to horizontality", a localized model, which may be related to the fact that the horizontal marks are drawn first when forming the characters of the vertical script.

One of the "most obvious" globalized models "rests on isomorphism among expressions meaning *in front of/behind* and *before/after*" and in most languages "the predominance of the vertical orientation" (Hill, 2003). For example, in indicating the cardinal points, we say north-east and not east-north. Besides this choice of word order, the predominance appears in more numerous "lexical resources" and "metaphorical extensions" relating to a varied range of domains: whichever the cultures and words employed, this idea of spatial symbol is invariably found. The cognitive basis for this predominance might be a universal given: that of "the standing position generally adopted by humans in reaction to the force of gravity" (Hill, 2003:166). There is a transposition of human verticality—the place people occupy in the world—to the surrounding environment. The perception of the city is influenced by this. Many representations are pyramid

10 Deixis means all the resources of a language by which subjects can give markers in time and space relative to themselves. For example, *here* is the place where I am when I speak while *there* is the place where I am not.

shaped. The construction of ever higher towers, a true technological challenge, is a direct expression of this.[11] The tower is a symbol of power, authority, and virility. The Chicago school showed that the "wealthy" live on high ground or on the outskirts, so they can keep their distance and protect themselves. But again everything depends on geographical and economic conditions. Skyscrapers in the United Arab Emirates or favelas, suburban housing in Europe or dormitory city tower blocks. What is at issue is the symbolic value of places and the way that value is expressed.

The use of language is therefore significant of the relationship human beings maintain with their geographical and mental environments through discourse that takes shape in individual languages, which are both filters of the real world and windows on the world. Language is a cultural heritage. Every utterance is a vehicle of what characterizes individuals and the society they live in. Maurice Halbwachs (1968) makes the point that "Collective memory rests upon spatial images… Each society divides up space in its own way… so as to form a fixed framework in which it encloses and finds its recollections". Names in particular keep a record of this.

Let us take the example of a few English expressions showing that space inhabits language and that language showcases space, doubly structuring mind and memory.

Spatial expressions of language

Humans have explored the world, gong ever further (behind the hill, over the mountains, or across the sea, and so on) thanks to ever more present technology. Words were being invented all the while to stand for the acts and objects in question. Humans were then able to remember space by locating the features around them, but they were also able to gain access to time by situating events in duration. This is what marked the beginnings of humanity: the ability to rely on time, the past—each experience, each stage in the progression being memorized.

Language naturally evolved with the new discoveries and inventions. This is what linguistic expressions speaking of space show. They can be used in geographical space as well as in the space of the mind. Examples include *not knowing where one stands*, *losing one's bearings*, *being eccentric*, *being on the edge of the abyss*, *climbing mountains*, *being all at sea*, *being on a slippery slope*, but also *finding one's marks*, *getting a direction*, *being at the helm*, *getting back on track*, and *marking one's territory*, etc. Lynch (1976:84) emphasizes "The very word 'lost' in

11 Towers have symbolic value whether of religious power as with bell towers challenged by certain monastic reforms (Cistercians); public power with castle keeps and belfries in competition with church steeples. Nowadays banks and corporate headquarters, and so on.

our language means much more than simple geographical uncertainty; it carries overtones of utter disaster".

Because everything has moved very quickly since the late nineteenth century, the pace of life and knowledge of the world have accelerated, and language has had difficulty keeping up. Reference is still made in the main to facts and features of the past, in connection with the earliest discoveries of the world. Examples include *getting into the saddle*, *missing the boat*, *making headway*, *tilting at windmills*, *being a slow coach*, and so on. The expression *to have a home port* expresses the link, the anchoring in an original point in space and time (a place where many generations have lived). There is currently a paucity of expressions directly representing this difficulty of "making do" with the acceleration of modern life and the psychic disruptions it induces. Such expressions are mostly (about three in four)[12] used to reflect difficulties felt: it seems we encounter more obstacles than we have ways of overcoming them. When a space becomes narrower, whether physically or virtually, humans get a "shrinking" feeling. This shows to what extent situating oneself, finding one's place in society is problematic for people, both in the spatial appropriation of the surrounding features and in relations with others.

In these expression, recent everyday urban life is barely represented. There are *the man on the Clapham omnibus*, *lighting-up time*, *living above the shop*, *being streetwise*, *being dragged through the gutter*, *kerb crawling*, etc. But overall they deal mostly with human infrastructures and means of locomotion such as ports and ships (*find a safe haven*, *any port in a storm*, *to cast off*, *to up anchor*, *be at the helm*, *change tack*, *pile on sail*), roads and vehicles (*drive round the bend*, *be at a crossroads*, *hit the road*, *backfire*, *live life in the fast lane*) or others (*enter the arena*, *step into the ring*).

These expressions, which are part of a linguistic and cultural heritage, beyond and short of verbal language, are also part of a semiotic perspective on spatial symbolics. Spatial symbolics shows us that left to right[13] and above all top to bottom are a way of behaving in space but also a way of being perceived by others. Geographical and social elevation are truly accorded more value. It is always positive to get to the top, with the social ladder being open "in theory" to all. Examples include: *to climb mountains*, *to be set on a pedestal*, *to rise to the occasion*, *to be at the height of fashion*, *to be bogged down*, *to hit rock bottom*, *to be deep in depression*, *to have that sinking feeling*, *to be feeling low*, etc. Movement from above to below is the symbolic representation of inertia (or even death) with respect to effective movement. It is likely that religion induced such representations: *to sit at God's right hand* and *in seventh heaven*, far from the flames of hell and the belly of the earth. Height "uplifts" humanity taking us closer to God. The heavens

12 Reference to the corpus in French compiled by S. Mariani-Rousset of about a thousand metaphorical spatial expressions using geographical features or spatial actions in a figurative meaning. Forthcoming 2016.

13 We represent time on a left-right axis.

are vast and represent every possibility; the depths of the earth are dark, enclosed, and the dead are buried there. "Up" therefore represents light, great aspirations, philosophy, the mind, whereas "down" symbolizes roots, secrets, the subconscious, sexuality, the depths, etc.[14] Any dwelling on high ground in a particular geographical setting grants some form of power. There are therefore several ways of seeing tall buildings: for protection and keeping watch (castles), for spiritual uplift (cathedrals), for dominating and displaying power (skyscrapers), or for cutting oneself off (ivory towers), and saving space and money (tower blocks).

This architectural metaphorical language can be studied in spoken language. There are many ways of thinking of the city and living there and just as many ways of expressing it. Contradictions between desires and reality, whether voluntary or subconscious—depending on utopias and urban emotions—give rise to satisfaction or dissatisfaction that can be more or less successfully expressed. Sometimes it takes several moves to clarify one's residential project.

From the faculty for language to different languages and from words to speech

Residential choice is thought through in words, when planning a move, and is then manifested concretely in discussions and sharing of views with the family and lastly when interacting with estate agencies. There comes a time when image and desire must be materialized so they can be communicated. What the locals have to say about certain places affects the decisions of the prospective inhabitant, in the range of uncertainty extending from the idea they have about their future location and the time when reality sets in: the city is expensive (another part of town has to be chosen, but which one?); the first requirement cannot be met (living close to water: there isn't any); amenities are far fewer than in the previous city; the location is ideal but too popular (high density); and so on.

The relationship between language and space, which is essential in articulating cognition through representation and verbalization is therefore contemplated—especially when addressing urban space—on two levels:

– the level of *multiplicity of language*, because spoken language is not the only form of signifying and interpreting in the urban space (gestures, tags, actions, etc.);

– the level of *complexity of discourse*, of which words are the component parts but which are only understood in texts that are constructed and make allowance for the speakers, situations, values, and an ideological and action-based dimension.

The study of signifying configurations and urban discourse can be approached from three angles: a semiotic angle proposing a predominantly logico-philosophical analysis of forms; what might be called a semiological angle,

14 This symbolism can be found in psychology (tree or village test) or in graphology.

associating forms of the urban world and discourse about those forms; and a more narrowly linguistic or sociolinguistic angle centred more on discourse.

Thus how space is represented and expressed follows from the way it is perceived. For example, "I wouldn't like to live there!" shows that it is not possible to imagine oneself in a certain type of place (in a particular district, near a railway line, in a new block of flats, etc.). Each of the elements encountered must be identified and analysed for it to be meaningful. This already involves the (internal) representation that one has of oneself in space (psychology of space), then the (external) concrete representation of that space. From this ability to establish a connection between one's personal space and the outside arises the possibility of living among others, in the city and in one's home with all the constraints that it imposes. For Stock (2006), "individual and society are not opposed, but can be used as concepts designating two separate manifestations of humanity". Several question then arise: How do things work between an individual and the numerous other urbanites around them, pedestrians, drivers, etc., but also neighbours? How is the sharing of space organized? How can one maintain one's personal space without encroaching on that of others, while protecting oneself adequately and effectively?

The semiotic angle

The subject of semiotics is not space but spatiality. Semiotics brings to light general categories of perception as much as of knowledge and culture (e.g. here/elsewhere, intensity/extension, boundaries/edges, separation/union) to apprehend both "thought about space globally" and spatial domains (painting, architecture, urban space, etc.). Semiotics therefore looks at "microanalyses" of verbal expressions (e.g. prepositions) and at "microanalyses of configurations that define different *models* of spatiality in a work, in a genre, in a culture" (Bertrand and Bordron 2009). Marcos (2008) explains that "architecture and town planning are intelligible forms of human activity… that can be apprehended in an organized and rational way" in their "communicational dimension". For Lamizet (2008), urban space is defined by the "confrontation of identities", integrating politics, culture, and linguistics in a triple *real*, *symbolic*,and *imaginary* plane.[15] This brings us to the notion of frontier, which may be as much physical as symbolic, as much social as imaginary. The level of the real describes the physical characteristics of an environment, the symbolic level brings us back to the meaning of words and representations, and the imaginary level relates to dreams. As a geographical site with its properties of physical space, the city is also a political system and a public space with its institutions, its places of exchange and encounter (*agora* or *forum*, cafés and marketplaces), its emblems of power and its protest movements, its fictional representation (theatre, cinema, novel, etc.). Lastly, temporality is an essential dimension because "urban identities are not expressed only in the present of actual social practices but also in the past and the long duration of the history of the city" (Lynch, 1976). The most formal semiotic research joins up with research in the psycho-cognitive domain, and with research on mental images (Lynch, 1976) or Greimas'[16] project of "topological semiotics" designed to study spatial languages of non-verbal objects to form a "grammar of sensitivity".

The semiological angle

In keeping with a suggestion by Barthes17 likening the city-dweller to a reader of the city, contemplating the city itself as a discourse-text (and so the discourse-texts in the city) comes under the semiological or semiolinguistic angle because the systems and processes of meaning are articulated around what is verbal. Objects may be the signaletics of it, with a practical function of directing and marking out, as may the verbal or multi-code traces specific to the urban world such as tags or posters or discourse held or picked up in the city by the inhabitants or passers by. It is a sociosemiology of the city of Grenoble that Lucci et al. (1998) for example, develop by taking account of the graphical and scriptural, instrumental and anthropological aspects of writings in the city (shop signs, subversive literature of tags and graffiti). Their social functions of identification and differentiation cross cut the issue of varyingly transgressive "interstitial urban cultures". The written word, because it is spatial and involves sight, takes precedence over the deambulation of the body as the condition of perception.

The linguistic or sociolinguistic angle

Urban sociolinguistics gives precedence to "language variation" in correlation with socio-spatial structures to "analyse the territorial organization of urban spaces" (Bulot 2001). It therefore fits into a linguistic perspective, but in subscribing to the definition of the city as a spatial form, cultural phenomenon, and historical phenomenon (Calvet 1994). Postulating that "being from a place is all about being able to say where one is from" (Bulot 1998), urban sociolinguistics is interested, for example, in the different names of city spaces and in categorizations, or even discriminations that they display. The words and discourse about (in and on) the city can therefore be apprehended from a linguistic angle ranging from linguistics *stricto sensu* to discourse analysis. The study of city words can be part of lexical and semantic analysis in one language or comparatively across languages. It then cross-cuts the questioning about the relationship between cognition and cultural factors. But the interdependence among languages, social practices, and discourses in urban spaces promotes multi-disciplinarity (sociology, social geography, discourse analysis) insofar as “discourses by inhabitants are also components of urban reality” and “urban identity lies between what languages say about living there and what living there says about languages” (Bulot 1998). Discourse analysis associated with urban sociolinguistics and socio-semiotics presupposes that the verbal-discursive dimension is not to be considered a reflection of reality but as constituting and producing representations and actions, as a factor of transformation of identities and practices.

3. The ability to live in society

Territory is delimited (at a time *t*), it is related to *having*; space is mobile, it is related to *being*. We occupy a lived space, indirectly related to territorialization. Territory is an object of desire (we want to acquire, to conquer land, etc.), whereas space belongs to everyone. Here we find the relations between outside and inside. Having is the subdivision people have made of space (territories, borders, countries, home),[15] whereas being relates to symbolic space; the space that humans make their own in the possible “social” field left by their counterparts (especially public space). I *am* necessarily in a space that does not necessarily *belong* to me, but that I make my own regardless.

3.1 Practices of territoriality

It is important to us here to determine how spatial practices play a decisive part in specific conducts of spatial mobility and residential choices. We have seen that in defining personal spaces commentators speak of “bubbles”, “buffer zones”, and “shells”. The words used are evocative. Whichever the name given, it is always an intimate zone to which admission is controlled as far as possible by the individual and reserved to “authorized” persons. The separation is real (by the skin or by an object) but it is above all symbolic or even imaginary. It serves to protect the individual. It surrounds them. It moves with them. This idea seems to be central in understanding phenomena of co-existence raised by the city since the direct material translation of this conceptualization of the notion of territoriality is that of conflict in use, that is, the claims that two individuals may make to one and the same place, at the same time and for what may be different uses.

Personal space and proxemics

Personal space is a zone surrounding an individual the functions of which vary with psychological and cultural factors (Hall 1971). Hall showed that personal

15 Will residential choice indicate what stems from having (home ownership) or being (location, life choice)?

space could not be encroached upon by others without provoking characteristic reactions.[16] In this case, there may be a feeling of intrusion interpreted as violence or aggression, which will be translated then by a reaction which, in turn, may be more or less violent or conflict-based. Personal space serves to protect individuals, to reduce sensory overload, and above all to control and regulate the level of intimacy desired by people. Intrusion into personal space is lived as a positive or negative experience, invariably an emotional one (sometimes impulsive and unreasoned) that may produce a physiological stress effect. It is perceived differently by children and by the elderly. Children trust their entourage more than adults do. Variations in personal space are related to the sex and culture of those present. This personal space tends to increase in the presence of a stranger. It is smaller among women together than men together. When too great a proximity is imposed, individuals tend to look away or to change the direction their bodies are facing. All of these components are variables forming a feeling of fear when individuals think they have no control over the proximity a situation engenders, if it does not match their educational and social prerequisites.

Among the codes of communication to which Hall (1971) pays most attention is that governing the subdivision and use of interpersonal space. For the American anthropologist, each culture organizes space differently on the basis of an identical animal substrate: “territory”. But westerners have also conceptualized the space they share with others in different ways. We might cite, for example, the social space of Bogardus (1926), who laid down a scale of social distances determining the willingness of persons to become involved, which contributes to social relations; the sociocultural spaces of Sorokin (1927), to whom we owe the concept of social mobility; and the topologies of Lewin (1936). To define the study of the human perception, use, and organization of space, Hall (1981) created the term *proxemics*. This covers “the study of how man unconsciously structures microespace—the distance between men in conduct of daily transactions, the organization of space in his houses and buildings, and ultimately the layout of his towns”. It is a semiotic discipline that aims to understand the use that individuals make of space for the purposes of meaning. Space is mobile and corresponds to what surrounds us (the environment) and to what we move with us (bodily limits, such as Anzieu’s skin-ego, seen above). Hall (1981) defines territory as a socially constructed space, in a given time and place, in a given society. Territory and transactional distances vary with cultures and uses. This raises the issue of the co-existence of different cultures in one and the same territory, since the values, norms, and rules inherent in each culture remain specific. “Living together” and social cohesion will therefore need to be actively taught to audiences.

16 It should be emphasized this a model for a North American population, that can be extended to western cultures but that is not applicable to all cultures.

It is important to take account of this notion of distance in residential appraisal. Its cultural aspect shows that the size and density of cities and populations, and climatic conditions, play a part in appraising living conditions. Living in Chicoutimi or Las Vegas does not procure the same feeling, it is not experienced in the same way by the body. Mediterranean and Indian cities are dense, Los Angeles is extended with large distances between individual houses, Japan forces clustering, Canada offers wide-open spaces, Australia is vast but has few inhabitable areas, and so on. Using contemporary means, it is possible to travel to a location (satnav in car) or to the other side of the world by plane, just as it is possible to get on to the Internet to "travel" by looking and (supposing) we get to know faraway places. This is what Augé (1992) called "spatial overabundance". Distances are dematerialized, acts of movement transformed. Space itself is no longer perceived in the same way. All areas of the globe are occupied, there are virtually no unknown or empty spaces, and yet we can find many sanitized "non places" such as motorway service stations or airports and so on.

Everyday territories

For Goffman (1973a) and therefore in western culture, territory principally covers notions of distance (inter-individual more than individual-object). For him, the concept of territory is related to places and objects, the concept of space to individuals (in mind and body). It is important to understand what happens within even a small territory.

By Goffman's definition, this territory comprises:

– the "home": the dwelling place with its subdivision such as the kitchen, lounge, bathroom, etc.;

– the "what's mine": more or less symbolic properties (this may equally well be an object such as a sports team or the "homeland", etc.);

– and "place" which is often temporary by nature (a place at table, at the cinema, on the bus, and so on).

So we differentiate among:

– temporary territories as they are called by Sommer (1969): tables, seats, places ("that's my place");

– and "portable" (Sommer 1969), "interaction" (Knowles 1973), or "mobile" territories (Cheyne and Efran 1972)—what Goffman (1973b), studying the microsociology of everyday life, called "territories of the self": personal items, clothing, handbags, etc. considered as extensions of the bodily schema.

It should be noticed that all of this takes on major cultural value. The way all these territories are thought of and experienced remains a function of prior anthropo-social constructs. This means that the organization of space and promiscuity are not experienced in the same way. Proximity, for example, is a sign of complex and close social ties in north-west Africa whereas it is a sign of indigence and poverty in the western world, where physical distance from others (size of holding, floor space of house or flat, etc.) remains an attribute of success and power.

Cigarette stubs, spit, chewing gum, dog dirt on the ground, which are all interpreted as the result of bad behaviour, just like advertising or odours can also be spatial intrusions for some individuals (Goffman 1973a).

There are tactics for defending territory. Goffman tries to understand the working of different procedures and strategies individuals put in place to maintain interaction with others, so that the relationship is akin to avoidance (looking down), preserving the other's territory (places), or ritualized contact (greetings, etc.). Notice that it is possible to think of avoidance by integrating it into an urban plan. It then becomes a defence strategy or at any rate a way to anticipate the act by constructing urban structures that render anxiety-engendering situations, damage, and wrongdoing difficult. This is what the concept of "situational prevention" laid down as a postulate in the 1960s further to work by the Chicago School, to ensure safety in the planning of public and private areas; a principle that is found again in the work of Lynch (1976), especially in allowance for poorly lit areas.

The *Umwelt*[17] is the space in which the individual perceives alarm signals (Goffman 1973b). While there are conscious avoidance strategies, there are also irrational fears leading to strange behaviour justifying certain residential choices, especially in the choice of neighbourhood. These fears, termed phobias, are of two kinds:

– *Behavioural phobias* related to the space itself: agoraphobia (fear of empty spaces, public places), claustrophobia (fear of enclosed spaces), acrophobia (fear of high places), topophobia (fear of unknown geographical places), aeroacrophobia (fear of open space at altitude), catapedaphobia (fear of climbing up high), dromophobia (fear of crossing the road), and so on.

– *Social phobias*, about physical or verbal contact, leading to the need to protect oneself from others: anthrophobia (fear of being with other people), blemmophobia (fear of being seen by others), ochlophobia or demophobia (fear of crowds), acoustophobia (fear of noise), esiteriophobia (fear of transport), and so on.

All of that gives rise to forms of adaptation with a view to protecting oneself and to managing to be in contact with others. To reduce one's phobia is also to shrink one's potential use of space. It is therefore a question of protecting oneself from others, finding one's place and keeping it, while living as well as possible and benefitting from life in society. The choice of housing follows from this position to define and give precedence to one's living space as a function of

17 This is a reference to Jacob von Uexküll and Thomas A. Sebeok. The concept means the "own worlds" that individuals share in the same environment.

one's environment. The *residential environment*, what happens around the place where one lives (the view as much as monuments or damage), offers a whole array of parameters that will affect decision-making, especially with regard to the neighbourhood (avoided or on the contrary sought out because reassuring) and settlement close to a strategic place (school, station, shops, etc.).

Moles and Rohmer (1972) evoke proxemics not by considering remoteness but by taking into account what is close, speaking of walls putting distance between the *here-point* and the faraway, between the individual and the world.

3.2 The psychology of space and the philosophy of extension

After sociology and urban anthropology, architecture and town planning, language sciences, economics, and human geography, it is psychology that has taken an interest in space (Moles and Rohmer 1972). "Being" in space, as we have seen derives from an ability acquired in the course of development, of the awareness of situating oneself in a particular context. Moles and Rohmer (1972) proposed various concepts taking into account the individual's centrality within their own space, with space being perceived both qualitatively and quantitatively. They speak in particular of the *here-point* and of *walls*, which are two equally important concepts. The here-point, unity of place and life, is a space that is constructed, appropriated, legally acknowledged, bounded by walls, the construction of which consolidates individuation. Around the here-point, the environment appears discontinuous because of walls that separate the human being suddenly from others and reduce the importance attached to phenomena. The wall creates an opposition between inside and outside, between interior and exterior, between perceived and imagined. It creates a sudden variation in the sensory gradient (physical, visual, sonorous, thermal, olfactory, social). Constructing a *here-point* therefore means constructing *walls*. The here-point is that much sharper when the level of discontinuity is greater, that much more meaningful when the wall that constitutes it is better formed, it is much more existent for the individual when the individual has occupied it for a long time, performed a greater number of acts there, and when it is composed of objects attesting to present or past activity.

The here-point

In geography, the psychology of space is involved in territorial organization. The region is thought of as an intermediate scale between local and remote. Space as experienced is space as it is perceived and practised by beings who live there (Lévy et al. 2003). They do not live in the world as it is but in the world as they see it; as geographical actors, they behave in accordance with their *social representation* of space. Moles and Rohmer (1972) distinguish *space* from *place*, because place is given an identity. They define experienced space and represented space by using the distinction between the philosophy of extension and the philosophy of centrality. The philosophy of centrality refers to space as experienced: what is close (self, here, now) is more important than what is remote (once, elsewhere). The being perceives the world and the environment from the point it occupies in space, the *here-point*. It is *here* that I live, it is *here* that I work, and so on. The consequences of centrality can be summarized in this way:

(1) Being is located in the field of things it observes.

(2) Not only is it aware of being part of those things but it considers itself as the starting point of the world, the centre of the world.

(3) The structuring of this space as experienced, which is limited by nature, is subject to an effect of *perspective*—that is, to attributing different importance to things and events, that is inversely proportional to the geographical distance separating this experienced space from those things and the places where those events occur. What is close is generally more important than what is distant. The closer one is to a place, the better one knows it. Hence the formulation of the proxemic law: the importance attributed to the environment is inversely proportional to distance. Some researchers (Pumain et al. 1997) evoke this aspect in speaking of perceptions of logarithmic distances; there is the same relationship of markers between 0 and 1 km as between 1 and 10 km or 10 and 100 km. Space is anisotropic but non-Euclidian, i.e. not all distances are calculated in the same way, everything depends on the speed of circulation and perceptions one has of it. This perception varies with geographical position and changes with representations of humankind. It should be noticed that a certain roughness of space, based on psychological factors, may entail a reality of distances that is very different from metrical reality. Thus, the fear of frequenting a place may lead to avoidance strategies, reflected by longer journeys, which are therefore not rational with respect to the extra energy expended, but more comforting and reassuring for the individual, which amounts to a gain. In the city being discovered, journeys lead from one point to another. Whether by obligation (diversion) or by a desire to explore, places become increasingly known via secondary routes. We gradually enhance our knowledge around these spaces by connecting up known paths. Even if such knowledge remains very unequal, it will lead us to discover, to reconnoitre places where we would or would not like to live.

(4) This experienced space is not homogeneous. It is made up of boundaries or *walls* that separate zones known as "shells" that fit one inside another.

(5) The philosophy of centred space posits, for Moles (1972), the basis of what might become territorial tension and conflict but also standard conflicts. Individuals recognize themselves as the centre of their world and thereby deny the individual centralities that other individuals construct in

the same way. Tensions quickly arise based on this way of thinking about the environment around oneself and therefore this way of denying the minimum interaction required for living as a collective group. Yet the city is characterized by living as a collective group and the necessary sharing of space.

Walls

The "philosophy of extension" concerns the space represented. By reference to Descartes' distinction between *res cogitans* (thought) and *res extensa* (matter), space represented in knowledge is engendered by axes (two for area and three for volume), the origin point of which is arbitrary, and that can be used to locate at a point in this, what is called representational space, each object or each observation depending on the position occupied on each of these axes. The consequences are: (1) the observer is no longer located in the field of observation as before but outside of it; (2) no point in this space is special; (3) what matters to the observer is the position of individuals or objects with respect to each other, clusters of positionings, that is, *densities* represented by clouds of points. This space is therefore formed from subsets, some being concentrated, others dispersed, interstitial. The space represented is above all considered as a quantity, whereas in the first case it is considered rather in qualitative terms. It is a rational space whereas space as experienced is emotional by nature.

In the philosophy of extension, as any point is equivalent to any other, there results an ethics of coexistence. What matters is the movement of beings within this space, the probability that they will meet depending on the densities to which they belong, even if the encounters imposed on them are often short and impersonal. The existence of others is perceived in different ways. Moles wrote: "The other appears to be similar to me, so the fundamental question arises: who then is the centre of the world, he or I… There is no 'logical' answer to a question of this kind within the actual system of this perception other than combat… In the end it is the stronger who, himself, pragmatically will constitute the 'true' centre of reference to which I must conform[21] as a source of organization of the world. The philosophy of centred space is a philosophy of conflict, combat between the pre-eminence of the Self and pre-eminence of the other" (Moles et al. 1972:12-13).

18 Conform but also differentiate myself, in comparison with others. J.-P. Codol spoke of the PIP (*primus inter pares*) effect to evoke this constant juggling between the need to conform (that might go as far as hypernormality) and the need to stand out.

These two philosophies are irreducible. They cannot be conceived together. Conversely, we shift constantly between them. But they concern in a particular way certain types of occupation: architects and urban planners conceive of space in terms of extension whereas the inhabitants and psychologists trying to understand the perception of it conceive of it in terms of centrality. Hence Moles' invitation to start up a dialogue between inhabitants and architects to "humanize geometry".

3.3 Interactions: choosing the right distance

For Moles and Rohmer (1972), people are not neutral objects in the space around them. They perceive, judge, react, etc. Space is a system of positions and relations between positions inducing interactions among individuals and reciprocal relations. Goffman (1973a, 1974) shows how it is important in the social sciences to take an interest in individual interactions.

Physical and social distances

For Altman and Taylor (1973) there are two types of distance: superficial and profound, where "regulation" of intimacy is at issue. They vary with the role of the individuals involved (government official, shopkeeper, classmate, passer-by, close friend, etc.). Suitable classified behaviour arises from it. Altman (1975) speaks of the control process of the interpersonal boundary.

Territory, that Hall (1981) calls personal space is therefore everything that is defended either passively (border) or actively (war, force, etc.) even if that space does not belong to us. Goffman (1973a) names them fixed, situational, and egocentric territories. Goffman also speaks of the metalanguage of intimacy. He addresses the concept through metaphor; we are on good or bad terms with others depending on whether the distance is right (controlled and/or respected) or wrong (unsuitable, constrained). One can work far away and in good conditions or close but with awful co-workers.

Many studies were carried out in the 1960s. Hall (1971) in particular came up with a scale of interpersonal distances:

(1) *Intimate distance* (0–40 cm). Generally being physically close involves contact, sound of breathing, and so on. The near mode (0–15 cm) is body to body. It is the distance of love or combat. All the limbs are in contact. In the far mode (15–40 cm), the body can be touched by the other's hands. Moving into this zone requires intimacy on the part of the two speakers. If one of them refuses, he or she will step back automatically. If the interaction occurs in a confined or overcrowded space (lift, underground, etc.), behaviour to escape the embarrassment felt will be observed: looking into the distance, motionless bodies, hands withdrawn. Each person will adopt an attitude of maximum indifference by ignoring the proximity.

(2) *Personal distance* (40–120 cm). At this distance, individuals can come into contact through their upper limbs. Details of the face and expression are fully perceived, but not natural body heat or odours. It is the standard conversational distance. The near mode (45–75 cm) is an intermediate zone between intimacy and conversation. In the far mode (75–120 cm), the speakers are "at arms' length". It is the limit of a physical hold on the other. It is a good distance for speaking of personal problems because verbal communication is effortless and bodies do not have to be on the defensive.

(3) *Social distance* (1.20–3.60 m). Bodily contact is no longer possible. In the near mode (1.20–2.10 m), the entire face is perceived. It is the distance of business negotiations, of people working together. In the far mode (2.10–3.60 m), this distance gives a formal character to professional and social relations and makes it possible to isolate oneself while in the same place without being impolite.

(4) *Public distance* (beyond 3.60 m). At this distance, an individual can take flight or put up a defence if threatened. The relation is impersonalized; it is the distance of important officials. The near mode (3.60–7.50 m) is the boundary of the social type; in the far mode (beyond 7.50 m), interpersonal relations become impossible. Details of the body and even of the voice are not perceived. It is the distance of declamation and arm-waving.

For Hall (1971), each individual is the centre of a series of concentric bubbles marked by different distances. These basic bubbles form four territories, common to both humans and animals. But each human culture defines the size of the bubbles and the activities appropriate to them differently. Inter-individual distance varies with the intra-individual system and the group system.

Intimacy as personal territory

Research in psycho-sociology has focused more on personal space than on intimacy. Goffman (1973a) studies what he called "territorial invasions" where "any penetration is felt as encroachment". He conducted experiments to try to understand what happens (changes in behaviour) in the event of invasion of space by proximity, touch or eye-contact. He developed (Goffman 1974) the concept of intimacy (initially so named to suggest the difference between private and public).

If one observes interactions among students of different nationalities, it can be seen that Latins, Arabs, and South Americans make more visual and even bodily contact than Europeans and North Americans (Watson and Graves 1966, Bochner 1982). Other researchers (Jourard 1966, Scheflen and Aschcraft 1976, Guéguen and Jacob 2005) have studied physical contacts in the course of an hour's conversation in cafés in various countries. They recorded 180 in Puerto Rico (Caribbean Sea), 110 in Paris, 2 in Florida, and 0 in London. The distance between two Cuban speakers is half that of Anglo-Americans (45 cm versus

90 cm). The "right" distance to adopt in a given situation is a very significant feature in an interaction.

If two people are engaged in conversation in a narrow street, they force passers-by either to make their way with difficulty behind one or other of them or to pass between them and be impolite by interrupting their interaction (Cheyne and Efran 1972). It can be seen that 80% of people avoid passing between them while the conversation is going on, and only 25% if its seems to be over. Space, then, becomes a territory. This shows the differences in accepted distances between individuals: people embrace when they meet in southern Europe, they shake hands in German and they greet without physical contact in northern countries.

To seek to remove distance between two individuals or to look to impede interaction may call into question the possibility of communicating or cohabiting.

From intimacy of living place to otherness

It is psychic space, personal space that defines intimacy. The idea of intimacy relates to the integrity of the person, to their identity, to private space, even outdoors. The "nothing to hide" argument, with cameras that are supposed to protect individuals, runs counter to the individual's vital need to move when he wishes, his psychic construction being related to space. So we see the importance of distance and of intimacy between people and the city itself, in what the appropriation of places represents; either negatively (degradation, incivility, violence, state requirements, etc.) or positively (street art).

We also see how much the utopia of "transparent" cities, designed to expose individuals entirely to scrutiny, aims to reduce humans to a single dimension. Utopian cities wish to remove chance, to make their own system, tending towards perfection. It is the human imprint on domesticated nature, a derisory gesture. Perfection here fits in with the idea of lock down, omnipresent control (ubiquitous surveillance cameras, open-space work places in high-rise glazed towers, etc.). Freedom and desire for intimacy then supposedly become a form of imperfection… And yet they are recurrent in residential choice, intimacy ensuring the preservation of one's territory. It corresponds to the "right distance" and therefore represents everything that means that we do not feel invaded by others and the environment, and concerns the places we protect and open only to those who are authorized. This is already not easy in a personal place (promiscuity, noise, insecurity), but it is even more difficult in an outdoor place that is to be shared, where the spatial appropriation of some can easily invade the territory of others (Bernard 1993:369): "The need to have some private space is a fundamental need of humankind who, temporarily and more or less intensely, depending on individuals, feel the need to maintain a distance, to sever relations with the physical and social environment". An incapacity to filter information about one's personal life and the revelation of the intimacy of others both lead to the destruction of the boundaries of private space. Individuation sometimes requires individualism. While isolation makes it possible to manage one's intimacy by allowing one to come into contact with others when one wishes, solitude offers no choice and is a factor of disequilibrium. Thus an isolated individual will make up their own rules and norms about how to live, which may produce anomic behaviour with regard to the society they live in. Group life, in this situation, is therefore not facilitated since the individuals confronted with such atypical behaviour will interpret it as a breach of commonly accepted rules of living together and social control functions will very soon kick in to regulate this abnormal behaviour (case of marginality, stigmatic figure, etc.). For other individuals, the dynamics of isolation described may be reflected by what has been called *cocooning*. In this instance, it results from the need to have a place to live, a protective sphere, a "cosy nest" where we can be isolated from a world that we are pleased to find when we want to, and only when we want to.

Yet, one's personal space is never completely empty. And while one must sometimes know how to protect oneself, the city also offers the great advantage that there are so many people to meet. The otherness to be lived develops each individual and the city itself. It is therefore essential to understand the problems of both geographical and human distance in their dimensions of mobility and co-spatiality. All this elicits ways of residing, networks, and dissimilar spaces. Otherness and remoteness are to be contemplated in the same light, with a positive value; because once sufficiently developed, the individual will want to enjoy life in the community, well beyond the idea of security (Paquot et al. 2007).

4. Conclusion

It can readily be seen that residential choice is the outcome, in a limited time, of a long journey begun in childhood. The child, once assured and reassured about its presence in the world, after having opened to otherness, faces the social world. As an adult, one has life choices to make. How will those decisions be made and in what context? How will choices evolve with circumstances at each stage of mobility?

Even if the protective and security aspect is often something taken into account (owning property is also a form of protection), a compromise is made between the need for intimacy, calm, distance, and being a member of a generally substantial population made up of neighbours and passers-by on urban streets. The paradox of the city is that it tries to have individuals co-exist who biologically and materially need social bonds but whose psychological and behavioural structuring pushes them increasingly towards individuation and even individualism.

To define, demarcate and delimit one's own space is essential in the construction of identity and the making of the future citizen. Inter-individual relations are marked by it; forms of mobility and by the same token spatial practices differ. What allows one to "keep one's distance" and to be mobile while feeling "anchored" in life, a skill acquired in childhood during one's upbringing, is what generates the possibility of "being oneself" regardless of the environment, living in society, and the ability to establish new ties and come into contact with others.

Living in the city supposedly comes down to putting up with others, the major challenge being in the actual social or psychological distance placed between self and other so that each achieves a feeling of satisfaction and well-being. However, the positive aspect of life together in a common space (social networks, mutual aid, possibility of big events, access to amenities, etc.) can be glimpsed. That is the fermenting agent of the major role to be taken on by spatial structuring and the way it is perceived in the construction of the relation between individuals and, on a collective scale, in the construction of social cohesion and harmonious "co-habitation".

The Wheres and Hows of Residential Choice

Anne Griffond-Boitier, Sophie Mariani-Rousset, Pierre Frankhauser, Jérôme Valentin, Victor Alexandre, and Bernadette Nicot

1. Introduction

A wide variety of choices and decisions are open to individuals when looking for a place to live: a flat or a house, renting or buying depending on one's resources and plans; living in a city centre to enjoy its buzz, or in a certain district to have a school close by, or on the outskirts in a more village-like setting; and in this last case, how far from urban centres and major access routes? What ultimately are individuals' preferences? All these questions presuppose looking at how they perceive and evaluate the urban environment so as to better grasp what it is that leads to residential satisfaction. However, it is not the evaluation or satisfaction in itself that is of interest to us here but instead the way in which these factors influence individual decisions.

We consider the way individuals apprehend the city, travel through it, interact with the material and social environment, and impart meaning to it; how individuals make mental representations of space that help them to better take the measure of places and set up criteria for evaluating their urban and residential environment. It is on these bases that they forge their decisions. This chapter attempts to specify the context in which decisions about residential and daily mobility are made.

On the collective scale, urban societies manage and organize all forms of mobility. They offer partial answers, constrain or adapt to individuals' coming and going, and even anticipate their aspirations. What planning strategies are put in place, how is social demand accounted for, how do planning strategies

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ultimately influence individuals' spatial practices and decisions about mobility? This chapter endeavours to answer these questions too.

Highlighting all the factors that have a part in the context of choice and decision-making about mobility is the subject of an introductory part to the chapter.

2. The decision-making context

For a proper understanding of the context of the choice and decision-making process concerning residential and daily mobility, we have drawn figure 1.[1]

The individual is considered within a social, psycho-social, economic, cultural, and geographical space (at the bottom of the figure). These various portions of space overlap because it is often difficult to draw sharp boundaries around each of them. The areas of overlap relate, for example, to the way in which individuals identify with their own residential space, the way they enhance or on the contrary devalue their social image by their dwelling place, by the type and cost of their housing. Another example is the way they perceive both the inside and outside of their residential environment: geographically or materially, allowance is made both for the inside of the housing (its size, decoration, etc.) and the outside (the architecture of the built environment, and the façades in the neighbourhood); socially and economically, individuals are sensitive to the cost of their own housing, but also to neighbourhood relations and the ease of access to service or work; psycho-socially, individuals may think they own a nice house in what is judged an unsafe part of town, in which case there is dissonance between the internal and external enjoyment, which may lead to a change of place. Lastly, the cultural reference frame provides an understanding of why the desire to own a home corresponds not just to a need to have a piece of land but depends more broadly on the social and political history of the country where one lives. Simultaneous consideration of all these dimensions enables us to apprehend the complexity of individual references, perceptions, and representations that emerge from them. In the diagram, this set of factors is continued by a halo, chosen to represent the atmosphere of places and the "scope of possibilities". The first term concerns everything to do with the residential environment and beyond the urban environment, whether the social

1 This diagram was produced in the context of the ANR ECDESUP project by a working group including V. Alexandre (Psychology Laboratory, University of Franche-Comté), D. Ansel (Psychology Laboratory, University of Franche-Comté), A.-C. Bronner (ERL LIVE, University of Strasbourg), A. Chauvin-Viléno (Laseldi, University of Franche-Comté), C. Enaux (ERL LIVE, University of Strasbourg), P. Frankhauser (UMR ThéMA, University of Franche-Comté), H. Houot (UMR ThéMA, University of Franche-Comté), A. Griffond-Boitier (UMR ThéMA, University of Franche-Comté), S. Mariani-Rousset (Laseldi, University of Franche-Comté), T. Ramadier (ERL LIVE, University of Strasbourg), C. Tannier (UMR ThéMA, University of Franche-Comté), and J. Valentin (UMR ThéMA, University of Franche-Comté).

environment or the landscape. This may be, for instance, lighting or the auditory setting, the climate, what the house fronts look like, the social atmosphere in a part of town, or contacts with the neighbourhood, and so on. The second term is deliberately vague and refers to spatial attributes: the urban offer that takes the form of different types of housing (to let or for sale, houses or flats, etc.) and infrastructure (transport, services, shops, leisure, etc.). The urban offer and the use made of it vary broadly with time (days of the week and times of day) and perceptions and feelings (stimulus or mood); the "range of possibilities" can also be used to contemplate these features. Lastly, "life cycle" is there as a reminder that wants, choices, and decisions vary with age, family situation, and social and material conditions that further widen the "range of possibilities". It should be emphasized that in some instances individuals are confronted with an absence of choice because their financial resources are so limited. Absence of choice then appears as an additional option because it forces individuals to apply for social housing.

All of these factors influence the choice and decision-making process which here corresponds to a block split into three phases:

– the first is an evaluation involving all cognitive aspects, representations and perceptions, and individual affects;

– the second is a more active phase and concerns preferences, choices, and decisions proper;

– the third is the action/realization phase of moving home, for example, and settling down in a residential location.

Territory stands alone at the output of the process of choice and decision-making and covers multiple dimensions. It is the constructed, collective space that integrates the ideas of planning policy, management and appropriation of locations, public and private spaces, sharing and boundaries, rivalry, competition or complementarity, etc. Between the "choice and decision process" block and territory, a halo is used to represent the spatial practices of individuals played out there, depending on the type of practices contemplated, in the process block (with action/realization) or in the territory.

Finally, the background to the figure is formed on one side by space as it is experienced by individuals and on the other by territory, which is more material and relates to the collective scale. Interactions between these two extremes are constant: collective construction constrains individual choices and vice-versa new aspirations overturn urban models. The diagram can therefore be used to understand that the choice and decision process is at the junction between individual and collective scales.

The plan used throughout this chapter takes up the various steps in the diagram: the living environment—or reference space—as it is apprehended by individuals is the subject of Part One which deals with the interactions between individuals and the environment, emotions towards the urban world, or movement strategies; second, the various types of choices, individual preferences, and evaluation criteria are recalled and discussed to show what makes decisions so complex when it comes to residential choice and daily mobility. Lastly, emphasis falls on the way the territory is constructed, the way it proposes answers through urban models, utopias that take the wishes of populations into account more or less sustainably. Even when renewed and often criticized, these models eventually fit into our collective references and feed back into our choices and decisions about residential and daily mobility.

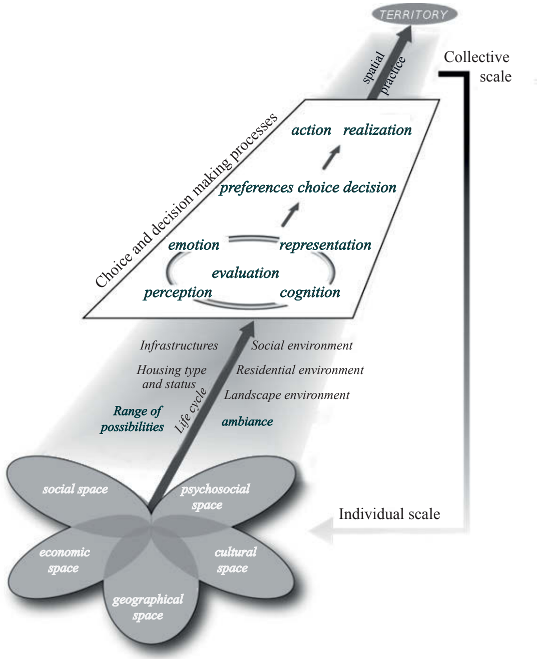

Figure 1—The decision-making context

3. Living environment and references

Our multidisciplinary approach enables us to dig deeper into certain ideas: space as individuals experience and feel it; the way individuals react with their environment; their affective relationship with the living environment, and the meaning they ascribe to it. Besides, observing individuals' travel strategies and the way distances travelled around the city are measured provides insight into how spatial practices condition individuals' mental representations (cf. chapter 3). This also enables us to consider how the individual scale articulates with the city scale.

3.1 The importance of space as a lived experience

Living in an urban setting presupposes the necessary "competence" to adapt to the input of stimuli and information that the city churns out continuously. The term "competence" is also to be understood as the capacity to act based on one's knowledge, experiences, or representations (knowledge, know-how, relational skills). As Chomsky (1971) put it when speaking of linguistic *competence* (and *performance*),[2] there is an urban competence (a "basic grammar") necessary for understanding and using the city that enables us to make sense of what we are travelling through.

Interactions between individuals and their environment

Environmental psychology studies the interrelations between individuals and their physical and social environments in space and time (Moser et al. 2003). It looks at the effects produced on individual behaviour and conduct but also at the way individuals perceive and modify their environment. It looks especially at urban space as it is experienced and the way in which individuals set out their living environment and implement strategies to solve everyday problems. Ittelson (1973) defines the environment relative to the individual. The city surrounds, envelops, and protects people but it may also "swallow them up", submerge, and frighten them or make them anxious. What city-dwellers perceive and feel pushes them to project themselves into the image they have of the city. Conversely, the city shapes urbanites' identity and gives meaning to their behaviour. In perceiving and interpreting the information that comes to them, urbanites gradually transform their living environment. The environment is therefore experienced through action; it has a symbolic, aesthetic and sensory value—all the environmental stimuli (smell, sight, sound) are involved at once. Lewin (1967) shows there is strong interdependence between people and their environment and speaks of the structuring role of space. Individuals create their markers, anchor points, symbolic places related to their emotional connection to the city… In turn, the city shows itself to be a structured, organized space made up of landmarks that facilitate first contacts and everyday life: institutional places or major infrastructure (town halls, theatres, swimming pools, etc.), places where one can walk about (streets, back alleys, parks, etc.), sociability nodes (meeting places, squares, cafés, etc.), and so on (see chapters 3 and 4).

2 Chomsky argues that linguistic competence is common to all speakers of the same language and enables them to interpret meaningful sentences, ambiguous sentences, etc. (see chapter 8).

In the 1950s when investigating urban sociology, Chombart de Lauwe (1965) raised the problem of urban density and its effects on behaviour. He put his finger on *crowding*, that is, the feeling of being packed in or stifling felt in an urban setting. Based on social housing studies in the Paris region, he showed that crowding can cause illness. Growing densities heighten the complexity of social interactions. In some circumstances, this may make individuals uneasy, resulting in territorial tensions related to the sharing of space. In addition, the rapid growth of major agglomerations has made the relationship between residents and urban space a fragile one. Urban space is becoming more complex and ever less readable and in large part quite simply unknown and so "threatening".[3] The need to make allowance for the human dimension in the environment—its planning, the protection and dignity of human beings—is a factor that environmental psychology was to defend extensively. Environmental psychology developed therefore in view of social demand. Garden cities and the work of Le Corbusier correspond to these precepts. They propose social housing that is "pleasant to live in", designed with interactions between individuals and space in mind (La Cité radieuse in Marseille or Firminy Vert near Saint-Etienne).

Urban identity and the meaning of the city

Urban space has an identity born of the appropriation of space by individuals and that is deciphered through their representations of it. Lynch (1976) considers that identity emanates from psychology and primarily concerns the individual. However, it is possible to transpose it and to speak of urban identity if one considers an urban community as a social actor; it is the representations of social groups that then make it meaningful. In this way, the attitudes and behaviour of human groups in space model the individual and personify the city (Moles et al. 1982).

Choay (1972) considers the city as a "non verbal system of signifying elements". The city appears as a space produced by individuals and criss-crossed by dynamics, representations, images, and actions.[4] Lynch (1976) was one of the first to want to make the city visible to all by updating the social and symbolic function of urban forms and public spaces. In the continuity of that, urban sociolinguistics became attached to the construction of meaning among individuals, groups, and spaces. It highlights the fact that individual and collective processes combine in producing significations and signifiers associated with space. In this way, "identity in the city is supposedly a process of construction of an intimate bond between the individual, the collective, and the urban environment through everyday usages and practices, perceptions, and the interplay of projection in space" (Bautès and Guiu 2010). Lewin and Faucheux (1967)

3 One need only notice how many cities boast that they are on a "human scale".
4 This definition refers to the semiology of space.

being very much interested in group phenomena looked into the question of the identity of city-dwellers, their dependence on the environment, and their dissolution within the group.

Meaning is not easily constructed among individuals, groups, and urban spaces. Practices and experiences in the city are odd and depend on personal histories and social conditions (cf. chapter 3). As the city is made up of an assembly of neighbourhoods with different aspects and functions—collective housing or detached housing estates, historical centre, business districts, commercial sectors, derelict areas, etc.—some zones will be experienced differently depending on whether they are perceived realistically or represented as hostile or on the contrary welcoming, depending on people's personal backgrounds. Space can cause anxiety (because of excessive densities, poor lighting of certain places, the run-down appearance of buildings, or clusters of "suspicious" looking individuals), without engendering crime for all that. Representations of violence guide how people feel about places and lead to a difference between *good* and *bad* neighbourhoods in a city. This quite plainly involves rules inculcated by social circles and family origins and that lead, for example, to it being normal to live in a place (with an unattractive climate) or type of place (detached house). Inner space (personal mental space, interiorized social space, mental representations, and knowledge of space) and outer space (geographical space available to individuals) constantly interact in perceptive experiences, adjustment of behaviour, and activities engaged in. This induces varying capacities to appropriate space: some places may represent putting down roots, a psychological anchor point (Feldman 1990); and leaving them may cause serious disorder (depression, nostalgia). Other places, on the contrary, may elicit a feeling of strangeness, of not belonging, or even of rejection.[5]

What people are sensitive to is therefore important in shaping the city's identity. Different experiences, especially childhood experiences, may be decisive (Prochansky et al. 1983). Certain choices of residence can be explained by the influences of the extended family and a geographical identity heritage: the place "one is from" (Bonvalet et al. 2001). Mental maps, for that matter, attest to the diversity of affective and emotional relations to places.

Urban emotions

The urban setting exposes us to numerous stimuli that cannot leave us indifferent. The sounds, smells, appearances of places procure us particular emotions that influence the way we apprehend our surroundings (Amphoux et al. 2004). These circumstances of feelings are to be taken into consideration. The senses are sometimes solicited to the extreme and studied in original ways. How do

5 Authier et al. (2010) discuss these many ties that are made and sometimes broken between persons and places from a social angle.

urbanites perceive the ambience around them? What effect does pollution or stimulation produce, whether it involves sight, smell, sound (Thibaud et al. 2007), etc. or the absence thereof? The work bears on snippets of sound, trips made live or blindfold (cf. chapter 8). The particular atmosphere of spaces is also related to the time of day; this is true of the night when rhythms speed up and awaken fear of the shadows and artificial lights, and so on. Observing these atmospheres and the impressions they make on us provides insight into the way we appreciate the places where we live and the spaces we frequent on a daily basis. This is measured especially through the emotions felt (cf. chapter 4).

What we call "emotions" are the affective and physiological reactions that are strong enough to be set apart from mere feelings (less intense affective reactions). Behavioural psychology counts four fundamental emotions (fear, anger, joy or pleasure, and sadness or sorrow) that may come in a wealth of nuances. These reactions are often short-lived. In our context, we are interested in emotions the city-dweller feels when travelling through urban space. The duration of these emotions and their intensity probably vary with the individual's position (stationary or moving) and mode of locomotion where applicable: on foot, by car, train, bike, wheel chair, etc. Their sum total, associated with a degree of regularity in paths taken or in the use of a living space, probably eventually produces a general or partial "urban impression" on the scale of the district, neighbourhood, or place of accommodation: impressions of order or disorder, upkeep or lack of it, cleanliness or dirtiness, wealth or poverty, safety or insecurity (cf. chapter 3).

Social psychology and more specifically what after Moles and Rohmer (1972) one might call social micro-psychology, show the importance of these small emotions, these minor facts, the brief moments of pleasure (a sunset on a façade), irritation (graffiti in a stairway), fear (slipping on dog excrement), precisely because they are small but frequent and because consequently they contribute, through their repetition—perhaps more than the major, intense but rare emotions (car crash, gas explosion)—to the quality of urban life and everyday well-being.

What are the triggering factors of these emotions? Because they are reactions, emotions cannot be treated separately from the context that prompts them. The triggering factors are therefore related to the environment. For example, the presence of individuals that public opinion tends to stigmatize (the homeless, disabled, etc.) may shock whereas others may amuse or even spark enthusiasm (artists, etc.). These triggering factors of social origin are quite varied: institutional (police), acquaintances one runs into with varying degrees of pleasure (family, neighbours, workmates, etc.), or on the contrary the absence of familiar faces may lead to a feeling of anonymity and isolation, even in the midst of the crowd. Other triggering factors may be material: monuments, squares, parks and gardens, shop windows, urban lighting, noises and smells, vibrations, or climatic factors (temperature, humidity, ventilation), and so on. Each of them causes positive or negative aesthetic and hedonistic emotions. People find it pleasant or unpleasant, for example, to look at a façade, sit at a café terrace, walk down the street to the baker's. But things go further. The same monument that inspires no particular sympathy elicits a form of pity if it is damaged or destroyed. The reason is that a special attention, related to the feeling of belonging, of collective ownership, is associated with the upkeep of urban spaces and consequently any damage, whether deliberate or not (broken windows, graffiti, burnt-out bins) have emotional effects on passers-by. In addition, we tend to associate attributes that refer to the social context with the urban atmosphere. Thus the appearance of a building, a façade, or a street may prompt us to presume that the inhabitants are rather well-to-do or less well-heeled.

Each of these emotional reactions gradually imprints "urban impressions" on each individual that probably play an important role in their overall appreciation of their place of residence. On a macroscopic scale, the amalgamation of these sensations is reflected by attraction or repulsion for places, conditioned by representations and nourished by our collective references (cf. chapters 3 and 4). The image of places conveyed in this way (good or bad) is reflected directly by the differences in land prices which may be completely independent of the amenities they provide.

3.2 Mobility

The possibilities of travel on a daily basis and accessibility to places are fundamental factors in the choice and appreciation of one's place of residence. This is why it is worth identifying individuals' movement strategies and the way the importance of these movements can be measured.

Movement strategies

Social psychology has studied the way in which individuals choose their routes around urban space depending on strategies (avoidance, speed, protection, etc.) and specific behaviour taking account of the estimated time from one point to another or the quality of the site passed through. As Lynch (1976) showed, our choice of trajectories derives from the environment, but on walking along the streets and passing other urbanites (in a neighbourhood or on the main thoroughfare), we necessarily enter into a communicational field, which we open and close as we wish. That depends on the people passed, places to avoid, places that are difficult to get to (narrow pavement leaving room for just a pushchair or always cluttered with parked cars), and so on. This may account for detours, longer but safer routes, appreciations due to an ornamental detail, stimuli triggered by shop windows, etc. Interactions in everyday life (Goffman 1974) also require knowledge of the place, local practices, attitudes, and the environmental structure, in addition to the use of language. Living on a large high-rise estate or in the city centre leads to different relations and interactions.

To move around urban space, people have to avoid each other. For Fischer (1965) "the passer-by's sphere seems to be governed by the same principle as the driver's, namely the principle of non-collision". All our senses influence our behaviour: whether walking or driving, our trips demand great watchfulness so that we do not bump into others. Goffman (1974) highlights the avoidance process: it enables one to avoid unwanted encounters in which a danger might arise. Besides, it makes other passers-by think we are not paying attention to them: we do not look them in the eye, we do not seek to put them at ease or make them uncomfortable. We therefore acquire a "façade", a particular attitude towards strangers, to keep them at a distance, morally and physically. According to Goffman (1974), "public order" is supposedly based on the phobia of contact. Promiscuity in public places increases the risk of aggression and intrusion. Goffman looked into the various procedures and strategies by which individuals establish and maintain interaction with others. These are techniques for protecting oneself while being able to live in contact with others. Goffman speaks of the look-out system used by each pedestrian: "visual scanning" according to the direction of passers-by, identification of the speed of movement, distance before crossing without collision. The "look" on the passer-by's face is also a "warning signal" for the pedestrian to give way, to move away quickly, or to force their way through. The type of interaction chosen (or not) among urbanites and the type of itinerary used indicates a choice of suitable distance and, ultimately, a way of perceiving the city and living there.[6]

Measuring journeys

In appraising and representing to oneself the sum and length of trips around the city, the main tool used in the social sciences is distance. It is a multiform concept that it is interesting to look at in detail. Distances travelled around the city are seldom measured using actual distances, which are not very explicit, but more often given in travel time, which is subjective. The individual who is unfamiliar with a city will consider the distance between two locations as much further than someone who is used to the district (we speak of cognitive distance). Traffic jams, imposed waiting times, and evening travel will also contribute to an overestimation of the true distance covered. Fuzzy mathematics can be used in processing these different forms of imprecision in calculating distances travelled or, more specifically, in the representations we have of them. Such methods have been employed, for example, in showing the forms of imprecision related to the mental representation of the world's various regions (Didelon et al. 2011)

6 Maurice Merleau-Ponty identified this idea of space as a lived experience and as perceived in 1976.

and could be useful in representing the imprecise contours of the "residential environment"—subjective space—which individuals take account of in evaluating their residential space.[7] The dimensions of time and transport cost (travel costs) that were once directly related to geographical distance are also very variable because of the diversification and improvement of means of transport through technical advances. A rail or air fare does not depend solely on the distance travelled but also on the supply of and demand for tickets at the time of purchase. Transport networks, the multiplication of activity centres, and so on, are all factors that "distort" the landscape and by the same token the journey cost.

The actual distance between two points remains useful for measuring physical accessibility to places or barrier effects. Various metrics are associated with urban space. Straight-line measures allow for travel in right angle patterns within urban space and provide a better account of a journey around the city than an estimation "as the crow flies". The "as the crow flies" measurement uses Euclidean metrics (the geometrical representation of a straight line joining two points or the minimum distance between two points) which is well suited for representing subsets of reduced dimension in the city. It is useful for example for determining the optimal localization of an urban amenity or for studying the commercial structure of channels of communication. But overall the most appropriate distances for the urban setting are functional distances (distances measured in monetary units, generalized costs, or time units) which are often the only ones relevant for quantifying intra-urban travel.[8] It is equally interesting to evaluate curbs on travel. Because the cost of distance, that is, the cost of access to transport, may be dissuasive indeed for some sections of the population. Petrol prices are currently extending this real-world fact not just to public transport but also to individual transport.

So the contemporary city is in theory the mecca of mobility where all travel, whether material or immaterial, constitutes flows. And the larger or more active the city, the more numerous and unceasing those flows are. But access to mobility is not shared equally all round (cf. chapter 3). It cannot be ruled out that this mobility does not engender more movement than social ties. Ascher (2004) reports that individuals frequent increasingly diverse physical and human environments; they take part in a host of separate social fields, in the family, at work, in the neighbourhood, and so on. But individuals do not all have the same capacities to construct social spaces of several dimensions or to move easily from one social field to another. Big cities impose such multiple belonging, though.

7 An approach of this kind was used to model the evaluation of accessibility to varies types of amenity from a residential location (Tannier et al. 2010).

8 The connection between distance and accessibility is discussed in chapter 3.

Thus the individual's living environment can be understood with varying degrees of simplicity, it offers varying levels of opportunities, of choices, and non-choices. It is to these aspects of evaluation of the residential environment and criteria of choice that we now turn.

4. Types of choice, evaluation, and preference

How does on choose to live in the city centre or to settle in the countryside, to live in a flat or a house, to have easy access to a high-speed railway station while remaining close to schools, shops or a park or garden, etc.? The choice of residential location often involves complex gymnastics! All the varied possibilities presuppose negotiations within the household and then quite fundamental choices because they ultimately determine the life style to be led. Constraints whether financial, occupational (proximity to workplace or likelihood of finding work), or family-related (partner's place of work, children or elderly relatives to look after, recomposed families, out-of-school activities, etc.) obviously have a strong bearing on the final decisions. A large number of analyses based on surveys has made it possible to explore the factors that determine residential choice. The most important ones include place of work and the household's budgetary constraints. Beyond these elementary material constraints, other factors come into play and may be associated with three groups:

– the type and size of accommodation and its level of comfort;
– the quality of the residential environment;
– accessibility to places the household members wish to frequent.

The content the household associates with these factors is not a constant over time and the hierarchy of priorities may differ widely within the household. It depends largely on the family context and previous experiences.

The process of choosing a residential location necessarily involves an evaluation phase to decide *in fine* on what spaces are preferred, what is to be avoided, or what is a matter of indifference. In attempting to better adjust the residential space to city-dwellers' tastes, ever more studies have been conducted to understand what procures satisfaction or not and how the processes that lead to satisfaction or dissatisfaction are strung together and can lead to moving home.[9] Beyond the elementary constraints that determine residential mobility and that are familiar enough (financial resources, change of employment, arrival of a child), some factors are judged positively or negatively with varying degrees of intensity. Ties of complementarity, compensation, or substitution are woven among them, which it is important to identify and which provide deeper knowledge of the rationales of residential and everyday mobility.

9 For an in-depth presentation of residential satisfaction, see Aragonès et al. (2002).

4.1 Life cycle and choice of location

The preferences highlighted for choosing a residential location are not fixed; they change throughout the life cycle. Individuals make choices when they leave their parents' home and then adjust their choices gradually to their past experience or rectify them to be more in tune with their wishes and constraints. Experience gained in the various places they live in also enables them to progressively refine their choices.

The literature on residential modes (Aragonès et al. 2002) underscores the spatio-temporal dimension of residential choice and its economic implications.

Cities have more young people and single-person households, which have relatively high preferences for rental dwellings… Generally, multifamily housing is a city phenomenon; rural areas have an almost exclusively single-family housing stock. Rental housing is also strongly over-represented in central cities, whereas suburbs and rural regions have a predominantly owner-occupied housing stock. These differences, of course, reflect variations in the availability and the price of land between cities and suburban and rural regions.

The reasons for moving house have been the subject of much research. Aragonès et al. (2002) in *Residential Environments, Choice, Satisfaction, and Behavior* review these aspects on the basis of sizeable international literature. All the stages in the life cycle appear to be periods of potential change: leaving the parents' home, sharing with a partner or otherwise, joining the labour market or changing jobs, having children, getting divorced, children leaving home, retiring, or simply growing old, and so on. All these situations may entail changes in geographical location or in accommodation size, type (owner/tenant, collective/individual), comfort, or environment (urban centre, suburb, outer suburb, countryside). Factors that prompt people to move out are quite well identified. However, factors that act as incentives for people to stay or to move in to a place, that make them hesitate to leave, or the time needed for deciding to move are less well known.

Once the decision to move has been made, the residential choice is based foremost on the choice of geographical location. As Dieleman and Mulder (in Aragonès et al. 2002) suggest, it is a compromise between the choice of a site and the interest for a situation or the position of a location. The site relates to the observable characteristics of the place: its physical aspects (landscape, climate, but also how clean it is, how green it is, traffic density, etc.), its social aspects (the social make-up of the neighbourhood, security, etc.) and its economic aspects (cost of the location, social and landscaped environment). Situation refers to the position of the place relative to other places that matter for the individuals: place of work, schools, cultural and sports facilities, services and shops, etc. The whole of this everyday living space must be within reasonable reach of the chosen residential location. And that holds for all the members of the household, each having their own specific living space and everyday activity space. Therein lies one of the challenges of choosing a single residential location.

4.2 Renting or owning

Getting on the property ladder is seen as an important step in individuals' life trajectories. It can be thought of as responding to a triple objective: it is a way to own a piece of land—"a place of one's own"—of satisfying a collective ideal—one ought to buy property—and a way to optimize one's financial resources (for example, anticipating a decline in income upon retirement). Duncan et al. (1981) speak of the symbolic importance of being a home-owner, which asserts itself more with age. It is in particular the symbol of economic independence.

To take France as an example, nearly 60 per cent of households own their own homes (Table 1). This figure is far higher than the number of tenants but is still far from the European average which reflects large divergences among countries.

In some cases (Germany, Switzerland, etc.), home ownership is very limited or even unlikely because land is so expensive. Accordingly, in Germany, most people rent. The countries of Southern Europe stand apart because of their very high levels of home ownership (Allen et al. 2004). The history of the particular countries and their political orientations explain these differences. After the Second World War, the various European states stepped in to promote new house building to replace the stock lost during wartime. They also played an active part in controlling rentals so as to ensure decent housing and low rents for the poorer sections of the population (Aragonès et al. 2002). In western Europe, states subsidized the building of council housing that now account for 15 to 40 per cent of the total housing stock (Feddes et al. 1997). The Netherlands, for example, has a very large stock of public-sector housing (55 per cent in some cities). By contrast, in the USA there is just a little public housing in east-coast cities and none at all on the west coast. Southern European countries have adopted a somewhat peculiar system of subsidies to promote home-ownership among low-income groups who, elsewhere in Europe, live in rented council housing. Hence their social housing policy has favoured home-ownership, which explains the large number of owner-occupiers in these countries.

These nuances are to be ascribed to indirect state intervention on the housing market through taxation or tax breaks. In the USA, for example, the high percentage of home-owners (60–70 per cent) is related to the tax deductions for mortgages. In Germany, the same system has favoured the construction of housing for let, which explains the size of the stock today. This same logic can be found in the Netherlands with the introduction of a rent-control policy which long made it preferable to rent, even if the trend has reversed today. It can be understood from these examples that home-ownership is not just about wanting to "own a piece of land", but that the social, political, and cultural history of the country one lives in is an equally important factor.

	Owner-occupiers (%)
Romania	96
Spain	83
Greece	73
Italy	72
United Kingdom	71
France	58 (54 in 1999)
The Netherlands	56
Austria	52
Germany	46
EU (27) average	65

Table 1—Home ownership in 2007

Beyond these considerations, it is interesting to observe that the number of owners in France rises significantly (70 per cent) if multi-residence is counted, which is much more common than is thought. This cuts across all social categories, including notably many manual workers, expatriate provincials, and migrant workers (Bonnin et al. 1999). The succession of waves of migration, the need to be mobile for work, and the increase in weekly or seasonal migration have uprooted large fringes of population who develop ties with new places but who also wish to maintain ties with their place of origin. The family home becomes something that is invested heavily in and reverses the priorities in terms of residence or attachment that people develop to the places where they live. The analysis of multiple places of residence refers to the notion of individuals with multiple attachments (Ascher 2004), caught up in a complex interplay in which social networks and networks of practices proliferate, as has been emphasized above.

4.3 Detached house or collective dwelling: the question of density

Surveys in France by various institutes (National Institute for Statistic and Economic Studies, Research Centre for the Study and Observation of Living Conditions, City Observatory) provide a good glimpse of the preferences of the French and what their living environment is really like. They remind us in particular that in France nearly 60 per cent of inhabitants live in detached housing and some 40 per cent in collective housing, although with marked disparities from one living space to another: the larger the city, the more limited detached housing is. That said, detached housing is not confined to the countryside, many periurbanites have adopted it and it is now the most sought-after form of housing. In this, the behaviour of the French is moving closer to that of North Americans.

In France, it is observed that the more removed an individual's living environment is from the house of their dreams, the greater their dissatisfaction. Dissatisfaction is therefore a concern for Parisians and their residential environment (Ortalda et al. 2000) and more widely for the inhabitants of large collective housing estates (Observatoire de la Ville 2007). These surveys highlight the desire to live in an isolated house with a garden. Even a detached house on a residential estate or in the heart of the city is not wholly satisfactory because the environment is perceived as too dense. It is the countryside that people want (Observatoire de la Ville 2007), or at a push, the outskirts of the city. Generally, one observes therefore a desire for privacy, to live in a cocoon with a garden, light, and access to nature, which are all features typically associated with detached housing. There are also desires to have urban and neighbourhood services and social relations that are more characteristic of a dense urban fabric. So the much sought after isolated house must be surrounded by schools, shops, and neighbours! All told, the surveys reveal highly contradictory feelings. The isolated house is attractive because it is calm and private, but is repellent too because it is isolated and therefore lonely; in contrast, the detached house on a housing estate or in the city is appreciated because it is convivial. Density, then, is a factor of appreciation of the social atmosphere of the place, whereas it depreciates the residential environment. As early as the nineteenth century, Howard's garden city highlighted these contradictory desires; the natural element is ubiquitous there and reinforces the impression of a town in the countryside. These utopias have probably contributed to gradually shaping current tastes; workers' allotments, which are still found in cities, are probably a legacy of this.

The rejection of collective housing is the corollary of these major trends. It concerns especially the big estates as we have already emphasized, but also the tallest tower blocks or even the collective housing in city centres which are all deemed faceless and unsafe and which are often associated with high densities (Observatoire de la Ville 2007) The rejection of this type of housing and the fears related to it, whether real or just urban myths, refer back to the concept of "crowding" mentioned earlier (cf. chapter 1 and 3.1 above).

The perception of density arises therefore from subjective experience, which is intimately related to the cultural conditions in which the individual lives. It also depends on architectural forms. In France, vertical densities engender negative representations that come in the shape of nuisances affecting quality of life (solitude, fatigue, stress, pollution, incivilities, etc.). Nowadays, in collective housing, individual accountability is being dissolved, which is why the trend is to build a community with both rental and privately-owned accommodation, with an aim to develop social control and joint-construction of the cleanliness of the place. "One observes therefore a paradoxical desire for privacy and communal living which calls into question urban densities more than it condemns them" (Observatoire de la Ville 2007). These observations raise questions about the form of the built environment as much as the types of land use, the place of pedestrians, routes, means of escape, or the desire for solitude, as much as for sociability and conviviality.

4.4 The form of the built environment

On housing estates, if the detached house is so successful it is because it gives the impression of better controlling the distance with the other and guarding one's autonomy (Jaillet et al. 2005). "It is not a matter of avoiding any relations, on the contrary, but simply of mastering their nature, frequency and timing" (Rougé 2010). We find here the factors referred to in chapter 1 about the construction of the individual and their relationship with others in space. This requirement to safeguard one's autonomy is true first of all within the family group; this is why it is helpful to have lots of "nooks and crannies" that divide up the domestic space even inside the house. The individualization of spaces and their use is a fundamental aspect that the house favours even more than the flat in the city. And that is equally true of relations with the neighbours. "On housing estates, the garden acts as a buffer…: however small it may be, it makes it possible to keep the neighbours at bay, to choose whether to ignore them or on the contrary to see them" (Rougé 2010). This possibility of controlling one's distance with others is thought to be the necessary condition for enjoying "good relations" both within the family and with the immediate entourage. In neighbourhood relations, neighbours are not *a priori* friends. At most, one does favours for them, but one only befriends them if there is something in common. One must "put up with" close neighbours, however, insofar as, while being accessible, they are not too close. The entire challenge is in finding this middle ground. "The social peace and quiet produced by the neighbours abiding by this code of good conduct makes it possible to distinguish the world from the detached house and is what makes it so valuable." (Rougé 2010)

This is probably one of the things that condemns the big collective housing estates, if one keeps at least to purely physical criteria to explain tensions in these urban spaces. One of the precepts of the Athens Charter, providing for the construction of social housing estates, was to free up the centre of the housing units that formed the large estate.

Arranging the built environment vertically and around the perimeter would open up a true heart and free the ground for recreational facilities and green spaces. This should have the effect of a massive return to the ground, promoting social mixing among the inhabitants. Promising as the idea was, the reality is quite different. The lay-out of the building, rather than clearing a public space, that is supposedly inviting and welcoming, leads to an impression of being surrounded, promoting the formation of a closed area. (Koci 2008)

Thus this type of built environment, rather than "creating distance" between individuals so as to "dose" relations with others, creates a public space always open to onlookers and denying the individual's need for privacy.

The other difficulty Koci (2008) points out is the face-to-face character of the built environment. Indeed, the position of windows also contributes to this loss of control over privacy (cf. chapter 1), while the "feeling of home is based on conditions that shelter the individual from the gaze of others while allowing visual access to the outside" (Koci 2008). Like reflections in a series of mirrors, the face-to-face inevitably refers the inhabitants back to their own condition. And it is on the big estates that the least-favoured social situations are encountered. These act, then, like a downward spiral in which individuals are caught up. Back in 1965, the German psychoanalyst Mitscherlich emphasized the negative impact of excessive urban hygenism that went to extremes to impose structure and uniformity on the inhabitants' living space. Little scope is given to children living in such districts to develop their imagination and their creativity. The functionalism that separates residential locations from purchasing places and in the end convivial places reinforces the inhabitants' feelings of isolation and they see themselves "shut up" in what is ultimately a hostile environment. Thus, the inhabitants fail to identify with their place of residence, which entails a danger of degradation and causes social segregation through exacerbated periurbanization (Mitscherlich 1965).

4.5 The social and residential environment

Several commentators have posited the hypothesis that there is a system of relations between the structure of the residential environment, the way it is perceived by inhabitants and their degree of satisfaction. A study of the social housing in a Spanish city (Amerigo et al. 1990) underscores that residential satisfaction (declared by survey) is based on subjective rather than objective criteria. Psychosocial factors (desire for better interaction with neighbours or difficulties with attachment to place) are evoked first, more than objective factors about improved living standards or safety however obvious they might seem in these places, but which are only mentioned secondarily by the populations. Adriaanse (2007) reaches a similar conclusion as to the significance of social climate in residential satisfaction, which is more important than the attributes of the housing or the reputation of the district. It would be interesting to better understand what the ingredients of a satisfactory social climate are: are they related to the existence of many local networks or a close-knit community or similarities among neighbours (Galster et al. 1981)? In work on the outskirts of Barcelona, Pol et al. (2002) show the level of satisfaction and quality of life perceived by populations are quite independent of objective living conditions and seem to be related to the emergence of a positive social identity over time. It can be concluded from this that to promote sustainable residential satisfaction, collective identity must be reinforced by the promotion of actions that enhance social cohesion.

In this research into social cohesion, Van Ham and Feijten (2008) explore Schelling's hypotheses about the search for social or ethnic proximity among neighbours. They report that a rise in the number of people of foreign extraction in a district entails an increased desire to leave the district. This is also the case for people who are of foreign origin themselves. Moreover, it may be thought that these results underestimate the real situation, at least for people who see no options for leaving the district. Dissonance theory[10] holds that people only express the desire to leave a district if they can (materially) contemplate moving out. Individuals tend to reduce the cognitive dissonance in which they find themselves. This highlights the lack of choice some individuals are faced with and how difficult it is to appraise the way in which they evaluate their environment: Aragonès et al. (2002) show that the importance of the choice made initially does not necessarily affect the level of satisfaction engendered some time after settling into a place.

This analysis raises questions about the willingness to intensify social mixing in many European countries (Atkinson et al. 2001), as mixing seems to be effective only if the housing market is very competitive and people are unable to achieve their preferences. Otherwise, the study shows that the levels of segregation might well increase.

In many other domains, the influence of the residential framework on individual behaviour is undeniable. Martinez et al. (2002) compare the perception of the district with problems of parenting and the development of young children and underscore how the characteristics of the district influence "parental skills". There is a great deal of literature on the effects of the district in which people lived or grew up and the repercussions for their upbringing and career prospects (see Ellen et al. 1997 for a review). Likewise, it is known that residential environment has a weak but constant impact on the residents' state of health, their well-being, and the quality of life related to their health. On the basis of a survey of eight European cities, Braubach (2007) managed to show that exposure to noise and the feeling of insecurity are the main difficulties. These factors are associated with low residential satisfaction, disturbed sleep, and even depressive behaviour. The proximity of playgrounds may also induce sleep disorders in the nearest inhabitants, but their absence paradoxically contributes to reducing residential satisfaction. Many studies have been made of these factors (Drukker et al. 2003, Ellaway et al. 2001). Brown (2003) thinks that the main challenge is to establish ties between health specialists, who observe the consequences of

10 This theory of psychology is explained in chapter 7.

urban nuisances and acquire knowledge about what environmental well-being might be, and those involved in planning (engineers, architects, town planners, etc.), who have not always taken these factors on board, for the good reason that the concept of well-being is eminently complex. From this perspective, it is obviously important to have control over the cognitive representations of urban space (Hanson 2009), the way in which the different types and levels of information are recorded with distances from places of residence or places frequented, so as to better identify to what parameters individuals are sensitive or not and up to what distances.

4.6 The landscaped environment

The benefit of a house with a garden was made clear by Francis and Hester (1990). And the impact of the proximity of green spaces on land prices has also been emphasized by a number of authors (Earnhart 2001). Some of these analyses make allowance for the physical built environment (Evans 2003, Jackson 2003) and underscore, for example, the effect of public places on sociability (Thompson 2002), the effect of green or open spaces on residential satisfaction, as much as the value of vegetation (Attwell 2000). Other authors point out the significance of access to leisure amenities (Guo et al. 2002) and particularly of their being within walking distance. Barbosa et al. (2007) show there is in reality little equity in access to urban parks depending on social groups, so the measurement of accessibility to leisure parks is not a negligible point. It may be asked, besides, whether owning a house with a large or small garden affects how often people go to green spaces or natural parks. Syme et al. (2001) show that the size of the garden has no real influence on the time spent there, any more than frequenting local parks. Indeed, in Australia households with a small garden display no less satisfaction and there seem to be no substitution phenomena between garden and park. What is observed, instead, is the desire for a certain variety of landscapes.

In the direct residential environment, landscape does play an important part in residential satisfaction and the state of knowledge in this area is increasingly specific. It is known, for instance, that trees are crucial (Kweon et al. 2010), whereas paved structures are viewed somewhat negatively. This suggests that it is important to improve the conception of paved areas especially in commercial zones where it is not enough just to satisfy functional demand for goods and services but where an aesthetically satisfactory environment must be created. Populations particularly enjoy vast islets of trees that are interconnected and that display varied sizes and forms (Lee et al. 2008). Generally, natural features are powerful factors of satisfaction and it is well-known that people perceive not only the amount of vegetation but also its arrangement and the landscape structure (Antrop 2000). Progressive improvement in knowledge of the rules of how landscape is perceived has positive repercussions on planning and management practices of urban landscapes. It becomes possible to formulate inhabitants' preferences in various domains, making social demand far more readable.

The studies presented show that a host of criteria determine residential satisfaction and are liable to affect decision-making and residential choice. It seems plausible that an individual or family looking for a place to live might take account of the different criteria and choose among them, when making a decision, having regard jointly to the criteria and seeking a compromise for all family members.[11] Schwanen et al. (2004) emphasize that households tend to choose residential locations that minimize distance or access time to work, but also to shops (Lerman 1976), and leisure areas (Guo et al. 2002). These authors conclude that densification of districts that fail to correspond to the residents' wishes may entail the departure of some households. Consequently, they see in densification a risk in the medium term of households relocating to less dense areas. Bramley and Power (2009) examine the necessary arbitrage among the social, economic and environmental dimensions of urban space. For them, compact urban forms exacerbate neighbourhood problems and discontent, while improving access to services. Policy must therefore be thought of in terms of compromise between the objectives of social equity (concerning access to services and infrastructures) and community problems.

5. Urban territory

Urban territory is seen as the place where the process of choice and decision-making about residential and everyday mobility goes on. By recalling, first, the attributes and qualities of this space we can achieve an overall, macro-geographic view of it. On this scale, it is interesting to show how the political and social organization of territories takes into account or constrains populations' wants. What is collective thinking about planning strategies? What are the policies introduced that are in turn capable of influencing individuals' evaluation criteria? The example of urban utopias, when they find a legal framework for expression, can be used to discuss these factors.

In analyses of urban territories, the social sciences often emphasize the malfunctions that disrupt the smooth running of social life. But it is agreed even so that many advantages arise from the urban world and the mass of individuals brought together in one place. In the Middle Ages, a large concentration of individuals was required to finance fortification works and shelter the population. Nowadays, political institutions, effective health or educational facilities are only justified and cost-effective when they serve a large enough customer-base. It is also known that such a concentration of individuals is a source

11 This is not a priori contradictory with an ordinal ranking of preferences as assumed in economic theory (cf. chapters 9 and 10) only the alternatives ranked then combine several criteria.

of innovation, and sharing of wealth and knowledge. It is also observed that crowds gather more readily where there is already a large population, for many reasons: to applaud an artistic or sporting event, or to share political or religious fervour.

If the effects of mass are of obvious economic worth, the urban advantage also results from the opportunities for meeting and exchanging. Their role is to facilitate communication among economic actors. This gives rise to the study of spatial interactions or the theory of central places. These central places are answers to many needs: nearby daily purchases, occasional longer-distance spending. Big cities promote synergy effects because they bring together many complementary activities. They concentrate rare medical, financial, cultural, or market services, etc. Once, living in the city was a jealously guarded privilege that city-dwellers maintained by controlling the city gates. Networks of towns arose from economic, political, and social exchanges and they became the locus of a relatively wide source of supply of social and cultural innovations that renewed urban values.

The more central places are, the more competition there is for land use, which generates force fields directly reflected by land values. The Chicago school in the 1930s to 1940s emphasized the relations of dominance among venues in urban space. It modelled them in mosaics reflecting phenomena of social, economic, or ethnic segregation. Recent studies internationally have shown the importance of income level for residential choice and so for the reinforcement of social segregation, even if debate continues as to the cause of segregation (Hedman et al. 2011). In western cities, the process of periurbanization which was initially residential, reinforces the culture of togetherness. This emerging city (Dubois-Taine et al. 1997), the supports of which are the detached house, the car, and a "village" environment, extends the parent-cities structured in concentric rings. Periurban zones comply with a logic of sites (mosaics), some of which have a marked landscape quality and others on the contrary are beset by nuisances, like city centres which have their spaces of gentrification and deprivation. Particular problems are associated with them (Rougé 2010): the redeployment of jobs and services on the outskirts which bolsters multi-polarity and lessens the residents' dependence on the central agglomeration; a reflection around these practices of mobility in strained economic and energy contexts; potential for socialization that needs to be accompanied by development (soft mobility, densification, public space).

Political organs play an essential part in managing these urban territories which result, ultimately, from actions implemented by governance at all territorial levels (local, but also national and supranational). Cities are places of political and economic power (they have long concentrated religious power, too). The resulting territorial planning promotes the spatial organization of people and activities and takes an interest in social and economic development, housing, transport, and communication. It is within this whole that the user, and therefore the person seeking a built environment, makes location choices, residential choices and so contributes to orienting urban development. To what extent does this social demand, which is an emanation of individual demand, entail collective reflection on planning strategies which in turn may influence individuals' evaluation criteria? This question, which shall be taken up again in other chapters (e.g. chapters 3 and 4), is only addressed here through an example illustrating the emergence of collective references (terms which are defined in chapter 6). These are urban utopias that urban models have long tried to propose in conjunction with social demand.

While "urban utopias" meet social demand at a time *t*, "a modern and renovated conception of housing" to quote Le Corbusier for example, they tend also to organize social life in line with an ideal: "The utopian order is that which guarantees against all the excesses of disorder by eliminating individual passions and desires. But the ideal, which is supposed to define a perfectly-ordered city, often justifies a perfectly inhuman city" (Baumont et al. 1996). The fact is that "Utopia often goes along with meticulous regulation of activities that sacrifices the individual to the collective and turns a *geometrical paradise* into a sort of *hell on earth*" (*ibid*.). This type of city remains ideal only for a given time and within a precise frame of reference. In China, for instance, these same high-rise blocks are now where affluent populations live and what is considered a modern form of architecture is collectively enviable. In Eastern Europe, by contrast, since the fall of the Soviet bloc, detached housing estates and denser zones of a postmodern stamp have largely attracted people to the detriment of high-rise blocks which have had to be refurbished or even demolished. Rejection of them is probably also related to their identification with the earlier period. The question of timing is therefore an important one. There is a time gap between the time the estate is designed, meeting the needs and tastes of that moment in a specific historical context, and the long time during which the estate is to serve as a place of residence. Thus, the criticism of functionalism in architecture has long since lost sight of its initial meaning and its reason for being in Europe.

Urban utopias have forever responded to new needs, corrected malfunctions, or even outpaced social demand. One example is the role ascribed to green spaces and landscape in the history of the European city. Because of the interest western society has taken in nature ever since the Renaissance, various urban models integrate "natural" spaces in town planning. Le Nôtre's landscape architecture is a fine example. Incipient naturalism inspired Ledoux and, in the city of Chaux, the built environment and nature interpenetrate. The upheavals of the Industrial Revolution were to strengthen this trend. The failure of the "liberal city" in Britain due to catastrophic hygiene prompted a rethink (Benevolo 1995). Many concepts highlighted green spaces: working-class estates required back gardens, the New Harmony utopia showed an industrial city in the midst of the fields, Howard's garden city brought green to the fore in the city and assigned recreational functions to its hinterland. Le Corbusier's leitmotiv "sun, space, greenery for all homes" picked up on these wants. In parallel, the idea of the house surrounded by a garden in working-class estates persisted and prepared the way for periurbanization.

Whenever they inspire a legal framework, utopias condition and constrain residential choice by highlighting the "collective interest". This was the case, for instance, of urban planning regulations after the liberal city was seen to be a failure. A current example would be the recommendation to make periurban areas denser so as to cut the length of journeys and reduce the consumption of space. There is, then, a danger that attempts will be made to circumvent or oppose regulations. Some commentators observe that densification policies have failed because they are rejected by the populations in question (Garcia et al. 2003, Gordon et al. 1997). This ultimately comes down to functionalism, but also, in the model of the ecological city, ecological arguments that are often perceived as necessary (and rational) but constraining even so. This model, which was developed very early on in Germany (Vauban district of Freiburg) is the forerunner of an ideological movement for the preservation of the environment. While it evolves with new technologies which allow improved energy saving and better value for money for materials, it tends also to amplify the social segregation phenomena in urban settings. Despite that, it certainly imbues individual choices about housing and has a feedback effect on entrepreneurs' choices.

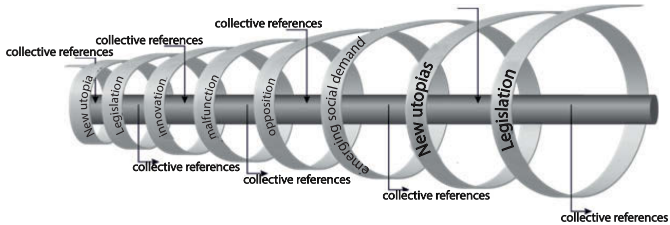

Figure 2—The connection between social demand, urban wutopias and collective references

In another style, the model of the emerging city is very close to social demand (even if, as seen, social demand is sometimes confused). It rests upon the idea that most individuals wish to live in a detached house and therefore promote this demand. But the nuances engendered are many: unlimited extension of urbanized areas, increased pollution, or even social isolation. The work of local governance is therefore to bring individuals to have more collective awareness of urban organization. The "New Urbanism" seeks to reconcile social demand and environmental requirements. For one thing, the size of urban villages remains modest, "on a human scale" and makes it possible to require a locally dense built environment. For another thing, what is often referred to as transport-orientated development (TOD) provides for good pedestrian access to local services and shops and to efficient public transport stops, whereas the use of cars is penalized somewhat. What is often postmodern architecture is inspired by the traditional European city, which is perceived as more "reassuring" than the all-concrete modern architecture. New urban utopias therefore emerge in close connection with the renewal of social demand. But planners and architects are divided between the desire to meet the wants of the population and the need to take account of material and environmental realities or economic, legal, and political constraints, otherwise termed the "collective interest". With these adjustments, the new models and new planning strategies are progressively integrated into our collective references, to the point of influencing our residential choices. This cyclic operation is suggested by figure 2: the establishment of urban models (or utopias) presupposes legislation and brings about innovation; with use, malfunctions arise which generally entail contestation that calls the model into question thus forcing it to evolve. New social demand emerges correcting the errors of the past, then new utopias that provide innovations in their turn, presuppose legislation and sooner or later produce malfunctions, and so on. In this way urban territories are renewed and sustained. Our collective references are nourished by these advances and ultimately affect our capacities to evaluate the environment and our choices in terms of residential and everyday mobility.

6. Conclusion

Despite the plethora of studies that try to better ring-fence individuals' behaviour, choices, or satisfaction in terms of housing and residential environment, it is difficult to simply synthesize such behaviour because it involves complex factors and arbitrage operations that are difficult to decipher and investigate. Individuals' expectations reveal significant paradoxes that show that urban space is a place of wants and of contradictory fears.

A great many hypotheses have now been confirmed contributing to a better understanding of residential satisfaction, and the use and perception of dwelling places. Three limiting features appear recurrently.

The exercise asked of the individuals' interviewed (when the analysis involved a field survey) is difficult because they are confronted with their own residential background which relates closely to their history, their personal construction, and their private lives. Thus the analysis cannot abstract away this interleaving of housing and inhabitant, and survey results must be interpreted while bearing in mind the bias induced.

Whenever a location is occupied by several individuals (a household), the choice of living place is the outcome of a negotiation within the family involving compromise. Each member of the household differently involved in everyday life will not have the same weight in the decision, nor even the same opinion about the advantages and disadvantages of a location and type of housing. That clearly complicates the collecting of opinions and makes them more complex to analyse.

Residential environment and living environment underlie spatial and social scales that are often specific to each individual. Consideration must be made of the housing itself (inside and outside), the direct neighbours (and which, when living in a block of flats?), the neighbourhood which supposedly implies more distant neighbours, the district or city? All these are imprecise ideas with fuzzy boundaries and they vary from one individual to another.

Despite these recurring difficulties, we begin from what is already a well-supplied basis for analysis to better grasp the decision-making process about residential and everyday mobility. The state-of-the-art we have reviewed here, even though partial, provides a panorama of advances on these issues, methodological curbs, and points still to be explored. Most of the studies presented remain partial. To the best of our knowledge, only a few analyses (Bramley et al. 2009, Doi et al. 2008, Pol et al. 2002) adopt a more comprehensive approach by integrating different dimensions of urban space (accessibility, urban forms and density, quality of life, social interaction or identities) in the perspective of "liveable and sustainable" urban development. Our multidisciplinary approach is a follow-up to those analyses.

Socio-Cognitive Accessibility to Places

Thierry Ramadier and Christophe Enaux

1. Introduction

Accessibility is a core concept in human geography when it comes to geographical mobility. And yet residential mobility is never addressed in terms of geographical accessibility! Choices, preferences, and decision-making processes are generally at the heart of descriptive and explanatory models of residential mobility. At best, geographical accessibility is only considered to be an issue for residential mobility when it relates either to anticipation of daily mobility (access to school, work, shops, etc.) when moving home, or to determining the price of housing when buying or selling a property.[1] In other words, accessibility relates far more to daily mobility than residential mobility, to land values more than the possibility of contemplating living in a particular place. Is there a difference in "kind" between these two types of mobility? It is likely that it is much more a way of thinking of accessibility. The aim of this chapter is to review the development of this notion in order to propose a social, geographical, and cognitive conception of it so that it can be included in the question of mobility, whether daily and/or residential (and in connection with what is termed migration or travelling).

The classical definition of geographical accessibility is stated either on the basis of the offer of mobility or on the basis of the cost of travel required to reach a place or other things: people, messages, services, and so on. This notion is also used by other disciplines than geography, such as sociology when investigating social mobility, or psychology when examining the degree of awareness

1 On this point see Marius Thériault, François Des Rosiers, and Jean Dubé, "Modélisation de l'impact de l'accessibilité sur les valeurs residentielles. Existe-t-il une ségrégation socio-économique des préférences révélées ?", 11th MSFS colloquium "Mobilités spatiales et ressources métropolitaines : l'accessibilité en question", Grenoble, 24–25 March 2011.

P. Frankhauser and D. Ansel (Eds.), *Deciding Where to Live*,
DOI 10.1007/978-3-658-15542-1_3

of behaviour, knowledge, or emotion. Accordingly, whether we are referring to the first Freudian topography of the conscious, preconscious, and unconscious mind, to social space (Bourdieu 1979) or geographical space, the notion of accessibility is a question of space. The difficulty for research then rests on the understanding of how spaces of very different kinds articulate together. A second point brings these disciplines together: accessibility is not a matter of intentionality on the part of the individual seeking to achieve a goal. It will be seen, though, that the latest developments in econometrics, drawing on the notion of potentiality (in the sense of what is possible but not yet expressed), tend to derogate from this characteristic. A third common point, which follows from the foregoing one, is that accessibility is not in itself a property of the object studied: it invariably depends on the context in which the object is situated (material, social, or logical ties with other objects, other ties among the other objects, the type of ties accepted by a given social group). To express it otherwise, accessibility relates to a relative position of the object and not its absolute location in the space in question. So, for example, in the context of geography, one district is not just more accessible than another because there are more routes that converge on it, but because a greater number of other districts may be reached by certain means of transport, within a certain time and for a certain type of individual. In other words, accessibility is a question of connectivity, which is in turn defined differently according to the interest one has in the object in the type of space under study (a farmer who only occasionally goes to the city centre from a periurban village may judge that it is accessible by public transport whereas an employee working in the central districts and who is looking for a fast transport offer to get to work may judge it inaccessible or not readily accessible by the same means of transport).

While the ordinary meaning of accessibility associates it with effort (of whatever kind), which is generally synonymous with a degree of ease ("it is easy—not easy—to get to"), we shall see first that human geography has partly escaped this conception by emphasizing first the idea of potentiality and then by holding up cognitive states or processes (choices, preferences, interests, knowledge) that finally introduce intentionality into the notion of accessibility and shift accessibility towards an entirely different meaning from its initial definition. Other fields of research have also enabled the concept of accessibility to evolve in other directions. Thus, in a second section, the development of the concept in the domain of disability will indicate the gradual transition from a physicalist approach (infirmity) to a normative approach (situation of disability) from the point at which it was possible to consider that the "lack" was not simply about an organ and its function but also about the individual's place in society. In a third section we will develop the idea of socio-cognitive accessibility[2] based on

2 Social cognition, by contrast with classical cognitive analysis, includes the social conditions and challenges in which cognitive processes operate to the point that, for one thing,

the stated changes in the idea of accessibility both in geography and in the domain of health care. We shall begin with the individual as a social subject, but also by referring to the ease of reading geographical space (social legibility). Lastly we shall keep what we feel is essential in the concept of accessibility as formulated by geographers, namely that accessibility, and even socio-cognitive accessibility because it is applied to the relation the individual has with geographical space, may retain its specific features, that is, it may remain outside of any individual intentionality and differentiate (in relational terms) places from each other.

2. Accessibility in geography

There are many reviews of the literature on accessibility (Ingram 1971, Geurs et al. 2004). They plainly show that even today accessibility remains a manifold notion, both in its definitions and in terms of the measures proposed as already indicated by Gould in 1969.[3] This diversity arises from points of view adopted by authors depending on the objectives pursued. To the best of our knowledge, only Geurs and van Wee (2004) have attempted to draw up an inventory of the component parts of accessibility used in the approaches of the various scientific communities. For those authors, the main aspects of approaches to accessibility arise from land use (the spatial distribution of opportunities, such as jobs, hospitals, shops), transport networks (supply of and demand for transport), time (institutional and individual time constraints), and the individual (the characteristics of individuals, their needs, capacities, and socio-economic standing).

Whichever definition is adopted, it still turns out that accessibility for geographers is *an instrument for analysing the working of space mainly in its spatial, social, and temporal dimensions*. Sometimes the developments of the idea bear exclusively on space, sometimes they include asocial and spatial dimensions at the same time. At other times still, all three dimensions are involved together. Our purpose is to contribute to setting out a few important markers introducing the cognitive dimension into geographical accessibility. To do this, we shall present in the following paragraphs a few key approaches to accessibility over the last fifty years, emphasizing their main characteristics. It is on the basis of these elements that we propose a conceptualization of geographical accessibility that will progressively integrate more cognitive dimensions.

those processes are no longer considered to be biophysical invariants of the organism but constructions that depend on the socio-physical conditions in which the organism finds itself, and that the information to be processed matters more for what it is worth (challenges and conditions are inseparable from the information) than for what it is (whereas the preference model considers to the contrary that information about the object is the same for all, that it is known to all, that all comparable objects are known, and that the value attributed depends above all on individual rationality).

3 "Accessibility is a slippery notion… one of those common terms that everyone uses until faced with the problem of defining and measuring it".

2.1 "Pure" geographical accessibility

Among these approaches, "purely" geographical accessibility is a first form that pertains fundamentally to places. A straightforward definition is given by Beguin (1984) and is identical to that in the Larousse dictionary, but uses more geographical terms: "accessibility of a place *i* is the degree of ease with which *i* can be reached". Underpinning this definition are several geographical notions and particularly those of location and distance. Each place has an absolute location on the Earth's surface, however, from the perspective of geographical accessibility, that *location is relative* because it is evaluated for a place with regard to a set of places that form the spatial system under study. Between the absolute locations of these places lie distances between them. But here again the distances in question are network distances, that is, distances reflecting the connectivity of places[4] of the spatial system through the transport network under consideration. Connectivity therefore expresses the friction of distance, that is, the effect of friction or resistance to movement to get from one place to another. Generally, the place with the lowest friction in the spatial system being studied is also the most accessible.

The ideas of location and distance are therefore closely related to the older concept in geography of situation, expressing the relative character of a location notably in connection with traffic networks. This concept of situation has the advantage of highlighting *the dynamic aspect of geographical phenomena*. Although purely geographical accessibility is therefore a form of situation of one place relative to other places, it is not fixed over the course of time for all that. Introducing new locations and/or changing the connectivity in the spatial system under study modify the accessibility of the place *i* under consideration. The next paragraph looks at how to measure this.

A first step towards geographical accessibility: Shimbel's accessibility index

A first example of this accessibility of places that provides the central position of a place in the spatial system under study is that of Shimbel's (1953) accessibility index. His measurement requires (1) a set of places of the same kind such as France's main cities, a city's public transport stations, etc.; (2) a transport network connecting these places and represented in the form of a graph indicating all the direct connections between places, with the places being the vertices; (3) a measure of connectivity of these places in the form of topological distance indicating the shortest path for getting from one place to another. In other words, it is a matter of counting the minimum number of edges to be taken to get to a

4 In graph theory, connectivity reflects the possibility of connecting one place to another using direct paths (order 1: there is an edge between two places) or indirect paths (order 2 to *n*, *n* being the graph's diameter). But other measurement units of connectivity of places may be used such as distance in kilometres, time, or cost (Enaux 1991).

place of destination from a place of origin (figure 1). For the set of places in the system, we then get the matrix (square and symmetrical) of shortest paths. On the basis of this matrix, Shimbel's accessibility index is calculated for each place i from the ratio between the sum total of shortest paths in the matrix ($\sum_i \sum_j$) and the sum of shortest paths of the place i ($\sum_i$). The higher Shimbel's accessibility index, the more accessible the place. In the example below, place B is in the central position within the spatial system under study. This index may be extended by considering other types of measurement of the connection between places that take account of certain characteristics of the transport networks.

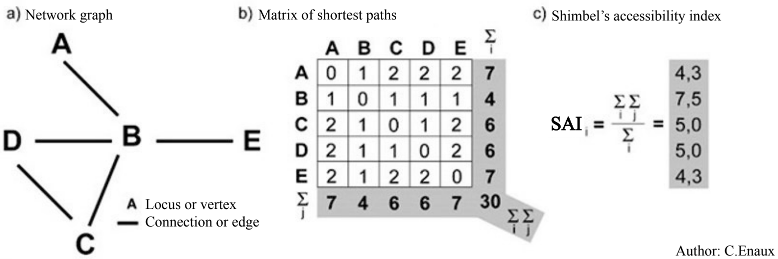

Figure 1—Construction of Shimbel's accessibility index

Geographical accessibility as an extension of Shimbel's index

For all transport networks, one can consider measuring the length of each connection in kilometres, or the time of transport required to reach each connection, or again the financial cost of travelling a connection. By the same principle, namely the minimum distance (in kilometres, time, cost, etc.) between a place of origin and a place of destination, it then becomes possible to calculate real geographical accessibility.

Apart from the preceding index, other calculations are used. The most common generally include (Cauvin and Enaux 2004):

– the mean geographical accessibility index (*GAI*) that represents the ratio of the sum of minimum distances from a place i and the number of places less 1 (n - 1, so excluding i because accessibility from i to i is ignored) of the system:

$$\boldsymbol{GAI_i} = \frac{\sum_{j \neq i}^{n} \text{Minimum distance } ij}{n - 1}$$

– the centrality index (*CI*) that represents the ratio of the sum of minimum distances of a place i and the sum total of minimum distances of the matrix:

$$CI_i = \frac{\sum_{j \neq i}^{n} \text{Minimum distance } ij}{\sum_i \sum_j \text{Minimum distance } ij}$$

Synthesizing the characteristics of this form of geographical accessibility, it clearly appears that it rests fundamentally on the spatial dimension. Space is taken into account by a choice of places and by a network distance between spaces. The spatial system then presents, in theory, an overall coherence that does not skew the overall logic of connectivity between places (Enaux 1999). The accessibility indicators evaluated for each place in conjunction with all the places studied characterize the working of geographical space (or functional space) by making it possible to identify for example the hierarchy of places and their relative location within the spatial system. With the exception of a background social and temporal context, representing the settlement of the spatial system and the emplacement of networks, the individual and temporal dimensions or their articulations do not appear explicitly in the form of a *functional space frequented* by individuals, that is, their use of this space. The minimum path logic does not arise from the logic of individual behaviour but from the logic of the network structuring approach. Other accessibility approaches integrate the social dimensions more directly.

2.2. "Potential" accessibility to a territory's resources

Accessibility to a territory's resources is another major family of approaches to accessibility in geography. When it comes to the details of the applications by the various authors this family is just as diverse as the previous approach, but even so its approaches are based on several common points.

The basic elements: the spatial system, resources, and connection between zones

The accessibility study zone relies on a spatial segmentation of a territory with zones considered as having specific attributes or that depend on the relation between zones such as the connectivity provided by transport networks. These specific attributes arise from the description of the resident population and from the inventory of resources taken into account in the study. The population is taken as an aggregate, either as the set of individuals living in the zone, or for more targeted themes, as a group of individuals sharing similar characteristics (the elderly, the working population, etc.). In some studies, the definition of the zoning of the spatial system is sometimes related to the homogenization of the target population within the selected zones.

Resources represent the amenities that may be available to populations. Depending on the topic of the study, they may be economic (firms, jobs), facilities (public transport stations, parks, shops), services (schools, doctors), etc. These resources are located in the selected spatial zoning and are generally understood either as aggregates belonging to a given zone or individualized by taking account of their point location within the selected zoning system.

Unlike geographical accessibility, *zone connection* is contemplated on different principles. The earliest studies are generally based on simple distances "as the crow flies" between zones.[5] For a good 15 years or so, with the development of databases on transport networks and the joint use of geographical information systems, distances included in potential accessibility studies integrated the characteristics of the networks even better but also the characteristics of the groups of populations under study. Thus for the study of underprivileged populations without their own means of locomotion, connection between zones is considered on the basis of a network of which such populations in principle make use.

Thus, with regard to the foregoing elements, accessibility to a territory's resources embeds the social (and economic) dimension in the spatial dimension. It is the characteristics of the population that determine spatial choices. By contrast, the behaviour of populations appears only in the background, mainly in the form of constraints on means of locomotion. *The overall logic of this accessibility to networks is that of a localized population that "sees" around it, and at variable distances, in the various zones of the spatial system under study, all of the resources integrated in the study.* The population has or can have these resources at its disposal.

Conceptualization of potential and its measurement

This possibility of having resources available clearly indicates that the approach of accessibility to resources is fundamentally a potential approach. Etymologically, the word "potential" comes from the Latin, *potens*, *potentialis*, meaning powerful, potent, or in other words, which from the point of view of the act or practise, may be implemented, but of which it is not known a priori whether it has been. Behind this first conceptualization of potential there is a whole wealth of literature on accessibility to resources that looks into territorial social inequalities, that is, based on differential localization of populations in space. Measurements of accessibility vary with the specific objectives of studies, but some forms predominate, for example:

– the indicator of the minimum distance separating the population located in a zone i from a type of resources;

5 The calculation is based on a zone centre (centroid) which then, as a postulate, summarizes the total content of the zone.

– the indicator of the number of resources of a given type within a radius of x units around the population located in a zone i.

Alongside this first conceptualization of potential related to resources, there is an approach to potential accessibility that relates to the spatial interaction paradigm. The concept of potential was introduced by the social physics school in the mid-nineteenth century. In 1858, Carey introduced gravity into social science in order to explain the forces of interaction among people, forces that he presented as being proportional to the masses of individuals in presence and inversely proportional to the distance between them.

In this gravitational context, the potential exerted on a body A by a body B corresponds to the mass of the body B in relation to the distance separating the two bodies A and B. Stewart (1947) first introduced the concept of potential in a population study. But it was essentially Harris who developed it in the form of a market potential in an analysis of industrial location. Lastly, Hansen (1959) was the first to use the concept to describe accessibility to employment resources by defining accessibility as the "potential for opportunity of interaction". The form he selected of potential accessibility (PA) of the zone i to all resources (R) in zones j corresponds to the mathematical expression:

$$\boldsymbol{PA}_{\boldsymbol{i}} = \sum_{j \neq i}^{n} \boldsymbol{R}_j \, \boldsymbol{d}_{ij}^{-\alpha}$$

where

– d_{ij} is the distance between i and j;

– α is the friction of distance.

This potential accessibility to resources approach has seen many thematic applications while being the subject of several adaptations especially through the use of different distance functions (power, exponential) as was the case for the gravity model. Thus, the potential accessibility to resources, whether addressed empirically or in the context of the spatial interaction paradigm, retranscribes what the geographical framework allows.

There is in the end the possibility of disposing of resources, but they are not necessarily mobilized, that is, used by populations. To the best of our knowledge, this idea of resource suffers in accessibility geography from a lack of conceptualization. Apart from the fact that in studies, a concrete content is attached to it (jobs, shops, etc.), the idea is not precisely defined. If one looks at computer science and especially in the area of the web, there is a precise meaning of the term resource. It is "something that can be identified, identification having two aspects, naming and addressing".[6] In geographical terms, for an object to be a resource, it must be known and it must be possible to locate it. As

6 Document RFC no 1738 (1994) dealing especially with the general idea of Universal Resource Identifier (URI).

potential accessibility does not integrate knowledge of the populations under study, as for example cognitive representations of the geographical framework, it remains, to our mind, a question of modelling, admittedly an important one, of what geographical space allows but not of what practised functional space is. What of the last major family of accessibility studies relating to economic geography and the school of time geography?

2.3. Towards "effective" accessibility to resource of a territory: the integration of practices

The final major family of accessibility studies comprises, like the previous one, allowance for the spatial dimension (spatial system, resources and connection of zones), social dimension (population characteristics), and for some approaches, apprehension of the time dimension. However, it stands fundamentally apart from the previous ones in its perspective based on the individual. Accessibility is thus evaluated on the disaggregated scale of individuals, knowing that the final objective is to tend towards a collective evaluation of accessibility to a territory's resources for all of the people living in the same zone *i*.

The econometric approach

The econometric approach rests on the traditional foundation of economic theory, which is that of individual rational choice. Thus, we suppose an individual *a*, located in a place *i*, has different alternatives of place *j* to carry out an activity *k*. Moreover, the individual associates a certain level of utility *u* with combinations *ijk* which generally takes account of the benefit derived from the location *j* for activity *k*, which benefit is reduced by the cost of traveling between place *i* and place *j*. Logically, the choice of place *j* in which activity *k* will be conducted by individual *a* corresponds to the choice with which maximum utility is associated. This utility may be interpreted as an effective accessibility index to the resources since the person does go to *j* to perform activity *k*.

The same authors have proposed a simple formalization of this accessibility as:

$$A_a = \mathbf{Max} \cup_{ijk}$$

This perspective raises a number of questions as to the matching of the principles adopted with individual possibilities and ways of doing things. *It assumes that the individual has a set of choices, which for some activities is absolutely not sure, and that the individual can rationally order these various alternatives.* Even if in this optic, accessibility tends to become an effective measure and individual behaviour is described explicitly, there are many behavioural rationalities, in reference to criteria other than economic ones, such as the emotional dimension that ties an individual to performing an activity in a specific place.

Spatio-temporal constraints

Hägerstrand (1970) in his famous paper "What about people in regional science?" proposed the idea of spatio-temporal prism. In this spirit, space and time are considered to be two finite fundamental resources that limit individuals' options as to their activities. By distributing them among the elements and actors in a given situation, individuals construct spatio-temporal pathways. The prism thus delimits the set of opportunities available to individuals for participating in transport and activities in a given space-time. The projection of this prism on a two-dimensional space constructs what is termed a potential path area. This area may be interpreted as an effective accessibility indicator which is measured, for example, by the total surface of the geographical space to which an individual has access.

More complex measures of accessibility to resources have been proposed on the basis of allowance in the agenda of activity for travel time (including traffic congestion), opening hours of activities, downtime such as dropping off the car, walking to the activity. Their formulation of effective accessibility rests on the sum of accessible areas j, each weighted by the possible duration of the activity. Thus for an area j of a given size, the longer the activity, the more this area contributes to the individual's effective accessibility.

Ultimately, the logic of the spatio-temporal approach rests upon allowance for certain behavioural characteristics of individuals and the set of constraints to which they are subjected.

This synthesis of accessibility in geography reveals several important aspects about the elements addressed by the various conceptions. The various spatial, social, and temporal dimensions are not mobilized in the same way, nor are they considered on the same plane. The approaches are sometimes aggregated and sometimes disaggregated and among the latter that consider the individual explicitly, behaviour is either approached globally, but in an unsatisfactory manner, or very partially on the basis of certain sporadic characteristics.

2.4 A first step towards a cognitive conceptualization of geographical accessibility

An overall observation is the absence of cognitive representations which, without constituting a mechanical determinant of behaviour, remain the guide by which to direct knowledge of resources and their localization in space. Thus, rather than considering a spatial system that rests on the understanding of accessibility through the intermediary of all the relations between places, it seems judicious to rely on these cognitive representations integrated by the individual to move towards an evaluation of accessibility of this nature. These representations reflect the knowledge an individual has (semantic representations) as much as the way to behave in certain circumstances (representations for action) such as the performance of an everyday activity or moving into a new home. To take a first step towards a cognitive conceptualization of geographical accessibility, it is essential to introduce these two fundamental aspects in the measurement of accessibility.

The individual and his patchy knowledge of the spatial system under study

Individuals are not all-knowing. Their knowledge of space is not just limited but is also patchy in the sectors they frequent, which in return conditions the value associated with spatial information. This knowledge is limited to portions of space that present an interest for individuals either because they can perform activities there, or because they associate them with impressions, feelings, emotions, or a history that is meaningful for them, or lastly because people around them speak of it. This limitation of knowledge of places is duplicated by ignorance of the totality of the resources present in a place and their position with respect to each other. Many works have confirmed these aspects since those conducted by Appleyard (1970). Even so, if we change perspective by focusing on the individual again, that is, by abandoning the external reference frame of the exhaustive inventory of the elements of a place and the comparison of individual knowledge with this inventory, the fundamental question asked is that of the way in which such knowledge is constructed.

Several vectors contribute to this construction. We can cite for example, all the media that broadcast information about the resources of places and social relations in the broad sense (family, friends, relations with others, etc.). The fact remains that learning through practice certainly remains the most fundamental process in constructing such knowledge. In moving through space, the individual gathers experience and memorizes it according to two complementary principles (Eustache and Desgranges 2010): the principle of correspondence, so that the representation memorized best reflects the reality of the experience and the principle of coherence, which implies that the representation does not enter into conflict with his beliefs about himself, others, and the world.

The individual and his space-oriented relationship

This second principle indicates clearly, then, that individuals' relations "with something", and therefore with space, do not work without an overall logic that serves as a guide. We come back to the idea of choice addressed earlier (cf. the econometric approach). This notion must be perceived rather as a set of alternatives intrinsically oriented by convictions rooted in the individual. This orientation leads to the *invisibility of certain places and certain resources in other places that are known*.

Empirical work on everyday mobility, residential mobility, and more generally on the search for resources in space (e.g. a shop, housing, employment) clearly shows that in the context of the conduct of action, this cognitive orientation of individuals is very significant. Quinn (1986) studying the spatial dimension of job seeking is particularly revealing about this phenomenon. His survey of the urban region of Birmingham shows that individuals have a propensity to retain employment opportunities depending on the degree of familiarity with the zones where the job is located. The favoured zones are those around the place of residence or in regularly frequented sectors like the city centre. Access time is not the main reason for this since, according to the author, certain zones that are very well served by various means of transport are not taken into account although they have many opportunities. He concludes that beyond the problem of accessibility, it is knowledge of the city and familiarity with the different districts that form good indicators of the spatial aspect of job seeking.

It can thus be asserted that the patchy knowledge of the spatial system and the oriented relation with space are two facets of the same thing: the process of construction of semantic knowledge. *This process is based on an experience that is first perceived and then memorized in the form of a representation depending on the beliefs rooted in the individual*. If one wishes to gain a suitable and comprehensive understanding of geographical accessibility of individuals from a given place *i*, it is essential that the measurement is centred on the individual and that it takes account of his cognitive representations. However, the individual is fundamentally a social being, which implies that cognitive accessibility to space must also be apprehended in the context of social conditions and issues, as shall be seen in the paragraphs to come.

3. Geographical accessibility and disability: a transition towards the socio-cognitive accessibility of space

Accessibility studied on the basis of disability may seem a pointless "detour" for getting to what concerns us, namely the socio-cognitive dimension. However, for one thing, it is in terms of disability that geographical accessibility is essentially thought of, problematized, and worked on both through and in our public institutions. For another thing, it is also in this area of research that its conceptualization, by which the individual occupies a central place from the outset, is most significant. And it is interesting to observe that, on the other hand, as shall be seen in more detail, in this area, and contrary to the tendency already described in geography, its definition gradually moves way from the individual to leave more scope for the relationship between the individual and the socio-spatial context. So what can this theoretical cross-over on accessibility provide us with? That the cognitive dimension is in any event ever more present… but in one case it is formalized in relation with economic models (models of rationality) whereas in the other case it is formalized in relation with sociological models (models of social cognition).

In the area of disability, therefore, three movements have been at work over the years when the individual's situation is included in the notion of accessibility to geographical space. These three visions of accessibility show that it is the standards and values associated with disability that change the representation and realization of improved accessibility for this specific population. However, all these conceptions rest upon a same base: the fight against the social exclusion of the disabled.

3.1 From infirmity to disability: the progressive emergence of the sociological dimension

The first movement, up until the First World War, was based on the idea that improved accessibility to the built environment meant compensating "infirmity" so that the disabled person could adapt to social constraints and not the other way round. Here the individual had to be "standardized" because it was the norms of physical or mental integrity of the disabled that were considered to be at stake.

The second movement, which appeared at the end of the First World War but intensified towards the end of the 1950s with the strengthening of the welfare state rested on the opposite idea. The premises of a new way of considering the deterioration of physical integrity rested on the increased number of accidents at work in the late nineteenth century with the development of industrial production. Then the maimed from the First World War strengthened the change in conceptions. In both cases, the ills that befell the person were no longer thought of as being of divine or individual origin but social origin (Winance, 2004). From "infirmity" came a gradual shift to "disability", this being defined this time as a variance from the standards of social integration (and no longer physical integrity). In other words, the idea of disability tends to shift the problems to be solved onto environmental factors, whether physical or social. Thus the idea of spatial accessibility becomes important when the disabled person is seen as someone who is above all "missing" a place in society. It should be observed too that "it is the difficulties moving in the outdoor environment that are the most frequent" (Chanut and Michaudon 2004) compared with difficulties at home. In 2004, such difficulties in moving around in public spaces concerned 5.5 million of the adult population of France (Chanut and Michaudon 2004).

These conceptual changes in the idea of disability are compounded by a reshaping of the disciplines involved with these issues. Disability is progressively considered as a specific feature of a minority of individuals which the remainder of the population must be able to recognize so as to comply with the legal principle of equal opportunities developed with the reinforcement of the welfare state. This development contributes to the emergence of multiple forms of disability, and consequently of accessibility in the broad sense.

Integration of the idea of accessibility into the conception of disability leads to a paradoxical situation though: while social exclusion can now be seen as being related in part to spatial exclusion, accessibility, even when geographical, is considered in its physical dimension only. In other words, its social dimension is generally passed over. The disabled person remains a person who is not "normal" (first approach focused on the person's physical integrity), even if the problems of accessibility to be solved no longer rest on their attributes but, of course, on those of the environment in the broad sense (second approach focused on social integrity). In other words, the disabled person, being stigmatized (Goffman 1975) cannot have access to all everyday living spaces unless we pretend that these stigmas do not exist (Winance 2004) and not just by "repairing" the body but by adapting geographical space so as to improve physical accessibility to places. It can be understood here that, although the physical problem might be resolved, it is not necessarily solved from a social view point. It is not because physical accessibility becomes possible that all social conditions are fulfilled for the individual to be able to frequent a place.

3.2 The normative dimension of accessibility

The final development, which arises from the 1980s onwards, involves disability, to try to palliate the paradox between the removal of the stigma by adjusting the environment and maintaining the stigma by differences as to social norms that continue to exist between what is "normal" and "disability". Until then, although disability remained a stigma, establishing a (negative) gap between a person's perceived attribute and the expected attribute (stereotype) [Goffman 1975], it was essentially because social interaction was ambivalent. That ambivalence was involved at both ends of social interaction: between the assertion of being like everyone else and being different for the disabled person; and because non disabled persons always integrate them socially (in the group of "normal" persons) as disabled persons (that is, belonging to the group of people who deviate from the norm). In other words, it is no longer on the environment that difficulties depend but on the "situation of disability", that is, on the combined relation between the person and their environment. By emphasizing the situation of disability, researchers then developed other concepts to escape from the restrictive character of accessibility. Fänge and Iwarsson (2003) proposed the idea of "usability" to include the user comfort that the environment allows people, here the disabled. This idea is similar to the research developed on "environmental congruence" in environmental psychology (Stokols 1978, Michelson 1980). Other investigators, such as Stark (2007) have developed the idea of receptiveness to address the social dimensions that impede or facilitate activities and the participation of the disabled (normative attitudes, depreciation faced with stigma).

Although this is an interactionist type of conceptual approach, and its limits shall be seen later, that has made it possible to address disability as a relative and no longer an absolute difference, the development of this research issue shows to what extent the idea of accessibility, even if restricted to its geographical dimensions, cannot be restricted to its physical and/or individual characteristics. The social dimension of individuals' relation to space and thought categories is important, that is, the socio-cognitive dimension. Although we can observe changes in this direction for societal problems related to disability, can we find normative aspects related to geographical accessibility outside of disability?

4. Socio-cognitive accessibility of geographical space

After these two major families of meaning of accessibility, it seems that several conceptual boundaries still remain to be crossed. First, in geography, speaking of access refers back to the functioning *of* and not *with* space. This compartmentalization of geographical space to make it into an object in itself introduces distinctions between accessibility and practice (the latter referring back also to attractiveness) that are only of operative interest in terms of managing space. The comprehensive or explanatory dimension very often remains secondary. In this way, conceptual models fail to go beyond the fact that we need to know, on the one hand, the spatial practices of individuals in order to measure the accessibility of a place and, on the other hand, the accessibility of a place to understand spatial practices. This explains here the two theoretical bifurcations that have been developed: either it is envisaged that it is the functional attributes of geographical space (potentiality) that are decisive, when the analysis is strictly spatial, or it is considered that it is intentional when the human factor is explicitly considered on the individual scale. In the first instance, it is the content of space that must be altered, in the second instance it is people's opinions, beliefs, and attitudes that must change if the geographical accessibility of a place is to be altered. Confining now our discussions to the second situation, what is missing in the econometric approach or in the approach referring to spatio-temporal constraint, is that the individual is assumed to know all of the possibilities so that the researcher can measure accessibility. Accordingly, the researcher at no time questions either the conditions of possibility or the conditions of production with respect to the accessibility of a place. The researcher asks, at best, about the working conditions, especially on the basis of possibilities (constraints) and actual output (behavioural drives).

By emphasizing both its normative character and the situation, accessibility from disability makes it possible to get out of the individual intentions (and to conserve an important dimension of geographical accessibility) and avoid keeping geographical accessibility and spatial practices conceptually separate. What matters in the situation of disability is the relationship with the person's physical and social setting, and no longer on one hand the attributes of the physical environment and on the other the attributes of the person, the two objects being considered in this second case as interacting. However, conjugating normativity and situation in the understanding of accessibility in general and geographical accessibility in particular presupposes that the norms and situations are not discovered each time by the person but that they are interiorized by the person. In other words, norms and situation refer back to social disposition, some being relative more to social relations (norms), the others to relations with geographical space (situations). It is in this way that the individual can be placed at the centre of the issue of geographical accessibility without mobilizing the rational individual model, aware of their preferences, and making choices depending on these preferences with a view to consciously serving their personal interests for the best.

4.1 From the physical, behavioural, and social legibility of space to accessibility

Socio-cognitive accessibility to geographical space maintains close ties with the question of facility in the individual's relationship with space. The degree of facility corresponds in the end, in this type of relation, to the distance between the subject (individual) and the object (place). As this distance is no longer metrical, its unit of measurement is still to be defined.[7] But it can already be said that facility here relates to the ease with which individuals can either project their presence into places or imagine the place (its physical and social characteristics, its location, etc.), or get an idea of the social rules associated with the place (what can be done there and how, who does what, etc.); all of these dimensions being neither exhaustive nor antagonistic. In short, facility relates as already proposed by Lynch (1960) to the representation we have of space and more specifically its legibility. Although Lynch attributes the legibility of a place to its physical and morphological characteristics and defines it as "the ease with which its parts can be recognized and can be organized into a coherent pattern", definitions other than physical ones of the legibility of geographical space have also been made. For Weisman (1981) legibility corresponds to the degree of ease with which individuals can find their way within a given built environment. This concept is then defined in terms of the environment/behaviour system rather than the environment's physical characteristics alone. However, Weisman observes, over the course of his investigations, that the concept remains strongly dependent on the spatial structure of the environment. O'Neill (1991) considers that legibility in connection with wayfinding practices may be measured objectively. He proposes measuring the complexity of spatial structure by calculating the density of interconnections.

7 An example of socio-spatial distance between individual and environment is presented in Ramadier and Moser (1998).

Physical legibility is therefore compounded by behavioural legibility of geographical space. The latter is a conception that is very close to accessibility such as geographers originally defined it. The difference, and it is a sizeable one, is that the denser the connections of a place, the weaker the behavioural legibility (it is harder to reach the place), whereas geographical accessibility is greater (it is easier to reach a place). Here we find the drawbacks of a compartmentalized meaning based on interactions from a process point of view of spatial and individual attributes of the system under study. Insofar as interaction is ultimately just a double determination (Ramadier, 2010) with opposing causal directions, it is not surprising that reversed conceptions are found for the same situation, whenever we switch the reference framework to account for a process or a state when analysing the relations with individuals' geographical space.[8]

A final conception of the legibility of geographical space seeks to understand the variable facility of representing the space under study by avoiding the pitfalls of interactionism. This approach to the legibility of space developed by Ramadier (Ramadier and Moser 1998, Ramadier 2009) pertains this time to the social legibility of space. Defined as "the facility with which an individual uses the socio-physical characteristics of the setting to interiorize a set of environmental significations to be able to organize the physical components into a spatial schema" (Ramadier 1997), it takes account simultaneously of the social dispositions of the person and the situation he is in. The representation of space and more particularly of urban space is a social construction (Jodelet 1982, Depeau and Ramadier 2011). And the consequences of this social construction, that differentiate, first the practice of place through life, second the meanings attributed to geographical space by the extended entourage (family, friends, media, etc.), and third the symbolic control over space by the projection of values of those who have the power to shape it (decision makers, planners, financers), mean that the reading of space is more or less difficult for the individual and differs from one social group to another. It is precisely this social legibility of space that diversifies spatial representations. Consequently, it is easier for someone to transpose their knowledge of a place or a type of place to another if its (physical, social, and functional) characteristics are very similar to those of the first. In other words, the degree of facility in question in social legibility of space depends less on the duration of the experience (time-related familiarity) than on cognitive schemas that are socially constructed, interiorized by the individual, and transposable from one place to another (socio-cognitive familiarity).

8 The strength of the interactionist approach lies in part in the fact that it can maintain researchers' disciplinary specificities while enabling them to readily display consideration for points of view from other disciplines, which amounts to building a way of thinking about the world to legitimize the transfer of knowledge and tools. The risk is that interaction will be seen as a process of construction of the objects even if it merely describes the situation in which the objects are found.

If there is a socio-cognitive accessibility of space, it is not so much because there are differences between individuals, or more specifically social groups, but differences between various places in space for one and the same individual. In other words, we retain a second important property of the concept of accessibility in geography (the first, it will be remembered, is the absence of intentionality), namely that the differences analysed relate above all to places. Consequently, socio-cognitive accessibility rests on the fact that each person cuts up and categorizes space into a multitude of places (the place then being the cognitive unit of geographical space).

Cognitive psychology has many a time shown that physical space is represented on the basis of the division of geographical expanse into spatial units that are hierarchized in memory (Hirtle and Jonides 1985). Each spatial unit is associated with a reference point (Wapner et al. 1981), that is, an urban element corresponding to the prototype of a spatial unit and summarizes it completely (e.g. the station is the prototype representing the “station neighbourhood” set, the Eiffel Tower represents Paris symbolically and spatially, etc.). The theoretical model of the double encoding of spatial information (Paivio 1971) can be used to articulate topological information from the reference point to a set of social meanings of space. However, spatial partitioning (i.e. the territory) is not just in the representation. It is also materialized by those who have the power to intervene in the lay-out of physical space. For example, elected representatives draw up administrative boundaries by assigning citizens to voting districts based on their housing, planners and architects build on the basis of urban areas defined by their function, and geographers divide up space depending on its composition (urban landscapes, etc.). Thus, if geographical space is divided, the (social) legibility of each of the spatial units by the individual is probably not the same. This is the hypothesis that makes it possible to consider a socio-cognitive accessibility to places (Ramadier 2010).

4.2 Socio-cognitive accessibility in acts

Socio-cognitive accessibility is, however, not just a question of the representation of space. We have already specified that it concerns the relationship to space more globally. Now this relationship to space is made up as much by representations as by spatial practices, the two facets being inseparable.

It goes without saying that practices, whether spatial or not, distinguish social groups. In other words, it is something of a truism to recall that the places frequented differ from one group to another. Plentiful literature on socio-spatial segregations describe this and try to understand the mechanisms at work. What is less of a truism, paradoxically, is to assert that this differentiation reduces the degree of freedom of places of destination on the individual scale; because it presupposes accepting the idea that a place of destination is not just an individual choice or a functional choice but a decision that is within our ready-made socio-cognitive schemas. This is the challenge when we speak about the practical aspect of socio-cognitive accessibility. For a given individual and for a given set of places, the probability of frequenting them is not the same for all places, because of the social legibility and social identities playing in the relationship with space. So, initially, we can say, by effecting disciplinary triangulation, that the mobility of individuals in space depends on spatial practices configurations that are at the same time social, cognitive, and geographical, "such that it makes it possible to cross functional boundaries of geographical space by minimizing the crossing of social and cognitive boundaries" (Ramadier et al. 2009), which we try to apprehend on the basis of the concept of *displacement identity*, a complementary concept to settlement identity (Feldman 1990).

Socio-cognitive accessibility supposes, then, that daily mobility of individuals is relatively stable, which we have been able to see by observing that some 70% of weekly trips are spatial routines,[9] whether the investigation is conducted in Strasbourg or Quebec (Ramadier 2007). So socio-cognitive accessibility seems to obey a general principle of *replacement*, which is defined as "a geographical displacement which seems to have as its principle to minimize the socio-spatial distance between the point of departure and the place of destination, in order to reinforce the cognitive familiarity of the place of destination" (Ramadier 2010), familiarity which, let us recall, is not dependent on the duration of the experience of places but on the schemas interiorized for thinking and acting in geographical space. So, as specified in the section on the legibility of space, we are confronted with the measurement of socio-spatial distances that remain to be defined. However, an attempt to analyse household travel surveys for the Strasbourg agglomeration has enabled us to test the principle of replacement by starting from the most restrictive possible socio-spatial indicator, namely the morphological similarity between the place of departure and the place of arrival of a trip, knowing besides that the two places must be part of two different spatial units (to avoid socio-spatial similarities related to very short travel distances, such as trips within the settlement area, for example). These analyses have shown us that spatial replacement varies greatly with the reasons for the trip and the social group. Even so, on average, some 20% of trips are spatial replacements (Ramadier 2010). The difference between the 70% of declared spatial routines and the 20% of observed replacements shows us that the measurement of socio-spatial distance between the place of departure and the place of arrival must be improved and made less restrictive than the measurement used so far.

9 By way of comparison, temporal routines of daily mobility represent just one-third of weekly trips.

5. Conclusion

If we had to summarize the socio-cognitive accessibility of place using the terms of the econometric model currently in force in geography, we would say that this form of accessibility relies on maximizing cognitive familiarity of place by relying on the *replacement* principle. But the maximizing process would have to be understood here as being largely unconscious and not resting on a set of possible outcomes (a potential) that is equivalent for everyone. In other words, the idea of maximization is largely used as a metaphor.

We have underscored the fact that socio-cognitive accessibility escapes from two notions that were highly structuring in other accessibility models, namely the ideas of potential and choice.

Potential, which is a disguised way to build on a classical deterministic model (invoking a potential determinant and not an effective cause), is at the heart of parametric models. Thus, the individual may or may not be "sensitive" to the potential determinants in question. And if he is, there is a gradient of sensitivity, a gradient that distinguishes among individuals or the same individual over time. The approach is more descriptive than explanatory or comprehensive, because causality is subordinated to probability to retain the idea of potential. Socio-cognitive accessibility relies on a reverse principle because it is the probability of being "sensitive" to the determinants, knowing besides that the determinants are more relational than substantial,[10] that defines the individual. Thus, as in quantum physics, the probabilities observed are subordinated to causal laws.

Lastly, the objective in socio-cognitive accessibility is not to categorically refute the models based on individual choice. Even if the idea of choice seems scientifically suspicious to us (especially because it is never really defined), this does not mean that the individual loses all margin of freedom to think and act. In many situations, individuals are forced to decide (rather than make choices) particularly when they are in a crisis situation[11] in which their cognitive and behavioural schemas are no longer operative. It is therefore, it will be recalled, the situation which is itself defined as the relation between the characteristics of the socio-cognitive dispositions interiorized by the individual and those of the socio-physical dispositions of the place, that is decisive for understanding the probability that the person frequents a given place. In terms of computer simulation of spatial practices, this means quite simply that programming must be able to formalize environmental situations, that is, to emphasize the type of relation that can be observed between the individual and the geographical space and not the characteristics of the individual on one hand and of the space on the other,

10 Remember an essential point here, namely that it is no longer objects that are determinants but essentially relations.

11 Notice, though, that etymologically "crisis" and "decision" are pleonastic.

even if this latest model is able to process both dimensions simultaneously. This means, then, that it is important to develop interdisciplinary research that leads to the explanation of the main indicators for describing and understanding the different possible relations between the individual and geographical space. Because it is, of course, on this point that research on indicators, as on the set of possible outcomes, is least developed: although we have geographical, psychological, and sociological indicators, we still do not have any indicator defining one of the dimensions on the basis of one other dimension; similarly, the set of possible outcomes is never a set of possible relations but a set of possible objects.

The interesting point to analyse in geographical mobilities (especially residential and daily) on the basis of socio-cognitive accessibility rests first on the fact that the theoretical model is compatible with the often repeated scientific observations of socio-spatial segregation, for the purpose of casting new light on the socio-spatial processes at work in this topic. Socio-spatial segregation has been regularly observed since the early works of the Chicago School, but it remains difficult to explain. And a conception of geographical accessibility that includes this phenomenon seems to us better qualified to participate in the analysis of residential mobility. Second, this observation makes it possible to investigate the relationship of individuals to space other than by using preferences. Here again, things must be nuanced. It is not so much to get rid of the idea that the individual acts on the basis of preferences (from a phenomenological point of view) , but that the term "preference" does not rest on a norm that is self-constructed by individuals enabling them to behave in accordance with the norm because it is closer to their material and psychological interests. While in appearance the individual acts as a function of hierarchical preferences, directly questioning these predilections is to look for the manifest content of a person's practices. It is often sufficient when researchers limit their investigations to the management of geographical space. However, it seems excessive to us to explain individuals' spatial mobility more generally with such a model insofar as one confuses, in this case, the manifest content of practice with the processes that engender that practice. Opening up the "preference box" requires simultaneously investigating cognitive (and affective) structures and social rationales that condition such preferences. Preferences are nothing but values, that is, social constructions put into action, or at least planned actions. The socio-cognitive accessibility of geographical space therefore makes it possible to look for psychological and sociological conditions of spatial practices. And in return, it can also be used to understand how geographical space influences the psychological and sociological structures to which each individual is subjected.

Affect, Uncertainty, and Decision-Making

Dominique Ansel, Bernadette Nicot, Arnaud Piombini, and Fabien Girandola

1. Introduction

Decision-making is a complex cognitive process of selecting an action among various alternatives. Everyday life is full of situations calling for multiple decisions: living somewhere, moving home, choosing a route, changing route are all decisions that determine our life setting and way of life. These decisions may have a limited impact or over the longer term may cause slight inconvenience, a fleeting feeling of well-being or deep unease, or possibly even unbearable anxiety. They are not unimportant, then. The elements on which our choices about daily and residential mobility are based are of different kinds and depend on economic, sociological, historical, and also psychological factors. This last aspect covers individual dimensions, involving cognitive and emotional factors, but also collective factors in the sense that everyone includes in their own decision-making their perception of the social universe in which they will partake spatially and their level of involvement in group realities they may be part of. In their endeavour to develop their understanding of the decision-making process, economics, geography, and social psychology have progressively sought to integrate the affective aspects.

It is no easy thing to define an emotion in a conceptual perspective that enables operationalization. Three main terms appear in scientific publications. Classically, the affect is rather a generic term used to designate all an individual's affective reactions. Emotions are defined as a set of extremely rapid responses of the organism in unusual environmental circumstances. Moods set in more slowly, more lastingly and more diffusely, with their triggering elements being difficult to identify and an absence of intentionality can be observed.

P. Frankhauser and D. Ansel (Eds.), *Deciding Where to Live*,
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Frijda (1986) proposes a definition of emotion in three parts that can overcome the question of multiple definitions. An emotional episode:

– implies that the event giving rise to the emotion is meaningful for oneself and has an impact relative to an objective that is found important for oneself;

– creates a state of readiness for action. Individuals concentrate their resources to respond urgently to the situation;

– is accompanied by an unusual mental state and physiological reactions.

An emotion can thus be understood as a three-level response system: physiological (heart rate, etc.), behavioural (facial expression, voice, gestures, etc.), and cognitive-experiential (set of mental processes that develop after an emotion and contribute to the perception of the situation, maintaining it in memory and transforming it. At this level, language is an essential vector).

The first part of this chapter develops the way in which economic theories have gradually taken account of the question of subjectivity in modelling the decision process. The development of the idea of rationality can be read in it between the lines. The second part proposes some of the main effects of emotion in research that problematize residential choice. The final part presents a more specific reflection on the question of daily mobility and the role of habits as important elements in decision-making.

2. Progressive allowance for affects

2.1 Bernoullian and neo-Bernoullian approaches

Von Neumann and Morgenstern's expected utility

The early studies on decision-making sought to formalize the process by reference to rational criteria developed by the theory of probabilities. Information is processed primarily in its cognitive aspect. Decision-making theories in economics are often presented as rational behaviour theories under perfect information, because they rely above all on Cartesian logic. This is translated by binary logic (0, 1) or an all-or-nothing decision. Although the concepts of risk or uncertainty were the subject of many reflections at different times there was renewed interest in the theory of decision-making under uncertainty when von Neumann and Morgenstern (1953) adopted Bernoulli's principle in the context of game theory. The objective of statistical theory of decision-making under uncertainty is to highlight an order of preference of actions or strategies when the environment is uncertain. The comparison of different actions (e.g. comparing the possibilities of buying a big flat in the city centre or a house on the outskirts) is facilitated by a Bayesian measure based on the criteria of mathematical expectation. The unit of measurement, the most exhaustive one, chosen to evaluate the decision maker's preferences is utility. Utility is supposed to reflect the quality of an act with respect to the decision maker's preferences or aversions or even indifference.[1] It therefore implicitly takes into account the decision maker's "state" at the time of choosing. Personal experience, mood, intuition, fears will influence the preferences of the decision maker who will then attribute a value (measurement) to utility. The upshot is that the mathematical expectation of utility is equal to the sum of the consequences of an act weighted by the probability of the determining event of each consequence. The origin of this mathematical expectation of utility goes back to Bernoulli. In an attempt to solve the Saint Petersburg paradox (see chapter 10), Bernoulli was the first to introduce the idea that the calculation of mathematical expectation must include not the gain but the utility. Thus the commonly used qualifiers "Bernoullian" and "neo-Bernoullian" refer to the proponents of the criterion of mathematical expectation. These what are termed "normative" models result therefore from measuring instruments. They emphasize the distortions between the results of individuals' observed behaviour and the search for the optimum sought by theory. Although the ideas of "utility expectation" or "expected utility" are the main pillars of decision theory, they were to be the subject of much controversy, as we shall see later (Savage 1972, Allais 1953, Kahneman et al. 1979, Shackle 1979).

Savage's subjective expected utility

Savage's criticism of the traditional idea of utility, by which probability is the limit of a relative frequency, leads him to construct his theory on both the idea of utility developed by von Neumann and Morgenstern (1953) and the concept of subjective probability introduced by de Finetti (1937). Here we consider an "uncertain" event of a process that cannot be repeated infinitely under independent conditions. The outcomes of the process are therefore not equiprobable, meaning that the probabilities of elementary events are not equal. In such a context, the resulting probability can only be subjective. It measures an individual's belief in the truth of a proposition. Probabilities are subjective in that they represent an estimation of an individual based on his/her knowledge and opinion. For Savage (1972), probability calculations cannot be used in decision-making under uncertainty unless all the imaginable alternatives are identified and unless they are associated with a probability a priori expressing our initial degree of confidence with respect to the eventuality of a state of nature. When states of nature are future states whose conditions of occurrence are not identical to those that engendered the observed states to which they may be likened (e.g. housing on plans), it becomes impossible to use objective probability as a basis.[2] Subjective probability relies on a number of axioms that must

1 The utility function is then represented by a convex, concave, or linear function, respectively.

2 More specifically, decision makers must be aware that they have several choices before them. First, it is assumed that they choose rational probability, then at the end of the process they attribute a number between 0 and 1 to each event. The resulting subjec-

be consistent with the standard rules of mathematical calculation of traditional probabilities and reduce the duality of frequency and likelihood. In order to unify these two conceptions and to have a unitary mathematical theory, Savage establishes rules of correspondence between them and shows that probability, like relative frequency, is merely a special case of a more general conception. Subjective probability rests on the principle that an unknown magnitude may be estimated by comparison with an objectively known magnitude.[3] The resulting subjective expected utility corresponds to the sum of utilities or satisfactions procured by an event, weighted no longer by objective probabilities but by their beliefs about their realization. It may be understood as a theory of an ideal agent, even if the decision-making process here becomes "more or less rational" because of the intrusion of "cognitive and emotional bias" in the subjective evaluation of probabilities. The individual introduces a degree of likelihood or a more or less firm belief in the realization of a given (objective) probability and probably with a view to drawing a parallel with the numerical translation of the decision maker's preferences (utility of gains). The decision maker's degree of confidence may also be interpreted as the probability of making a wager; his belief is stronger when the decision maker has a preference for gain and vice versa if he has an aversion to gambling.

2.2 Criticisms of the Bernoullian criterion

The Bernoullian criterion itself has not been unanimously accepted. Allais (1953), Kahneman and Tversky (1979), and Shackle (1967, 1979) keenly oppose the theory. Although they concur in criticising Bernoullian theory, their respective theories are not convergent themselves. All these authors dismiss the criterion of rationality. For Allais (1953), only reasonable decision criteria can be defined. For Kahneman and Tversky (1979), decision-making is more about delving into the psychological (cognitive) and contextual[4] foundations of decision-making behaviour contrary to Bayesian behavioural theory which is more descriptive and quantitatively orientated. Tversky and Kahneman (1974) had already remarked that psychological approaches and decision theories based on probabilistic analyses served different purposes. The former sought to describe actual mechanisms by which people estimated likelihoods, the later sought to characterize the set of probability judgements that can be admitted in normative

tive probability then reflects the decision maker's opinion about their personal appraisal with respect to the realization of an event.

3 Decision makers compare random "state" variables (case of discrete random variables) with various events for which they have objective knowledge of the probability. It follows that the subjective probability must comply with the usual axioms of probability computation (additivity, summing to unity, axioms of conditional probabilities, etc.).

4 The authors take particular account of the effect of "framing" the problem and the differences observed in the choice made by individuals depending on whether they are in a perspective of gains and losses (cf. Section 2.3 of this chapter).

terms. But both sought to improve human judgement. Shackle was to break down the actual operations in the mind of a man making a choice. While Allais is wary of introspection and uses the idea of probability, Shackle resorts to introspection and introduces the concept of potential surprise. When decision makers have no statistical series enabling them to establish objective probabilities, when faced with such a new situation that they are unable to construct subjective probabilities, in other words when uncertainty does not come down to randomness, whether subjective or objective, a decision can, however, be made on the basis of Shackle's potential surprise (isolated house may be the object of expropriation at date $t + n$ or the possible route of a motorway or high-speed railway line close to a house). Shackle's theory is characterized by the "inspiration concept" of the person choosing. This characteristic is designed to involve essential novelty in the unfolding of events. With regard to his inspiration or intuition, the decision maker will in some respect take an acceptable decision and no longer necessarily an optimal one. While Bernoullian theories implicitly presuppose a more or less rational calculation on the part of the decision maker, Shackle's potential surprise involves reasoning in which emotion impels the decision maker's imagination. Two types of extreme situations may cause surprise among individuals, their behaviours are different because they are not of the same nature. Surprise may be attributable to an error of judgement in which case it does not alter the reference framework to which his expectations relate. Conversely, surprise may stem from a mismatch with the reference framework; in this case, it puts the decision maker in a position of ignorance (as with the construc tion of a motorway that may entail expropriation of his house). For Shackle (1967): "It is the degree of surprise to which we expose ourselves, when we examine an imagined happening as to its possibility, in general or in the prevailing circumstances, and assess the obstacles, tensions and difficulties which arise in our minds when we try to imagine it occurring, that provides the indicator of degree of possibility. This is the surprise we *should* feel, if the *did* happen; it is *potential* surprise". Thus only potential surprise,[5] that is surprise at the moment of deciding, matters in the analysis.

2.3 Importance of context and the nature of information

The theories referred to previously arise from the works of economists. They readily fit in with the approaches by psychologists and more specifically social psychologists who have sought to understand how psychological factors might interfere with the decision-making process to diverge from the classical conception of rationality. We shall not labour here the development of prospect theory by Kahneman and Tversky (1979). Rational theories (EU, SEU)[6] take a number

5 Potential surprise differs from actual surprise, which is the surprise when the event occurs.

6 Expected Utility and Subjective Expected Utility.

of assumptions to be true. In particular, in decision-making, they take it that individuals are fully informed of the probabilities of the various solutions and the consequences of the choices made. They also consider that individuals are in a position to understand the information available to them and implicitly or explicitly weigh the pros and cons of each alternative. Ultimately, they postulate that individuals compare the various options on the basis of previous elements so as to maximize their gains. The resulting normative decisions presuppose a rational individual, that is, one who thinks in accordance with the classical model of probabilistic rationality. Kahneman and Tversky's (1979) research shows that decision-making seldom follows this procedure. The information available is often incomplete and the individuals have a selective perception of it. Memory fails and data processing is biased.

Prospect theory diverges from classical probabilistic theories on several points. First it replaces the notion of utility by the notion of value. While traditional utility is reflected by intensity, value is calculated in terms of gains and losses (deviation from a reference point). From the perspective of a loss, value is not the same as from the perspective of a gain. The curve of the function is steeper on the loss side. So, for example, a €500 loss is of greater value than the equivalent gain. This asymmetry entails aversion to loss (Quattrone and Tversky 1988). This effect is compounded by the endowment effect (Thaler 1980) which enhances the value of a good through the mere possession of it. For example, when people are asked to set a price for selling something they possess, they often choose a higher price than they would be prepared to pay to acquire the item (Kahneman et al. 1990). Possession of the item, even if temporary, raises its value for them making it more difficult to part with it. From this perspective, being an owner or tenant or changing status (owner versus tenant) alters the cognitive evaluation made in making a decision (stay versus leave), even before wondering about the consequences of the change in terms of feeling at home and the associated emotional aspects.

Prospect theory introduces the idea of cognitive distortion into the evaluation of probabilities. Accordingly individuals reportedly tend to over-evaluate unlikely events and under-evaluate highly likely events. This tendency is particularly marked when shifting from a situation of certainty to a situation of uncertainty. The expression "better the devil you know" is a good illustration of this. Transposed to the context in question here, it is likely that the reasons that prompt individuals to stay somewhere are not necessarily the same reasons that prompt them to leave, and the decision to leave is more difficult to take than the decision to stay. Prospect theory therefore integrates context variables into its predictions. It underscores the importance of taking into consideration the environment into which the problem raised fits. Many experimental findings show that for the same problem individuals' preferences may be reversed if a change is made not to the terms of the problem but to certain characteristics of the context and in particular the way the problem is presented (concept of framing).

2.4 Thinking about astonishment: attraction function and potential surprise

The question of context or the frame of analysis refers us to decision-making as in Shackle (1967) which is analysed as a break between past and future, it is the effect of an invention more than the result of a calculation. A decision of this kind is essentially unpredictable. Shackle frees himself from the use of probabilities, which are deemed too stringent, giving a poor account of human behaviour and not readily amenable to the time dimension.

More specifically, it is above all the property of additivity (imposed in the axiomatics of probabilities) that he finds restrictive. So Shackle replaces probability by a non-additive, non-distributive variable such as possibility. Possibility must be understood in such as way as it can be marked off by degrees, setting it against a scale of potential surprise based on the "desirability" of the possible consequences of an act. In this way, when certain extreme situations arise in which the available data amounts to little, if anything, the "Shackelian decision maker" comes back, as it were, to the "minimax principle".[7] This was the basis for the construction of possibilities by Zadeh (1968) [§2.5], derived from his fuzzy set theory. Shackle replaces the utility function by an "attraction function" which in a way idealizes the concept of value. This function reflects the degree of interest or attraction of an item, which is one way of taking into account the affective dimension of a process in model making.

The potential surprise of an event corresponds to the expected astonishment for an individual at the occurrence of an event. To judge the possibility of an event occurring, the decision maker's belief must in some sense "precede" in the imagination the occurrence of the event. A high degree of belief means one will hardly be astonished by the expectation of the occurrence of the result. Conversely, if the degree of belief is low, the expected astonishment will be high. It is this new dimension that enables uncertainty to be introduced into Shackle's model. The concept of time in Shackle's theory does not appear to be an ordinary dimension but a succession of moments in being that have their own individual character. The time dimension for a given individual forms the support of lived experience. The decision maker in a Shackelian universe, contrary to Bernouillian theories, appears to be the creator of a world he is involved in. The unfolding of time is accompanied by an accumulation of memories of successive

7 In order to make optimal decisions, this principle, which is also known as the "precautionary principle" consists in minimizing the greater possible risk. This cautious behaviour is observed especially when the consequences arising from certain decisions entail high costs, or unquantifiable but qualitatively or psychologically unbearable costs. Other decisions may be associated with low utility (location in places liable to catastrophes [earthquakes, atomic testing, cyclones]).

states which give each "moment in the making" an individual aspect, in which each instance experienced has its own specificity "point of concurrence of various sensations past and present"as if stored in memory.

2.5 Towards a generalization of potential surprise: the theory of fuzzy subsets

Imperfect information may arise from two antagonistic points of view, imprecision and uncertainty. As Dubois (1983) observes: "If information is represented in the form of a logical proposition, then imprecision refers to the content of the proposition and uncertainty refers to its truth, understood as its consistency with reality. Given a body of knowledge (a set of information), the antagonism between imprecision and uncertainty is expressed by the fact that making the content of a proposition more precise tends to increase its uncertainty". This leads us to the concept of possibility defined by Zadeh (1978). Possibility can be explained by a complex superimposition of what is measurable on to what is not, of what is accepted as objective and what is subjective. True uncertainty is uncertainty that is not due to chance alone. It corresponds to non-measurable risk and arises from the complexity and ambiguity that go along with any reduction in generality of information. Breaking down the interval [0,1] into probability weightings bearing on elementary events precludes probability measurements from representing a situation of doubt or ignorance. Complete ignorance defines a state of knowledge in which all imaginable events are equally uncertain. It therefore escapes from the simple probabilistic model and can only be taken into account by uncertainty measurements such as possibility or its dual, necessity. Unlike probabilities, these measurements are valuable in that they introduce non-additive and non-distributive variables. Possibility generalizes probabilities in the sense that before being probable, an event must be possible, and it must be probable in order to become certain. We come back in a sense to one of Shackle's conceptions whereby, because of the nature of decision-making, the future can only be imagined. So at the frontiers of knowledge, traditional probabilistic calculations, which may be characterized as stringent but limited quantitative methods, are supplemented here by subjective methods that reach further and admit just as sharp an image.

Contrary to the binary language of ordinary sets, in fuzzy subset theory, the third-way solution is not excluded and values between "0,1" are also taken into account. The values assigned to the fuzzy subset characterize an individual's mental representation of a subset as they imagine it at a given time. A fuzzy event is a fuzzy subset that has a precise membership function graduated between zero and unity (e.g. 0.8) and no longer by either zero or unity. The analysis of the decision maker's behaviour may also be subject to imprecision. A decision maker's likes or dislikes are not always clearly defined. Individuals may vary in the extent they prefer such and such a flat and be more or less reluctant about its location. They may look for accommodation with specific characteristics only to choose a place of residence whose characteristics differ from those initially defined, simply because they "were smitten by" such a place of residence. The upshot is that the measurement of an imprecise but well-defined preference for the decision maker may be represented by fuzzy utility (cf. chapter 9). The decision maker then makes an acceptable decision, particularly with respect to their own intuitions and emotions.

2.6 Interdependence of cognitive and affective factors in explaining behaviour

More recently many investigators have included the role of affects in their studies. Zajonc (1980), for example, emphasizes the decisive role the emotions play in the way individuals see their choices, preferences, decisions, behaviours, and interpersonal relations. He defends the view that emotion and cognition are two independent processes and that emotion comes into play ahead of the cognitive process. By contrast, for Lazarus (1984), cognition takes precedence over emotion and cognition can be swift, uncontrollable, and unconscious. Nowadays, there is a very marked tendency to defend the idea of interdependence between emotional and cognitive processes (Storbeck and Clore 2007) and the idea of the complexity of their interactions with behavioural variables (Baumeister et al. 2007). For these researchers, emotion is neither dependent on cognition, nor has primacy over it, nor is it automatic. Emotion is likely rather to modulate cognition and vice versa. Emotion is understood here as a feedback system rather than as having a direct causal effect on behaviour. Conscious emotional experiences stimulate the cognitive process. Individuals learn to anticipate emotions and choose the options that favour the emotions they prefer. Baumeister et al. (2007) do not deny that some emotions may have a direct causal link with behaviour (as with the "smitten" effect, for example, in the decision to buy property) but they think that in such cases the decisions made are not optimal. By contrast, conscious human emotions are thought to be factors included in cognitive processes and favouring positive decisions for individuals. The debate on these questions is far from over, but it is worthwhile at the very least in that it sheds light on the differentiation between processes depending on the time dimension in play: those involved in managing immediate emotions, those focusing on anticipation of emotions, and those anchored in individuals' deep-rooted experience.

Studies of the relations between affects and decision-making head off in multiple directions. Affects may be analysed as items of information that may help decision makers with their choices[8] or judgements (Slovic et al. 2002). They then become markers by which to compare the various decision-making options. Other approaches seek to determine how certain particular emotions such

8 How do I feel about this?

as fear or anger (Lerner and Keltner 2001) or regret (Connolly and Butler 2006) influence individuals' perception and behaviour. Others still (Caruso and Shafir 2006) show that the mood of the moment may lead to precedence being given to certain solutions. While many researchers agree about a reciprocal influence of cognitive treatment and emotions in the decision-making process (Storbeck and Clore 2007), the nature of this interaction and its consequences on decision-making provide many avenues for enquiry. For example, Loewenstein et al. (2001) argue that emotions affect conscious cognitive evaluations but via different mechanisms (spontaneous emotional reactions without cognitive mediation) that occur at the actual time of deciding. For these authors, these emotional factors may orient the decision in a different direction from that predicted by strictly cognitive models. In recent research, affects have a central role that is complementary to cognitive processes in decision-making. They stand clearly apart from the view that emotions are an impediment to rational decision-making.[9]

2.7 Emotion and decision-making

Emotional reactions are often tied to a particular unforeseen event (different from previous, usual experiences) that by its nature is difficult to grasp. Such emotions may lead individuals to revise their choices (Bochet et al. 2002). Accordingly, unlike moods that set in over a relatively long time and that can be modelled in decision-making, emotions orientate behaviour in a different direction from that predicted by rational choice models. From the standpoint of spatial choices, emotions must not be thought of, though, as irrational disturbances but rather as sporadic reactions to a mismatch between our intentions and the contradictions that arise from a given spatial situation and determine well-being or ill-ease over a generally longer period.

So, if someone has felt fear because they have felt unsafe in a district, they will call into question, in light of this alarm signal, their habit of frequenting the district so as to be consistent with their preferences, here their need for safety. Even if the event is sporadic, the individual may rightly or wrongly consider that it can happen again in the sense that it will be perceived as revealing a particular and established spatial situation. Emotions therefore lead individuals to act differently, to escape their spatial routine, for example, in the context of daily mobility, to adopt new spatial behaviour: exploration, attraction, avoidance, orientation (Golledge and Stimson 1997). For example, the behaviour of a region's inhabitants will be dissociated from the behaviour of first-time visitors and tourists. Tourists "consume" tourist spaces which are de facto typical spaces that are sought after and immediately subscribed to for some of them. In the case before us, we shall pay particular attention to the reason for travelling

9 For a development on the current state of research between emotion and cognition, see Channouf and Rouan 2002.

or for moving house, for example, because those reasons will influence the way in which affects and emotions come into the reckoning.

On the basis of these elements, individuals' spatial behaviour can be modelled. Geo-simulation techniques rely especially on multi-agent systems in which agents interact with each other and their environment while making decisions about their travelling. The objective is to test hypotheses about individual behaviours and d ecision-making to understand the spatial consequences. In this matter, it is interesting to observe that the behaviours tested are increasingly fine. In dynamic choice modelling, two types of behaviour are usually utilised: reactive behaviour, the simplest forms, and "premeditated", thought out, intentional behaviour (Ferber 1999). Reactive behaviour includes (1) reaction to stimuli, reflexes, (2) instinctive behaviour related to social context, (3) instinctive behaviour related to physical needs, and (4) emotionally-triggered reactions. Premeditated or cognitive behaviours are defined by reference to earlier choices and action plans that individuals implement to achieve objectives they have set themselves. Affects, because they are part of a longer time frame, correspond more to this type of behaviour. Cognitive models are usually based on a BDI (beliefs, desires, intentions) architecture of agents which breaks down into three steps: (1) first each individual's knowledge of their environment is identified; (2) the objectives to be attained are set, the options available for each agent; (3) finally the selected options that lead to action are determined. The BDI model is problematic in that it relies on the principle of rationality in decision-making. This is why the PECS (physical conditions, emotional state, cognitive capabilities and social status) model was proposed (Schmidt 2000). This model can refine individuals' behaviour by introducing notions such as emotional state or cognitive capacities, which work against strict rationality. Simulated decision-making then becomes closer to the real behaviour of social actors. For example, it is possible to take into account the emotion an agent feels and, depending on their temperament, to define the impact it will have on the choices made.

3. Affects and residential questions

3.1 Space and emotion

Space is not just structural and functional; it has a wealth of other dimensions (images, myths, symbols, etc.) related to the way in which individuals perceive it. Several types of spaces can be made out. The space of action, which is the potential space known only by proxy, by hearsay… it is a represented space that leaves a great deal of scope to the imagination, to fantasy. The space of activity is that of daily spatial practices. In this category of space, it is possible to distinguish the space of lived experience which is laden with values by people, with affective investment (Bochet and Racine 2002), that unite them to the place; we can then speak of identity space (Golledge and Stimson 1997). These spaces correspond to three cognitive levels identified by Frémont (1976): see, remember, and enhance. Thus individuals establish relations of intensity and variable senses with space: from aversion and rejection to hyper-belonging when they fully identify with the space, by way of mere tolerance or even indifference when the space is considered as a simple medium (Di Méo 1991).

According to classical rational logic, peoples' actions on and in space, spatial strategies are supposedly developed from a utilitarian calculation of the gains and costs of each possible option. Thus the relations between people and space are often considered fully understandable whereas this relation is highly complex and not all the dimensions of the relations have been taken into account; this leads sometimes to speaking, mistakenly, of irrational behaviour. However, it seems that our approach to human behaviour can be renewed; Weber (cited by Audas and Martouzet 2008) speaks, for example, of "affectual rationality" to explain human action. We should therefore not speak of irrationality but rather of poor knowledge of behaviour; by leaving aside emotions and affects in particular, we have only an imperfect understanding of relations between societies and environments.

Bochet and Racine (2002) thus recommend allowing for emotions to renew the study of relations between people and their environments. For them, space is constructed and experienced through emotions; there is an affective relationship with space that guides spatial decision-making. The fact that this theme has remained on the fringes of the discipline can be explained in that it relates, in geographers' minds, to the study of oddities, of specificities that cannot by their nature be readily generalized. Bochet and Racine (2002) challenge this point of view and emphasize the nomothetic character of this topic. It is supposedly thus possible to bring out common features from general, sometimes collective rules.

Affect is a general state of mind towards an object conferring on it an emotional value and negative, positive, or neutral valence. It can be considered that affects enable individuals to give meaning to territory; this is the inhabitant dimension of territory. It is supposedly possible to characterize spaces in terms of these emotions: spaces that are friendly, threatening, worrying, frustrating, aesthetic, and so on. Sansot (1984) speaks of sentimental geography, topophilia and topophobia, that is, places that are loved or hated; which can be summarized by a degree of affective distance between individuals and places (Bailly 1995). Analysis of this distance refers back to the semiotics of space, that is, the study of signs that space produces and their meaning for individuals (Lévy and Lussault 2003). It shall be attempted to show how places, through their elementary properties and their disposition in space, are meaningful for individuals and the interactions between meaningful space and actors and categories of actors. It is then possible to study what can give rise to an emotion, an affect (e.g. the landscape, interactions with other individuals) but also the outcome (reactions, etc.) and what that can engender from a spatial point of view. Individuals will in turn have a feedback effect on space. Di Méo (2000) calls this phenomenon the production-inclusion of people in their living space.

Certain ideas such as perception, cognition, or representations of space can be used to relate objective spatial structures and social cultural and sensitive meanings of places. Monuments mark out volumes and become territorial markers, administrative boundaries give way to cultural and historical boundaries, networks and thoroughfares serve as a medium for a symbolic system of coordinates (Bailly 1995, Lynch 1969). The city thus shifts from something concrete to something represented, from objective to subjective (Santos 1997). Everyone, through the slant of their own culture, personality, and emotions and affects of the moment, interprets the physical features of places (and the places themselves) and lends them a personal meaning. Spaces are thus endowed, in the eyes of each individual, with affective attributes that influence behaviour and decisions.

3.2 Ambiances, particular features of the relationship between individuals and space

Lynch's work in the 1960s emphasized the visual dimension of human perception that favours the creation of individual and collective mental pictures of the environment. Thus the landscape exists "in its relation with a subject whose particular consciousness and emotion transform the sensory objectivity of looking (the world which almost all of us see in the same way) and lead to the representations that derive from it" (Brossard and Joly 2004). Landscape therefore only exists through each vision of it; here we find phenomenological principles since we endeavour to describe experience as it emerges in a context, as it is experienced by each individual depending on their subjectivity. People speak of perceived landscape, subjective connation of places (Sansot 1984), affective appraisal of landscapes (Wong and Domroes 2005), the outcome of individual and collective constructions (physiological and psychological characteristics, socio-cultural environment, education, etc.). For our part, we shall prefer to landscape, which is essentially visual, the idea of ambiance, which synthesizes the five human senses and that Augoyard (1979) describes as the "encounter between a physical given and what the senses perceive of it". So, the analysis of urban ambiances and of space more generally involves an analysis of representations, which relates to disciplines like sociology and psychology. There is no inhabited or constructed space without its own ambiance, no human gathering without a peculiar climate. There are in truth infinite variations that are always on the edge of what is perceptible. Bittolo (2007) emphasizes that "to be in the ambiance, is to enter the collective space in its most undifferentiated fringes and to espouse, more or less willingly, 'for better or for worse', the sensory envelope that this space offers you. Ambiance places us in the core of the carnal and situated character of sensory experience". Body and place become inseparable and the boundaries between the individual personal world and collective space more diffuse. Ambiances are part of an emotional resonance the origin of which cannot readily be identified or defined; they fit in amidst the spatial, architectural or more broadly spatial traces. They clearly raise the question of the connection between the individual and the collective in its environmental dimension.

3.3 Emotion and individual and collective identity

In the context of choice and residential mobility, it is common practice to make allowance for objectively ascertainable factors in the processing of information by individuals. The choice of dwelling place often results from an analysis in terms of confrontation between the needs of a person or family, their economic and occupational constraints, and the identifiable offer of a given space. It is more difficult to include in this analysis the psychological aspects in particular those that refer to the emotional dimensions of choice. Yet in the interaction between the individual and their environment lies an issue of identity in which there interferes a cognitive dimension in terms of treatment of information and emotional factors. For example, Fried (1982) describes what he calls place identity. This identity that is directly related to the individual's environmental history supposedly results from progressive cognitive organization integrating feelings, attitudes, and values in relation with the physical world. For some commentators (Korpela 1989) this identity dimension operates in its relation with the environment via active self-regulation in a strategy of maintenance and coherence of identity. The inhabited space is both a social marker and an anchor point for the self. A positive place identity arises from a process of identification with a place that is valued by the individual. This potential valuation has a double dimension, that is both individual and related to the personal history of individuals and collective in reference in particular to the reputation or image of the place inhabited and its near environment (essentially the part of town).

This connection between the individual and their environment is constructed very early on in childhood (Chawla 1992). Fleury-Bahi (2000) emphasizes that "it is precisely this environmental memory strongly imprinted by affectivity that reportedly forms a component part of everyone's personality". Individual identity is thus supposedly plainly marked by the various residential contexts in particular those of one's childhood and adolescence. Everyone forms their physical (country, city, suburbs, type of housing, etc.), organizational (what is it possible to do in such a space?), and aesthetic landmarks. For Wohlwill (1976) individuals' past experiences determine specific needs behind the construction of a framework of references for evaluating a place to live. Stokols and Shumaker (1981) propose a similar analysis. They suggest that the adaptation of individuals and their appraisal of their current residential situation depend on the perceived quality of their current environment compared with their past experience of residential situations. This approach integrates cognitive and affective dimensions that depart from a strictly economic analysis of comparison between needs and the potential for satisfying those needs. It seems difficult, for example, for people who spent their childhood in the provinces, whether in town or country, to forge a residential identity associated with the city of Paris in adulthood (Fleury-Bahi 2000). Here the time factor is crucial because "representations, systems of attitudes and values, and behaviours that unite an individual with a particular type of residential environment are structured and develop with time" (Fleury-Bahi 2000).

Individuals make choices that depend on their personal expectations but also on socially shared values (ideas, cherished principles; for example respect for nature, aesthetics, enrichment, etc.) [Di Méo 1991]. Work on social representations has shown that an individual's membership of a social and cultural group is fundamental in the relation they have with their environment, in their way of "interpreting" and evaluating it. Thus socially constituted groups share common knowledge, tastes, and behaviours whereas major divergences appear among those same groups. These differences have repercussions on space because space is constructed by social groups depending on their self-image. Some research has shown for example that negatively evaluating a place with which one identifies could engender cognitive inconsistency. In some badly run-down parts of town, inhabitants do not necessarily say they are dissatisfied (Avenel 2005), which is one way of maintaining a positive self-image when one feels an identity with the part of town and its inhabitants. These findings are consistent with those obtained in the context of self-consistency theory (Aronson 1997). This theory develops the idea that most individuals attempt to preserve a consistent, stable, predictive, and competent self-image through a change of attitude when they find themselves in a situation of psychological discomfort (cf. cognitive dissonance theory, chapter 7). This perspective is clearly part of a psycho-social conceptualization between self and others (process of group categorization) for thinking about the question of social identity in its relation with space.

The social composition of urban spaces very plainly influences the way in which spaces are perceived in parallel with any objective consideration. Similarly, the portion of territory that a group occupies is part of the group's identity. There thus occurs "a reversal and the hold on territory impregnates the holder as much as the holder imposes its mark on the space in question" (Bordreuil 2000). The human/space analysis must not therefore deal with individuals "as the finite modes of a single world… It has to do with a series of ambiences and environments in which stimuli are involved depending on what they mean and what they count for" (Merleau-Ponty 1942). Thus, despite the break-up of daily practices, urban boundaries, and especially symbolic ones, do not disappear and "the residential district maintains an identifying value" (Bordreuil 2000). This spatial rooting around the home gives ground, however, to multi-site anchorage, a multiple spatial belonging that has been made possible by the change in daily mobility practices.

The works mentioned in the foregoing paragraphs clearly show the many factors involved in the decision-making process of residential choice. The emotional factor interferes with the cognitive treatment of economic, spatial, and socio-economic data and is involved in the construction, development, and modification of individual and collective identities. However, living somewhere is thought of also by reference to the potential for movement attached to the place and the modes associated with such movements. The final part of this chapter looks at this question by developing the impact of habit, a significant dimension of the individual's psychological functioning, one of the main functions of which is to reduce the zones of uncertainty, especially those of an emotional order. The theme of modal choice will be treated here as a special case of daily mobility but the elements developed apply potentially to all choices involved in the decision-making chain associated with individuals' movements (choice of places frequented, spaces crossed, etc.). This succession of choices to which the modal choice belongs is very closely related to issues of identity and feeds back into residential issues.

4. Making a modal choice

4.1 Definition

The modal choice is defined as the choice among the use of various modes of transport. The *homo economicus* model prevails in the area of transport (Kaufman 2000, 2008). It is usually thought that individuals are beings who base their daily transport practices on rational economic choices. This is to forget that individuals are cognitive misers or have bounded rationality. They make as little cognitive effort as they can. They take short cuts to make decisions about alternative modes. The anchoring of repetitive everyday practices entails inertia and it becomes very difficult to modify their behaviour.

4.2 A sociological point of view

From a sociological point of view Kaufman (2000) lists four reasons for motorists refusing to switch modes of transport: (1) economic rationality: cars are considered more efficient than other means of transport in terms of money and speed; (2) the reason of the heart: it is a powerful symbol of freedom and membership of a social class; (3) perceptive rationality: the use of a means of transport supposedly creates its own dynamics: because I use it, it is the best solution. So using cars call for further use of cars because the habit of using them makes such use more desirable; (4) force of habit: modal practices supposedly define habits that form a way of life or even specific social insertion. The use of one means of transport could not be substituted for another without calling into question certain aspects of social inclusion.

4.3 A psychological view point on the role of habit

From a psychological view point, research into modal choices has focused primarily on the concept of habit. It is Verplanken and co-workers who most precisely defined this concept (Aarts et al. 1998). For them, habit can be defined as a sequence of acts that have become automatic in certain situations. The same behaviour is repeated in the same circumstances and usual behaviour is performed without thinking. For example, the past and present habits of a person's use of transport modes affect their future use of means of transport.

Those researchers showed that habit induces a particularly resistant bias. When a habit is ingrained, cognitive efforts to process information are reduced to a minimum and consequently the individual ignores new information that might call the habit into question or create a new judgement. Aarts et al. (1998) have shown that the stronger the habit of driving the less individuals seek out information about other modes of transport. Knowledge of force of habit is therefore a major factor in predicting future behaviour.

To break a habit, some outside event must occur to call into question all of the behavioural process. For example, Fuji and Kitamura (2003) show that a temporary change of transport mode has long-term effects on future modal choice. Drivers were given an incentive, through an offer of free tickets, to use public transport in a large city for a month. The results showed that repeating an action, taking the bus, promoted the emergence of a positive attitude toward public transport and in so doing increased bus use over the long term. Similarly, taking advantage of the temporary closure of a motorway, Fuji et al. (2001) proposed free tickets for public transport for a week. Here again the results showed a shift to public transport. In addition, this research shows us that the use of cars entails an overestimation of the time required for journeys by public transport. Actually using public transport enables motorists to correct this overestimation. This correction in turn increases the use of public transport. We are close here to a classic bias in psychology in predicting durations: the planning fallacy (Kahneman and Tversky 1979, Kahneman et al. 1982). This bias consists in underestimating the time necessary to perform one or more actions (here driving from point A to B): the expected duration of the trip is lower than the actual duration.

In a recent study Verplanken et al. (2008) showed that moving was a good way to break habits. When individuals are on the point of changing habits more or less by force as in the example of a removal, they supposedly barely take account of their habits any more and by so doing might make judgements based on their convictions or deep-seated values about the environment. This hypothesis was tested on university employees who had recently moved versus those who had not moved, all else being equal (i.e. gender, number of days worked at the university, distance between home and work, transport of children). As predicted, those who had recently moved and at the same time were particularly environmentally conscious used their cars less than those who were not environmentally conscious but who had moved and those who were environmentally conscious but had not moved. Thus a change of context may activate values that might guide behaviour—using public transport rather than cars—and break habits.

A procedure promoting a move into action is based on the implementation of intentions (Gollwitzer 1993). The aim is to tell individuals the place (Where am I going to act?), the time (When am I going to act?), and the way (How am I going to act?) of the action. Fixing these three parameters increases the likelihood that the individuals will act on the basis of their conviction or pro-environmental intention and no longer out of habit. Bamberg (2002) presented drivers with various possibilities for using public transport in their city to test changes in mobility behaviour. A first group had to commit to using public transport (how?) on a specific day and time of day in the week (when?) at the nearest stop (where?). In a control situation, a second group of drivers was simply asked whether they intended to take the bus or not. The results showed that 53.3% of drivers in the first group actually took the bus as against 31.1% in the control group. Thus implementation can break habits that are well-rooted among drivers.

4.4 Habit and mobility factors

More generally, residential location in urban space, accessibility proposed by various means of transport, family ownership of cars, and the family's social networks appear from the literature as being of importance in changing habits. Accessibility of means of transport covers three specific aspects: the quality of the supply of public transport in terms of the spatial and temporal coverage of the area lived in; the road network; and parking conditions. These three factors determine the choice of resources, and especially the number and type of cars the household owns, and habits and routines as to means of transport (Wood and Neal 2007).

Individuals' choices may be influenced by a handful of opportunities and constraints that depend heavily on the ecological context. This context includes a spatial dimension (distances, locations, space-time), a social dimension (family decision, social networks, occupational environment), and lastly a psychological dimension since these contexts are probably interpreted through the filter of social representations. For example, public transport may be stigmatized as the means of transport of people "not in employment" (e.g. teenagers, the elderly). In this way, choice of mode of transport could not be reduced here to a utilitarian logic. It is also a matter of representations, standards, and values that are ultimately the expression of individuals' identities. In this context, the place where one lives appears as a structuring feature, not just for the living space but also for the individual's spatial identity (Gifford 2008, Proshansky 1979).

5. Conclusion

The research presented in this chapter emphasizes the importance of taking into account the study of representations in order to explain the influence of information acquisition processes on spatial practices. It seeks to show that, as each individual bears their own representations, there is an infinity of links that unite a given territory with those who frequent it. "Space only exists through the individual's perceptions of it" (Bailly 1977) and ultimately, to speak of the urban environment only, "everyone carries their own city around with them" (Ferras 1990). Every place therefore cannot be characterized from its economic, historical, or social values alone; space is also psychological, symbolic, and identity-related (Di Méo et al. 1996) because it is composed of an image endowed with an identity, a meaning that varies depending on the characters of the observers and their life experiences. Space therefore is a mental construction, a way of thinking in which the image one has of space takes precedence over space itself. Space, in its connection with individuals, is a whole that cannot be reduced to the sum of its objective component parts (Golledge et al. 1997). Of course, there are tangible aspects in the human–environment relation that can be readily described and identified (human–nature mix, economic value of spaces, slope, plant cover, presence of water, etc.) but there are also intangible aspects that cannot be so easily characterized (beauty, mystery, cohesion, aesthetic values, peace and quiet, legibility, etc.).

If our particular residential histories go towards constructing our identities, in return that construction influences our behaviour. In terms of emotions, it is common to differentiate positive emotions that relate to positive experiences and negative emotions. In accordance with the theory of feeling as information, we consider emotions as sources of information among others on which judgements and decisions can be based. A positive affect informs us that all is well in our environment, whereas a negative affect sends the opposite information. This difference between affects in terms of valence highlights different strategies of information processing. Positive affective states promote more general processing and the use of heuristics (Isen 1987), negative affective states a more analytical treatment (Bless et al. 1992). These processes have behavioural consequences. The reference to approach and avoidance motivations (Higgins 1987) throws an interesting light on this. Grégoire and Dardenne (2004) show a connection between affective states and social interactions. A positive affective state induces a greater tendency to be outgoing than a negative affective state. More social interactions and better quality interactions, more altruism in social situations, these are all consequences that in a residential context where a person feels at ease may well reinforce that feeling. Conversely, social cut-offs lie in waiting, even if the specificity of emotions ought to be taken into account. As Bodenhausen et al. (1994) emphasize anger, sadness, anxiety, and guilt are all negative emotions that do not necessarily produce the same behavioural tendencies. Tiedens and Linton (2001) show for example that emotions characterized by certainty (contentment and anger) lead to a heuristic process and emotions characterized by greater uncertainty (worry or surprise) induce deeper and more systematic processing of data. In this research, the level of uncertainty related to emotions seems to outweigh the intensity or valence of those emotions.

So in both affective and cognitive terms, the uncertainty/certainty dialectic seems to be at the centre of the issue of decision-making. Among the factors of uncertainty related to residential choice and residential mobility those that prove most relevant for a finer understanding of their dynamics remain to be identified.

Neuroscience and Decision-Making

Thierry Moulin and Laurent Tatu

1. Introduction

Decision-making may be defined as the ability to select one option from among several alternatives depending on the context and the subject's needs and aspirations (cf. chapter 10). The outcome is the most favourable choice within a set time.

This psychobiological process calls on a set of cognitive, affective (cf. chapter 4), and motivational functions that are drawn on to varying degrees depending on the type of choice (simple or complex), context (uncertain or reassuring), and short- or longer-term challenges.

The "neuroscience of decision-making" is a recent branch of knowledge and studies brain activity associated with questioning about choices. The boom in functional neuro-imaging techniques has made it possible to study the cerebral organization that underlies emotions, individual human behaviour, and behaviour in social interaction. In decision-making situations, these techniques show up the changes in brain activity and highlight the intervention of networks of cerebral activity for evaluating objectives, motivations to act, and behavioural choices.

Understanding the intervention and role of those networks in decision-making sheds fresh light on many areas of society such as the specific field of consumption and the context of decisions that affect the everyday living environment over the longer term, such as residential choice.

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2. Decision-making from the perspective of neuroscience

Study of the theoretical bases of decision-making is a long-standing area of research concerning disciplines as wide-ranging as economics, statistics, psychology, robotics, and neuroscience (Clark et al. 2004).

Logic and mathematics have long been at the forefront of explaining the basis of human behaviour. Thus the theoretical principles defining rational decision-making have been identified in accordance with the principle of utility in a given situation (cf. chapters 9 and 10). But in real situations, subjects often make decisions that depart from the purely rational (Berthoz 2003).

Observation of the behaviour of individuals taking account of decision-making errors has brought out the importance of neurobiological and cognitive processes. The first stage in this approach was conducted on the basis of brain-damaged subjects (Damasio 1994). The approach was then enhanced by advances in neurobiological theories that could explain behaviour.

On the basis of lesional data and imaging, two opposing theories can be identified. They concern neuropsychological processes and the neurobiological substrates necessary for decision-making. On the one hand, there is somatic marker theory which postulates that it is essentially affective processing via the orbitofrontal cortex and amygdala that allow suitable decisions to be made (Bechara et al. 1994, Damasio 1994) and, on the other hand, a more cognitive theory that postulates that cognitive processing of various options via the dorsolateral prefrontal cortex is sufficient for identifying the most favourable options.

Lastly, the development of neuropsychological tests specific to decision-making has made it possible to formulate new hypotheses such as decision-making in known situations of risk, uncertain situations or in competition with other subjects (Li et al. 2010). These tests call on different cognitive, motivational, affective, and neurobiological processes, with the most widely used being the Iowa Gambling Task (IGT), Cambridge Gamble Task (CGT), Game of Dice Task (GDT), and the Ultimatum Game (UG).

More recently, the merger between economic theories of decision-making and neurobiological data has given rise to a new discipline of "neuro-economics". It is of interest for determining the neurobiological bases of various aspects of decision-making guided by rewards in the broad sense of expected or actual choice (Glimcher and Rustichini 2004). The objective here will be to show that such advances may also serve to better understand decision-making processes in the context of residential choice. Since here a priori we do not consider financial gain, we associate the notion of gain with that of an improved residential setting compared with the current situation.

3. The analytical approach to the decision-making process

Analytically, decision-making can be broken down into four main stages: identifying options, evaluating options, proposing a preference, and evaluating the consequences of the choice (Ernst and Paulus 2005) [figure 1].

The stage of identifying options calls on various senses, especially sight and hearing. Decision-making is often consecutive to perceptive stimuli that are available for a very brief time. The currently accepted model is one in which perceptual information is integrated initially and stored in memory before it comes into account in the decision-making process (Ratcliff and McKoon 2008). Thus when visiting various flats, the individual will be attracted or repelled by certain characteristics of the housing and will bear those impressions in mind.

Evaluating the options available involves attributing a value to the various options. The value attributed depends on the characteristics of the option and the hoped-for consequences. The characteristics of the option include the positive or negative valence, the salience, characterizing intensity and magnitude, probability, and the time to secure a gain. These various factors are analysed and compared to weigh up the "cost-benefit" aspect of each option.

The third stage leads to the expression of a preference among the available options after comparing the various options against each other. The easiest way to establish a preference would be to choose the option for which the value is highest. As the exact value of an option is seldom known, we speak of the option's "expected" value. The choice of the least probable values corresponds to risky behaviour, in contradistinction to the choice of the most likely options, which reveals adapted behaviour (Nasrallah et al. 2009).

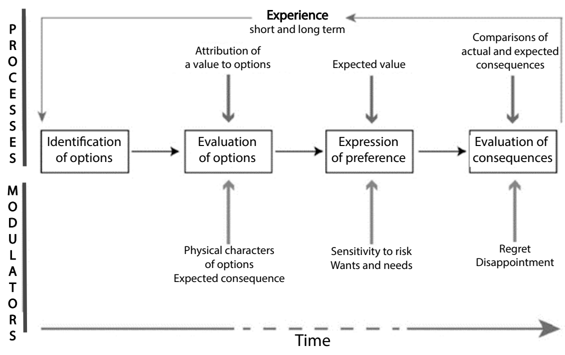

Figure 1—Analytical aspects of decision-making

The final stage compares the "expected" consequences of the choice with the actual consequences. This evaluation is sensitive to emotions such as regret, surprise, or disappointment (Coricelli et al. 2005). The discrepancy between expected consequences and actual consequences is an important element in the learning process. Learning allows better adaptation to the context when a similar situation recurs requiring a choice to be made. The development of better knowledge of the consequences associated with each choice induces "experience", uncertainty declines, and decisions are essentially oriented with full awareness of the risks being taken. Unexpected changes in the environment or limited knowledge of it push subjects to explore their environment and memorize the new conditions in order to reduce uncertainty (Doya 2008). This refers us back to the importance of earlier experiences in residential choice (cf. chapters 2, 3, and 4). If we hoped for an improvement relative to a criterion of choice and we were disappointed, we assign special importance to that element when we next move home.

In all situations of choice, the notion of time is involved between the moment the decision is made and its consequences. It has been clearly established that the increased time for making the decision reduces the value of an option. There are various hypotheses as to how timing fits into the evaluation system (Kable and Glimcher 2007). If an event close in time plays a greater part in an evaluation than a more remote future event, it can be assumed that the individuals will rely more readily in their decision-making on criteria that can be seen to have an immediate impact. Conversely, events for which an immediate impact is less apparent may be retrograded in the evaluation. Accordingly, the current situation of accommodation may have a greater influence than information about future plans (refurbishment, change of residential environment, etc.).

The subject's motivation, wants, and needs for a specific situation are also fundamental at the moment the decision is taken (Doya 2008). They will influence the propensity to move (cf. chapter 6). In everyday life, choices are often made under uncertainty. All the more so when the decision is a complex one. In the case of residential choice, as we have seen, many criteria are involved but access to knowledge of the new location remains limited until one is on the spot. Thus the risk is lower if, for example, one moves house but within the same part of town.

Thus decision-making needs to be an adaptive process reflecting the way the subject adjusts to a complex and dynamic environment. Suitable decision-making makes it possible to apprehend new situations and to move forward by taking account of mistakes that should modify inappropriate actions.

4. The neuropsychology of decision-making

Three major functions of the executive cerebral system are involved in decision-making: emotional, cognitive, and motivational processes. The combination of these various processes is essential to suitable decision-making. It is also possible that these different affective and cognitive mechanisms may be more or less involved in the task depending on the context, stakes, and according to factors inherent in the subject such as age, sex, and personality (impulsive, hyperactive, thrill-seeking, etc.).

The emotional process attributes a subjective value to a behaviour or an action in a given context. Cognitive control consists in activating behaviour or action in the subject's present, future, or past context based on their subjective value. Motivational aspects concern the subject's intentions in relation to the events that have occurred in the environment. This confirms the importance of emotions considered in chapter 4 but also the reflections in chapter 3 on the cognitive aspect and the role of motivations (cf. for example chapter 2).

Finally, making a decision in an uncertain or conflict-ridden situation is a more complex process involving numerous neuropsychological processes that are still poorly defined.

4.1. Cognitive aspects

Executive functions bring together capacities of attention, evaluation, working memory, behavioural inhibition, cognitive flexibility, and planning, all of which are necessary to performing complex tasks.

Decision-making involves evaluating the costs and benefits associated with each option, such as comparing different houses, recollecting information about the options, comparing that information in the working memory, selecting the most favourable options, and evaluating the consequences of the choices. Decision-making also requires behavioural flexibility. Accordingly one must be able to change behaviour when the value of an option changes, for example, through additional information.

Capacities for planning, working memory, and behavioural flexibility are therefore the most important cognitive aspects in decision-making (Cohen and Aston-Jones 2005).

Ability to plan

Decision-making makes it possible to achieve a specific objective over the more or less long term. For this, it is necessary to determine a plan of action by organizing a hierarchy of secondary goals that will contribute to achieving the primary objective (Gazzaniga et al. 2002). This corresponds to a rank order of choice criteria (for housing, for example, price, size, comfort, peace and quiet, etc.).

Various neuropsychological tests have shown that brain-damaged patients lose their ability to plan ahead. They avoid the most favourable long-term options preferring the less immediately aversive options, although this choice is not the most favourable long-term one. These results support the hypothesis that such patients are "future short-sighted" making them insensitive to the future consequences of their choices. Their choices are planned in the very short term, depending on the immediately available perspectives.

This inability is a complex form of behavioural disinhibition dissociated from motor impulsiveness.

Working memory

The working memory involved in decision-making is the short-term memory system. It means we can keep information temporarily "online" and manipulate it at the same time. When making a choice, it is important to be able to hold different items of information in the short-term memory so as to compare them or associate them with other items. This information processing seems crucial for evaluating the options available and making adequate decisions. Under conditions of uncertainty, subjects' choices are seemingly made unconsciously first, guided essentially by the affective representation of the consequences of choices, working memory not being necessary for decision-making in such circumstances (Kable and Glimcher 2007).

This aspect may also come into play if the choice proves complex, which may mean that the decision is made spontaneously and emotionally. Indeed, during the survey for the ECDESUP project, some respondents said the decision to buy was just "the heart speaking".

We should note, though, that current research into connections between emotion, cognition and behaviour do not draw any clear dividing lines between "mental operations governed by emotional states of mind and operations guided by reason".

Behavioural flexibility

Behavioural flexibility is the ability to change behaviour or strategy when environmental conditions change. Adapting one's behaviour to a new situation requires inhibiting inappropriate behaviour, evaluating new conditions, and being able to change one's behavioural response. When a previously learned behaviour is no longer favourable, one must be able to inhibit it or even reverse it. The importance of this ability to change preference to make the right decisions has been tested on patients with frontal lobe damage (Fellows and Farah 2005). The disorder in decision-making among brain-damaged subjects is supposedly due to a problem of behavioural flexibility and an inability to reverse a preference after further learning (reversal learning). Schizophrenic patients often have difficulties in reversing learned behaviour. Nonetheless, this lack of flexibility does not prevent them from performing well in tests. In our context, this means that people looking for somewhere to live can quickly take in extra information, but also include in their strategy the results of discussions with other family members.

4.2 Emotional aspects

It is increasingly accepted that emotion is at the crux of a number of choice processes and especially choices of a financial order. The somatic marker theory developed by Damasio (1994) emphasizes the essential role played by emotional processes and affective processing in decision-making. The role of emotions in the context of residential choice has been highlighted in chapter 4.

Somatic marker theory

In this approach, an emotion caused by a particular situation (winning or losing money, or a positive or negative experience, for example) is supposedly "marked" in the form of a particular somatic state that shows up at the muscular-skeletal, visceral, and vegetative level. The signal reportedly "marks" the unfavourable options to be avoided, allowing the subject to redirect their choice towards the more favourable, long-term options.

The autonomic nervous system is thought to be one of the main vectors of somatic markers. So the expression of the somatic signal can be evaluated objectively by measuring the heart rate, body temperature, or changes in skin conductance response. The electro-dermal reaction supposedly signals, unconsciously, the unfavourable options even before the subject is aware of the long-term value of those options.

Some studies challenge the significance of electro-dermal reaction as a somatic marker in decision-making. Facial muscle activity and heart rate are other more rarely measured somatic markers (Dunn et al. 2006).

Other emotional processes

The influence of stress on decision-making preferences is incontrovertible. Acute stress affects the performances of men and women differently. Men are more prone to taking risks, unlike women who avoid the most unfavourable options. Such behaviour is thought to be modulated by variations in the cortisol levels induced by stress.

Regret, surprise, and disappointment are powerful emotions that supposedly also modulate the evaluation of a consequence, a choice. Regret is an emotion that arises from comparison between the choice made and the choice discarded. This emotion, which is related to a strong feeling of responsibility, might deeply affect individuals' choices. In our context, regret or disappointment might, for example, come into play under the influence of an earlier change of home that determines the decision so as to avoid this type of feeling when making the new decision. Accordingly, the individual may regret not choosing a flat with certain characteristics and be particularly sensitive to such criteria at the next time of choosing (Coricelli et al. 2005).

4.3. Motivational aspects

Motivation is the process by which a subject becomes engaged in a specific activity, the representation of the consequences of which corresponds to their wants and needs. Motivation determines the triggering of an activity in a particular direction with suitable intensity. It ensures it is continued until it is completed or interrupted.

Motivation can be influenced by various factors that alter the perception of events and the attraction they hold. So, for example, the evaluation of information available about accommodation may be altered by the motivation to move home. The motivation for a type of behaviour depends also on sensitivity, specific to the individual, to rewards or penalties. It has been suggested that men and women might display differing sensitivities to rewards and to losing money. Different studies indicate, for example, that men are more sensitive to rewards and less sensitive to losses than women (Garon and Moore 2007).

5. Anatomo-functional underpinnings of decision-making

The neuro-anatomical and neurobiological underpinnings of decision-making are still poorly understood. Many cerebral, cortical, and subcortical anatomical structures are involved in this complex mechanism. The emotional state at the time a decision is made and emotions related to the act of decision-making are therefore much involved in the decision-making process (Harlé et al. 2012).

The prefrontal cortex is one of the anatomical crossroads of the mechanisms for decision-making adapted for simple and complex situations. It is connected up to the main subcortical networks involved in the decision-making process.

The importance of the prefrontal cortex in decision-making has been known ever since the accident that befell Phineas Gage (1823–1860) in the United States in 1848. While working on building a railway line, a metal rod was accidently rammed through his skull as a result of an explosion. The frontal lobes were damaged and he lost the use of his left eye. He was not paralyzed in any way but his behaviour became coarse, even asocial, and he lost his ability to make suitable decisions. Gage was an exemplary case and became the first to illustrate the importance of the frontal lobes in the elaboration of emotions and personality, as well as decision-making. The pathway of the metal rod through Gage's skull has been reconstructed by computer using the rod and his skull conserved at Harvard University (Damasio 1994).

The behavioural changes observed in Gage have since been found in many other patients with frontal lobe lesions. Generally, such patients have good cognitive abilities but are unable to make favourable long-term decisions and fail to learn from their mistakes. Damage studies and imaging have since largely confirmed the critical role played by the frontal region in decision-making.

5.1 The prefrontal cortex

The frontal lobe is the largest of the brain lobes in volume. Morphologically it has a lateral face, medial face, and an inferior face known as the orbital face. Functionally, the frontal lobe cortex is divided into a motor cortex and premotor cortex, which are preponderantly involved in motor abilities, and a prefrontal cortex.

The prefrontal cortex is usually subdivided into three main regions: lateral (further divided into ventrolateral and dorsolateral), median (including the anterior cingulate cortex), and ventral (or orbitofrontal). The prefrontal cortex is largely connected to the neighbouring cortical regions and the subcortical structures. This strategic position means it can integrate and synthesize information from many regions of the central nervous system (Tanji and Hoshi 2008).

Functional neuro-imaging and electro-physiology studies have highlighted the preponderant role of the orbitofrontal cortex, anterior cingulate cortex, and dorsolateral prefrontal cortex in decision-making (figure 2).

The orbitofrontal cortex

The orbitofrontal cortex is involved generally in evaluating and filtering social and emotional material. It is connected to various structures of the limbic system such as the amygdala and the nucleus accumbens and receives many sensory inputs.

The orbitofrontal cortex is at the heart of decision-making processes. It appears particularly important in processing the value of expected rewards (Rolls and Grabenhorst 2008).

The function of the orbitofrontal cortex is also essential for fast decision-making in complex situations. The representation of the outcomes of a choice by the neurons of the orbitofrontal cortex is essential for motivating goal-directed behaviour (Mainen and Kepecs 2009).

The orbitofrontal cortex is closely connected with the insular cortex that is also involved in decision-making. Functional neuro-imaging studies have shown that the anterior part of the insular cortex may be thought of as a site involved in the representation of emotional states and in predicting an emotional state expected after making a decision.

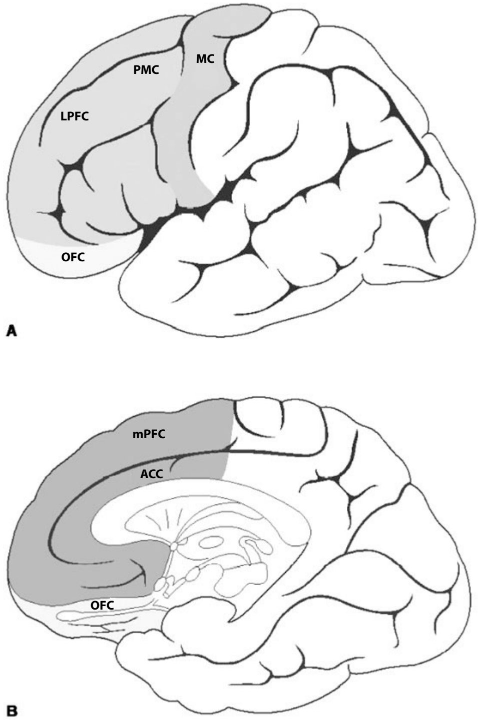

Figure 2: (A: lateral view of brain / B: median view of brain) MC: motor cortex. PMC: premotor cortex. LPCF: laterel prefrontal cortex. OF: orbito-frontal cortex. CA: anterior cingulate cortex. PM: medial prefrontal cortex.

Figure 2—Human frontal lobe cortex

The anterior cingulate cortex

The anterior cingulate cortex belongs to the median part of the prefrontal cortex and is the anteriormost part of the cingulate gyrus which itself is a satellite of the corpus callosum. This region is involved in selecting action and preparing choice. The anterior cingulate cortex receives inputs from regions involved in the cognitive and emotional processing of stimuli. It projects onto the basal ganglia, motor cortex, and spinal cord. In a decision-making context, it is involved in evaluating possible choices in situations of uncertainty or conflict and in evaluating the consistency between an action and its consequences (Magno et al. 2006). The anterior cingulate cortex reportedly also plays a major part in the updated representation of an action over the course of time. It supposedly underpins decision-making based on accumulated experience (Kennerley et al. 2006).

The lateral prefrontal cortex

The lateral prefrontal cortex in the broad sense is essential to cognitive processing, selecting and recovering information. It is the seat of the working memory. It is also involved in attentional processes, action planning, judgement, and other cognitive aspects of behaviour.

The lateral prefrontal cortex may be subdivided into two, functionally different, ventrolateral and dorsolateral regions. The ventrolateral part is thought to be involved more in executive processes such as information recovery and selection. The dorsolateral part is believed to be involved in higher order executive processes for planning behaviour such as control, manipulation, and integration of different types of information (Tanji and Hoshi 2008).

In decision-making, the lateral prefrontal cortex is responsible for maintaining and manipulating information in the working memory making it possible to evaluate the cost-benefit of an option (Cohen and Aston-Jones 2005). It is also involved in various forms of reasoning and in behavioural flexibility.

5.2 The subcortical networks

The prefrontal cortex is tightly interconnected with other cerebral cortical areas and with subcortical structures such as the basal ganglia, amygdala, and hippocampus. These anatomical structures are therefore equally involved in the decision-making process through cortical-subcortical networks.

The basal ganglia are a group of subcortical neurons composed schematically of a lens-shaped nucleus (separated into a peripheral part, the putamen, and a central part, the globus pallidus), the caudate nucleus, the subthalamic nucleus, and the substantia nigra of the midbrain. The basal ganglia behave like an information-processing centre with inputs and outputs. Within the basal ganglia, information is processed by various channels (Albin et al. 1989).

The functional system of the basal ganglia operates via its input and output structures in loops with the rest of the central nervous system and in particular the frontal lobe. The operating loops feed back to the cortex via the thalamus, another grey matter nucleus. The main loops concern motor activity, the planning of voluntary movements, and the management of automatic movements. Other functional loops of the basal ganglia, in connection with the various zones of the prefrontal cortex are involved in decision-making (Alexander et al. 1986).

The basal ganglia loop connected to the orbitofrontal prefrontal cortex is involved in controlling behaviour and especially in selecting appropriate social behaviour. The loop connected to the dorsolateral prefrontal cortex is involved in executive operation, including memory, attention, abstraction, and behavioural inhibition abilities. The functional loop, including the anterior cingulate cortex associated with the nucleus accumbens, is involved in maintaining activity and regulating motivation.

The amygdala, a subcortical structure of the temporal lobe that receives information from all of the sensory modalities, is involved in processing emotions (both aversive and appetitive). It is part of the subcortical circuits connected to the prefrontal cortex and anterior cingulate cortex. The hippocampus, another temporal structure that is fundamental to memory processes, is an important structure for learning about situations of choice.

5.3 The role of neurotransmission systems

Among the neuromodulation systems of the central nervous systems, two systems, the dopaminergic and serotoninergic systems, are related to decision-making abilities.

Dopamine is a neuromodulator that plays an important part in goal-directed behaviour. It is involved in the reward and associative learning system, which are essential in decision-making. Dopamine neurons are activated by predictive stimuli for reward earning. So, when a decision is made, dopamine is thought to play a part in evaluating options, calculating probabilities and motivation to act (Haber and Knutson 2010). Several functional neuro-imaging studies have confirmed the involvement of this dopaminergic system of reward in allowance for appetitive value of food, drugs, and monetary gain.

Numerous pathologies are associated with disturbances of the dopaminergic system such as schizophrenia, Parkinson's disease, chronic amphetamine abuse and pathological games, and poor performance in decision-making tests (Mimura et al. 2006). Conversely, increased dopaminergic activity, as in the case of taking amphetamines, makes deferred rewards more valuable than immediate rewards, suggesting that dopaminergic activity is associated with the evaluation of the delay, magnitude, and valence of outcomes of choice (Sevy et al. 2006).

The serotoninergic system is involved in controlling many behaviours, mood, circadian rhythm, and certain affective behaviours. Malfunctioning of the serotoninergic system induces various behavioural disorders, impulsiveness, or anxiety that interact with decision-making (Bear et al. 2001).

Hormonal variations in the course of women's menstrual cycles also act on the dopaminergic and serotoninergic systems. The modulation of the two systems over the course of the cycle might explain differences in decision-making abilities according to sex (Ho et al. 2001).

6. Conclusion

The observation of human behaviour in real and not supposed decision-making situations and recent work using brain imaging call into question the postulate of rationality that has prevailed for decades in economics.

Work in neuroscience is providing new evidence for understanding the mechanisms at play in processing information in the context of decision-making. It shows the interdependence of emotion and rationality in information processing and decisional choice.

It seems therefore that it is now possible to integrate advances in neurological research into modelling decision-making processes. While recent studies have pointed to ways of modelling certain interactions of components of the prefrontal and posterior cortex (Taylor et al. 1999),[1] it also seems possible to integrate such results in behavioural models via the reflections set out in chapter 10.

1 These authors propose a model to formalize the role and interactions of components of the prefrontal and posterior cortex involved in recognizing facial expressions of emotions and that includes learning. This model is based on a mathematical formulation of the processes in question and on simulation via neuronal networks.

Spatial Decision-Making: Between Individual Choices and Collective References

Cécile Tannier, Myriam Morer, and Dominique Ansel

1. Introduction

Our individual spatial behaviours are all guided by collective references, whether for a choice of routes (by road, on foot, etc.), places frequented (choice among various shopping centres, etc.), or residential choices (choice of moving to another part of town or another locality). The ideas conveyed by our entourage (family, friends) or by some wider social group (e.g. via national surveys or the media) influence us. However, our individual spatial behaviours are not guided by collective references alone; individual determinants also come into play such as the means of transport we have for our daily commutes, the number of children in our household, or personal past experience (especially during our childhood). All these will determine how each individual adopts, integrates, and expresses certain collective references in their behaviour and not others.

The aim of this chapter is to discuss the role of collective references in spatial mobility choices in the light of various social sciences: economics, geography, psychology, and sociology. We shall illustrate what we say with examples from the different disciplines in the social sciences mostly on the theme of the choice of residential mobility. These theoretical or factual illustrations will need to be accessible to readers from a range of disciplinary areas and not marginal but central issues in their original disciplinary field.

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2. Collective references: what are we talking about?

What we term collective references are the references of a group, that is, the beliefs, convictions, or references common to the group members. The size and nature of the social group sharing a collective reference may be very variable, ranging from the local neighbourhood (block, district) to much wider national or supranational social networks.

We distinguish initially between two types of collective references: social representations and spatial representations (figure 1). This distinction shall be discussed and challenged later in the chapter.

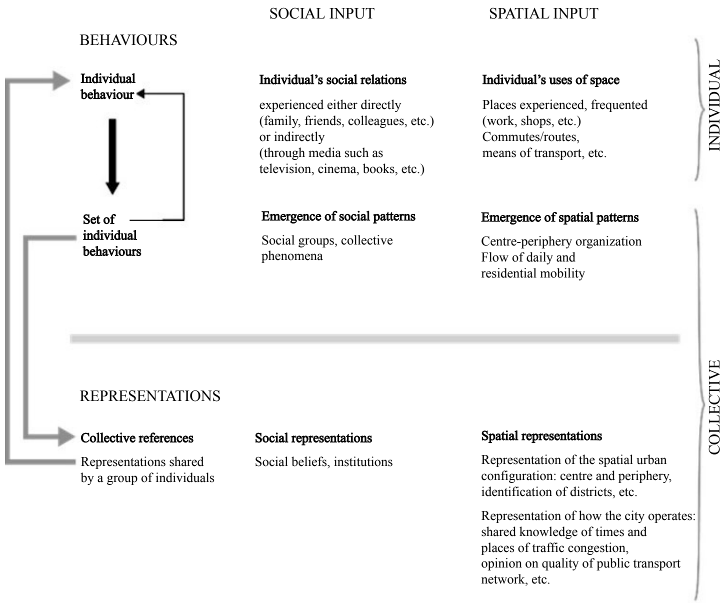

Figure 1—Collective references, both social and spatial representations

The social representations of a group of individuals are determined by the individual's feeling of belonging to that social group (or network) rather than another. As Orlean (2002) emphasizes, "social beliefs originate in the multiple common historical and cultural markers defining the group's identity". Institutions are part of social representations because, being interiorized to some degree by individuals, they govern social interplay, help to guide individual behaviour and ensure the compatibility of all individual behaviours within a given context (Walliser 2003). Two types of institutions can be identified: "norms (rules of courtesy, dress codes) are of a conceptual nature and essentially fulfil a role of coordination among actors. Groupings (families, associations) are of a social nature and essentially ensure a role of coalition among actors" (Walliser 2003).

Spatial representations have urban space as their subject. For the inhabitants of a city or a particular part of town, they consist, for example, in the common identification of a centre, the distinction among various districts (with more or less fuzzy boundaries and denominations) or the characterization of those districts (rich versus poor suburbs, attractive versus repulsive districts, etc.).

Each individual, through their social and spatial behaviour, contributes to constructing emerging social and spatial configurations. Through their belonging or not to a social group or a place, each individual also contributes to constructing the collective references that refer thereto. In return, adopting or not these collective references influences the individual's behaviour and lifestyle.

3. Individual spatial decision-making: several dynamics at work

Our entry point is to consider that spatial decision-making leads to change: change in residential location, change of places frequented, change of itinerary. Thus, the decision not to change or the absence of decision are ignored, even if many forms of spatial behaviour actually observed arise from them. This is the case in particular of spatial routines, for which we no longer find the initial intentions about destination and route. In the case of an itinerary taken every day between A and B, for example, individuals do not wonder daily about how to go from A to B. Because of its repetitive character, everyday activity becomes entrenched in habit leading to the emplacement of routines (Ramadier et al. 2005).

So for us, deciding means choosing change. And a *spatial* decision means that such change relates to itineraries or places frequented and experienced. We shall confine ourselves in this chapter to studying individual spatial decisions, not collective ones. In this context, a single individual decides, while taking into account other individuals' decisions, behaviours, and representations.

In systemic terms, the creation and development of collective references result from the operation of a feedback loop between individual behaviours and collective references over time, with collective references being both generated by individual behaviours and influencing individual behaviours (figure 1). As individual spatial decision-making is incorporated in time of varying lengths, collective references may evolve and likewise individuals may change collective references in very different time frames.

The spatial decision-making process begins when the individual glimpses or starts to evaluate the possibility of changing itinerary, places frequented, or residential location. In some cases, the process may be very short and the decision may be made very quickly. Imagine, for example, the case of an individual always taking the same route to commute by car. One day major road works force them to change route. They then realize that the new route is better than the old one and decide to use it in future even when the road works are completed and they could go back to the old route.

Analysing interactions between collective references and individual behaviours by a systemic approach presupposes that we consider spatial decision-making as a process that is dynamic in its essence. In this chapter, the entry by which we consider the dynamics of spatial decision-making is that of push-pull interaction between factors of choice and factors of propensity to change (figure 2). It is via this entry point that we study interactions between individual behaviours and collective references. Thus we propose a representation of the spatial decision-making process that combines two feedback loops (figure 3): a push-pull interaction and interaction between individual behaviour and collective references.

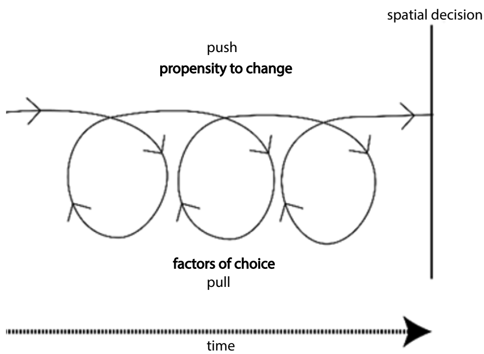

Figure 2—Individual spatial decision-making as a result of push-pull dynamics

The push side of the push-pull interaction loop represents propensity to change. This includes all the factors that push the individual to make a decision, for example, to leave their present accommodation (Permentier et al. 2009). It determines the extent to which individuals are ready to change their place of residence or to alter their spatial practices; it prepares the ground for individual choice, directs it in a particular direction notably via individuals' dissatisfaction with their current situation. Multiple personal factors prompt individuals to change the places they live in or frequent: factors relating to their life history, their personal experience such as lower tolerance to noise because of an unfortunate past experience with the neighbourhood or an eardrum problem further to an accident. Other factors may be entirely psychological such as problems of identity, especially negative territorial identification (Marchand 2002, cf. chapter 4), or purely economic such as a variation in income. Propensity to change involves phenomena with different temporal values: phenomena working over the long term (e.g. progressive rise in a phenomenon), triggering events occurring at a time *t* or over a relatively short term (e.g. death, divorce, arrival of a new child in the case of residential mobility). Some factors become trigger events when a threshold is reached. A threshold may be a value at a given time or a sum of values aggregated over the course of time.

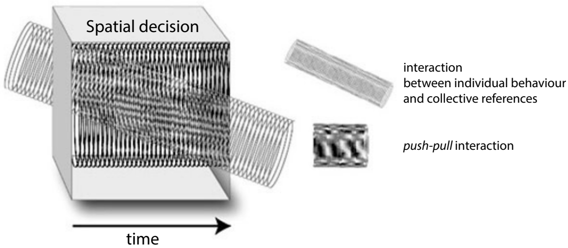

Figure 3—Individual spatial decision-making as a complex process

The pull side is the side of choice. It consists in applying and combining factors of choice. The factors of choice determine which solution (district, locality, itinerary, etc.) the individual is moving towards. They consist in the evaluation of what the individual could have, what they could live or experience elsewhere. Choice factors represent individuals' wishes or preferences (cf. chapter 2). They exist independently of the need for action. They do not necessarily assume that the individual is able to evaluate all the places or itineraries in the city; the context of choice may be confined to a subset of known places among the set of existing places (cf. chapter 9).

It is by distinguishing propensity to change and the factors of choice that the decision-making process can be addressed in its dynamic character. This distinction between push and pull factors is classically found in residential dynamics models (Ben-Akiva and de Palma 1986, Weidlich and Haag 1988; Pellegrini and Fotheringham 2002) [see also chapters 7 and 9]. However, propensity to change and choice are usually involved successively in these models. First, individuals decide to change (for example, to move home); second, they choose the place or itinerary that best suits them. Our position, in this chapter, is to consider that the spatial decision is not the outcome of two successive stages in the decision-making process but the interaction between the two stages over a more or less long span of time (Tannier et al. 2011) [figure 2]. The dialectic between propensity to action and factors of choice, the more or less repeated toing-and-froing between these two aspects, lead at some point to the spatial decision being made.

Three categories of variables are involved in individual spatial decision-making:

– individual attributes (what characterizes the individual): age, income, health, personal history, social relations, etc.;

– place attributes (districts, streets, buildings, paths, etc.): distance to city centre, length (journey), aesthetic and landscape qualities, social environment, property prices, diversity of property on offer, amenities, attractiveness (do many individuals take the route, frequent the place, come to live there?), history, heritage, nuisances (noise, insecurity) etc.;

– the economic, social, technical, and political context (more or less local): fuel prices and by extension transport costs, land and property market characteristics, taxes, population dynamics, etc.

These categories of variables are not independent. For example, occupational mobility, social mobility and the induced variations in income (individual attributes) are often caused by a change in the local or national production system (context variable). Each variable may be involved as much in the propensity to change as in individual choice factors. For example, individual choice factors may become over the course of time individual factors of propensity to action and vice versa. However, the same variable will play a different role and be evaluated by different means and value systems according as it is involved in propensity to change or factors of choice. It may be, for example, that an individual is unhappy with the quality of the bread they buy every day on their commute. This dissatisfaction forces them to change the route of the commute (propensity to change) so as to buy from a baker's that sells better bread (choice factor). Let us take the example of another individual who wishes to change the journey to and from work because of several misadventures during recent journeys. To choose a new route, he allows for the fact that along one of the possible new routes, he will pass a baker's that his aunt has told him makes very good bread. The reasons an individual decides to change or not (route, accommodation, etc.) are not necessarily the same. In terms of decision-making, this aspect refers also to the idea of preference intransitivity. There are plenty of examples from everyday life and numerous experiments to illustrate that the results of individual judgements under uncertainty do not systematically match the predictions of rational models. Research more specifically bring out departures from transitivity principles (cf. chapter 10). An interesting illustration (cited by Palmarini 1995) is to be found in an opinion poll conducted in France into subjective factors contributing to happiness. In the rankings of factors contributing to happiness "being in good health" was in the last position. The main factors of happiness relate to the quality of relations with others and the fulfilment of individual potential. However, in the same survey, to the series of questions relating to the causes of unhappiness, "not being in good health" came first. This contradiction may be explained as follows. In the first instance, good health is considered a normal presupposition and so is not a priori a cause of happiness. However, ill health (judged abnormal) may be an essential cause (indeed the primary cause) of unhappiness (abnormal state). "Preference intransitivity" described by Allais (1953) as a paradox was demonstrated experimentally by Tversky in 1968 by a task proposing to subjects to choose among five wagers knowing the probabilities of winning and the values of the win. The bets were designed so that the likelihood of winning and the corresponding size of the win were inversely related. The bet the most likely to win brings the lowest gain and vice versa (cf. chapter 10). The author shows by confronting the subjects with two separate decision-making procedures (comparing bets one with the next versus direct comparison of all possible bets) that the principle of transitivity is not respected. In the first decision-making arrangement, the bet with the lowest expected value is preferred to the one with the highest expected value; under the other arrangement, the results are reversed. When transposed to the context of residential choice, this problem affects the process of change.

4. Role of collective references in individual spatial decision-making

In each part of the decision-making process (propensity to action and choice factors), individuals make a more or less rational evaluation of place attributes and context variables against the yardstick of their individual characteristics. Collective references are involved in this process by influencing individuals' evaluations, contributing to determining their levels of aspiration and their preferences (figure 4). The influence of collective references is observed both on factors that force individuals to change places or spatial behaviour and on factors that orient them to choose such and such a place or itinerary.

Collective references themselves arise from individual decisions via feedback (figure 1). The three categories of variables that determine the individual spatial decision (individual attributes, place attributes, and economic, social, technical, and political context) therefore exert an influence over collective references. Accordingly, any change in value of each variable may lead to a change in collective references. A change in place attributes (e.g. pedestrianization of the city centre) may lead directly to a change in the associated spatial representations. A change in individual attributes (e.g. ageing) may give rise to a different evaluation of places frequented and therefore a change in behaviour. Such a change in an individual's behaviour, if combined with a change in behaviour of other individuals, may ultimately lead to a change in collective reference. Similarly a marked rise in fuel prices (context variable) may prompt many individuals to desert remote suburban districts. Such areas will decline in importance in the criteria of choice of candidates for residential mobility. From this may emerge a collective reference disparaging suburban areas (devaluation of the image or reputation of such spaces).

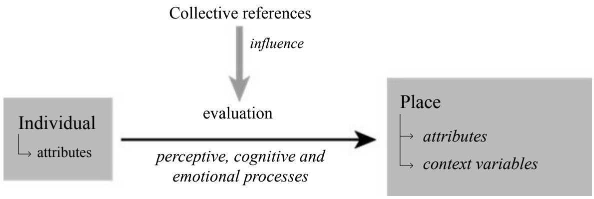

Figure 4—Influence of collective references on an individual's evaluation of places

4.1 Collective references as expressions of social influence over individual spatial decision-making

Quite simply, taking collective references into account comes down to considering that the individual decision-making process takes place within a social environment. Thus Devisch et al. (2006) consider that a household's residential choice process occurs in a physical environment, that is the housing market, and a social environment made up of other households. This distinction between physical environment and social environment is found in many studies. Bailly (1996) claims it was to be found in the earliest analyses of urban representations, some relating to the structure of place (concrete space perceived by people), others relating to economic and social significations. The social environment exerts an influence on individual behaviour. All social science disciplines recognize this truth, although it is discarded in some spatial choice models, particularly in economics. As social animals, humans do not behave independently of the individuals around them with whom they rub shoulders. One person's behaviour is influenced by the decisions and behaviour of others.

Permentier et al. (2009) report that place reputation has been largely studied as a factor of choice. For example, many investigators emphasize that residential address is an indicator of an individual's social status and stands for individual prestige. Conversely, place reputation as a factor of propensity to change has come in for less study. Van Ham and Feijten (2008) have shown from an empirical study in the Netherlands that an individual is under more pressure to leave a place of residence in which all the neighbours are different from him or her. Permentier et al. (2009) have shown that intention to move does not depend solely on satisfaction with the place of residence. It depends also on the reputation of the place as represented by the residents, that is, the way residents in the place suppose that others in the city see their place of residence. The literature study by Permentier et al. (2009) thus shows that self-image is strongly influenced by the way individuals think others think of them. Many studies have highlighted the effect of negative reputations of districts on the self-image of residents of these disreputable districts.

One of the leading indications of the influence of the social environment on individual decisions is the fact that individuals favour the social groups they belong to, otherwise known as their in-groups. Numerous studies in the social sciences suggest individuals have a propensity to choose their behaviour depending on the prevalence of such behaviour in the group to which they belong (Manski 2000). Doi et al. (2008) and Arentze and Timmermans (2008) report social network theory studies showing that individuals tend to adjust their preference to the mean of their social group. This tendency is more or less asserted depending on the cohesion of the social group and the individual's characteristics. Much experimental research in psychology leads to the same finding. Behaviour consisting in favouring the in-group may be identified on the basis of the paradigm of the minimum group in which a simple us/them categorization is enough to illustrate such discrimination. To understand this in-group bias, Tajfel and Turner (1986) propose cognitive and motivational explanations. Individuals think of themselves via a self-categorization process as members of a given group by reference to a number of relevant criteria for them: sex, age, ethnicity, social class, or occupation. Individuals compare themselves by identifying with certain groups with respect to valued dimensions and in a specific context of intergroup relations. This process is the starting point for social identity theory. The idea defended is that to achieve a positive social identity, the group they are members of must appear different from other groups. Favouring one's own group amounts to creating the conditions for constructing a positive social identity. By this logic, it is possible to identify social groups by bringing individuals together on the basis of individual characteristics, assuming that individuals belonging to each group share the same collective references. The individual characteristics considered may be occupation and social category but also attitude (e.g. environmentally friendly) or lifestyle. This amounts to identifying social groups according to a rationale of minimization of within-class variance (between individual characteristics) and maximization of between-class variance as for example in Fernandez et al. (2005).

The argument about members of the same social group flocking together is taken up in economics under the name of peer effect. Considering individual spatial decisions, collective references lead individuals above all to reside in the same place, frequent the same places and use the same means of transport as other members of the social group(s) they belong to. This process may or may not be conscious. Lacascade (2008) and Ramadier et al. (2008) show that young people on social housing estates frequent their own housing estates or other big estates a great deal, often in connection with their network of acquaintances.

In economics, acting in favour of the in-group is also found in externality theory through the idea of club, which is a voluntary group procuring mutual benefits arising from sharing one or more of the following: production costs, member characteristics, or a good characterized by benefits from which one may be excluded (Buchanan 1965; Sandler and Tschirhart 1980). Formally externality theory defines individual utility and therefore behaviour as depending both on the level of consumption of goods, for a given basket of goods, and the levels of consumption of at least one of the goods by other agents (Paez et al. 2008).

Although collective references are the expression of a social group, their influence is expressed both on the scale of the individual and the social group. This fits in with the standard assumptions of economists that preferences are either idiosyncratic[1] and may be thought of as determined solely by individual factors or vary with the socio-economic group and therefore form a collective reference. So far we have evoked above all the influence of the social environment seen as a variable external to the individual and that influences individual behaviour (figure 4). But in some instances, investigators place the collective reference at the level of the actual individual. Collective and individual references are then not dissociated; they form a whole, which is a system of values interiorized by the individual. Those values are thought of as general and lasting. They guide the individual in life choices. Conversely, the preferences that derive from them are the result of instantiation (realization, quantification) of those values with respect to a given context and object of choice (Doi et al. 2008). Thus, preferences are less general and lasting than values (Hechter 1992). The distinction Doi et al. (2008) make between held values and assigned values is worth mentioning here. Held values are comparatively stable over time for an individual whereas assigned values change as the individual adapts to changes in context. Let us take the example of a held value which would be to pollute as little as possible. In the context of energy supply in the 1980s–1990s, an individual might have assigned very positive value to individual natural gas heating, which was considered to pollute far less than individual electric heating. In the energy-supply context of the years 2000–2010, the value attributed to gas heating might have declined sharply while that attributed to wood heating might have risen correspondingly. Similarly for travel, the same individual might have attributed a very positive value to fitting a catalytic converter to the car in the 1980s whereas in the 2010s, the value attributed to catalytic converters would have declined substantially alongside a rise in the value attributed to using public transport and soft transport modes.

1 In psychology, idiosyncrasy is the human disposition for different individuals to feel an external or sensory impression differently.

4.2 Collective references as both spatial and social expression

Collective references that influence individual spatial decisions may be references about a space experienced (place of residence or place frequented). Borgers et al. (2007) proposed the idea of spatially differentiated utility functions to give more weight to spatial factors in economic modelling of residential choice. One of their hypotheses is that preferences in terms of green spaces vary with an individual's residential location. They assume therefore that the collective reference is not determined solely by membership of a social group but is also constructed on the basis of places lived in and frequented. Places are also carriers of social representations. A social representation is a set of beliefs, values, information, and affective factors that can be used to grasp the meaning of an object or a situation (Moscovici 1961). Space experienced procures meaning and identity landmarks by situating individuals socially, economically, and culturally. Individual identity is constructed in part on a set of routines, actions repeated in space and time in the environment (Dépeau 2007). Proshansky (1978) defines an urban identity as a component of identity that is constructed dynamically in conjunction with the different places that punctuate a person's residential history (cf. chapters 1 and 2). Feldman (1990) describes a settlement identity when she observes that individuals tend to maintain continuity in their successive residential experiences by transferring values and affects among past, present, and future places of residence provided their morphological characteristics remain similar (Ramadier et al. 2009). The hypothesis of settlement identity underpins the work of Feijten et al. (2008) who identify a statistical relationship between the type of residential environment previously experienced and individuals' successive residential choices: individuals having previous experience of living in the city and suburbs are more likely to move back there at some point in their residential trajectory; individuals who have experienced a rural residential environment are more likely to move to a rural area again. In the context of daily travel, beyond the commute to work or the school run, families give precedence to places and levels of mobility corresponding to their history, in connection with their representation of space and their residential biographies (Fortin and Desprès 2008). Accordingly, place attachment, which is found in psychology, sociology, and geography (Ramadier et al. 2009) is one of the processes that constitutes the individual's identity.

Spatial representations are also historically anchored; places have a history, a past and an expected future, and these are so many markers that guide our actions depending on the representation we have of them. This connection with history forms the social memory of the place. The inhabitants of a city construct their memories by integrating places, characters, events, or temporally and spatially identified symbols that are shared collectively. Thus, being part of a district or city implies sharing a set of representations about the group's past. As

Grafmeyer (2005: 34) emphasizes, individual preferences are evidence of cultural models (social representations) but existing urban configurations contribute largely to embodying cultural models, inscribing in specific places the social frameworks of collective memory and the objects of individual desire and so help to shape everyone's preferences.

Urban spatial structure itself is the subject of a collective reference. Schelling (1960) gives the example of two people who separate having forgotten to decide on a place to meet up. Where are they most likely to meet up, each one knowing their own concerns, whet the other knows of them, and the other's concerns? He invents the idea of "focal point" which, in game theory, is a solution around which participants in a game who cannot communicate with each other will tend to rally because it seems to them to have some characteristics that will mean the other also chooses it. In the previous example, the focal point for students was the main station; for non-students it was the central post office. Observation of the existence of implicit collective spatial references shows that the formation of social norms integrates space among the significant normative and identity-related dimensions. Other studies show that an individual arriving in an unknown city initially moves along the main thoroughfares. Then, as the individual becomes increasingly familiar with the spatial layout of the city, starting from the main thoroughfares, they gradually build alternative itineraries (Hirtle and Jonides 1985, cf. chapters 2 and 3 also). The ready identification of the structuring thoroughfares in an unknown city is the manifestation of a shared spatial representation, therefore a collective reference. Bailly (1996) thus differentiates two sets of references that individuals build to find their way around space: a self-centred reference set, specific to the individual, and an exo-centred reference set, depending on external codes or societal symbols independent of the subject. For Bailly, symbolic properties connected with the representation of space reflect the magnetism of the centre, the centre-periphery opposition, and the differentiations among districts with good or bad reputations (even if these reputations no longer quite correspond to the current situation).

In the study of the role of the social environment in individual spatial decision-making, an idea often put forward is that any individual is more likely to be influenced by those closer to them than those further away. This proximity is expressed jointly in terms of social and geographical distance, both being related notably in the case of a space experienced. Paez et al (2008), based on reflections of Marsden and Friedkin (1994), point out the resemblance of methodological tools used for analysing social dependence (e.g. auto-correlation measurements in social networks) and spatial dependence (spatial auto-correlation measurements and more generally geostatistics and spatial statistics). The principle underlying all these tools is that proximity in space (whether geographical or social) increases the likelihood of two phenomena being related, at least statistically. The first law of geography according to Tobler (1970) is that physically close phenomena have more chance of being related than remote phenomena, particularly as the friction of distance tends to attenuate the influence of phenomena as they become ever more remote. Geographical space and social space can both be represented in the form of a network of space (material or immaterial networks), a continuous space (made up of fields, areas of influence) or discretized space (composed of bounded spatial or social entities). Distances of different kinds can be measured: Euclidean distances, degrees of contiguity, degrees of resemblance,[2] and so on. The objective is then to establish a correlation between the distance measured and the similarity or difference, attraction or repulsion, between individuals and the places considered. Identifying a correlation between the behaviour of individuals sharing social or spatial proximity leads to the search for an explanation for that correlation. As Manski (2000) says, we look whether the correlation stems from individuals sharing the same source of information or the same individual characteristics (correlated effect) or whether individuals have the same individual characteristics resulting from self-selection (contextual effect or exogenous social effect) or again whether individuals really exchange with each other (endogenous social effect). In the case of a correlated effect, variations in the phenomenon observed are not caused by a social effect of any kind.

For practical reasons (especially conducting research), the influence of collective references on individual spatial decisions is often analysed by favouring either a spatial input or a social input. These two aspects are in actual fact interwoven insofar as social groups fit into and function within different spaces and mark them. Thus social identity theory postulates a connection between constructing identity and belonging to a group, just as urban identity (Proshansky 1978) identifies a strong relationship with place. For us, these two processes (spatial and social identification) are comparable in that they both mobilize strategies for instigating and developing a positive identity and that they are intensely interwoven insofar as group membership is also spatially inscribed in the place of residence and places frequented. This is also what Twigger-Ross and Uzzel (1996) defend: "We would, however, suggest that rather than there being a separate part of identity concerned with place, all aspects of identity will, to a greater or lesser extent, have place-related implications". Those authors base their research on Breakwell's model of identity to define four components that make up identity that are self-esteem, distinctiveness, continuity, and self-efficacy. Self-esteem (whether individual or related to the social group with which one identifies) is associated with attachment to place in the sense that the individuals increase their self-esteem through the place they live in or frequent. This process is different from a mere positive evaluation of a place. A positive or negative difference between places currently or formerly lived in may also have a positive or negative effect on self-esteem. For

2 Cf. chapter 3.

example, arrival in new accommodation may represent a move up for an individual or on the contrary a move down. A second component in Breakwell's identity model is continuity, to which there are two aspects. First, the individual attempts to maintain continuity by reference to specific places with specific emotional significance for them (place-referent continuity). Second, the individual maintains continuity of identity over time by frequenting or living in places that share the same generic characteristics that can be transposed from one place to another (place-congruent continuity). The absence of this form of continuity may lead to general dissatisfaction and a desire to leave one place for another that is more congruent (Feldman 1990). The third principle, that of self-efficacy, presupposes living in a manageable, practicable environment with regard to individual functioning and everyday practices. The fourth and final principle, the distinctiveness process, consists in a comparison between places and the identification of positive elements associated with places experienced. For a comparison among places to be possible and fulfil its role in terms of positive differentiation, collective representations of different spaces involved in the comparison must throw light on their singularity. In other words, the part of town where I live must have characteristics that I value (possible creation of an identifiable level of cohesion) and that other parts of town do not have. This "us and them" categorization may operate on various levels: district to district, town/country, region, etc. Weiss and Marchand (2006) show that if this dual function of place is missing, territorial identification may be negative. It is then likely that residential mobility will increase. However, in the case of underprivileged urban areas other phenomena may also be observed. Initially, individuals move in because of the "peer effect" or for economic reasons. The difficult economic and social integration of "peers" and its consequences (little academic success, problems of violence, lack of public infrastructure because of scant fiscal revenues, etc.) may have resulted in the social group they belong to being depreciated. The individual is then prompted either to maintain positive social identity in their current place of residence or to move (Bourhis and Gagnon 1994). In the first instance, individual strategies for enhancing social identity may arise, for example by opting for social mobility by marrying a member of another social group or adopting the language of a dominant group, or comparing oneself within the social group with individuals more unfortunate than oneself or of lower social standing. Such strategies for individual social or spatial change presuppose a degree of permeability among groups (Ellemers 1993). However, there is also another solution which is a collective one, that is, social change. This may be achieved in various ways. First it is possible to redefine the characteristics supposedly devalued about one's social group: *Black is beautiful*. Native peoples of North America or Polynesia, for example, are turning back to their cultures of origin which were long looked down upon, with new positive differentiation (relationship with nature, balanced social relationships, etc.). In

Europe regional identities are developing in a similar perspective. In this social competition, dominated groups can thus develop strategies for internal change to maintain a potentially threatened, positive social identity. Such strategies are also the source of prejudices and discrimination with regard to the out-group.

Beyond the social and spatial nature of collective references, there is crossed interactionism between collective references and individual determinants of spatial decision-making. This dimension can be apprehended through the ideas of private space and public space, when individual choices become inseparable from social markers. In terms of identity, personal equilibrium is thought of in its dialectic between individuality, with the assertion of its own singularity, and collective references. When transposed to the study of choice of a place to live, this comes down to asking the question of the boundary between private and public space. Living somewhere, feeling "at home" becomes much more meaningful than a simple functional dimension (cf. chapter 1 "Individuals in Their Spatial and Social Environments"). Ratiu (2006) underscores the idea that this boundary is not impassable by developing five dimensions so that a dwelling can become a "home": centrality, continuity, intimacy, self-expression and identity, and social relations. Centrality is the physical anchor point associated with the feeling of belonging to a place. Continuity relates to a form of permanence or stability, a source of a feeling of security. Intimacy refers to the quality of refuge and well-being in the environment (chapter 1). The way they conceive of their inner space and its layout, its decoration are all indications individuals use to stage aspects of their identity. Although these characteristics correspond quite well to the idea that one may have of a private space in the sense that it concerns only the occupants of the place, identity replaces social and collective as constituent parts of individual residential choice. Thus "home" is also at the junction of social spaces and networks frequented by the individual (work, leisure, friends, school, etc.). Such networks may include the neighbourhood, local shops, and sometimes integrate larger areas (city, region) that may be little frequented if at all, or even only imagined. "In all cases, the spatial scale of appropriation interferes with that of social structuring in primary social groups (family, friends) and/or secondary groups (neighbours, formal associations, communities)" (Ratiu, 2006, p. 53). From this point of view, individual residential choice is inseparable from social markers that shape the construction of identity.

5. The configuration of a city is the outcome of multiple spatial descisions, and therefore of interactions between individual and collective factors

In the social sciences, two opposing scientific postures can be found that aim to explain urban spatial patterns (centre-periphery organization, socio-spatial differentiation of districts, etc.). These two postures are those of social determinism on the one hand and methodological individualism on the other. In this section, we seek to describe the differences between these two approaches so as to expound in what and how they can be mutually enhancing. Our starting point shall be the analysis of the social division of space, which has the specificity of having been studied transversally in the disciplines of interest to us.

The social division of urban space takes on various forms depending on the country in question. In the United States, the wealthy population locates on the outskirts of the agglomeration; conversely in Europe, it is the city centres that are generally settled by a well-to-do population (gentrification[3] of city centres). Ghettos may be found within one and the same district; part of Paris' 13th arrondissement is populated mostly by residents of Asian origin. San Francisco and New York both have their Chinatowns. The Bronx in New York is reputed for its large concentration of Blacks. Social, ethnic, or religious segmentation of population is the outcome of a process related to selection. This selection is not necessarily authoritarian or institutionalized as under apartheid regimes. For Schelling (1971), the social division of space results from discriminatory individual behaviours "reflecting an awareness, conscious or unconscious, of sex or age or religion or color or whatever the basis of segregation is, an awareness that influences decisions on where to live, whom to sit by, what occupation to join or to avoid, whom to play with or whom to talk to". Whether residential or not it is largely related to economic factors that engender discrepancies in resources and social positions. "[It] is the process, largely but not entirely economic, by which the poor get separated from the rich, the less educated from the more educated, the unskilled from the skilled, the poorly dressed from the well dressed, in where they work and live and eat and play, in whom they know and whom they date and whom they go to school with." (Schelling 1971) The very search for positive externalities (search for togetherness, preference for local landscape or cultural amenities, etc.) or the aversion for negative externalities (e.g. the refusal of otherness) may lead to situations of spatial segregation (Bouzouina 2008; cf. chapter 2 also).

5.1 Social division of space in the context of social determinism

Social determinism defines the primacy of society over the individual; the action of society and its principal institutions determine individual behaviour and therefore the resulting spatial configurations. Social determinism is integrated in part in the holistic strand of thought by which individual behaviours cannot be understood without appealing to the overall properties to which they belong (top-down approach). It is an approach that is found widely in sociology, a scientific domain in which social interactions are considered as a predominant

3 This idea is explained in chapter 2.

factor for understanding individual behaviour; individual actions are governed by social norms, rules, and obligations (Coleman 1988). Sociologists use the same idea as the psychologists' in-group or the economists' peer effect, without using the same terms, to explain the urban socio-spatial configurations observed. When the individual's position within the social network is decisive and from knowledge of that position one can infer the whole of individual behaviour, then we are dealing with social determinism. Thus researchers who are part of the Marxist urban sociology strand explain urban segregation in the light of relations among social classes; the social division of urban space reflects the social division of labour (Castells 1972, Lefebvre 1968) or more generally the division of society into classes as much as it is the urban mode of reproduction of it (Préteceille 1995). In the tradition of European and especially French geography, residential segregation is reduced to the distribution of socio-occupational categories, creations of the mind that are more or less directly related to social practice and opinion. The works derived from it are mostly about social determinism.

5.2 The social division of space in the context of methodological individualism

Methodological individualism posits that collective phenomena of a social and economic nature may be described and explained entirely on the basis of the properties and actions of individuals and their mutual interactions (bottom up approach). This implies that all socio-economic phenomena can be explained ultimately in terms of theories that refer solely to individuals, their dispositions, beliefs, resources, and relations. Thus Schelling (1978) airs the idea that segregation is due to the sum of small decisions about location made in isolation by individuals motivated by a conscious or an unconscious discriminatory perception. There supposedly emerges from the sum of these individual decisions a not necessarily voluntary segregation. “It is because they seek to move closer to their peers that households end up excluding each other from areas where differences between them and their neighbours seem too marked. Segregation is therefore merely the reverse side of aggregation.” (Coiffier et al. 1990)

Methodological individualism is a scientific posture that is currently adopted in economics especially to explain the emergence of urban spatial configurations. For example, according to the mono-centric urban model (Fujita and Thisse 2003),[4] agglomeration is constructed around a centre where jobs are concentrated. In choosing their place of residence, individuals decide between proximity to the centre (measured in terms of transport costs) and the surface area they can have to live in (measured by the price of housing including the land price). Individuals who opt to live near the centre will have lower transport

4 This model was first developed in the 1960s notably by Alonso (1964) and has been extended several times. See Fujita and Thisse (2003) and Huriot and Bourdeau-Lepage (2009).

costs (transport costs include actual spending such as for fuel or car maintenance but also costs in terms of time, energy, stress, etc.) but a small surface area and high housing costs. Conversely, another candidate for moving may opt to settle well out of the centre. They will enjoy a large living area at a comparatively low price but will incur high transport costs. By introducing into the model a difference among individuals in terms of a single variable, income, which is considered an individual choice factor (individuals have the same preferences and the same transport costs functions), it can be shown that the social stratification of consumers within the city follows the concentric ring rule such that by moving out of the central business district towards the outskirts, consumer classes are ranked by growing order of income (Fujita and Thisse 2003: 118).

This finding is consistent with what happens in the United States where well-to-do households tend to live on the outskirts of agglomerations. However, by introducing into individuals' choices, apart from proximity to the centre and the area occupied, an additional variable in the shape of amenities, a spatial segregation process more similar to that of the French position may be found. Brueckner et al. (1999) look at three types of amenities: natural amenities that depend on physical geography, historical amenities such as monuments or architecture, and social amenities that depend on the social environment in the broad sense (restaurants, sports facilities, etc.). Collective references in the form of the in-group, "peers", would seem to belong to this last type of amenities. The authors show that residential location is a function of the level of amenities. If this level declines slightly from the centre to the periphery, then wealthy households locate in the periphery and poor households in the centre. Conversely, if the level of amenities declines strongly with distance, the rich will choose their place of residence in the centre and the poor on the outskirts. It can be understood then why residents of US cities like Detroit are rich on the outskirts (comparatively few amenities declining little with distance) whereas residents in the Paris agglomeration are rich closer to the centre (comparatively plentiful amenities declining rapidly with distance).

Methodological individualism does not deny the existence of collective references. For example, according to the mono-centric urban model, the municipality or district where the wealthy live is a collective reference insofar as the new urban spatial structure does not influence solely the social group or in-group of the wealthiest; it also influences the behaviour of individuals belonging to other social groups. For districts that are undergoing gentrification, their very positive reputation means that property prices and rents rise (because of greater demand). The district is then gradually abandoned by the less well-off because tenants who wish to become owners and the less well-off who wish to move home, for example for a larger flat, have an incentive to choose some other district.

Another central concept in economics, that of social well-being, is also constructed on the basis of individual utilities built into collective references. Thus in local public economy models known as fiscal competition, local elected officials seek to cause firms and/or individuals to move by means of local taxation so as to maximize the social welfare of the residents of their municipalities (Tiébout 1956, Gordon 1983).

Nadal and Gordon (2005) applied the idea of a modelled collective reference at individual level in the form of an affinity. In their model, each individual wants to be in the group of individuals like them and so maximize their utility. Affinity between a pair of individuals is represented by the difference between the number of criteria on which they agree minus the number of criteria on which they differ. When many individuals are considered, they fall into two groups in two possible ways. Either they choose one group or the other on the basis of a single criterion from among all those considered (case of "short-sighted" individual choice dynamics in which each individual revises their choice at each instant depending on what they observe); in this case, it is the initial conditions that determine the particular criterion on which the group will focus. Or all the groups formed include a mix of individuals with varying characteristics. Finding oneself in one or other configuration depends on the way individual choice criteria are distributed.

The idea of affinities formalized in these individual choice models clearly joins the theory of social identity of psychologists and sociologists evoked earlier. Social identity theory is based on a process of comparing individuals with each other in which the social reference of one individual is made up of other individuals that he or she judges close or comparable to him or her. It can be understood, then, that it is possible to take explicit account of social influences, and therefore to model the role of collective references, in the context of methodological individualism. The important thing is to be aware of the fundamental difference between modelling phenomena at the individual level and postulating the existence of purely and solely individual determinants. Paez et al. (2008) argue that allowance must be made for both individual factors and collective references in order to explain the socio-spatial patterns observed in more detail, more realistically, and more distinctly. This makes it possible to go beyond over-socializing approaches (postulate of social determinism) or under-socializing approaches (postulate of total free will of the individual to choose). As early as the 1980s, Coleman (1988, 1990) defended a theoretical orientation in sociology based on the concept of social capital that includes allowance for individual factors and collective references. Coleman associates social capital with one group and with the structure of bonds between the group members. For Degenne and Forsé (2003) this definition of social capital can be used to connect, via an intermediate level of the group, the level of individual social ties and the level of social norms.

Modelling (individual and collective) phenomena at individual level does not necessarily mean explaining them. This leads the geographer, Pumain, in particular to reject the explanatory power sometimes attributed to the Schelling model. For Pumain, the model shows how local fluctuations give rise to an unplanned, stable structure on the scale of the city as a whole, but does not explain urban segregation. "The explanation for segregation is not physical, it is social, institutional. Even if we settle for an individualistic explanation by 'preferences', these are maintained by the feeling of insecurity associated with the other, with difference, and such 'preference' invariably has origins and reinforcements in collective representations. More often than not, statutory provisions are at the origin of such segregations and contribute to maintaining them." (Pumain 2006)

5.3 Joint consideration of bottom-up and top-down phenomena in dynamic modelling of spatial decision-making

Most economic models that fit into the context of the individual theory of decision-making represent the behaviour of "selfish" individuals, that is, individuals acting solely on the basis of individual determinants. Such models reach a state of equilibrium when no individual can further increase their individual satisfaction. Other models, on the contrary, represent the behaviour of "altruistic" individuals, that is, integrating collective references into their individual choices. In order to explore the differences between these two approaches, Grauwin et al. (2009) took up Schelling's spatial aggregation model again and explicitly introduced a variable representing individuals' allowance for a collective reference. The collective reference modelled is the variation in the sum of utilities of all individuals; the individual choice factor is the local density of individuals. When the variable modulating the degree of allowance of the collective reference is 0 (absence of collective reference) or 1 (absence of individual choice determinant), then the resulting spatial pattern is very different. In the case of "altruistic" individuals, the final spatial pattern maximizes individuals' global utility. In the case of "selfish" individuals, space takes on a segregated spatial pattern in which individuals, for want of coordination, fail to maximize their utility. Does this mean that urban spaces display forms of socio-spatial segregation because individuals act "selfishly"? Akerlof (1997) shows that this is not necessarily so.

Akerlof (1997) designed a choice model based on a process of social comparison. In this model, social exchanges among individuals depend on differences between the current social positions of individuals and their inherited social positions (i.e. as fixed in the initial state of the model). The fundamental idea of this model is that the impact of an individual's choices on interactions they may have with members of their social network are the essential determinants of their decision, whereas the usual determinants of economic choice (consumer utility) are merely secondary. This idea was taken up and extended for example by Glaeser and Scheinkman (2001). The decisions Akerlof's model applies to are those with repercussions on social relations: investment in education, marriage, residential location, etc. On the strength of this model, Akerlof shows that introducing social interactions into economic decision-making leads to individual behaviour that is more consistent with the intuitions of sociologists than economists. Most of the states of equilibrium achieved by the model are economic sub-optima corresponding to social optima in terms of the quantity of social relations with other socially close individuals. This model may explain, for example, why individuals "choose" to be academically unsuccessful so as not to be ousted from their social relations (friends, family). So by using data from the French employment survey for 1991 to 2002, Goux and Maurin (2005) have shown that the endogenous neighbourhood effect on the probability of being behind academically at age 15 years is important, independently of the level of diploma and the nationality of parents or again the proportion of foreigners in the neighbourhood. Apart from the diploma and parents' nationality, children living for at least one year in a district are much more exposed to being behind academically when they are close to other failing children and families with modest incomes (Bouzouina 2008). Spatially, Akerlof's model could explain the fact that individuals remain in a socially de-valued district to maintain their social relations even when they have sufficient income to live in a more highly-valued area. Substantial literature along the lines of Clark (1986) refers to this relation to explain spatial segregation of ethnic minorities, in contradistinction to the discriminatory hypothesis defended by Galster (1988) [Bouzouina 2008].

According to a bottom-up approach, spatial patterns (socio-spatial segregation, centre-periphery organization, etc.) emerge from individual behaviours (cf. chapter 7). However, we have seen that spatial configuration influences individual behaviours in return. One way to allow for such feedback is to consider that a collective reference is a global variable of the system (Nadal and Gordon 2005). It may be formalized using an order parameter (e.g. density of built environment, percentage of pensioners in population, etc.), a vector or even a probability distribution. It may equally well represent a directly observable fact or a belief or a social representation, if any of them influence the behaviour of all individuals. This influence is manifested differently, it produces different outcomes depending on the characteristics specific to the individual. Nadal and Gordon (2005) present counter-intuitive examples of patterns (spatial or otherwise) depending on the order parameters defining collective behaviour (i.e. that of other individuals). They show that modelling the influence of a collective reference on individual choice gives rise to multiple equilibria. As the system modelled is complex,[5] the behaviour of the system cannot be represented by a simple mean of individual behaviours. The authors show too that, for a

5 Non-linear equations resulting from the introduction of interactions between the individual and collective (global) levels.

population made up of a large number of individuals, collective behaviour is well defined by global variables, even in the presence of vagaries (heterogeneity) in individual decisions. This is an illustration of the possibility of an order at collective level, that may seem to respond to a rational logic, but with very heterogeneous and fluctuating individual behaviours (Gallegati and Kirman 1999). Taking up a broader perspective, Weidlich (2006) proposes a concept for dynamic modelling in the social sciences that can be used to represent interactions among collective references and individual behaviours. This concept of sociodynamics[6] may be applied to the study of a wide variety of social phenomena (opinion shaping, emergence and disappearance of social groups, economic competition among firms, etc.) including spatial dynamics (especially residential migration) [Pumain 1991, Sanders 1992, Weidlich and Haag 1988]. The concept of sociodynamics explicitly relates the dynamics of each individuals' behaviour and the global dynamics of the system under study. The feedback loop between individual behaviours and collective references is modelled as follows. On the individual scale, behaviours are represented in the form of a probabilistic choice process guided by motivations (driving forces). These individual motivations are represented in the form of functions of the global pattern of the system considered at a given point in time. The (collective) macroscopic variables of the system thus influence individual decisions through their inclusion in individual motivations. In return, individual decisions induce elementary changes in the global configuration. One of the interests of sociodynamics is that the collective references are not simply represented by a global variable characterizing a structural property of the system under study, as is the model of Nadal and Gordon (2005). Collective references are represented more widely in the form of a global social pattern (or socio-spatial pattern in spatial models). This global social pattern depends both on collective "material" variables (e.g. the number of buildings in a city, the level of car ownership, the unemployment rate, etc.) and individual variables (personal characteristics, attitudes, emotional states, etc.).

6. Conclusion

The study of individual spatial decision-making has revealed the complexity of this process, both through the permanent and perpetual interweaving of propensity to change and factors of choice, between individual determinants and collective references, and by the mobilization of multiple complementary geographical, economic, psychological, and sociological factors. By adopting a cross-disciplinary approach to individual spatial decision-making, the process as a whole can be studied more acutely. Economics provides sound theoretical and methodological underpinnings for modelling choice and decision-making

6 This modelling is presented in detail in chapter 7.

in the context of methodological individualism. The contribution from sociology is to highlight the fundamental influence of the individual's position within a social structure or social network. That of geography is to characterize and model interactions between spatial patterns and individual behaviours. The contribution from psychology is to define an individual's identity as an interaction between personal dimension and group membership (both social and spatial).

The perspective is very different between allowance for a collective reference in the form of a global variable of the system (Nadal and Gordon 2005, Grauwin et al. 2009), dynamic modelling of interactions between individual behaviours and collective references on a somewhat aggregated scale (Weidlich 2006), and direct consideration of social interactions in modelling individual behaviour (Akerlof 1997). However, in all instances the models can produce multiple states of equilibrium, corresponding or not to social or economic optima. Akerlof specifies, though, that it is very difficult to make out unambiguously, by modelling or statistical analysis, whether a process is really determined by the existence of social interactions. For him, the only way to be certain is to resort to ethnographic and biographic analysis of individual trajectories. This is what Lacascade (2008) and Ramadier et al. (2008) do, showing that teenagers and young adults from housing estates frequent their own estate and other similar ones a great deal, often in relation with their network of acquaintances.

Collective and Cooperative Behaviour Models

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1. Introduction

In modelling residential choice we cannot escape the debate about the effect of societal context on an individual's decision-making. This debate depends on whether we set more store by the aggregate scale of society or by the individual's decision-making. An individual-centred approach will focus on the particularities of an individual and the way her past, for example, influences her decisions. The emphasis is on diversity (Sanders 1999) and the idea of "average behaviour" encounters a degree of reticence (Winder 2000). This type of approach is found widely in microeconomics (cf. chapter 9) but also in a strict application of individual-centred modelling in certain multi-agent models. Against this type of approach are concepts that highlight group phenomena with an interest in the specifics and the emergence of trends on a collective scale. However, this does not mean that these approaches, which Winder (2000) points out derive generally from "thermodynamic modelling", are not concerned with individual behaviour but that comparable behaviour is assumed within certain groups (a point also accepted in economics). For example, it can be said that the organization of daily routines gives rise to group behaviour in the sense that such behaviour is triggered by the same situation (going to work or to school in the mornings, coming home in the evenings) and has a character that sets it apart from the diversity of individual occupations.

As indicated in chapter 6, residential choice must be considered an individual act or the act of a "mini-group" (family) that is determined by collective

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references. Accordingly, it relies on information (reputation of a district, school, access to services, shops, etc.) but it also contributes to the emergence of trends (preference for certain life styles and districts, etc.) that may give rise to migratory flows. These may contribute to the emergence of new spatial patterns on the scale of the city and so to macroscopic phenomena. Such trends are therefore the outcome of interactions among individuals and social groups, among individuals and society, and this leads us to consider emergent phenomena in this chapter.

This chapter draws on economics, geography, and social psychology for a multi-angled view of the concepts of self-organization, bifurcation, equilibrium, and steady state, all of which are key concepts for analysing emerging structures. The aim is to show how such concepts derived from physics and taken up more generally in the domain of complex systems and meta-theories (we speak of meta-theories when they are not specific to any single scientific object or discipline) may be exploited for analysing the emergence of collective behaviour and cooperation in the domain of residential mobility, activity/travel spaces, and fiscal cooperation in the context of urban planning.

Emergence is a polysemic notion that experiences paradigm developments depending on the approaches used. Of the set of definitions proposed in the domain of complex systems, most refer to connections between the constituents of a system, the relations between the microscopic and macroscopic levels, and the appearance of structures, properties, or forms at macroscopic level. For some commentators (e.g. Haken 1977) such entities or structures described at macroscopic level cannot be reduced to the composition of individual properties at local level. With regard to the domain of human behaviour, the macroscopic level is usually that of the population and organizations, whereas the microscopic level corresponds to the individual level. Individual behaviour therefore plays a decisive part in our understanding of collective behaviour.

Many approaches rest upon these foundations grounded on work by British theorists but are less restrictive. Thus, compared with the pre-existing system, emergence is either “the creation of a new category of elements or attributes or the appearance of a new structure or even a new system or the invention of new rules by the protagonists of a simulation game” (Pumain 2003) or “an unintended consequence of a large number of individuals cooperating while each pursues his own interests” (Friedman and Friedman 1990). Emergence therefore makes reference to at least two levels of analysis.

By contrast, in some areas of research, particularly those of risk, other properties can be used to characterize emergent behaviour. This is behaviour of a non traditional kind, that breaks with everyday behaviour (such is the case of a removal, for example, even if residential choice is influenced by our everyday activities), behaviour that can be observed both individually and collectively, short-lived behaviour, that is behaviour limited in time.

In order to address emerging behaviour in the domain of everyday and residential mobility, four theories forming the framework of this chapter are presented. Two of them fall within disciplinary fields, namely physics and social psychology, while the other two are from the domain of complex systems. They are the theories of synergetics (from laser physics) and cognitive dissonance (from social psychology), and the theories of critical self-organization (Bak 1996) and games (von Neumann 1944). The choice of these four theoretical frameworks is not an innocent one. They allow theorists and model makers to focus on the phenomena emerging around interactions and the interplay of scales, around the study of critical phenomena and break points (synergetics, critical self-organization) or equilibria (use of cooperative and non-cooperative game theory in economics) and around slow and fast systems dynamics. The authors have opted to associate models with each of these theoretical presentations, some specifically designed as part of the ECDESUP project, others constructed by our predecessors.

We present the concept of these models which are concerned with the emergence of urban shapes based on strategies of residential choice and migratory flows and the emergence of activity/travel space of individuals. A third concept, game theory, is illustrated on the basis of spontaneous fiscal cooperation among local authorities, a phenomenon that is involved at another scale in urban dynamics. This latter example might seem remote from the general subject matter of this book. We have used it because this type of cooperation promotes business mobility and thereby induces residential mobility. The objective of the models proposed is to reproduce a stylized fact in the sense that the model makers have sought to "identify a set of very simple rules at the level of elementary level entities and their interactions that lead to the formation of observable structures which are sustainable at the higher level of organization" (Sanders 2006).

To make the chapter easier to read, we should state from the outset that the use of the concept of equilibrium is not the same in the various approaches to modelling. In the approaches to synergetics and critical self-organization, we consider the possible existence of different states of equilibrium (static, periodic, chaotic) without them necessarily corresponding to an optimization strategy. It is therefore the intrinsic dynamic that lies behind the movement towards the points of equilibrium. Conversely, in game theory, entities exploit the information available to them optimally. Dynamics is thus introduced through the sequential character of games. In non-cooperative games, players do not exchange information in the course of the game, they optimize their strategies relative to the results achieved in previous moves. This is therefore individual optimization that is local in time.

2. Theories and models centred on analysis of interactions between microscopic and macroscopic scales

We present the theories of "synergetics" (Haken 1977) and cognitive dissonance (Festinger 1957) and examples of applications of those theories or some of their concepts. Two models are presented. One related to intra-urban migrations (Weidlich 2006) and the other to residential mobilities (S-Ghost model). These theories and models rest upon an explicit formalization of interactions between the microscopic scale (individuals) and macroscopic scale (city, spatial pattern, society).

2.1 The synergetic approach to self-organized phenomena and its application to intra-urban migrations

From the late 1970s several schools of thought arose in the hard sciences and investigated self-organizing phenomena and more specifically the mathematical modelling of them. The origin of this work lies essentially in the discovery of different new phase transition phenomena. The primary characteristics of any phenomenon of this kind is a sudden change in the characteristics of matter whenever certain environmental conditions change. A familiar example is the melting of ice or the evaporation of water, where the passing of a critical temperature is the origin of the change of structure. However, there are many other changes of this kind, such as the appearance of magnetism. Others, like superconductivity, were discovered in this period.

One particularly spectacular discovery was the laser, the light from which displays characteristics that it had not been possible to produce before then. The explanation and formal deduction of the underlying processes gave rise to laser theory and the development of the more general modelling concept of synergetics by Haken (1977). Its field of application has spread far beyond physics and it is perceived by commentators as a universal principle located between reductionism and holism. The basic principles have been used in biology and medicine but also form the foundation for conceptual thinking and models in the social sciences (Weidlich and Haag 1983, Weidlich 2006).

We should emphasize that synergetics is not the only concept that complies with such logic. The discovery in chemistry of reactions that generate multi-coloured structures within a liquid the structure of which varies over time prompted Prigogine and others to develop the dissipative system approach which has also been applied in other areas such as the modelling of urban dynamics (Allen and Sanglier 1978, 1979).

The common ground to the two approaches (synergetics and dissipative systems) is the observation that there are open systems in nature in which macroscopic structures appear that are the result of interactions among their constituent parts which are situated on a microscopic scale. These structures remain stable far from equilibrium, but may become unstable if external conditions change. We shall see (section 3) that critical self-organizing systems are also based on the idea of the emergence of macroscopic structures and forms resulting from interactions among elements. Such critical self-organizing systems, once the critical threshold is reached, shift from an unstable to a stable phase, usually far from equilibrium and without intervention from an outside agent. Thus the operation of a laser requires a constant input of energy that produces outgoing light the characteristics of which display a higher degree of order (coherence, monochromaticity) than the incoming light. However, if the energy input is insufficient, the laser loses its specificity and becomes a standard light source. The emergence of a higher degree of organization thanks to effective use of incoming resources is certainly a characteristic of biological systems, but it can also find applications in the social sciences. Such logic is in opposition with an idea long advanced that is inspired by the closed systems studied in thermodynamics for which progressive deterioration of the internal order is observed as equilibrium is approached.

Steady state from the standpoint of systems dynamics

If the system is in a steady state and outside intervention slightly varies the values of one or more variables, the system may either return to its steady state or depart from it. In the first instance we speak of a stable steady state, in the second an unstable steady state. The idea of equilibrium is similar to that of steady state. A system is in equilibrium if the sum of the influences—for example forces exerted on a mass or energy flows between two neighbouring pools of water—offset one another. Then no change in the system is observed, the mass does not move, the temperatures of the two pools are the same, and so on. Such a state is therefore steady and the same situations of stability or instability are found. However, it is possible to be far from equilibrium and to find a steady state. This is essentially the case in non-equilibrium thermodynamics. A flow of particles, such as laminar (vortex free) flow of a liquid can be observed. This phenomenon is stable in itself because the flow pattern remains constant. However, the forces do not cancel each other out because the particles are moving. Laser light is a similar case. Note too that for stochastic systems, for which irregular fluctuations are observed, the concept of steady state is broadened. If the mean calculated for the different time sequences is the same (transitivity), we then speak of steady state.

We illustrate a few fundamental principles using the synergetic approach for which socio-economic conceptual thinking is particularly interesting in our context. The starting observation is that “the whole is more than the sum of its parts" because there are specific characteristics at the macroscopic scale that are not found at the scale of the component parts. Thus in thermodynamics, pressure and temperature do not exist on the scale of molecules, and in economics stagflation is meaningless on the scale of individuals. However, in physics interactions occur between well-established scales, because their scope is clearly identifiable.

Weidlich (2006) in his recent book emphasizes that interactions in biology or the social sciences are more complex. Thus businesses, political parties, institutions, and pressure groups are on an aggregate scale and operate on the basis of interactions among individuals active there, but they also interact with each other, and therefore on their own scale (competition, cooperation). Moreover, the component parts may act on several levels; an individual is a part of her family, the firm where she works, clubs, and so on. Since the work of von Neumann and Morgenstern (1944) and Nash (1953), game theory has imparted a conceptual framework to the study of these cooperative or competitive games in domains as varied as biology (study of relations among prey and predators, hosts and parasites), economics, and sociology. We shall return in section 4 to game theory and its application to the competitive/cooperative strategies of local authorities.

In addition Weidlich (2006) emphasizes the peculiarity of human beings whose behaviour may depend on circumstances, mood, affects, miscellaneous stimuli, earlier experiences, and cultural references. Thus interactions with other individuals but also their own reactions or decision-making criteria may vary over time. This is valid not just in direct interactions among individuals but also for what are referred to as indirect interactions. We shall cover (section 5) the interplay of interactions between individuals and their spatial, social and cognitive environments, the role of experience and learning in the emergence of activity/travel space, in the significance of all of an individual's places of activity over a given period of time.

These indirect interactions play an important part in the concept proposed. In a thermodynamic environment, a molecule usually interacts with a large number of other molecules through its gravitational field and its electromagnetic field. The set of all molecules contributes to a "collective field" or "average field". This superimposition of individual fields is a bottom-up type of aggregative approach (this point is addressed in chapter 6). However, the average field exerts a top-down influence on each molecule and so determines its movements. We thus speak of bilateral emergence (Walliser, 2006) in the sense that there is a feedback action of the macroscopic phenomenon on the microscopic level. This idea finds an interpretation in the social sciences. Weidlich (2006) emphasizes that individuals, although autonomous in their thinking, contribute through their ability to develop "behavioural markers" to forming a "collective field" specific to a civilization and that includes cultural, political, religious, and other aspects. Through the possibility of developing collective value systems expressed through rules of behaviour, humans are able to think about collective institutions, which are designated as ideal institutions, in the sense that they best ensure the desired working of society. In the top-down logic, the "collective field" influences individuals and institutions are liable to constrain their aspirations. The following diagram, taken from Weidlich (2006) summarizes these ideas. For the design of these models, Weidlich highlights two fundamental principles.

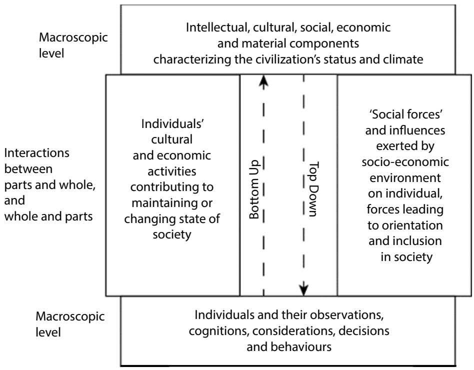

Figure 1—Interactions between scales in a social system (after Weidlich, 2006)

The principle of self-consistency refers to the concept of average field already mentioned. In a way it relativizes the idea of causality. The individual contributes to the working of society and society conditions the individual. There is therefore a two-way relation between the levels of organization. The bottom-up direction shows how interactions among microscopic entities give rise to an emergent phenomenon while the top-down direction shows how the emergent phenomenon conditions in turn the microscopic entities. Through the interplay of micro-micro interactions and the looped micro-macro/macro-micro relationship, we recognize the principle of self-organization that we shall return to in section 3 when presenting critical self-organization theory. Through this interaction between the microscopic and macroscopic scales, the system stabilizes itself. This effect exists besides for physical, chemical (self-catalysis), and biological systems. This does not exclude modifications to the system by interactions that may stabilize it but possibly destabilize it too.

The slaving principle or driving principle directly takes up Haken's fundamental principle that enabled him to explain laser operation. It consists in the idea that it is possible to identify different types of constituent components within a complex system according to their dynamic behaviour. There are those components that rapidly return to a state of equilibrium after a disturbance and others that take longer to do so. In the case of the laser, there are molecules and the electric field. The two types of components obviously both interact, their dynamic equations (differential equations) are coupled by non-linear terms (hence these are "non-linear models"). In addition, the dynamic equations depend on certain external parameters referred to as control parameters (the flux of light for the laser). These parameters may modify the stability of certain steady states of the system whenever they go beyond critical values. Imagine now that the system is in a stable state of equilibrium. By varying the control parameter, we reach the threshold beyond which the stationary solution of the slow variables becomes unstable, causing an increase in them. This affects the fast variables via the interaction but they rapidly find a new equilibrium. Their dynamic is therefore finally not important for the global dynamic of the system which eventually comes to another steady state (the emergence of light from the laser, which is a steady state but not a state of equilibrium). This makes it possible to remove their dynamics from the system of differential equations and insert the stationary values of the fast variables into the slow variable equations. However, their role is not negligible. The fast variables contribute through their stationary values to the dynamic of the slow variables. The slow variables are referred to as order parameters because they cause the emergence of a macroscopic structure of the system thanks to the order they impose on the fast variables.

Obviously the change in structural state may be of interest when modelling socio-economic processes. It is possible to interpret the components with fast dynamics as those that describe the properties of individuals that adapt rapidly to new situations but that, through their stationary value, contribute to slow dynamics occurring at the macroscopic scale of a society. Thus even if game theory (section 4) says nothing explicitly about scales but only about time sequences, we might liken the concept of leaders (or pilots) in von Stackelberg's model to that of slow variables and the concept of "satellites" (or followers) to fast variables. In 1934 von Stackelberg modelled firms holding information about rivals in a competitive context. He identified different types of interaction depending on firms' behaviour (Table 1). Where firms had no information about one another they were characterized as "satellites" and a Cournot equilibrium was identified, that is, firms competed in terms of quantities. Each firm, for the same good sold, thus maximizes its profit for a given production of the other firm. Each firm adapts to the other's decision. Where there is asymmetric information, that is, when one firm has information about the other, von Stackelberg (1934) calls this firm the leader, while its rival having no information is called the "satellite" firm. In this situation, the leader decides (slow variable) and the "satellite" adjusts rapidly by reacting to the leader's behaviour. In this configuration the equilibrium is stable. However, if the two rival firms both have information about one another and act commonly in a situation of rivalry, there is a risk of overproduction and a fall in profit. We then speak of Stackelberg disequilibrium.

		Firm 2	
		Leader	**Satellite**
Firm 1	**Leader**	Stackelberg disequilibrium	Stackelberg equilibrium
	Satellite	Stackelberg equilibrium	Cournot equilibrium

Table 1—Stackelberg equilibria

The approach developed in synergetics highlights the interaction between scales and emphasizes the importance of the aggregate scale corresponding in the given context to society. Even so there arises the question of the contribution from individuals who represent the "components" of the system and who play a role equivalent to that of molecules in physical systems (even if obviously an individual has more complex properties than a molecule). It is obvious that in both instances this is already an aggregate scale because molecules are made up of atoms which are made up of nuclei and electrons, and so on. Similarly, an individual is a complex biological system. However, in physics it is possible to deduce from fundamental laws the dynamic equations on the scale of molecules. Weidlich (2006) and Weidlich and Haag (1983) emphasize that this is not so—for the time being—in the social sciences. A dynamic equation on the individual scale should explicitly describe individual behaviour, and therefore their decisions (cf. chapter 10). From our point of view, we will have to specify their acts instead. Weidlich (2006) says we should know the processes inside the brain that give rise to decisions. He suggests considering the brain itself as a system that operates in accordance with synergetic mechanisms with order parameters.

Within the concept of "sociodynamics", Weidlich and Haag (1983) choose another path. They introduce a probabilistic approach for decision-making. This approach allows for the fact that decision-making processes are "partly free and independent" and "partly guided by the social system as a whole". As we are interested primarily in the macroscopic scale, individual decisions come into play through dynamic equations on the aggregate scale. We therefore consider macrodynamics or "dynamics of order parameters" and study the social, spatial, economic configurations and so forth on this scale. From this point of view, the concept is therefore depleted compared with the original concept. We are interested in the macroscopic scale and not that of individuals, that is, groups of people who adopt relatively homogeneous behaviour. We assume therefore that groups of people can be distinguished on the strength of certain characteristics (place of residence, political outlook, socio-occupational category, etc.).

The formal concept introduces various types of variables describing the state of society. We present two types of variables and the trend parameters.

– *Personal extensive variables*: these are quantifiable variables characterizing the "socio-configuration" such that the number of people n_i^α living in a municipality i = 1, 2… C and belonging to various groups of people α = 1, 2… P. We then introduce a state vector characterizing the system:

$$\mathbf{n} = (n_1^1, n_2^1 \ldots n_C^1, \ldots n_1^\alpha \ldots n_C^\alpha \ldots n_C^P)$$

– *Personal intensive variables*: in some cases we consider individual attitudes that do not show up explicitly, behaviour being conditioned by undisclosed attitudes (e.g. degree of consent or disagreement with a political situation). These variables δ_i^α may be defined on the individual or group scale. They refer to the individual's attitude towards the characteristic i (preference for a political party i or residential location i). Their values vary within a range $(-\Theta < \delta_i^\alpha < +\Theta)$. These variables may be time-dependent, a possibility that the authors of the concept seldom took into account.

– *Trend parameters*: these intensive parameters represent the characteristics of the sociocultural context (parameters for oppression, attraction/repulsion between population groups, etc.). They are often given externally, are statistical, and characterize a certain population group α.

External conditions or "boundary conditions" (in the terminology of differential equations) that are defined by the societal or geographic context and designated as control parameters in accordance with the synergetic concept. If these control parameters are subject to feedback (influence of one subpopulation on another), they are considered to be personal intensive variables.

We have seen that the "sociodynamic" concept is based on a probabilistic approach to individual behaviour, so we assign a probability to each potential configuration and consider how it changes over time. As the states are discrete and time is introduced as a continuous variable, the temporal change of probabilities may be described by the master equation. This is an equation describing the change in probability of finding a certain socio-configuration at a time t. It is based on a Markovian hypothesis that assumes the agent reacts only from the current situation, so without referring to her earlier experiences.[1]

As there is a very large number of potential configurations, we move in actual fact to equations of average values. This assumes there is a single-mode distribution on the macroscopic scale and that the dispersion is globally low

1 This assumption appears reductionist and has been discussed in various contexts (e.g. Winder 2000). In actual fact it is not so restrictive because changes from one "social group" to another can always be included, each social group corresponding to a certain type of experience. In principle, because these groups are freely defined, the constraint is weak. However, such an approach makes the model more complex, which is not what the model's designers intended.

(which can be contested whenever we approach critical values or whenever the structure changes, because complex systems exhibit stronger fluctuations at that time).

The examples we present show that the synergetic concept is not opposed to economic modelling a priori but it lays greater emphasis on bilateral emergence (figure 2), namely on the individual over the group contribution and vice versa on the group over the individual contribution. The approach is therefore less individual-centred. A fundamental difference, though, is that at no time do the authors introduce maximization of the utility function. Such optimization is also introduced in random utility theory (McFadden 1978).

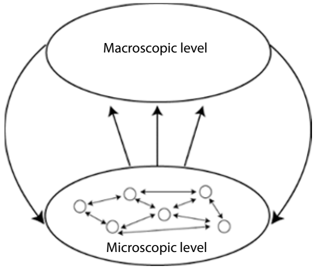

Figure 2—Bilateral emergence

In addition, the synergetic concept focuses on societies' dynamics, their stabilities and instabilities. It is unsurprising that the titles of the two books on this approach used the prefix "socio-".

We illustrate the interaction between the individual scale and that of society and structural changes on the basis of an example proposed by Weidlich and Haag (1983) and Weidlich (2006) dealing with the influence of intra-urban migrations on the spatial pattern, that is, the distribution of population in different localities.

A sample model centred on intra-urban migrations

The general framework of the model is set out in box 2. Readers interested in its mathematical development might like to refer to it.

Formal framework of Weidlich-Haag models on residential choice

In their general concept Weidlich and Haag (Weidlich and Haag 1983, Weidlich 2006) introduce the "socio-configuration" $\boldsymbol{n}$ of inhabitants belonging to a group α living in different spatial entities $i = 1, 2, \ldots C$

$$\boldsymbol{n} = (n_1^1, n_2^1 \ldots n_C^1, \ldots n_1^\alpha \ldots n_j^\alpha \ldots n_i^\alpha \ldots n_C^\alpha \ldots n_C^P)$$

This socio-configuration changes through migrations between spatial entities i and j and we obtain a new configuration $\boldsymbol{n}_{ij}^{\alpha}$. We ascribe to this change of configuration a rate of transition w_{ij}^{α} formalized as follows:

$$
\begin{aligned}
w_{ij}^{\alpha}\left(\boldsymbol{n}_{ji}^{\alpha}, \boldsymbol{n}, \kappa^{\alpha}\right) = n_i^{\alpha} p_{ij}^{\alpha}\left(\boldsymbol{n}_{ji}^{\alpha}, \boldsymbol{n}, \kappa^{\alpha}\right) & \\
= n_i^{\alpha} \nu_0^{\alpha}(t)\exp(-d_{ij})\exp\left(u_j(\boldsymbol{n}_{ji}^{\alpha}, \kappa^{\alpha}) - u_i(\boldsymbol{n}, \kappa^{\alpha})\right) & \\
= n_i^{\alpha} \nu_0^{\alpha}(t)\exp(-d_{ij})\exp\left(u_j(\boldsymbol{n}_{ji}^{\alpha}, \kappa^{\alpha})\exp(-u_i(\boldsymbol{n}^{\alpha}, \kappa^{\alpha})\right) &
\end{aligned}
$$

p_{ij}^{α} are individual rates. As we assume identical behaviour within the group, it is weighted by the number of inhabitants of zone i and group α under consideration. We distinguish the following terms:

– Parameter n_0^{α} describes group α's propensity to migrate.

– Distance d_{ij} creates a dissuasive effect of distance between locations that is introduced via a decreasing exponential function as in the models of both Clark and Wilson.

The difference in attractiveness of locations i an j comes into play in the exponential term which contains a difference in utility in living at j compared with i. This is broken down into two terms, one describing the attractiveness of zone j and the other describing the repulsiveness of zone i. This is push-pull logic (cf. chapter 6).

The utility function is often a linear function of demographic and socio-economic variables, but it is possible to add non-linear terms. We therefore have the form:

$$
u_i^{\alpha}(\boldsymbol{n}, \boldsymbol{\kappa}^{\alpha}) = \frac{1}{2}\left(\delta_i^{\alpha} + \sum_{\beta=1}^{P} \kappa^{\alpha\beta} n_i^{\beta}\right)
$$

Parameters δ_i^{α}, designated as "preferences", can be used to describe the characteristics of location i, that is, the quality of housing, landscape, accessibility to services, shops, or places of work. The terms of the sum describe phenomena related to the presence of persons of a group β. Thus parameter $\kappa^{\alpha\alpha}$ describes the affinity among members of the same group while $\kappa^{\alpha\beta}$ $\beta \neq \alpha$ describes the interaction between different groups. A positive sign before the parameter will indicate an affinity, whereas a negative sign will express a hostile attitude. The choice remains fundamentally conditioned by the comparison of the utility of locations i and j for which a cardinal ranking is possible, but this does not exclude migration in the direction of reduced utility, only its occurrence will be lower.

The system dynamic is considered on the basis of the change in probabilities $P(\boldsymbol{n}, t)$ of finding a given configuration $\boldsymbol{n}$ at time t. As said above, this change is described by the master equation:

$$\frac{dP(\boldsymbol{n},t)}{dt} = \sum_{ij\alpha} \left(w_{ij}^{\alpha}(\boldsymbol{n}_{ji}^{\alpha}) P(\boldsymbol{n}_{ji}^{\alpha};t) - w_{ji}^{\alpha}(\boldsymbol{n}) P(\boldsymbol{n};t) \right)$$

We have already seen that it is not finally this equation that is used, because it would be impossible to consider this equation for all the potentially imaginable configurations. Accordingly, it is assumed that very few configurations are truly of interest and that the dynamic can be limited to average values in the sense that they are "expected values". We then obtain a dynamic equation for each average value $\hat{n}_i$ which takes the form of a master equation:

$$\frac{d\hat{n}_i^{\alpha}}{dt} = \sum_{j} \left(w_{ij}^{\alpha}(\hat{\boldsymbol{n}}) - w_{ji}^{\alpha}(\hat{\boldsymbol{n}}) \right)$$

in which the configurations $\hat{\boldsymbol{n}}$ are the average configurations.

We present a model centred on intra-urban migrations for which analytical solutions can be found and probability distributions calculated.

It is an intra-urban model in which we consider migratory flows between two residential zones $i = 1, 2$ but in which two types of populations $\alpha = \mu, \lambda$ are distinguished (Weidlich 2006). The socio-configuration therefore takes the form:

$$\boldsymbol{n} = (n_1^{\mu}, n_2^{\mu}, n_1^{\lambda}, n_2^{\lambda})$$

If we assume that demographic change is comparable in different places for the different groups and we consider changes between these two zones, we can simplify the system by considering for each group of individuals only the difference in numbers residing in zone 1 or 2.

For each individual belonging to a population group α we introduce a utility $u_i^{\alpha}(n_i^{\mu}, n_i^{\lambda})$ for which we choose the form:

$$u_i^{\alpha} = \left(n_i^{\mu}, n_i^{\lambda}\right) = \frac{1}{2}\left(\delta_i^{\alpha} + \kappa^{\alpha\mu} n_i^{\mu} + \kappa^{\alpha\lambda} n_i^{\lambda}\right)$$

If we choose a negative interaction between the two groups, the model exhibits common features with the Shelling model which uses a cellular automaton mechanism to illustrate the emergence of segregation. We confine ourselves to giving the results of the calculations and simulations. Besides, a simplified version has be used for the model.

The two total numbers of subpopulations are identical and are posited as N for each population:

– Affinity between individuals in the same group is the same, $\kappa^{\mu\mu} = \kappa^{\lambda\lambda} = \kappa$.
– Preferences for the two zones are the same, we therefore posit $\delta_i^{\mu} = \delta_i^{\lambda} = 0$
– Propensity to migrate is identical, and we posit is as ν.

Analytical analysis of system stability shows threshold effects exist. For values:

$$\kappa < \frac{1}{N}$$

$$\kappa^{\mu\lambda}\kappa^{\lambda\mu} < \left(\kappa - \frac{1}{N}\right)^2$$

The homogenous distribution of the two populations in the two zones is a stable stationary solution, therefore there is a tendency towards segregation. If we begin therefore from a non-homogeneous distribution, individuals will change zones until a perfect—i.e. homogeneous—mix is achieved. Conversely, if attraction among members of the same group is strong:

$$\kappa > \frac{1}{N}$$

or if there are strong repulsive forces between groups:

$$\kappa^{\mu\lambda}\kappa^{\lambda\mu} > \left(\kappa - \frac{1}{N}\right)^2$$

The homogeneous distribution becomes unstable and segregation occurs.

Notice that it is not necessary, depending on the conditions indicated, for interactions between the two groups to be positive for the homogeneous distribution to be stable. For a weakly "repulsive" force ($\kappa^{\mu\lambda} < 0$, $\kappa^{\lambda\mu} < 0$) homogeneity remains the stable solution. It is possible, too, to calculate the distribution in the case of values κ, $\kappa^{\mu\lambda}$, $\kappa^{\lambda\mu}$ promoting segregation. Unlike Schelling's model, the tendency towards segregation does not entail the emergence of absolute "ghettoes", the stationary solution corresponds to a distribution in which each district contains a certain percentage of the population of the other group, even if it is in a clear minority. For the conditions stated, the stable stationary solutions are nodes, that is, the trajectories directly approach a fixed point. If we are therefore initially in a distribution other than the stationary distribution, migrations occur but the final distribution is reached fairly directly.

An interesting case arises if it is considered that one group favours contact with the other, but the other adopts the opposite behaviour. This corresponds for example to a situation in which living in a district where a wealthy group is located entails an attraction effect for the other group. If the parameters are always below the segregation threshold, the homogeneous solution remains stable. The population that is not too much in favour of the other is still tolerant enough not to change zone. However, the trajectories are now different. A cyclic behaviour is observed. This means that before attaining the stationary solution, oscillations occur between the districts, that is, we approach the stable solution via migrations that alternate between the two districts. The situation becomes more complex if the parameter values are beyond the tolerance limit. Now we observe a boundary cycle as the stationary solution, therefore a situation that never achieves a lasting distribution. The group looking to live close to the other group moves into the zone where most people from that group are to be found. Now this group seeks to cluster and avoid the other. It therefore leaves and settles in the other zone but the other group will follow it again.

By restricting ourselves to two population groups and two zones, the types of dynamics shown are the only ones possible. By switching to numerical simulations, the model can be extended but that lies beyond our present scope.

These modelling results show how the emergence of macroscopic social and spatial structures can be formalized on the basis of interactions among individuals. The wealth of situations generated by this model is a fine illustration of the synergetic approach that postulates it is more useful to design models that remain readable with few parameters and a limited number of assumptions so as to keep the model transparent, while introducing complexity phenomena. The possibility of at least processing the questions of stability analytically ensures reliability, even for results achieved by simulation.

In the ECDESUP project, a model has been developed illustrating that urban growth generates periurbanization and shows itself to be a "phase transition". This model formalizes household behaviour via a microeconomic approach that is not therefore dynamic a priori. The dynamics of the macrostructure of the urban fabric is considered via a cellular automaton.

2.2 Affined modelling of individual residential mobility strategies: the S-Ghost model

In this model the city is perceived as an open system that can attract new households from outside the region, which plays the part of an unlimited reservoir. If the city sprawls continuously initially, this growth becomes unstable at some point and households choose to settle further from the urban core. This is a sudden structural transition self-engendered by it being an open system. Individual behaviour therefore has a direct effect on the shape of the urban macrostructure (Caruso et al. 2011).

The cellular automaton conditions the dissection of the territory that is composed of square cells. Three types of land use are identified: (1) farmland cells that are considered to be land reserves as well as "green amenities"; (2) built environment cells that procure "social amenities" for the close inhabitants; (3) cells that are part of the road network to which neighbourhood services and shops are also assigned. Initially there is a road network composed of two perpendicular thoroughfares. Where they intersect is the urban core which forms the city centre and is where all jobs are concentrated. Each built environment cell is connected to the centre via the road network. This network is built by the public authorities as urbanization advances as a result of a household settling in cell *ij*. A tax τ is levied to compensate the owners of cells assigned to the network. The model considers interaction between two types of actors, households arriving from the outside and farmers. In keeping with the logic of asynchronous cellular automata, households arrive progressively. A cell is attributed by an absentee landowner to the household offering the highest land rent. Once the conversion has been made, it is irreversible.

Household behaviour is modelled by a microeconomic approach based on the standard urban economics model. The household selects a location in accordance with a principle of maximization of its utility function, which rests on a joint evaluation of several factors:

– it wants a social setting providing certain amenities (commercial infrastructures, public services, etc.). These "social amenities" are evaluated on the basis of the number of built cells within a given distance of the location under evaluation. We call the zone corresponding to this distance the "evaluation window";

– it also wants green amenities nearby for enjoyment and leisure activities. It therefore also evaluates the non-built cells within the evaluation window;

– its members must travel to work in the city centre. The household therefore takes into account the travel costs to the city centre;

– it purchases a set of non-real estate goods;

– depending on these items, the household is willing to pay a certain maximum land rent ("land bid") to the owner.

The utility function is written in the form of a Cobb-Douglas function. If this utility function is maximized allowing for the household budget constraint, we obtain the indirect utility function V_{ij} for each non-built cell *ij*. This ultimately determines residential choice. Depending on the chosen formalization, it takes the form

$$V_{ij} = \left(Y - \tau - \Theta d_{ij}\right)\left(e^{-\rho_{ij}}\right)^{\beta}$$

where Y is household income, τ the tax serving to expropriate the land required to build the road network and Θd_{ij} the cost of transport to the city centre which lies at a distance d from the chosen location, with Θ being the unit price of travel. The exponential term summarizes the influence of the composition of the evaluation window on the utility function. It depends on the share of the built environment ρ_{ij} within the evaluation window centred on cell *ij*. The parameter describes the preference for green amenities compared with social amenities.

Thus values $\beta > 0$ correspond to a greater preference for green amenities than social amenities.

The free choice of residential cell of each incoming household and between-cell mobility of households already in place ensure equal utilities of all households, through short-term equilibrium on the land market.[2]

A household moving in changes the spatial configuration and so the indirect utility function for the next incoming household. This stepwise growth by which all households have the same utility regardless of location makes the model reminiscent in its logic of the dielectric breakdown model used to simulate electrical discharges (Mathiesen et al. 2008) or biological systems (Chikushi and Hirota 1998).[3] The indirect utility function supposedly plays an equivalent role to electrical potential. However, there are a number of differences between the two models essentially because of the chosen form of evaluation window. This finally determines the structural transition referred to above. As the city grows, distances to the centre become ever greater, thereby increasing the cost of travel to the centre for each incoming household. Accordingly indirect utility falls at each step until it reaches the value prevailing outside the region and urban growth stops at this long-term equilibrium.

This means that allowance for the four components of household utility entails "bifurcations". Consider households with a pronounced liking for green spaces. For so long as the city remains small, the household will find within its evaluation window enough non-built sites to satisfy its preference for leisure areas. It will therefore choose a location as close to the city centre as possible, that is, a place adjacent to built zones, because this will minimize its travelling expenses. But the more the city sprawls the more it will find settled sites within the evaluation windows. Once the city reaches a critical size, the household will prefer to settle further from the edge of the settled zone. This effect engenders leapfrogging, that is, a vacant space between the city and the most recent housing developments. In this way it is the dynamic of the emergent system itself that generates this morphological bifurcation.

This first bifurcation can be deduced analytically in a two-dimensional space. To simplify things, we confine ourselves to a single dimension, and so to linear growth along a road. We illustrate this bifurcation through the indirect utility function for the case in which the city has already attained a certain size. The indirect utility functions in figure 3 correspond to different situations. Case (a) corresponds to the case of a very small city in which the evaluation window still contains enough non-built sites, and therefore green amenities, even if it

2 If any one household were to obtain a higher utility than others for a given location, its cell would be sought after because of that utility; competition to occupy it would then lead to increased land rent being proposed until the increase cancelled out the advantage of that location.

3 Similarly Batty and Longley (1994) used this type of model to simulate the emergence of urban fabrics without, however, explicitly introducing a behavioural model.

encompasses the entire city. The other two cases are for a city that has already attained a certain size, but for which agents' behaviour differs: in case (b) the preference for green amenities is weak, while in case (c) it is strong. In all three cases, part (1) of the curve corresponds to sites close to the urban boundary for which the evaluation window still contains the entire city. Thus the share of settled sites is constant in the evaluation window and the decline in the utility function is simply related to the fact that transport costs increase with remoteness from the city centre. As soon as the window no longer contains the entire city, farmland sites are added (part [2]). In case (a) the utility function declines less quickly without the trend changing. However, for cases (b) and (c) indirect utility increases and reaches a local maximum. For yet greater distances, not only do transport costs become too high, but the window no longer contains many settled sites, and the preference for social amenities is no longer satisfied. For distances corresponding to part (3), the window no longer contains any settled site and transport costs are again the only effect that comes into play.

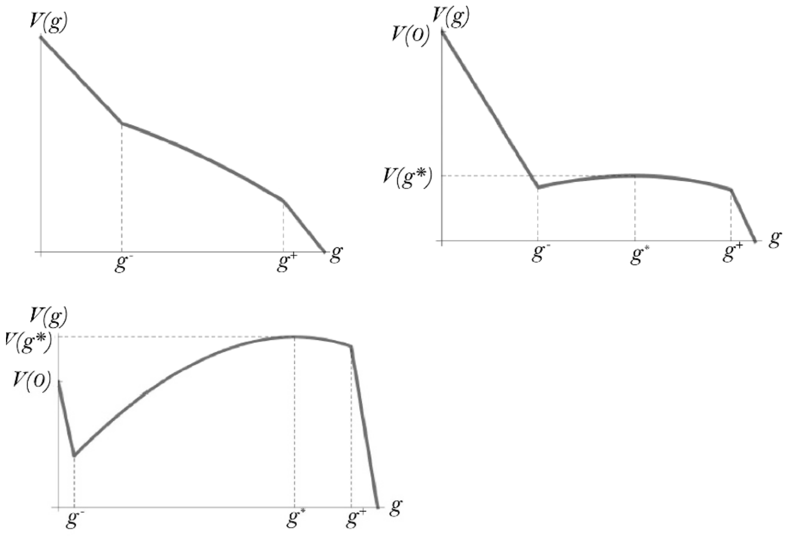

Figure 3—Different forms of indirect utility function in the S-Ghost city model
The x-axis represents the distance g to the edge of the already urbanized area (urban boundary). The function's maximum indicates the newcomer household's location.

In case (b) where the preference for green amenities is relatively weak, the value of the local maximum remains below the value reached for the urban boundary, however; so no leapfrogging occurs. In case (c) the situation is different because of the strong preference for green amenities, the function reaches its absolute maximum only for a certain distance from the urban boundary, when the non-built share within the evaluation window is large enough.

Bifurcation corresponds therefore, for a given β value, to the transition from the situation in figure (b) to (c). At this point, the solution of settling on the city boundary becomes unstable. This is a true self-organizing phenomenon because growth itself triggers leapfrogging as soon as the city attains its critical size. As leapfrogging does not occur for low β values, this parameter acts as a control parameter.

This simple deductive model thus provides a heuristic explanation of the periurbanization phenomenon based on diversification of preferences for different types of amenities.

Compared with the synergetic approach to self-organizing phenomena and the models presented, dissonance theory is interested more in attitudes and changes of attitude of an individual, changes that pertain to the action of the individual alone (interpersonal interactions) or the interaction of the individual with a group or with her environment (natural, material, relational, institutional, cultural, etc.). These attitudes or changes in attitude contribute to reinforcing an existing trend or on the contrary bring out new individual behaviours. We find here one of the thematic ideas set out in the introduction for which emergent behaviour may be observed on an individual scale.

2.3 Cognitive dissonance. A theoretical framework within which to understand the processes of individual attitude changes

The question that concerns us here relates more specifically to the processes of change (e.g. moving house) and the theoretical contributions that might shed light on them. Socio-cognitive approaches to the decision-making process include the notion of attitude as a fundamental concept (Doise 1989). This concept was first introduced by Thomas and Znaniecki in 1918 and many definitions (Zanna and Rempel 1988) have come to clarify it. The current cognitive formulations are oriented towards an evaluative conception. More simply, an attitude is an internal psychological tendency of the individual or a propensity to act favourably or unfavourably towards a particular object or class of objects (Eagly and Chaiken 1993). Attitudes orient behaviour (Petty and Krosnick 1995) and a change in attitude is part of the nature of interactions between the individual and her environment (natural, material, relational, institutional, cultural, etc.) but above all the way each of us processes those interactions cognitively and affectively. Festinger's (1957) dissonance theory rests on the idea of a marked individual need for internal coherence and shows how each of us may try to reduce potential dissonance between attitudes, behaviours, or contextual factors (contradictory cognitions). If within a social or spatial context a certain frame of reference of values or opinions changes, it may be uncomfortable for the individual to find herself in a situation that has shifted compared with the earlier situation that had served as a decision-making criterion. The individual will therefore tend to reduce the mismatch with her environment through rationalization inciting her to find "good reasons" to change attitude or not. Social interactions and group membership also play a fundamental role in the process of reducing cognitive dissonance. One way to reduce dissonance is to turn to one's peers (group membership) to look for consonant features. This is what Festinger and his co-workers (1956) defended in analysing the working of individuals in groups (sect) when a prophecy failed.[4] On the basis of work about social identity, Cooper and Mackie (1983) show on the strength of experiments with politically committed university groups that group identities can influence reduction of dissonance.

Other examples closer to our question of residential choice highlight different dissonance reduction strategies. Take the case of a household that realizes after having invested in a small detached house in the suburbs that the expected peace and quiet might be harmed by a plan to set up a huge commercial estate a few hundred metres away. Several dissonance reduction strategies are possible. They may be attitudinal ("the noise might not be so bad", "I'll be able to do my shopping faster") or behavioural (install soundproofing, set up an association to counter the project, move away). The consequences may be individual (intrapsychic modification of internal equilibria) or collective (group actions with possible impact on spatial realities). However, this need for internal coherence often runs up against realities that are difficult to grasp. Without even evoking the limits relating to our cognitive capacities for information processing (Simon 1956) or developing decisional biases engendered by those limits (Kahneman et al. 1982), let us consider simply that the social situations we are confronted with are so many messages containing ambiguities and uncertainties. Confronted with this piecemeal information there are individual differences in the ability to process such messages. These differences relate to the idea of a need for closure, that is, as desire for "an answer on a given topic, *any* answer,… compared to confusion and ambiguity" (Kruglanski 1989). People with a great need for closure use initial information more quickly to forge a final opinion and do not readily re-examine their attitude in the light of new information (Richter and Kruglanski 1999). It is also accepted that a change of attitude can only occur when the individual feels she is making a free choice.

More recently Beauvois and Joule (1996) propose a radical version of cognitive dissonance theory. They attribute a special status to the cognition against which other cognitions are to be deemed consistent or inconsistent. They consider

4 In this study, the authors show how members of a sect observing the failure of the prophecy announced by their guru were able not only to find psychological support in their membership group but also collectively construct a new way of thinking about reality so as to reduce their state of dissonance.

that when tension cannot be reduced by the cognitive channel, "act rationalization" may be used. This approach emphasizes the strong ties between cognitive processes, actual behaviour, and changes in environmental realities. Marchand (2002) observes for example that when people notice a mismatch between the representation they had of the city centre and their expectations of it, they react differently to this state of dissonance depending on their position in the life cycle. In Le Havre (France), the working population adopts an active strategy of environmental enhancement, the function of which is clearly identity-related. Conversely, students, despite their low degree of satisfaction, rationalize their choice by postponing behaviour that is better matched to their current attitude. In the continuation of this work, while some investigators ascribe to behavioural commitment the status of a necessary condition for arousing dissonance, others propose to make a distinction between behavioural and informational dissonance. Vaidis and Gosling (2011) show that the counter-attitudinal character of information is sufficient to arouse psychological discomfort.

In the dialectic between microscopic levels (individual psyche) and macroscopic levels (group processes) continuous and feedback linkages are formed in a logic of circular causality. When it comes to decisions, permanence and generality seldom hold constant. Each of us selects the relevant, available or salient information depending on the context pertaining to our conception of rationality (Cadet 2002). These individual and potentially group rationalities if they are indeed shared, that is, if they are part of a perpetually contextualized, normative perspective of social interactions, contribute in this sense to the emergence of social systems and to their evolution.

Other theories make it possible to apprehend the emergence of group behaviour and systems by focusing not specifically on interaction between two levels (microscopic and macroscopic) but more on interactions established between entities acting on the same level. These are self-organization theory and game theory.

3. Individual interactions behind the emergence of structures

3.1 Critical self-organization theory

The synergetic approach attributes an explicit and mathematically formalized place to the articulation between microscopic and macroscopic levels. It thereby establishes the rules for interaction between two pre-existing levels of systems. Conversely critical self-organization theory while taking into account possible but not systematic interactions between microscopic and macroscopic levels starts from the postulate that macroscopic structures emerge from interactions between entities at a lower scale. The macroscopic structure is therefore not modelled a priori. Moreover, critical self-organization theory places greater emphasis on the creation of emerging structures and an explanation of bottom-up mechanisms (Pumain 2003, Sanders 2006). This is why we often speak of bottom-up models in the sense that the model is defined "from the bottom upwards" and the "top" level can be observed by simulation of the model.

In the continuity of the idea of dynamic interactions between entities on the microscopic scale, the physicist Bak claimed that many physical and social phenomena could be modelled in the form of a percolation system that will tend naturally to move towards its critical state. It shall be seen that, as with synergetics, critically self-organized systems stabilize far from equilibrium and evolve in two ways; very slow general change and sudden change over a very short interval of time.

Most systems (physical, social, economic, biological, etc.) have a double time dimension involving both the long and the short term. In the physical world, for example, energy builds up (slow dynamics) in fault networks before being released as earthquakes (fast dynamics). In the social domain, the transformation of a part of town into a ghetto also occurs on two time scales: a slow dynamic of side-lining, of spatial relegation and a fast dynamic where the system forks passing from one attractor to the other (e.g. a ghetto).

The theory of critical self-organization is a theory of complexity by which sudden changes in system behaviour can be studied. The idea of self-organized criticality was proposed by Bak, Tang, and Wiesenfeld in 1987. In his book *How Nature Works–The Science of Self-Organized Criticality*, Bak (1996) applies this theory to numerous complex phenomena, notably the phylogenetic evolution of living species, earthquake triggering mechanisms, avalanches, traffic congestion, and stock exchange crashes.

This theory teaches that some systems, made up of a large number of dynamically interacting components, evolve towards a critical state without any outside intervention or control parameter. When this critical state is reached a small internal fluctuation may cause a chain reaction leading to catastrophe (in the sense of a behavioural change of the system and not the everyday sense of spatial and social disorganization of a territory). Bak demonstrates that any self-organized system has a slow dynamic that leads it towards a critical state (fast dynamic) heralding a catastrophe.

This theory is based on two key concepts of self-organization and criticality which already featured in the synergetic approach. The term self-organization refers to the capacity of the components of a system to produce a structure on the scale of the system without that structure arising on the level of the components (Deneubourg 2002) and without it resulting from the intervention of any outside agent. As Pumain (2003) observes, self-organization explains how identical processes can produce different effects and structures depending on the initial conditions and values of parameters controlling the interactions and their evolution. The prefix "self-" alters the meaning commonly assigned to the term organization. Self-organization is an emergent process of organization. But it differs from organization in that emerging organization does not result from outside forces (even if the system remains open to its environment) but from interaction among those components. If this concept is applied to the study of the living world and society, this means there is not necessarily any order-giver, organizing centre or programming at individual level of an overall project. This does not exclude some individuals or groups from being trend setters through their initiatives (slow dynamic) and so getting others to imitate them (fast dynamic). These self-organized phenomena can be observed for example in animal societies (anthills, flocks of birds) just as in human societies (applause, mass panic, voting intentions) or geographical systems (urban networks). It should be clarified from the outset that no positive or negative connotation is associated with the idea of self-organization of a system. In human groups for example and more specifically in the case of the emergence of propagation of rumours or panic in crowds (Provitolo 2009) self-organization is not the outcome of any predetermined intent. Interacting agents or entities create a particular form of organization without any previously defined common goal, unwittingly and by imitation and contagion. What characterizes self-organized systems therefore is the emergence and continuation of some overall order without there being any conductor of the orchestra. This self-organization means that the same properties are not to be seen at the micro and macroscopic levels. The processes of imitation and contagion are familiar in crowd psychology and have been captured by the term of emotional contagion (Hatfield et al. 1994). Emotional contagion relates to the fact that the perception of an emotional expression triggers in the observer an automatic imitation of the expression; it thus designates the phenomenon of propagation of an emotion from one individual to others. Emotions thereby find a natural context for expression in crowds. It is emotions that structure crowd behaviour and set in motion the individuals that make it up. In behaviour of the "crowd panic" type, the circulation of emotion little by little changes a sum of individuals into a group acting collectively.

The second characteristic of critical self-organized systems is their criticality. Criticality characterizes systems that undergo a phase change. For example, the transition from water to ice, from individual to collective panic. The system becomes critical when all the components mutually influence each other. When this critical state is attained the system bifurcates, that is, it reaches a break point and suddenly changes behaviour switching from one attractor to another. This critical state is an attractor of the dynamic system reached from different initial conditions. The critical state is said to be self-organized because the state of the system results from dynamic interactions among its components and not a specific outside action. Self-organization is therefore a process that can attain criticality.

Bak uses a simple model to illustrate this theory: the sand pile. The experiment consists in steadily adding grains to a heap of sand. Little by little the sand forms a heap the slope of which increases slowly and brings the sand pile to a critical state. Adding just a single grain more may cause an avalanche of any size, meaning that a small internal disturbance does not necessarily imply small effects. In a non-linear system, a small cause may have a large-scale effect. Avalanches may be of different amplitudes all generated by the same initial disturbance (one extra grain of sand). While it is impossible to predict the size and time of the avalanche, the theory does inform us about the set of responses of the system when it reaches the critical state. The self-organized critical state of a system is therefore a state in which the system is generally metastable but locally unstable. This local instability (small avalanches in the sand pile model) may engender overall instability (large avalanches leading the heap to collapse) moving the system to a new metastable state.

According to Bak, one of the peculiarities of critical self-organized systems is that they have a double fractal signature that is both temporal and spatial. The variables describing the system's behaviour follow power laws and critical self-organized systems construct fractal forms.

Although this theory has found many applications in physics it is more seldom used in the social sciences. In geography, Dauphiné (2003) has applied the theory of critical self-organized systems to urban networks establishing a connection between functional (Zipf) and spatial (Christaller) fractality of urban networks and this theory. Cities in an urban network are ordered by a first fractal law, the rank size law or Zipf's law (power law). Moreover, the nesting of cities in a hexagon, revealed by central place theory, is an example of fractal territorial organization. The metastable urban system (e.g. a local system) supposedly attains a critical point before shifting to a new metastable state (a regional system). But to our knowledge this theory has not be applied to residential mobility.

However, this type of thinking is found in artificial intelligence models. While it is commonplace to contrast mathematical and computerized models, or macrosimulation and microsimulation models, connections between these two types of models have been highlighted by Phipps (1989), Sanders (1999) and Winder (2000). For Winder (2000), "many microsimulation models contain (albeit weak) couplings between micro and macro-dynamics and so are, at least in theory, capable of spontaneous self-organisation". Accordingly we attempt to illustrate the theory of critical self-organization by presenting a multi-agent simulation model of residential mobility in a periurban zone (Agbossou 2007).

3.2 *VisualSimores*, a multi-agent simulation model of residential mobility

A number of "computerized models" adopt a logic comparable to that presented so far in that they begin also with an "average behaviour" of a group of agents and take an interest in the emergence of macrostructures or in our case in transformations of urban fabrics. This is essentially true for a number of models based on the concept of cellular automata (Batty 1991, White and Engelen 1993, Antoni 2003). These computer models are based on simulations and do not seek analytical solutions (Winder 2000).

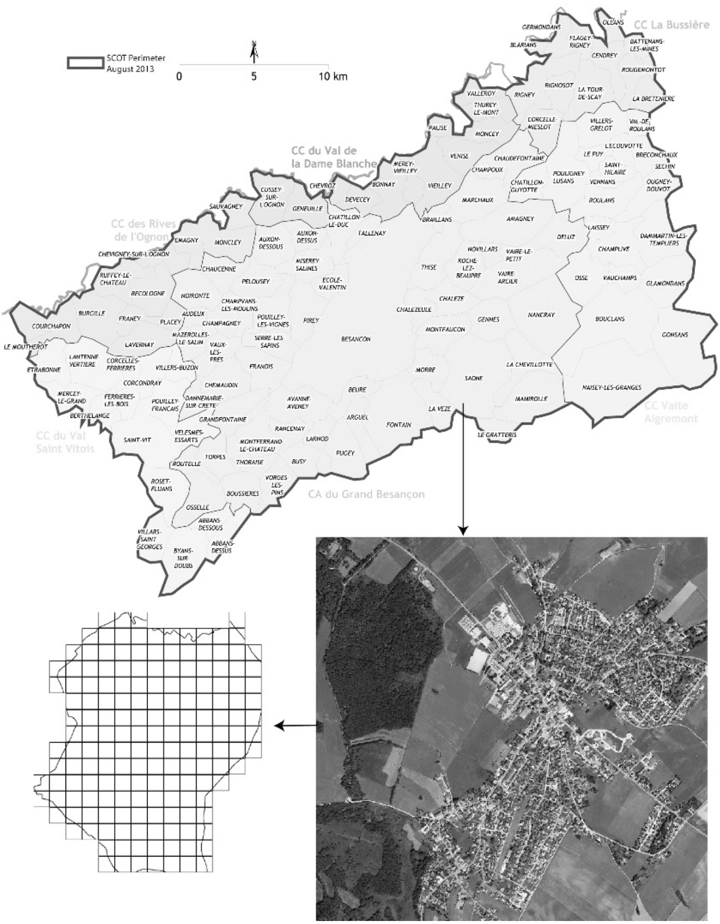

Figure 4—The study zone: the municipality of Saône

Certain results of surveys recently conducted as part of the ECDESUP project based on the methodological considerations presented in chapter 8 (individuals' attributes, diversity of real estate offer, time elapsed between two moves, accommodation occupation status) were included in the *VisualSimores* multi-agent simulation model. This model illustrates interactions among households and interactions between each household and its socio-spatial environment.

The interactions arise when households are looking for accommodation or when a household frees up accommodation. As soon as accommodation is vacated by a household the information is updated and sent to the households looking for a property via the "Social Network" variable. Households looking for accommodation interact with the socio-spatial environment in two complementary ways. First via the "Social Network" variable, they interact with other agents who are promoters and estate agents. This enables them subsequently to interact with the formalized spatial environment via a cellular automaton (the states of which are the different types of accommodation plus open spaces, transport networks, etc.) by locating their next residence within a neighbourhood.

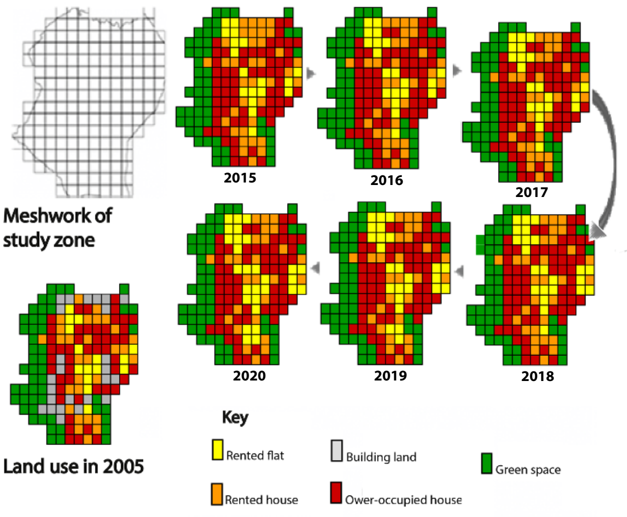

Figure 5—Emerging spatial patterns simulated for the period 2015–2020

These interactions have a spatial repercussion that is materialized for the cellular automaton. This in turn has a feedback effect on household behaviour. The process unfolds therefore in this way throughout the simulation. The set of probabilistic transition rules governing the residential dynamic of the system is formalized by the system of conditional probabilities associated with a Bayesian network composed of characteristic variables of households and accommodation.

The simulation results illustrate the emergence of unexpected spatial configurations on the intra-municipal scale given that only the configuration is known and represented as it is in reality.

The area of application of the model is the municipality of Saône (France). It is one of the 59 municipalities that make up greater Besançon. Saône is a market town with a commercial and industrial estate and is located 11 km from Besançon. The municipality covers an area of 21 km^2 and had 3043 inhabitants in 2005. Steep relief and marshland separate the municipality from Besançon. This means that Saône acts as a central place for the surrounding more rural municipalities. The municipality is connected to Besançon by rail and by a major road. This road access is to be further improved by the building of a tunnel linking the area to the Besançon ring road.

In the system simulated over 15 years (from 2006 to 2020), the spatial dimension materialized by different types of accommodation is modelled by a cellular automaton based on a cartographic grid and households by a multi-agent model. All interactions are low level, that is, they model solely relations among households (interactions among entities of identical levels) and the relationship to space of each category of household agent (interactions of households with their environment). The different states of a cell are: rented house, owner-occupied house, owner-occupied flat, rented flat, buildable land, and open space.

In the example proposed, two types of process have been identified: the *feedback* processes (negative and positive) and *information flow* management.

Positive feedback is a process the outcome of which reinforces group action by amplifying or facilitating it. In the case at hand, it is a matter of change in the accommodation occupation status of an agent between two moves (in the case of effective mobility) because of progression on the scale of socio-occupational categories; or simply from the transition from tenant to owner. Positive feedback can amplify *fluctuations* of the system enabling non obvious information to be updated.

This updating of information is manifested in the case of the simulated residential system by knowledge or discovery by an agent of vacant accommodation that may satisfy her choice criteria by more than 50 per cent. It may also be the increase in the number of one type of agent in the system through coupling. Such processes can easily lead the system to explode if they are not kept under control by *negative feedback*, which also serves to stabilize the system. In the simulation model under discussion, these are the reverse processes to positive feedback processes. We can cite in particular a household's regression on the socio-occupational category scale. Such regression may be accompanied in some instances by residential mobility without a change of occupier status or residential mobility with a transition from the status of owner to that of tenant, or again residential immobility with or without a change in occupier status (where part of the accommodation is sub-let or a property is joint-owned under a partnership agreement). Each form of feedback will engender a feedback loop. When combined, these processes make certain spatial patterns emerge.

With respect to the management of information flows, we have relied on research in behavioural biology. In this domain it can readily be understood that interactions among the components of a system very often bring into play *communication* processes, information transfers among agents. Generally agents can communicate either via signals, that is by using a specific means to convey information, or by cues, whereby the information is conveyed accidentally. Similarly information may come directly from other agents or alternatively through the state of ongoing work. This second possible way of exchanging information via modifications in the environment is termed *stigmergy*.

Stigmergy is a concept underpinning the creation of ant colony metaheuristics (Dréo et al. 2003). It is defined as a "form of communication involving modification of the environment" but the term "indirect social interactions" is used to describe the same phenomenon. Biologists differentiate "quantitative" from "qualitative" stigmergy but the actual process is identical. In the simulated residential system, stigmergy manifests itself through social contacts among different types of agents on the one hand and through the relations each agent entertains with her immediate and remote residential environment on the other. Emerging spatial patterns are local here because of the issues being addressed.

In figure 5 they can be identified by the clusters of nine light-coloured cells in the north of the grid displaying a very strong concentration of flats let out from 2017 to 2020 and the group of five light-coloured cells in the east of the grid materializing the same land use from 2018 to 2020. What is interesting in the results is not just the new constructions but also the conversion of zones with tenanted houses into zones with tenanted flats, because of the various feedback processes described above. The great strength of stigmergy is that individual agents exchange information through their environment and modify it in accordance with individual strategies that, on a global scale, can generate patterns that are not formally foreseeable. Generally, all these processes are more or less interconnected allowing the system, when made up of a relatively large number of agents acting together but with individual objectives, to achieve emergent configurations.

4. A strategic interaction among individuals approach: game theory

Many socio-economic phenomena arise from group effects and collective behaviour. A theoretical understanding of them rests upon modelling interactions between the entities of a group. When these interactions are of a strategic nature and occur between actors on the same level (e.g. interaction on the level of and between individuals, or populations, or institutions and not interactions between separate levels, such as individuals and institutions), then they are usually modelled in the context of game theory.

The foundational work in classical game theory is by von Neumann and Morgenstern (1944).[5] The theory comprises two families of games: cooperative and non-cooperative games. A game is said to be cooperative when players may communicate and make agreements in the general interest. A game is said to be non-cooperative when it offers no opportunity for coordinating the strategies of the various players. In such cases, individuals do not communicate and adopt self-serving behaviour at all times; each player is out to maximize their own gains individually. “Players” may be institutions, firms, regional councils, local elected officials, consumers, and so on. Here we are interested more especially in the theory of non-cooperative games to study situations in which each action or decision a “player” takes influences the other “players”. The protagonists are therefore interdependent and led to adopt strategic behaviours. This theoretical framework can be used to answer the question whether the strategies of local decision makers motivated by the interest of their electors alone can result in the emergence of spontaneous fiscal cooperation?

The fundamental principles of game theory are straightforward enough: “The game is fully described in terms of structure by the opportunities of each player to act, the utilities that result for each of them and the beliefs adopted about the foregoing characteristics” (Lesourne et al. 2002). Game theory deals therefore with situations in which strategically interacting individuals are led to take individual decisions and in which each one’s gain depends on her own and others’ choices. Interactions among players may give rise to equilibrium situations. “A notion of equilibrium can characterize social states within which players’ actions prove compatible, their existence having to be demonstrated and their multiplicity duly studied” (Lesourne et al. 2002). Moreover, “a game is a situation in which individuals (the “players”) are assumed to be rational. They interact: they choose among a number of possible actions and within a pre-defined framework (the “rules of play”), the result of those choices is the outcome of the game, which is associated with a positive or negative gain for each participant” (Guerrien 1995). As players are rational it is assumed they are out to make the maximum gain.

There are various types of game. Primarily games with complete or incomplete information and games with perfect or imperfect information. Schematically, a player has imperfect information when she does not know what the other players have done previously. So a “simultaneous” or synchronous game in which all players play at once may be called an imperfect information game. Conversely in an asynchronous or sequential game in which players take turns, having each time the information about the opponent’s move, the game is said to be with perfect information. A player has incomplete information when she

5 Readers are invited to consult it for detailed development of the topic.

is not aware of the precise characteristics of her adversaries (preferences, types, motivations, set of strategies, possible gains).

The now famous "prisoners' dilemma" is a classic example of a non-cooperative game with complete and imperfect information, that is, a game in which players do not play in turn but simultaneously without knowing the other's decision, hence the imperfect information. The prisoners' dilemma explores the conditions in which two prisoners accused of a crime cooperate spontaneously to escape a stiff prison sentence. The dilemma lies in the fact that if the two prisoners go it alone, they will be worse off than if they cooperate (Axelrod 1992).

The prisoners' dilemma game can therefore serve as a basis for examining the emergence of fiscal cooperation among local elected officials. Take two identical municipalities of the same size. The elected officials have the choice between voting for high tax rates, that is, opting for fiscal cooperation to generate optimal production of local public goods through the induced fiscal take, or unilaterally choosing a low tax rate to attract firms from the neighbouring municipality. Tax competition is then a source of sub-optimal production of local public goods (see Wilson 1999 for a round-up of tax competition models) because of insufficient tax revenues. Out of fear of deviant behaviour by the neighbouring municipality, elected officials tend to opt spontaneously for tax competition. As in the prisoners' dilemma the problem is to find a mechanism that prompts the elected officials to spontaneously choose the cooperation solution rather than the competition solution (Morer 1999).

Until January 2010 in France, at which time local business rates were reformed, municipalities used the business rate as a strategic variable for attracting firms and so residents by a knock-on effect. Past economic facts show that, just as in a prisoners' dilemma, local elected officials competed to attract firms and inhabitants. Little spontaneous consultation was observed among local elected officials to levy a common business rate or finance infrastructure to provide incentives for firms to set up. Central government had to step in to create public bodies for cooperation among municipalities and induce collective cooperation among local decision makers through financial incentives. This dynamic of cooperation is not self-organized but the result of outside intervention by central government.

The question that arises and that is addressed below is whether or not this group phenomenon of cooperation among municipalities might not have emerged[6] spontaneously, without state intervention, out of spontaneous cooperation among local elected officials. The question is not without its consequences. The choice between competition and cooperation over taxation will eventually af-

6 Emergence has been defined in many ways. Here we use it as in Friedman M. and R. (1990), "Economic order can emerge as the unintended consequence of the actions of many people, each seeking his own interests".

fect residential mobility via the number of firms attracted to an area and the standard of local public goods available thanks to the induced tax revenue.

4.1 An example of emergence of fiscal cooperation among local elected officials to attract firms and inhabitants

To the best of our knowledge, little research has been done to analyse residential mobilities on the basis of game theory. Accordingly we have opted to present work pertaining indirectly to mobility, namely fiscal strategies of local elected officials to attract firms and indirectly inhabitants to their municipality. Geographically we are working on an aggregate scale in the sense that the local decision maker represents the municipality. However, in terms of modelling, this is an individual-centred approach as usually employed for modelling behaviour on a micro-geographic scale.

The interplay of local decision makers, when they have the choice between competing or cooperating (whether budgetary competition, that is over the level of public spending, or fiscal competition) is akin to a prisoners' dilemma (Morer 1999, Walliser 2003).

Drawing on Gordon's (1983) model, Morer (1999) applied the prisoners' dilemma game (game with complete but imperfect information) to two fictitious and identical municipalities. The strategic variable is a rate of taxation on firms. The municipalities have the choice of cooperating—that is, opting to levy tax at the same high rate so as to maximize the welfare of residents of both municipalities (joint tax revenues and so the supply of local public amenities for the residents of both municipalities will then be Pareto-optimal)[7]—or on the contrary of competing—that is unilaterally levying tax at a low rate so as to attract firms (joint tax income is then lower than in the cooperative case and the supply of local public amenities is sub-optimal). Out of fear of defective behaviour by the neighbouring municipalities, the local officials prefer to opt for tax competition and so get themselves into a prisoners' dilemma (Morer 1999). Empirically these results hark back to the situation in France before the 2010 business rate reform when municipalities of the same demographic level preferred fiscal competition to attract firms and residents whereas it would have been better to cooperate in terms of the welfare of residents and municipalities.

The problem that needs to be solved is how to prompt municipalities to cooperate so that the collective phenomenon of fiscal cooperation emerges strategically and spontaneously, that is, without central government intervention.

First we show to what extent cooperation between municipalities can be likened to an institution and what light game theory can shed on its origins. Then

7 It will be said that tax competition or cooperation achieves an optimal level of production of public amenities or an optimal or effective production when the distribution of public goods produced in the entire economy is Pareto-optimal, that is, when no municipality can improve its own situation without worsening the other's.

we set out (without mathematical developments) the solutions recommended by game theory to see the cooperative equilibrium emerge spontaneously in a prisoners' dilemma before expounding an example of fiscal cooperation through reputation-building.

Game theory and the origins of institutions

We owe to Walliser (2003) the idea that game theory can account for the genesis of institutions. Walliser (1989) says of an institution: "A more operational definition makes it a rule in a social game that is interiorized by agents and helps to guide their behaviours so as to ensure they are compatible in a given context." When local elected officials decide to cooperate, they interiorize the fact that they must not defect and this rule guides their fiscal decisions. Cooperation between local authorities may therefore be likened to an institution.

Walliser sees the role of institutions as righting shortcomings in the game. The shortcoming in the prisoners' dilemma game is the non Pareto optimality of equilibrium. The creation of an institution for fiscal cooperation would make good the failings in the local authorities game presented above. There are three solutions for making an institution, each part of a separate paradigm. Walliser (2003) identifies three possible origins for an institution:

– The institution may be a voluntary act of creation by an individual or group that has the power to do so. In the context of municipalities, the government has the power to opt to merge municipalities. This first explanation makes institutions part of "methodological holism" (entities found on the macroscopic scale impact the actions of individuals but do not arise from those actions). For sociologists, institutions are of such origin.

– "The institution may be engendered by a multilateral agreement among various players and so results from talks among actors pertaining specifically to the institution." The powers-that-be may choose to create legal entities such as public bodies for cooperation among municipalities, local authority groupings, or urban communities. This second explanation fits institutions into the framework of "strong methodological individualism" (institutions are supposedly the result of rational and concerted behaviour). Economists tend to be proponents of this strand of thought.

– The institution may be the "materialization" of a game equilibrium. The institution is then the result of players' rational behaviour. Fiscal cooperation then supposedly emerges from the spontaneous behaviour of local officials prompted by their individual interests (and more specifically the interests of the electors they represent), that is, with the intention of maximizing their gains and not expressly cooperating. There is thus a middle road, "weak methodological individualism", in which institutions emerge from somewhat unintentional individual processes (Walliser 2003).

We go down this middle road and see the spontaneous emergence of the institution of cooperation as a solution to a game. Depending on the players' degree of cognitive rationality, we use either classical game theory or evolutionary game theory (involving the learning mechanisms used by agents). We can now set out classical game theory to study the emergence of the institution of cooperation as a solution to a game, council leaders supposedly being endowed with substantial cognitive rationality.

Cooperative equilibrium in the prisoners' dilemma

Assuming that elected officials are driven by the interests of their residents, the question is how to get fiscal cooperation to emerge (with identically high taxation rates in common) so both municipalities can maximize the satisfaction of existing residents by offering a high level of local public goods.

In order to have cooperation emerge in a prisoners' dilemma, game theory recommends two solutions. The first is to repeat the game an infinite number of times. Classical game theory shows that in the context of an infinitely repeated prisoners' dilemma, the use of threats enables cooperative equilibrium to emerge. In this case, cooperation is an unintentional consequence not sought by the players and they are driven by their individual interests alone. So, for instance, the threat of an aggressive fiscal policy, that is, low tax rates in the event of defection by the neighbouring municipality would be an incentive for local authorities to cooperate fiscally and so enable municipalities to escape the prisoners' dilemma. The second solution is to repeat the game a finite number of times. But the repetition of the prisoners' dilemma game applied to local officials' strategies shows that they have every interest in choosing the non-cooperative situation throughout the supergame. However, it is possible to have cooperation emerge when the prisoners' dilemma is repeated a finite number of times by introducing even a very slight degree of uncertainty about the opponent's type (rational, that is, non-cooperative type, or irrational, that is, cooperative type), that is by relaxing the assumption about complete information.

As in game theory applied to industrial economics, it may be thought that building a reputation as a "cooperative" may or may not promote the emergence of a spontaneous and stable agreement about fiscal cooperation. We illustrate this example below on the basis of repeating the game a finite number of times.

4.2 An example of emergence of fiscal cooperation through building a reputation as a "cooperative" elected official

Local elected officials serve a limited term of office. As well-meaning officials, they are invariably concerned about the well-being of local residents. However, the future of those citizens is of no concern to them over the longer term. The local elected official seeks to maximize the representative resident's utility over a period equal to the length of her term of office. She naturally wishes to be re-elected. The framework for analysing elected officials' strategic decisions therefore tends to come under the theory of games that are repeated a finite number of times.

By introducing a degree of incomplete information into the behaviour of elected officials, that is, by relaxing the complete information assumption a little, it can be shown that this supergame can sustain fiscal cooperation over a substantial time period. This outcome depends on the reputation the municipality has earned for its ability to maintain cooperative behaviour.

It is assumed the game is repeated $N + 1$ times from the date $t = 0$ at date N, that is each of the $N + 1$ years of the term of office of the elected official. We assume a discount factor of 1 (or a zero actualization rate) in order to strengthen the assumption of the appearance of cooperative type behaviour and simplify the computation. We introduce even a tiny amount of uncertainty about the elected officials' behaviour (Kreps et al. 1982) in the subgame. Each player attributes a probability $(1 - \varepsilon)$ that the other will behave rationality, that is, will choose not to cooperate; each elected official attributes a probability e that the competitor will behave irrationally by choosing to cooperate.

In the supergame, the elected official's strategy is the following: she begins by cooperating at date 0 and continues to do so for so long as the other cooperates. If the opponent defects, she no longer cooperates and definitively so. Let us consider two municipalities, 1 and 2 respectively, and envisage two cases. In the first case, municipality 1 behaves uncooperatively at date 0. In the second case, the municipality behaves cooperatively until N, unless municipality 2 defects, in which case municipality 1 decides not to cooperate any further from date $t + 1$ to date N.

It can then be shown that the cooperation solution between municipalities will be all the more likely for high e values, that is, when municipalities are certain that the opponent will cooperate. In other words, if municipalities want the tacit agreement on cooperation to be relatively stable, they must convince others of their good intentions, that is, build a sound reputation as a cooperative type. The more highly reputed the opponent is as a cooperative type, the more chances there are that cooperation will be achieved. The fear of being cheated by local officials then declines.

At the end of the supergame, the municipalities have largely amortized their investment in their reputation. Potential defectors then find an advantage in no longer cooperating in the final period in order to enjoy the gains from defecting. They will do so all the more readily when they have gained considerably from cooperating and have comparatively little to lose since the end of their term of office is close. Fiscal cooperation no longer holds. However, it should be emphasized that in actual practice there are three arguments to prompt a council leader to cooperate fiscally until the end of her term of office: if she does not intend to stand in the next elections, if she wants to keep her reputation for being "cooperative", and for political reasons, especially with a view to a career at some higher echelon, if voters reason with complete information.

So, according to classical game theory, when local elected officials have a limited term of office, building a reputation as a cooperative elected official is one solution for ensuring the emergence of spontaneous fiscal cooperation that might cause residential mobility through the high tax income thus engendered and therefore the substantial offer of local public amenities.

Cooperation is a form of collective organization. We have set out one example of it. But this question of production of forms could not be complete unless we look at the production of spatial forms. This is a central question in many disciplines and more specifically in geography. As the science of space, geography is concerned with spatial forms and the processes that contribute to giving rise to them and maintaining them. It emphasizes the question of forms arising from the various forces at work and that reflect a situation of dynamic equilibrium. We shall look at the specific form of activity-travel space.

5. The emergence of activity-travel space: the question of underlying self-organizing processes

Activity-travel space is defined as all the places in which an individual performs activities over a given period of time. It provides a synthetic measurement and reveals the daily travel behaviour of individuals inasmuch as it includes the places frequented, times at which they are frequented, the way they are interconnected by the sequencing of trips and modes of locomotion used. We study the morphogenesis of activity-travel space by focusing, from a cognitive perspective, on the behaviour system and by looking more specifically at the mechanisms involved in the system.

5.1 Individual/environment interaction

An individual's system of behaviour in terms of everyday mobility fits into various environments. Any individual moves within a spatial environment that is a source of both opportunities and constraints depending on its content and the way in which its elements are arranged. Opportunities because the spatial environment includes places where the individual can satisfy the need for outside activities; those activities being constrained because those places are located at distances that have to be covered, involving a greater or lesser degree of effort. The spatial environment is also the locus of an equally complex social environment composed of multiple elements and especially the set of actors and organizations with which the individual is in direct contact or comes into contact through various media.

These first two environments define in some sense an individual's external setting. The third, the cognitive environment, relates to an internal setting. This is composed of a set of memorized representations that are tools for operating before or during action, as with scripts, for example, that encapsulate a way of acting in a given situation. These representations result from the experience acquired by individuals over the course of their lives. Some act as filters when information from the outside environment is perceived.

From interaction to stimuli…

Individuals interact almost uninterruptedly with their spatial, social, and cognitive environments. From the individual's point of view, such interactions are stimuli conveying information. But those stimuli only acquire the status of recognized information if they cross the cognitive representation barrier, a status that internal stimuli from the cognitive environment have as of right and that are generally identified under the label of "desires". All of the information recognized is processed cognitively, during which processing the individual sorts out the recognized information, selecting some and transforming it so as to take it into account in future trips. But ultimately, since intentions are not always materialized, it is by crossing the intention stage that this recognized information is identified with events that the individual uses to effect her daily trips.

… and events

These events are very varied in their nature. They cover several aspects, one of which, and not the least, is the set of external activities to be performed. The content of this set of activities is diversely rich and dynamic, varying from one individual to another. An activity performed by someone may be done exceptionally, not because it seldom occurs but because it is a transient coordination action among different members of a household. Among more recurrent activities, some such as returning home or going to work, are related to places whose spatial fixity, or even spatio-temporal fixity, if we include the constraint of the times they are frequented, is high. These places of activity have a pivotal role around which other daily journeys are organized (Cullen and Godson 1975).

Events also depend on the conditions of the moment with which the individual is confronted. Such conditions depend on the circumstantial context encompassing all of the elements that are to affect the implementation of the activities. This context comprises elements know before the activities of a given period of time are performed or those that arise in the course of their performance. For someone who is exclusively a motorist, finding that the car is unavailable leads either to the activities being cancelled or postponed if no other requirement is to be taken into account. The same goes for the performance of an activity when it lasts longer than planned and so prevents the following activity from being completed.

Thus interaction of the spatial, social, and cognitive environments leads to an individual having a set of activities to be performed over a given time (i.e. an activity schedule) but also to throwing up circumstances that will interfere with the implementation of everyday mobility. This actual performance of activities relies on cognitive representations.

5.2 Cognitive aspects related to activities and activity sequences

These representations are simplified models of "reality" as an individual has perceived and memorized it, and they are action-oriented, that is, they enable the intended goal to be achieved. Data collected on daily mobility in the context of institutional or research surveys provide pointers as to the type of cognitive representations individuals have. To perform some activities such as shopping, individuals generally have several possible venues, which means they have in some sense a catalogue of potential places for their activities. Moreover, records of travel practices indicate that individuals organize their out-of-home activities by grouping them into travel sequences that are repeated from day to day, such as dropping off children at day-care or school before going to work. However, the interpretation of journey sequences may be extended on the basis of pivot points (place of residence, place of work, school, etc.) around which individuals organize their daily mobility. Everyday journeys invariably imply a sequence of activities. Whatever the trip based on a single motive (purchase, visit, work), the return to the pivot point is implicit (e.g. the return home activity), so that we are constantly dealing with a sequence of activities.

The catalogue of potential venues for activity and activity sequences are therefore two cornerstones of everyday mobility for all individuals. But what are their cognitive components.

Potential venues for an activity

For individuals to implement an activity they must know its spatial location. This implies at least two forms of knowledge: where it takes place (position) and how to get there (way-finding). Knowledge of the venue for the activity and the path to get there are related to relative reference frameworks, such as way-posts that enable one to reach the place from other known positions. These two forms of knowledge refer back to the cognitive representation of space (Kitchin and Blades 2002).

Performing an activity also presupposes knowledge of the time dimension. If they are activities for which access is regulated by opening times, time-related knowledge pertains at least to the potential access times when incomplete, or to a well established time slot otherwise. But even in the case of activities with no institutional time regulation, such as visiting friends or family, the time dimension operates as a form of more or less tacit agreement as to possible meeting times. Admittedly in this type of regulation, the forms of knowledge about time are much more variable from one individual to another. However, knowledge of time does not concern just the activity but also the time it takes to reach the venue for the activity, even if such knowledge is often deformed (Cauvin 1984).

Lastly the implementation of an activity also associates information about the means of travel. Spatial knowledge of the route to take to the activity venue and knowledge of the time needed for the trip depend at bottom on the mode of travel. The path is known because it has already been taken, even if for some other reason. Spatial location, time dimension, and mode are thus the essential attributes for performing an activity. Together they form a representation that corresponds to a schema, that is, a "cognitive set that is simultaneously activated in a given situation" (Flament 1981).

Activity sequences

A second type of pattern corresponds to sequences of activities. These are an ordered series of activities forming a minimum unit of action and implying at least two activities, one of which is generally implicitly related to the pivot place. Activity patterns of this type different from the previous patterns in several respects.

As an activity sequence includes at least two activities and therefore two trips, this characteristic introduces not just an associational relationship between the activities but also an order of succession of activities giving direction to the associational relation. This linkage of activities within the sequence has repercussions on its attributes. Spatial knowledge of how to travel from one venue to another in the sequence is strongly focused on the succession of the activity venues. Structuring by way of a sequential order of activity venues also influences the time dimension. Unlike the activity pattern, temporal knowledge interconnects potential time periods of the activities. Depending on the constraints on one or other activity in the sequence, such as a time requirement, the inter-relation wavers between fixed and flexible time slots implied by the sequence. With regard to the mode of locomotion, the sequence associating different activities reflects a mode of use related to each activity. The activity sequence thus reflects an actual implementation that may be single- or multi-modal.

Whatever the representation (activity or sequence of activities), it ultimately reflects a way of doing things integrated by the individual. To rely on memorized lines of conduct is to call on cognitive routines (Betsch et al. 1999). Such routines are defined therefore as ways of doing things, manners of engaging in daily mobility, that have been memorized and to which an evaluation is attached. They are the product of an earlier decision-making process the result of which, that is, the action, has been the subject of a judgement. Thus a routine is knowledge that is employed for action and in that, this conception of routine differs from the common usage based on habit of doing something and synonymous with identical repetition.

5.3 Morphogenesis of activity-travel space

The structural components of travel behaviour are therefore fundamentally interaction (individual/environment), events (activity schedule and circumstantial context), cognitive routines (activities and activity sequences), and evaluations of these routines. The behavioural system of the resulting daily mobility depends on the constitution of this set of components leading to a mode of functioning. In other words, it depends on its organization, a concept that "expresses this duality between action and its results" (Lemoigne 1995).

Self-organization of the behavioural system

Individuals go through different stages of mobility over the course of their existence. In childhood, travel is supervised by parents, especially in public places, who leave little leeway as to the activity venues frequented, itineraries taken, and means of transport used. However, the individual's experience of the world about her forges her earliest cognitive representations relating to the performance of activities out of the home. As the child grows it progressively acquires a degree of autonomy in its daily mobility. Parents let children go to school on their own; they can walk or cycle to see nearby friends, go to the corner shop, and so on. Even if they are generally closely supervised in terms of time, they gain in independence and the accumulation of new experiences gradually enhances their cognitive routines and gradually refines their attributes for spatial location, time dimension, and mode of travel. This process continues throughout the individual's life, even if it is highly likely that it slows at times when the individual is "settled" or accelerates when they migrate or change pivot point in everyday mobility (moving house, changing workplace within the same area) or stagnates especially later in life.

The implementation of cognitive routines also involves an evaluation. Performance of an activity reflexively produces an appraisal of how it was performed. Everyone can remember, for example, going shopping at the rush hour resulting in a waste of time that had a knock-on effect on activities planned for afterwards… and promising never to be caught out again. Thus when implementing an activity programme, individuals are guided in their choice of routines by evaluations associated with them depending on the circumstantial context. There is therefore a feedback process for activities through the use of evaluations that increase the likelihood of successful routines being used again.

By enriching the stock of routines and by swapping routines for others over the course of their lives, individuals' behavioural systems change their organization depending on experience accumulated in the environment in which they find themselves. This change of organization is inseparable from and concomitant with the performance of activities in each individual's circumstantial context. Such a mechanism corresponds to self-organization in which the change in organization of the system depends on their experience and environments. It may be called self-organization through learning or more specifically a form of learning through feedback from experience.

Emerging form and property

Self-organization leads to the construction of remarkable semantic forms, the most directly observable expression of which is the activity-travel space. On the strength of survey data, commentators such as Boulahbal (2000) show that typical forms of such space arise and continue in being over time for individuals. Three typical forms are especially interesting for what they signify. The first is an ellipse reflecting the anchoring of everyday mobility around two pivot points with time available for activities other than just the travel time shuttling back and forth between the pivot points. The second form is a simple straight line segment on which activity time outside of the two pivot points located at its ends is almost entirely devoted to travel time. The third form is a circle and so rests on a single pivot point around which daily mobility is organized and corresponds to the individual's home. But all directions around this point are used within a radius generally depending on the spatial range allowed by the means of transport used.

The production of these forms, which result from the assembly of routines and their use depending on their evaluation, the introduction of new activities depending on the circumstantial context, is a type of emergence because the forms only exist in the global behavioural system in operation and cannot be reduced to the structural components of the system, nor exist outside of them. The nature of this emergence can be specified, though. It rests fundamentally on the use of cognitive routines, more specifically when the activity programme is intensive, on a combination of ways of doing things by introducing into activity sequences activities selected from the catalogue of potential venues where they may be performed. To use the term proposed by Cariani (1997) we may speak of "combinatoric emergence" that we shall characterize as dynamic because it ultimately depends on the circumstantial context.

Self-organization also produces a property that is not found in any of the structural components of the individual's everyday mobility system. This is a global property related to the emergence of the activity-travel space that reflects the individual's feeling of satisfaction/dissatisfaction with daily mobility.

In the event of a negative feeling, Carpentier (2007) speaks of "tension" resulting notably from the spatial mismatch of the location of the place of residence with the distribution of other places of daily activity including any other pivot points. For that observer, individuals may reduce that tension by psychological processes if they find themselves unable to change the way they perform their activities. But they may also eliminate it by reorganizing their behavioural system for mobility, which may go so far as modifying the residential pivot point, which in other terms induces residential mobility.

The individual's behaviour corresponds, then, to a system whose material form, the activity-travel space, is the outcome of self-organized emergence. This perspective has powerful implications for the very concept of individual behaviour and the way we understand it. Individual behaviour is generally conceived so that the behaviour is an attribute specific to the individual, a characteristic residing only within the individual. In fact, as seen, this heuristic simplification has to be abandoned for another more complex and more appropriate understanding by which individual behaviour is part of the individual's characteristics and relations with the outside environment.

6. Conclusion

We had two aims in writing this chapter: (i) to set out discipline-specific theories and meta-theories with which to address questions of the emergence of collective and cooperative behaviour and (ii) to apply those different approaches to the social sciences and more specifically to the analysis of mobility. This double objective may have left readers with the impression of a rag-bag collection, especially as the fields of application presented are not always directly related to the modelling of residential and daily mobility and the models themselves may be very different, ranging from conceptual formalization to mathematical and computer science formalization. But despite this and to conclude, several points of interconnection may be established.

First, the theories and models presented shed light on the common points and divergences of approaches relating to the study of the emergence of collective phenomena. They show that many phenomena governed by social interactions share similar properties with regard to their dynamics and stationary states or equilibria (Nadal and Gordon 2005). For all emerging collective structures or phenomena, we can observe:

– The preponderance of the role of interactions and spatial levels.

– The double time dimension: accumulation of a process generally occurs over a long time period whereas the transition from one state to another (the change of attractor, the tipping point) usually happens very quickly. Think for example of revolutions, the transformation of parts of town into ghettos, disasters such as earthquakes, or health crises.

– The capacity of a system to find a new state of equilibrium or return to the initial state and to recover more or less rapidly from a disturbance. This is a form of resilience based on the idea of resistance to change and preservation of existing structures.

– Coexistence of equilibria: entities interacting on a microscopic level may generate different solutions on a macroscopic level. Walliser (2006) speaks of "multiple states of equilibrium in a static case or attractors following bifurcations in a dynamic case".

– Models from synergetic and organized criticality theories consider structures that may stabilize while far from equilibrium, unlike economic models.

These theories thus exhibit what are a priori divergent approaches to answer one and the same problem. On the one hand, the synergetics and critical self-organization theories illustrate that it is possible for a system to experience different states of equilibrium—static, periodic, chaotic—without a priori involving an optimization strategy. There is a progressive adjustment of entities' behaviours. On the other hand, in game theory, entities exploit the information they have optimally. So on the one side, in the synergetics, critical self-organization, and cognitive dissonance approaches, we look to ensure the continuation of systems (living, social, institutional, etc.) via strategies of self-organization, adaptation, resilience, and transition through various states of equilibrium, while on the other side, that of game theory, we look to optimize strategies.

Moreover, all of the models presented begin with mechanisms and not data. All of the models developed include several levels of organization. But for some only the microscopic level is explicitly modelled, the higher levels (macroscopic for the emergence of a new spatial configuration or mesoscopic for the emergence of a cooperative institution) being "simply" observed; while for others, the factors explaining the current state of a system must be sought in the dynamics of interaction with the environment, in the feedback of the whole (e.g. society) on individual actors (since they adapt to their environment), and in interactions among entities of identical levels.

Observing The Decision-Making Process

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1. Introduction

In this chapter we ask how knowledge can be acquired about the decision-making processes associated with residential choice. As shown by the results of the many areas of research set out in chapter 2, a great number of factors may influence the decision to move home. Because we are more especially interested in the actual decision-making process, we must consider the mental factors that may condition it. It can be assumed that this decision is influenced by earlier experiences that may be positive or negative (cf. chapter 3). Thus feelings and affects such as attachment to a place or to existing social networks may come into play as may painful events (cf. chapters 2 and 4). Moreover, collective values expressed by symbolic values of a type of housing or place may also influence the decision to move (cf. chapters 2 and 3). All of these factors cause a feeling of satisfaction or dissatisfaction with the current situation and a possible change of place of residence; they may either make the individual move home or act as a brake on such a decision (chapter 7). Moreover, moving home is often not an individual act but in a family situation becomes a collective decision. We therefore look at the rulings required among family members but also the way individuals take account of the various factors that seem important to them in their choices.

It is therefore a complex context in which a large number of factors come into play. How heavily do these factors weigh in the decision? Would the decision process be the same tomorrow as it is today?

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In addition, it seems impossible to observe the actual decision-making process directly; it only becomes effective through the directly observable acts that follow the decision. And even if one were to imagine devices that might record the neurological processes associated with such decision-making, would it be possible to ascertain their potential influence on decision-making?

Although our approach looks into the factors that come into play on an individual scale, we begin with the assumption that there are certain common or comparable factors in individuals' behaviours and seek to identify them. We therefore take up a position that is rather socio-anthropological or socio-psychological.

It should be recalled that one research objective is to use the results as a starting point for spatio-behavioural modelling based on mathematical or computerized formalization; the results must therefore be quantifiable as far as possible. These requirements seem reminiscent of the approach in the hard sciences that focuses on the search for "general laws" based on quantified observations. However, it seems difficult or even impossible to ascertain the reasons or affects associated with the decision to change residential location by drawing solely on observations of the actions performed (location of places of residences, counting trips made, etc.) So even if there are methods such as experimental psychology and praxeology that, in terms of their method, are inspired by an approach similar to that used in the hard sciences, such methods do not seem to be the most suitable for answering such topics.

It appears difficult, then, to choose the methods of observation best suited to our objectives. Without wanting to go back over the history of the theory of science, it seems essential to recall certain epistemological reflections on the acquisition of knowledge. This will enable us to highlight the criteria required for choosing the right methods of observation. We shall therefore review several general concepts relating to scientific observation. There will prove to be a number of questions that arise in comparable ways both in the hard sciences and in the social sciences, such as the interaction between the observer and the phenomenon under observation or the comparability of several observations. We shall then focus on the question of which approaches enable us epistemologically to study the processes contributing to decision-making relating to residential choice.

These epistemological reflections will then serve as a basis on which to consider the different methods of observation suitable for acquiring information in the given context and revealing its strengths, weaknesses, and complementarities. This overview will enable us to better situate the approach we then propose for collecting information from individuals and will act as a bridge towards the modelling concepts set out later on.

2. Epistemological reflections

2.1 The context of scientific observation

To consider observation as the inescapable element for acquiring scientific knowledge takes us back to the birth of empiricism. This approach was set against rationalism from the Renaissance onwards and was initially championed by physics. The findings collected from observations took precedence over exclusively logical-deductive reasoning that could be entirely rational. An example of this is Aristotle's argument that a fly has only four legs because it needs no more than four to move around.

The importance thus attributed to observation and the conditions in which it is conducted explains why scientific observation is seldom "unstructured" (a term often found in sociology to characterize an observation that has been framed, directed or pre-shaped little if at all). Observation usually requires the situation to be prepared and careful and justifiable thought to be given to the methods of observation implemented. Of observation generally, Bunge (1984) specifies that the object of an observation is an actualized fact; an observation gives rise to a datum, which is a particular or existential proposition, that expresses certain features of the outcome of the observation. For Bunge it is also a premeditated and enlightened perception because it is made for a well-defined purpose and guided by a body of knowledge.

An obvious consequence is that the collection of information must be *reliable*, which obviously means thinking about reliability criteria. In astronomy and physics, domains that were formalized as early as the seventeenth century, it is assumed that human observation is imperfect and unreliable because it can be influenced by subjective and non-rational factors such as the observer's state of mind, mood, and so on. Moreover, human observation does not provide precise quantitative information about the phenomena in question that are essential if they are to be formulated quantitatively. Measuring instruments that reduce the observer's influence as much as can be are therefore seen as the best guarantee for obtaining 'objective' information. This outlook is not necessarily confined to the hard sciences. Using GPS to record a person's movements also stems from the assumption that such recording makes the results more reliable, supposing that for some reason or other the person does not record or inaccurately records all of the trips made. Similarly observations of people using concealed cameras may be based on the realization that it seems impossible to make a precise record of the movement of people caught up in crowds or in panic situations, and so forth.

However, the use of devices does not mean that people are removed from the observation process. Bunge (1984) summarizes by arguing that an observation is not something that exists in itself. It is an operation between two or more systems, at least one of which is the experimenting organism. Experiment always requires something and someone. Moreover, "any investigator may be careless, too fast, even insincere (…). This is by no means specific to psychology as a science but to the investigator's psychology" (Droz 1984).[1] In the scientific context, observation must also meet certain communicational criteria, i.e. satisfy scientific, disciplinary, technical, and linguistic conventions. Earlier results and accepted paradigms direct research in each discipline and determine certain expectations and therefore the investigator's observational disposition. Watchfulness with regard to possible falsification is therefore an important feature.

However, the influence of pre-existing theoretical concepts on observation has already been discussed in a controversial manner. Heidelberger (2003) identifies three approaches to what is often referred to as theory-ladenness. A first approach presupposes that it is ultimately possible to obtain information by observation without any underlying theoretical concept, but such observations of a phenomenological order would be "of little use". An observation must therefore serve to produce an *explanation* via a causal relationship. Conversely, Duhem (1906) identifies two stages in physics. The first is limited to a straightforward observation of fact (which still requires an observational protocol to be put in place) and the second stage is given over to interpreting observations, which requires knowledge of the "recognized" theories and their application, but the observation is not supposed to provide an explanation of the phenomenon in question. For Duhem, the second stage relies essentially on an "abstract and symbolic" transcription of the observation. He argues that for less mathematically-based sciences, the observer may rely on "common sense" to develop a deeper analysis of the observations. The third approach refers to the work of Kuhn (1970) for whom previously defined theoretical concepts—*paradigms*—are essential for performing any scientific observation. However, since scientific observations are then conditioned by the paradigm, the scientific context influences the observation directly.

Even if these approaches diverge, it can be "observed" that observation is never passive. Each observer is involved beforehand in the design of the measuring instrument or some observation protocol and afterwards in collecting, exploiting, and interpreting the results of the observations (Van Fraassen 2000). It is obvious that this approach requires prior knowledge or an intuition that is involved at the time the measuring instrument is devised. Such implicit knowledge leads to the formulation of hypotheses that are confirmed or invalidated by observation. This applies also if we design an interview protocol or survey questionnaire, because they must be constructed so as to serve in acquiring the knowledge in question. Moreover, the observer is also involved in collecting

1 The French tradition of epistemology from Comte to Bachelard is clear on this point: mathematization makes it possible first to limit the investigator's psychological idiosyncrasies in her scientific work and second to limit the collective circulation of such idiosyncrasies by generalizing an unambiguous communication.

data and will define a processing protocol. This protocol corresponds to a certain methodological conception and it rests on hypotheses such as the validity of certain statistical tests (cf. below). As Bunge (1984) also notes, "objectivity" is ultimately ensured by conventions among investigators stipulating they avoid as far as possible adopting any personal or emotional position. For example, observers must consciously eliminate any unpleasant memories of an earlier experience or any association with a negative human experience at the time an observation is made (which presupposes an awareness of them).

In the spirit of first-order empiricism that considers only objects that can be directly perceived by a "knowing subject",[2] the use of measuring apparatus comes down to placing a device between the phenomena to be studied and the observer. Thus the observation becomes *indirect*. The direct character of an observation is related to the direct access to the information through the senses, that is, to make a direct observation is to extract information by means of our senses. Within this narrow meaning of empiricism, an object is observable insofar as it might be observed with our unaided senses.[3] For example, if we could move closer to the remotest stars we would be able to see them. Conversely, objects that only manifest themselves through indirectly recorded signals such as physical particles appear to be theoretical entities.

This is true also for research that examines the *reasons* for an action,[4] because the reason cannot be directly observed—either we extrapolate it through the interpretation of an action or we proceed by questioning. In this case we ask an individual to think about themselves, and therefore their own past or present behaviour, and possibly interpret it. This approach is called *introspection* (cf. below). Through the survey statements, then, we collect only indirect information.

In addition, it must be borne in mind that whatever the nature of the observation, it is invariably made in a restrictive context because a camera, for example, covers only a part of space and records only a certain colour spectrum, and so on. This argument holds also for direct observation because our senses are limited, too, to our field of view, a certain time of observation, a certain range of colours, etc. In this sense an observation is always instrumental in that it instrumentalizes perceptive interactions (1) through instruments that are better equipped than our own senses; (2) by arranging representations and coordinating them in a cognitive pattern; the information collected will therefore always be incomplete.

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2 An observer who already has some knowledge of the observational context, for example to design measuring apparatus and then derive scientific benefit from the observation.

3 Notice that logical empiricism distinguished through the concept of observational language objects that are directly accessible to our senses from those measured by devices that are described by theoretical language.

4 It can be emphasized here that "reasons" become purely theoretical entities, like the subconscious for psychoanalysts. In this context the individual remains the "informant" or the device that seems most suitable for collecting this type of information.

A more moderate form of empiricism considers that an indirect observation is useful but corresponds only to an extension of our senses, a sort of technical re-adjustment. What is observable is therefore what can be perceived by the senses or their possible extensions. These two points of view are based on the causal theory of perception which considers perception and observation as one and the same thing: to observe is to perceive, as a result of a causal chain leading from the entity observed to the observing subject (an object that absorbs electrons and reflects light, that strikes our eye and is then transformed into chemical and electrical inputs that cause certain neurons in the brain's perceptual zone to fire). To put it simply, observation is not limited to perception (even if perception is necessary for observation up to a certain point) because the causal theory of perception, based on our understanding of the physical mechanisms of perception, fails to give us to understand what it is about a neuronal impulse that leads to a representation (Agazzi and Pauri 2000). Perception is an opening, a physical opening to the world; observation is an intention, an oriented perception.

Shapere (1982) proposes splitting the observer-observed system into three parts to be theorized so as to make a successful observation. But we are entitled to think there is no need to have a clear awareness of the workings of the observational system in order to observe, just as we do not need to master optics in order to see. Even so, any observation puts into perspective three theories simultaneously: *emission/transmission/reception*. In the case where we observe an everyday object, we shall say that the object *is* such and such a colour, that we are able to say so because certain conditions of visibility prevail for our visual apparatus (short-sightedness, colour blindness, sunglasses, etc.) and for environmental parameters (distance, luminosity, etc.). Thus we presuppose a degree of homogeneity between theories of emission and transmission. We take it for granted that the book really *is* blue and that this reality is *immediate*; and that we rely on our eyesight so long as certain known conditions are met to validate our observations, which is also essential as a hypothesis for the hard sciences, otherwise it would be impossible to read and use any measurement result.

Two types of action can be identified in the observation situation described by the diagram below: (a) the dispositions of the object to be observed are defined and applied to an artificial concrete system, i.e. it acquires a degree of "observational performance" by conceptualization and manipulation; (b) the observer determines the objective and appropriate methodology. The general conditions of observation are defined and applied to a concrete situation.

By way of a summary, we attempt to come up with a general diagram to identify the various stages of scientific observation by drawing on Bunge (1984). The diagram emphasizes the active role of the observer at each stage.

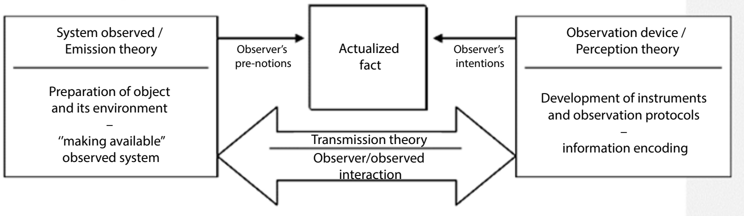

Figure 1—The observer–observed system (Chapuis after Shapere, 1982)

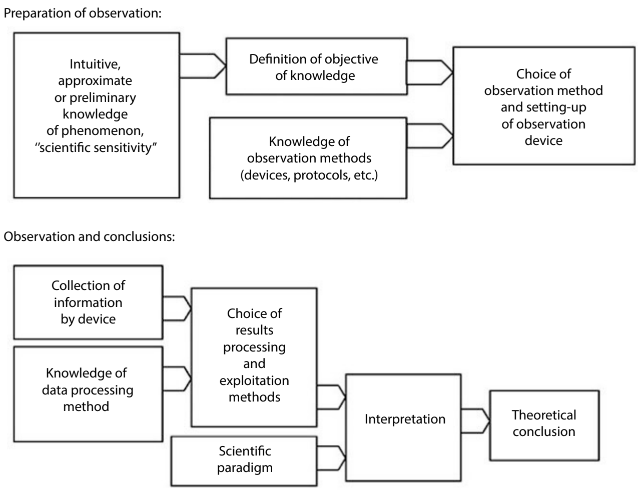

Figure 2—Observation schema (Frankhauser after Bunge)

2.2 Standardized conditions, reductionism and the notion of law

Observing in accordance with a defined protocol does not mean a priori that we obtain the same results by making an observation several times over. However, the hypothesis that there are a limited number of eternally valid fundamental laws, advanced by positivism as developed especially by Auguste Comte,[5] has implications that extend further. By this hypothesis, each observation of a

5 By the positivist approach the formalization of scientific laws in the form of mathematical relations replaces the idea of causality.

phenomenon subject to this law must also be consistent with it.[6] This implies that observational conditions that are comparable enough should yield similar results. This relates to the *invariance principle*. So measuring instruments or more generally observational devices must also serve to repeat observations under comparable conditions, meaning that the observational device reacts to the phenomenon to be observed identically and that samples are taken and results processed in a genuinely identical way. These requirements correspond to the concept of standardization of observational protocols already referred to, but they go further than that. The purpose is to control observational conditions while making them vary in a predetermined manner so as to progressively extract "general laws" that cannot be observed directly. These laws correspond to abstract concepts such as the laws of conservation in physics that are brought into relation with certain mathematical properties of symmetry. This approach, that is referred to as inductive, attempts therefore to move from the individual observation towards general knowledge.

The objective is, through knowledge of such laws, to make it possible to reverse the logic, that is, to predict what will happen if a system is put into a particular situation, in what is called a deductive approach. In the extreme case, it is considered possible to predict phenomena that are so far unknown, which assigns to fundamental laws, in a way, an almost absolute value. This is then purely deductive thinking that might recall non-empirical rational reasoning.[7] Such thinking is distinct from such an approach, however, as it accepts that this theoretical approach may be falsified by an experiment; thus we come back to observation.[8]

The search for sufficiently comparable results and reproducible ones is at the origin of reductionism. The reductionist approach seeks to create an artificial observational environment for the purpose of reducing as far as possible interactions that are judged unpropitious for observation of the phenomenon in question. Such an observation usually requires preparation of the observational situation. Such preparation is aimed at a particular objective in terms of arrangement of the components of the situation, including the composition of the entities observed.

6 This approach that isolates the object being measured from its "usual" environment is referred to as reductionist.

7 Thus particle physics (developed by Pauli in the 1930s) predicted and so "required" the existence of the neutrino because the law of conservation of energy and the law of angular momentum so demanded.

8 Remember, though, that in the case of microscopic scales of quantum physics, such observations are purely indirect requiring highly complex observational equipment. The history of science also contains many examples (including recent ones) of investigators who were "disappointed" by the results of their experiments because they failed to come up to their expectations which were consistent with the theoretical concepts accepted at the time by the scientific community.

This holds also when it is not possible to conduct experiments, for example in astrophysics where the objects in question cannot be manipulated. Similarly the concept of *systematic observation* in experimental psychology or the approach to *praxeology* that is limited to a remote observation of individuals submits observational conditions to a strict protocol. Even if direct manipulation is not possible, these approaches share the common feature with the experimental approach that they tend to control interactions in the observation system. On this point we can draw on the "experimental reasoning" defined by Claude Bernard: "To reason experimentally we must generally have an idea and invoke or provoke facts, that is observations, to check this preconceived idea" (Bernard 1966 [1865], p. 50). Thus defined, experimental reasoning is not limited to artificial adjustment of the apparatus and the object of the observation. It is characterized more essentially by "making available" the observation system *with a view to having certain conditions act on the results obtained*.

Let us recall that the concept of general laws is not limited to the hard sciences. In introducing sociology as a discipline, Comte defined as the objective "the positive study of all fundamental laws specific to social phenomena". Similarly Durkheim emphasized the need for a "positive" approach for which "it is always a matter of discovering the general law of sociality" (Durkheim 1887/1888). The canonical example of his approach features in his work on suicide: social facts must be objectified so that they can be extracted from common sense. This radical break is made using *statistical tools* that make it possible to go beyond the specific conditions of the multitude of social situations to extract social facts from them. By this token, Durkheim moves away from the strict conception of Comte's positivism insofar as he conceptualizes social laws as general regularities.

The resort to statistical methods has greatly influenced the epistemological debate. Comte radically opposed the use of statistical methods or probabilistic approaches, unlike Bayes, Condorcet, and Laplace (cf. Engel 1999). As Engel shows, the refusal of these approaches goes along with the critique of introspective psychology because "the first like the second are unable to go as far as true laws".

However, even in physics, the standardized conditions of experimentation or observation do not guarantee that exactly the same results are always observed. Various phenomena that cannot readily be controlled may be involved. Statistical theory has provided criteria for evaluating such influences. Things are based on a series of data for which the mean and deviations from the mean are calculated. If these deviations obey Gauss's law, they are distributed "entirely randomly" around a mean and are referred to as "noise". This reveals there is no other dominant phenomenon than that we consider under given circumstances of observation. In this case, the "central limit theorem" indicates that the mean is the value that best describes an observed reality if it is calculated from a number of observations that tends towards infinity.[9]

This type of reasoning has also become a reference in experimental psychology which has its origins in the psychophysical approach of Fechner, Wundt and others of the time (cf. Engel 1999). Quetelet (1846) introduces the paradigm of the "average man" referring directly to the concept of the mean and Gaussian noise.[10] Later on, behaviourism was to adopt a highly naturalist point of view which is part of positivist logic and rejects recourse to introspection.

The naturalist approach, especially through the work of John Stuart Mill and Ernst Mach (1896), highlighted the probabilistic approach in psychology and not just in the sense of "eliminating noise". Thus Mach "admits the existence of laws that are only statistical generalizations relating to the statement of special circumstances (what are now called *ceteris paribus* laws) and admits that such laws may well hold in psychology, sociology and the moral sciences in general" (Engel 1999). The "statistical law" is thus opposed to the concept of the deterministic law.[11]

Control or at least good knowledge of the circumstances of observation or experimentation is therefore also an element that is highlighted in observations in experimental psychology. Different situations are generally distinguished. Systematic observation follows a precise protocol without putting the person observed in any particular situation—which does not exclude the person being aware they are being observed (cf. below).

Approaches based on observation often explore the relation between behaviours and certain circumstances revealed through statistical analyses (correlation). Such an approach is also used in praxeology which focuses particularly on the study of sequences of acts (Alexandre 2003).

Let us emphasize that control over the conditions of observation is easier to achieve if there are few interactions with the environment liable to influence the result. Such interactions are less of a constraint if there is a clear hierarchical

9 The observational apparatus extends therefore to the interpretation of observational data. Observation is thus also made on the information collected and is not limited to a key moment or perception (idea of a miraculous observation that instantly throws up knowledge).

10 Thus in economics, the concept of utility is initially based on a deterministic approach that is consistent with Comte's positivist logic, which may seem surprising given the somewhat probabilistic approach of Mill, one of the illustrious representatives of the concept of utility. Thurstone's criticisms referring to Fechner's work were at the source of the concept of stochastic utility that assumes a Gaussian distribution around average behaviour (cf. chapters 9 and 10).

11 Economists have thus posed the question of "determining the origin of this probability. Is it a reflection of individual behaviours that are *intrinsically probabilistic* or does the description in probabilistic terms reflect the *model maker's inability* to precisely apprehend individual behaviours" (De Palma and Thisse 1989). Those authors establish a connection with quantum mechanics.

arrangement of phenomena. To give a simple example borrowed from physics: the movement of the Moon is influenced by the Sun and planets, but it is the "first order" effect of the Earth that dominates. In physics, the interaction between the observational device and the object under observation is generally greater when they are both on the same scale. Thus optical geometry is a valid approximation so long as we do not approach the scale of electromagnetic waves which, by contrast, give rise to diffraction and diffusion phenomena.[12]

In the social sciences such a hierarchy seems more difficult. In experimental psychology attempts are made to reduce the influences of different factors liable to alter individuals' behaviour through putting things in situation in a laboratory context, which is similar to the approach in the hard sciences. The advantages are the control of circumstances and therefore the reduction of complexity, the possibility of varying certain factors (conditions) and exploring their influence on behaviour and of controlling ambient variations. It is thus possible to study causal relations between circumstances and behaviour, unlike what happens with straightforward correlation analyses.

It seems important to make a distinction concerning the control of observational data: a priori control of the observational conditions will serve to define certain relative aspects of the object and an a posteriori numerical control can be used to identify and delimit the importance of negligible aspects. For example, in an interview designed to measure the impact of the weather on emotions, it is obvious that "the present weather" is a *relevant and non negligible* variable of the observation system. However, in an interview about emotions relating to different places in which someone has lived, it will be assumed a priori that the influence of the weather on responses is negligible. This does not dispense with identifying the impact of this variable a posteriori as need may be. These two control options share the common objective of delimiting the relevant or marginal aspects of the object we wish to observe. It is therefore a question of identifying relevant aspects to be observed and the relative importance of negligible factors. This comes down to the hypothesis that standardization of the observation makes it possible to marginalize certain effects and to return implicitly to a degree of hierarchical ordering of phenomena. Accordingly it seems possible to reduce influences arising from the respondent being in a different emotional state during a second observation, from the interaction not occurring at the same time and in the same weather conditions or with the same arrangement of participants, and so on.

Studying the influence of circumstances on a situation observed provides an incentive to repeat an observation in defined conditions. Even if it is difficult or even impossible to claim or check that an individual is really in a "comparable

12 This is why it is said that classical mechanics corresponds to the same approximation of quantum mechanics as that characterizing the transition from undulatory (wave) optics to geometrical (ray) optics (the eikonal approach).

situation", it can at least be checked whether the answers they give, for example in an interview or survey, are consistent with earlier answers. Easterlin (1974) gives a glimpse of this in different studies designed to check the "reliability" of answers through a "test-retest" procedure concerning the feeling of well-being. Various studies show "remarkable" stability of the responses both if the test was repeated after a short (a few days) and a long (several months) lapse of time.

Application of a statistical approach with sufficient repetitions of an experiment and associating a large sample of people makes it possible to adopt the stated logic of searching for a "statistical law".[13] However, one must be aware that the individual faced with such an artificial situation feels constrained in some way or other and that may influence their behaviour without that influence necessarily becoming observable.

2.3 The limits of reductionism and observer-observation interaction

The reductionist approach implies that it is possible to design experimental conditions that can isolate a single or possibly a controlled number of phenomena that come into play and largely dominate the results obtained. This type of reasoning is only applicable in cases in which it is possible to reduce or largely control interactions between the phenomenon observed and its environment. But it is not always possible to isolate a phenomenon from its environment and indeed may not be helpful. Thus reductionism in its elementary form has run up against limits in many observational contexts.

In physics, for example, the diffraction of light or certain phenomena observed in open systems are directly related to interactions between a system and its environment.[14] On the microscopic scale of elementary particles studied in quantum mechanics, the role of interactions becomes fundamental as it is impossible to dissociate the object under study from the measuring instruments. The two must be thought of as an inseparable entity and reading the result is not a neutral action because it acts directly on the measurement. An example is the paradox of Schrödinger's cat in which quantum logic is applied to a macroscopic system. We shut a cat up in a box and trigger a device that poisons it by a random phenomenon in much the same way as we record radioactive decay. From the point of view of quantum mechanics, the cat is only dead when we open the box (observation), because before that the system is in a mixed state in which the cat is alive and dead with equal probability.[15] Seeing that the cat is

13 Notice that with observations in physics, it is likewise impossible to re-create identical observational conditions in the narrow sense. We simply re-create a situation which is assumed to be equivalent with respect to the phenomenon we wish to observe (which implies a number of hypotheses).

14 This is particularly so for phenomena of structural change such as phase transitions.

15 The line of argument is perceived as truly valid because the cat's death results from a microscopic process. It may be interpreted more obviously: if we have a set of boxes

dead is what is called preparation of the system, only interaction with the observational device defines the state of the observed system. Thus the three stages of "emission, transmission, and reception" identified by Shapere (1982) are closely interrelated. The reason for these paradoxes flows from the fact that there are "non commensurable" variables in quantum mechanics, that is incompatible variables that cannot be precisely measured together. Thus it is no longer possible to "measure A and B jointly". These findings annoyed scientific theorists especially those who subscribed to positivist thinking and those who claimed to be logical empiricists.[16] Thus the Vienna Circle started from the assumption that the natural sciences were free from any logical contradictions. In order to remove the inconsistencies throw up by quantum mechanics, they proposed to characterize "measure A and B jointly" as *meaningless*, and therefore as false by their terminology. Carnap, a logician of the Vienna Circle, proposes several avenues for finding a solution to what remains an absurd observation for our usual experience. Let us mention the one of those avenues that consists in altering the means of transition from one law to another that should be made more flexible (Birkhoff and von Neumann 1936) and Reichenbach's (1949) proposal[17] to introduce ternary logic which distinguished not just the logical values of "true" and "false" but adds a third "indeterminate", "neutral", or "intermediate" value. An experience for which we measure A would have as its intrinsic consequence that B is indeterminate. This should be seen as a first step towards the introduction of "fuzzy set theory" by Zadeh in 1965 the value of which for the social sciences shall be addressed in chapter 10.

In the social sciences, observer and observed are always on the same scale, which is that of direct observation,[18] even if we use recording instruments (recording of an interview, video recording of a crowd, GPS, etc.). Hence it is unlikely then that we will be confronted with the same type of logical contradictions as are found in physics and that are specific to scales remote from our scale of direct observation. It is obvious, though, that the psychological relation between observer and situation observed takes on a particular dimension in the social sciences whenever there is a direct exchange of information between observer and observed.[19] Such interaction may play an equivalent role to that observed in quantum physics. Thus, in an interview, the emotions expressed by the interviewee or interviewer may influence the other's reaction and so condition

containing the device, the quantum probability would tell us (by a frequentist interpretation) in what proportion of boxes the cat would be dead or alive.

16 This school of thought is also termed "logical positivism", "neo-positivism" or "rational empiricism".

17 Reichenbach came up with the expression "logical empiricism".

18 Explanations for phenomena observed on scales less than that of humans are not sought in the social sciences, unlike in life science.

19 In the hard sciences, direct observation (e.g. a falling object) or generally indirect observation by instruments (telescope, video camera, etc.) do not trigger a psychological reaction on the part of the object in question.

the outcome of the observation. Moreover, the interaction with the interviewer causes a reaction anyway for the interviewee because each answer is an act for her; she is forced to take a stance, which may change her attitude and/or behaviour.[20] Managing such interactions seems in principle possible, but requires that both the interviewee and interviewer are aware of the risk that is beyond control.

Such an influence may have a non-negligible effect not just in interviews or surveys but even in the "controlled" context of experimental psychology. Droz (1984) explains that "an individual who comes under observation changes status consciously or not with regard to himself or the other. He is no longer just a subject, but also an object". He recalls that "observation (…) is always made in a complex context: that of the situation and that of the observer's conscious or unconscious attitudes". It is inevitable that "the observed makes an interpretation of the situation. This interpretation escapes almost entirely from the observer because (…) the observed only restores the share that seems appropriate to the situation". Thus the observed may suppose—perhaps wrongly and unconsciously—that there is a certain expectation on the part of the observer. This may lead the observed to reply in such a way as to satisfy the investigator or to give an image that seems consistent with their attitudes and social norms, corresponding to what is called "social desirability" in psychology (cf. Davis 1965). The influence of investigator's expectations of a response has been studied systematically (cf. Rosenthal and Rosnow 1969). Barber (1984) speaks of "involuntary expectations" that are part of the "experimenter-introduced bias". It has been shown, for example, that a closed questionnaire can increase "social pressure" on the respondent compared with the use of an open, self-administered questionnaire, but this is not systematically the case (Wilson 1967). There is no "rule" for predicting how a respondent will interpret a "social norm" because the mental references are not the same for everyone (Easterlin 1974).[21] In the case of direct exchanges with the observed, it might be supposed, pursuant to commitment theory (Kiesler 1971) that the observer will try to avoid disappointments by playing on the drafting of protocols without consciously wanting to "cheat". Investigators are "looking for logical coherence" in their actions. They may also be tempted to list only the respondent's positive characteristics ("generosity effect") or to show empathy with the respondent, which may also influence the interviewee's attitude and the interviewer's.

Whatever the situation, the observed's "mental system" is therefore "prepared" within the meaning of quantum mechanics by the very act of observation.

20 It will be recalled that the two notions are separated in cognitive psychology. Attitude is in a sense a predisposition to act in a certain way and cannot be observed directly, unlike behaviour.

21 Easterlin (1974) mentions another potential bias in the order of the questions. A certain question asked before another may direct the respondent's thinking and change their attitude with respect to the question's contents.

Even so Droz (1984) nuances this point. He thinks that there is a difference in the sense that in quantum mechanics, the interaction between the measuring instrument and the object measured is intrinsic, unlike what happens in psychology. He emphasizes that in psychology "the problem is reduced, in some sense, to an affective problem that could probably be resolved by good will or where necessary by appropriate therapies". However, Goffman (1973a) disagrees. He sees social life as a stage: we are always performing, in a play that constantly implies the other is watching (even the prompter who whispers our lines) and which is interiorized even behind the scenes in our personality, where self-control takes over from the audience watching us, and we are no longer the object for others but for ourselves, thus ensuring a permanent social control. Observation is an intrinsic dimension of social interaction—the situation of sociopsychological observation is just one way of making it explicit (and linking specific constraints with it). Thus the concealed observation, if it does not occur in a context in which the person thinks she is isolated and unobserved, therefore only makes it possible to change the situation and observational bias, not its influence on the information collected which is inseparable from social interaction, and observability is thus an essential characteristic of social interaction. If we begin then with the principle that interaction is an a priori phenomenon, then the probabilistic character of the results obtained from observations in psychology would seem to be the expression of a priori indeterminism and not just of imperfect observation. We are approximating, then, the view point of quantum mechanics for which the result of an observation is a priori unpredictable.[22]

Recent results in neurology make it possible to trace certain simple decision-making processes in part. It turns out that humans may only become aware of a decision after it has been made in the central brain (Soon et al. 2008, see also chapter 10 and chapter 5).

Depending on the intensity of the interaction between observer and observed it seems useful, however, to distinguish three situations:

– The first situation is one in which the observer does not participate in the unfolding of the process and is not known as such to the subject. The subject, not feeling observed, supposedly behaves naturally. This position is generally considered ideal but is not always possible.

– The second position implies that the observer takes part in the event that unfolds but is not known to be an observer. She conceals her identity in a way, but must act with skill because she may be led to play a part, unwillingly, that might influence the outcome of the event (Festinger et al. 1956).

22 Remember that by this theory for each potential outcome of an experiment only a probability can be indicated, contrary to what happens in classical thermodynamics where the use of a probabilistic approach is only the expression of a lack of access to information, which does not detract from the supposed deterministic character of the phenomena in question.

– For the third position, the observer takes part in the collective action and is perceived by others as an observer. She asks questions, goes into the subjects' personal lives and drives the investigation forward depending on her research objectives. This third situation necessarily influences the observation but the observer may remedy this in part at least for example by concealing or shifting the true objective of her action.

In order to reduce the artefacts mentioned it is also possible to attenuate the observed's fears relative to the observer's expectations by establishing at most a *trusting relationship* between observed and observer. In this sense, it may appear preferable to conduct an interview at home rather than in the laboratory. But in other instances, the opposite might be the right solution, being aware of potential interaction, for example the influence of the interview location, we work this into our observational approach. The investigator must, though, avoid falling into the trap of taking an empathic attitude or more generally showing any emotional reaction.

However, as Easterlin (1974) points out about studies of the relationship between income and well-being, such bias does arise but is not sufficiently significant to invalidate the findings. He specifies, "Perhaps the most important basis for this judgment is the impressive consistency of the results in a variety of times and places with widely differing cultural and socio-economic circumstances".

Epistemologically, it also seems clearer to speak simply of a *conditional observation* in which observer and observed form a common system. As Droz (1984) states, "as the observer-observed pair is made up (…) of human beings, the study of the psychology of interpersonal relations becomes for the psychologists not just a field of knowledge but moreover a source of methodological inspiration (if not of norms)".

2.4 The utility and limits of introspection as a method of observation

It is possible to collect information about the affects found in a certain situation without making direct contact with the individual because at least basic emotions can be identified from facial expressions (e.g. Haidt and Keltner 1999). So, by confronting an individual artificially with a specific situation without her being aware of it, we can observe her reaction. However, such an observation does not mean we can discover the deeper causes of the reaction since different kinds of anterior experiences or imagination may be at the origin of the reaction. Likewise it is impossible to collect direct information about the path taken by the thoughts and reflections that precede the decision or the affects with which the people involved have been confronted and may have influenced them. But how is it possible to collect information about effects that are not observable by our senses or instruments?

Here we address a question that plays an important part in epistemological stances in psychology. Behaviourism, for example, concentrates on the behavioural consequences of allowances for influencing factors, considering the mind to be a "black box" that is inaccessible to any analysis other than introspection, whereas cognitivism seeks to discover how individuals transform the information obtained from stimuli (Moscovici 1972). Even if the cognitivist approach remains rooted in the natural sciences and especially neuroscience, it rejects a reductionist approach that would reduce mental states to bio-chemico-physical phenomena. As Steiner (2005) states, "from the cognitivist point of view, the mind is therefore of a material nature (…) but also possess a conceptual or logical autonomy; that autonomy supposedly makes it possible to study it in terms of description relating solely to the function of mental entities". This mind-based approach is therefore based narrowly on "assertion of the importance of strictly internal processes, which are both real and autonomous" (Andler 1992).[23] However, as Steiner (2005) also clarifies, cognitivism too rejects introspection which it considers "hardly objective". Thus cognitive psychology generally gives precedence to observational methods from experimental psychology and tends to use computers as tools for exploring cognitive processes.[24]

In economics the question of knowledge of preferences for a good and therefore the decision to buy it necessarily play a crucial role. The economists' approach relates directly to the idea of utility, which is related to the idea that people act to improve their well-being—which fits perfectly with the situation of residential choice that interests us. Various methods have been studied to ascertain the utility that individuals associate with certain actions, such as the acquisition of goods (cf. chapter 9). Bentham (1789), one of the theorists of the utility concept in the eighteenth and nineteenth centuries, associates the concept of utility directly with a "happiness principle". For him it is a definite quality of sensation or feeling identifiable by introspection which Kahneman (1994) terms "experienced utility". Note too that Mill accepted introspection in the sense that thought is not directly observable and introspection the only means to access it. This concept was challenged subsequently by highlighting that hedonic subjective experiences are not directly observable and the concept thus has cognitive, social, cultural, and other limits. Indeed inconsistencies are often observed between individuals' stated preferences and actual behaviour (Gärling and Friman 2002). Economics has thus turned towards a rather behaviouristic approach (Loewenstein 1992). It has given precedence to an approach corresponding to the concept of revealed preferences or decisional utility which is based on observations of acts performed and inferred via rationalistic hypotheses. It is assumed then that the acts reflect individual optimality. Accordingly it is enough

23 Accordingly cognitivism follows the rational of complexity theory.

24 There is a close articulation between the cognitivist approach and computing, as computers are perceived as tools with which to explore the workings of the mind via simulations.

to restrict oneself to observing choices to determine utility ("results utility") because it is assumed that utility and choice are perfectly (and unequivocally) matched.[25]

Kahneman has criticized this approach and contradicted the argument that it is not possible to observe experienced utility (Kanhneman et al. 1997). He introduces two complementary concepts: the instant utility function and remembered utility. The first is utility as felt by an individual at any point during a sequence of events and that she is asked to note. The second refers to an overall a posteriori evaluation by the individual. It is observed that the maximum values of instant utility and utility felt during the very last period of the experiment determine the overall evaluation, which is not therefore the simple mean value of instant utilities. This shows that the unfolding of the experiment affects the evaluation. Kanheman et al. (1997) deduce from this that an individual may expose herself to an unpleasant situation because the remembered utility may abstract away a particular situation. So decision-making utility is not the same as experienced utility and does not necessarily correspond to an optimization principle.[26]

The neuro-economic approach highlights the point that it is possible (at least in the long term) to obtain information about cerebral processes that inform us about the way individuals go about making evaluations and decisions. It has thus been possible to ascribe different utility concepts to the activity of different parts of the brain (Camerer et al. 2004).

As our objective is to identify the processes that lead individuals to take decisions and put them into action (e.g. move house), neither behaviourist nor cognitivist approaches seem to give us detailed enough answers in as complex a decision-making context as the one under study here. It is certainly not possible to directly observe the conscious or unconscious aspirations and intentions of an individual that impel her to act or prevent her from acting. Mere observation of an act is not enough to ascribe *a single intention (or reason)*. If it is accepted that the act has a hierarchical structure in which several levels are nested, low levels comprising mainly gestures, movements, trips, and high levels comprising intentions, purposes and ends of the act (Vallacher and Wegner 1985), we are led to think that the entire structure of the act is not equally observable. Two individuals with opposing intentions may carry out a similar low-level act. For example, going into a shop may be motivated by the wish to buy something or the intention to rob the shop. It may also be that the person prefers to buy the product from this particular shop because they have a soft spot for the shop assistant. This simple example highlights the problem of exploring the relation between acts (behavioural statements the empirical dimension of which is not

25 The hedonic approach underpins the major studies presented in chapter 2 on the weight of the various factors that determine residential *choice.*

26 Kahneman's approach refers to observations made under standard conditions such as are used in experimental psychology.

especially problematic) and intentions (psychological statements relating to states of awareness, the empirical dimension of which is problematic).

Even if the neurosciences provide most interesting and promising results as seen (cf. chapter 5 too) it seems difficult to obtain information about all of the brain processes that contribute to making so complex a decision as to move house. Moreover, Kahneman's reflections show that, generally, the way individuals live an experience may condition the way they evaluate it and make decisions. Moreover, it seems materially unlikely that we should have the opportunity to observe—whether directly or indirectly—individuals *at the time they make so rare a decision* as to move home.

This prompts us to consider something of a reverse approach: the presence of an observer over a period of time that is not perceived as inconvenient might inform us directly about this phase of decision-making. This is the opposite approach to reductionism since it comes closer to *immersion*, a method used in anthropology and sociology. However, because it is a decision taken individually or in a family context, this seems impracticable. It seems ineluctable then to look at observation methods based on introspection while remaining aware of the associated difficulties.[27]

So we begin from the principle that if we wish to know the intention of an act and if the intention is revealed by the meaning the individual imparts to the action, we are then entitled to give credence to *what individuals have to say about their actions*, especially the *whys and wherefores* of them. Obviously there is no assurance that the actor herself is fully aware of the intentions behind her action. There is even no assurance that all actors are not submitted to a law of silence, or a form of collective conditioning that prohibits them from saying or even thinking about the intentions behind their actions. We must then not seek to observe intentions but to consider intention as a general hypothesis, an overall model of human action (consistent with modelling perspectives) that conditions observability. On this point and following the principles of comprehensive sociology, Weber claims that significant interpretations of concrete behaviour are never as such, even in the case of the most "obvious" but mere hypotheses based on imputation. It is essential therefore to subject them to all possible verifications, to have recourse, in principle, to the same means as those we use about any other hypothesis (Weber, 1904–1917).

If introspection as a method of acquiring knowledge has come in for criticism it must be recalled that the concept has evolved considerably over time. In the early nineteenth century the notion referred to reflections advanced by individuals on certain subjects and not on matters of "common sense" (Vermersch 1999). Criticism was aimed at it being impossible for an individual to be both observer and observed. In addition, Comte had pointed out that introspection

27 Some authors who are interested in residential choice propose combining the stated and revealed preferences approaches (e.g. Earnhart 2001).

"modified the object it was directed toward". Given what we have observed about the limits of reductionism—and in physics too—this argument is to be relativized. In addition, in the early twentieth century the way resort was had to introspection changed. Binet, who played a fundamental role in the development of psychological research in France, defines introspection as "the act by means of which we perceive directly that which takes place in us" (Binet 1894 cited by Vermersch 1999). The content aimed at by introspection therefore changed. Moreover, Janet and Binet suggested individuals should use *retrospection*. In this way the act of observing is dissociated from the object being observed which precedes the observation. However, as Vermersch (1999) points out retrospection requires "reliability of memory and the necessity of establishing the nature of the link between what is described a posteriori and what is lived at the very moment the former is being described".

The next stage is therefore the "physical" separation of the observer and observed which obviously introduces the problem of interaction between observer and observed already discussed and that Vermersch summarizes thus: "The influence of observation on what is observed is a major epistemological problem, but it is a problem which extends throughout the sciences".

From the early twentieth century onwards there developed a methodology that fitted in with the rationale we encountered in experimental psychology. We speak of systematic introspection or experimental introspection. Specific tasks are defined and a sample of people is asked to perform them.[28] This approximates then to the logic of experimental psychology and implicitly the idea of "statistical law". One important point and that is still current is the orientation of the respondent towards "the description of the subjective experience itself as opposed to the reality evoked or any second order commentary" (Titchener 1912 after Vermersch 1999).

The question is also raised of the extent to which people observed should be trained beforehand for such an experience, but it is obvious that this makes them less spontaneous and substantially increase the risks mentioned of conscious or unconscious manipulation by both observer and observed.

For Vermersch (1999) the results obtained by introspection in Titchener's time were somewhat "disappointing" and "meagre" because there had not been put in place "a supplementary stage which philosophers call 'meta-reflection' (Misrahi 1997)".[29] Still according to Vermersch it proves necessary to take account of an include in the scientific approach several stages during introspection. If the subject performs a task in a first stage t1, he will describe the lived experience (L1) of this task at a second time t2, which gives rise to a second lived experience (L2) by bringing the initial experience to consciousness "which

28 These methodological works which diverge in part are used essentially by three schools of thought, the Paris school under Binet, Titchener at Cornell (USA), and Külpe and others at Würzburg in Germany.

29 A current reflection on an earlier one.

transforms the act which I accomplish (…) into an object for my attention". There then arises a third stage at t3 "directed at the act of introspection carried out at L2". So for Vermersch "the content of L3 is the past accomplishment of [w]hat I did in L2. There has to […] have been an act of the kind which has come about in L2 in order for L3 to be carried through. In other words, one must first have practised introspection ([at] time L2) in order to make of it an object of study and so to practise an introspection of an introspection". Thus "In the second place a more or less durable vacuum is experienced" and "reflecting activity is a constituting activity, it creates new data on the representational plane ([…] which begins with a stage of reflectivity) and this creation takes time" because it "takes place by stages and in accordance with a rhythm which is different from that of reflected activity". In this approach the observed is therefore integrated in the observation process and in a way plays the part of a "measuring instrument" that transforms "the initial information in accordance with a protocol". The investigator's role remains important because she occasionally plays the part of mediator and must "master the techniques and deploy them in the course of the exchange". Vermersch is obviously aware of the interaction between observer and observed. He emphasizes that "the mediator is still bound by the limits of his culture, his pre-conceptions, his implicit blinkers, his unconscious projections". He concludes from this that "intersubjective regulation" with series of independent data is necessary.

Vermersch emphasizes that "The goal of introspection is to gather factual descriptions not to expect the subject to become knowledg[abl]e about his own subjective experience. In consequence, it seems completely out of order to ask the subject for explanations of what he did or to expect him to understand the causes of his behaviour". He specifies that in processing results it is therefore essential to avoid giving "the same weight to description that one gives to commentary, judgment, the spontaneous expression of theories". He insists in this context on the importance of suitable training for investigators.

We observe that the approach Vermersch proposes includes the "act of observation" directly. He therefore accepts a possible transformation of an earlier experience by the observed becoming conscious of it during the observation process and "operationalizing" an inescapable effect, which seems to be an effective and justifiable strategy.[30] Remember we have already noted for surveys of well-being that answers are stable for an individual compared with her evaluations if she is asked the question repeatedly (Easterlin 1974).

30 And which is reminiscent of the logic of acceptance of interaction in quantum physics in the sense of "system preparation".

2.5 The role of language in information collection

Language certainly plays a fundamental part in any research context. Communication among scientists, the definition of scientific concepts used, analysis of observational results, collection of information from observers or observed, all these involve language. Much reflection has been given over to the role of language in the context of research but it gained importance in the 1920s. First we shall consider reflections that may be associated with the Vienna Circle. Frege and later Russel, Wittgenstein, Carnap, and other representatives of this school of thought placed the analysis of statements at the heart of epistemological reflections by examining their logical value. They drew a distinction between analytical statements that are purely logical but convey no real information and synthetic or empirical statements that refer to "verifiable" observations. It should be possible then to translate any scientific statement into a universal language highlighting logical relations. But not all members of the Vienna Circle took up the same positions (Engel 1999). Wittgenstein, for example, was later to change what he had said and Quine, one of the last of the illustrious disciples of the Vienna Circle, dismissed the hypothesis that it was possible to make a hard and fast distinction between analytical and synthetic statements. Quine also claims it is illusory to want to construct a single and therefore deterministic symbolic language, meaning he renounces any ideal of translating psychological statements into physicalist terms (Engels 1999; Quine 1974). The translation of mental or intentional statements also remained indeterminate. As Engel specified "if an intentional psychological statement formulated in the language of 'propositional attitudes' in terms of mental contents cannot be correlated systematically with statements about organisms' behaviour or physiology, then nor can statements of the first type be translated into the second type", which fits in with our remarks about the fact that observation of an act does not provide incontrovertible information about the reasons for it. It arguably follows—by positivist reasoning—that mentalist psychology "cannot be a science" (Engel 1999). Ultimately Quine points to two possible consequences. Either we leave the floor to neurosciences alone by condemning intentional psychology, or we accept that "even if psychology cannot be reduced to physics, it formulates even so psychological laws and psycho-physical laws that while not strictly deterministic are nonetheless statistical and ceteris paribus laws" (Engel 1999). This brings us back to the notion of probabilistic laws in psychology to which we have already alluded.[31]

Although verbal communication remains therefore an inescapable feature, if we are looking, for example, to explore the results of introspection into the reasons or intentions behind an act, we must be aware of potential communication

31 In any event, advances in quantum mechanics have clearly shown that positivist determinism is no longer current in the sense of making unequivocal predictions.

artefacts between observer and observed.[32] Saussure was among the first to attempt to establish a coherent theory of language, which he did on the basis of a structuralist approach. The *signified* of a word is synonymous for him with a *concept* and therefore expresses the mental representation of some content.[33] He further distinguished between *signification* and *value*. Thus in different languages (which may also correspond to different social contexts) the semantic field may be narrow or broad, the meaning of a word may be the same but the value would then be different.[34] Language is therefore closely related to cultural context and so also to mental representations, which may also depend on the individual's personal experiences or social background.[35] Thus while the idea of kitchen seems comparatively straightforward, because essentially functional, the dividing line between "terrace" and "balcony" is less so. In evaluating a flat, the idea of "neighbourhood" may refer to spaces of very different extents and natures. Neighbourhood may be confined to a stairway or include an entire urban district. However, what matters in the specific context is not to know the meaning of a notion systematically but to know the role of the notion in evaluating the residential location or when deciding to move home. The meaning of notions can be pinned down regardless by additional questions.

Sapir and Whorf (cf. Hoijer 1954) go further because for them the grammar and vocabulary an individual uses influence her thinking, which may make communication between people ambiguous. This has prompted relativists to challenge the possibility of irrefutably defining concepts, because there is no way to check that two scientists associate the same content with a word, which also goes for investigator and respondent. Standing against this relativist approach is the universalist approach of Levinson and Chomsky. Chomsky (1975) works from the hypothesis that there is a formal language that must be thought of as a universal grammar and which, Fodor (1983) claims is an innate linguistic capacity allowing people to learn any particular language.[36] More pragmatically, it can be argued that if some other individual performs, in accordance with

32 Let us emphasize that in verbal expression, other aspects come into play, such as the sound of a voice that may be perceived as pleasant or unpleasant, intonation which may express, for example, empathy, the presence of an accent, and so on. These factors may be controlled by the investigator, which does not mean they are avoided. They may also be caught on a recording which, conversely, may make the respondent less confident (see above).

33 Which he distinguishes from the signifier that designates the acoustic expression of a word, specific to a particular language.

34 The meaning given to a word may vary quite fundamentally. In one survey we conducted, a question about "access to property" was interpreted by many respondents as "physical access" (path) and not the "possibility of purchasing property".

35 Moreover, it is also possible for the meaning of words and so possibly the content associated with concepts to change over the course of time, which has recently been confirmed by various analyses on spatial cognition, for instance (Majid et al. 2004).

36 Chomsky's approach is not to be confused with that of Frege and Russel because it remains critical of the purely logical approach of Viennese empiricism but also of behav-

my expectations, an order I give or identifies the expected object from among a set of graphical representations, then communication proves at least some degree of "performance" even if "communicative competence" cannot be verified (Chomsky 1971). This means that it is possible to give certain instructions to an individual and that a degree of intersubjective verifiability is possible if we limit ourselves to the observation of acts in given situations. Even so the more concrete notions are, the less is communication subject to problems of communication. Conversely, the more mental representations come into play, the greater is the risk of ambiguity. Notice besides that Chomsky accepts introspection if it is the "means of arriving at conjectures or conclusions only insofar as these can eventually be made sense of in terms of external observation" (Quine 1976). It is obvious that the same type of reasoning is valid for non verbal communication, because it too is conditioned in part by cultural codes or individual experiences.

As Vermersch (1999) points out, the discussion of language has entailed a focus on the collection of verbalizations and therefore on the *products* of introspection. As he observes, "in order to produce these verbalisations, the subject has to have access to something even to be in a position to describe his mental acts, the contents of his representations, and […], in consequence, he certainly does make use of a particular cognitive act". Accordingly a question in which a word is changed without altering the meaning will bring much the same answer. But extreme care must be taken for one thing because it is difficult to test this kind of assumption in the context of a classical survey (it would have to be repeated with various formulations) and for another because a number of investigations on this topic indicate a significant influence of formulations, especially ready-formulated answers, on the quality of responses. In our context it is admittedly important to explore the meaning (and values) the interviewee assigns to words, but this must be done through the context of situational reconstruction by stages in the way Vermersch understands it (see above).

Notice that beyond the meaning given to a word, respondents may choose to express themselves more or less precisely about a situation for various reasons. This may be the case when a respondent says something about the positions of other family members when deciding to move home—possibly to avoid revealing tensions within the family. They might say "he was *rather* in favour of the move" or "*I'm not sure* he was in favour of the move". We think it is important to accept such an expression because it informs us that the context was apparently unclear, but we suggest introducing the notion of *degree of precision* of a statement. This question is addressed in chapter 10.

iourism. Quine's (1976) hypothesis about the "indeterminancy of translation" is for that author consistent with Chomsky's approach.

3. Methods of observation and their contribution to the research context

The importance of emotions and earlier experiences in decision-making has been highlighted by the results of research in psychology (chapter 4) and neurosciences (chapter 5). In addition, the role of collective references is underscored in other chapters (chapters 2, 3, 6, and 7). In our context we are more especially interested in actual interactions among emotions, earlier experiences, collective references and the decision to move home. As our epistemological reflections have shown, this type of information is not directly accessible. It is necessary, then, to resort to methods of observation that enable us to know individual experiences in the decision-making context, which directs us towards methods such as *interviews* or *surveys*. However, there are a number of additional methods of observation in the social sciences apart from surveys and interviews that may provide other types of information about the influences of spatial practices and the emotions individuals feel and motivate their decisions as to residential mobility.

It is obvious that observation in the social sciences always requires certain precautions because the interviewee's response to the observational situation is sensitive to the circumstances of the observation (interactions among individuals, interaction between observer and observed, etc.) as noted above.

Since one of the objectives is to foresee the possibility of using such results in the context of preferably mathematical modelling of the decision-making process, the results should lend themselves to formal transcription. Epistemologically, the modelling we favour presupposes the existence of average—in the sense of "statistical laws"—behaviour alluded to and is not designed to recreate individual experience that aims at an explicit representation of all of the phenomena involved in decision-making and allowance for all of the interactions among individuals. This can be explained by the fact that our point of view is part of an approach that is interested not so much in the individual scale as in a semi-aggregated scale that puts forward the more general trends in a society (cf. chapters 7 and 9). It will therefore be a question of taking account of the suitable means for encoding the information collected. Table 1 recalls the encoding methods used in the social sciences in the context of surveys that appear to be suited to objectives of this type.

We subsequently present the methods that seem to us to respond to the questions raised. The purpose will not be to describe them in detail but to recall their major characteristics and to identify their potential contribution to our line of questioning and highlight their limits. We also develop avenues of enquiry into a specific approach suitable for exploring decision-making processes related to residential choice.

Depending on the different approaches described, four types of observation can be made out.

Name	Encoding method	Performance
Likert scale	Discrete or continuous scale [0, N]	Ordinal or cardinal transcription of information
Osgood scale	Discrete or continuous scale [-N, N]	Ordinal or cardinal transcription of information
Emoticons	Representation of faces with schematized emotional expressions	For prompting interviewee and identifying emotions in a past situation
Bargaining game: items weighted by (limited number of) tokens	Tokens of one colour (Likert scale logic) or two colours (Osgood scale logic)	Causes a certain decisional stress, staging a decision under constraint
Bargaining game: items weighted by (unlimited number of) tokens		Avoids stress and allows information to be collected, e.g. about the importance ascribed to alternatives (ordinal ranking)

Table 1—Various types of information encoding employed in the social sciences

3.1 Methods based on observation

It should be recalled that in social sciences methods based on observation of phenomena are referred to as methods based on direct observation. These methods provide information of a "descriptive" nature and only interpretation by the observer can assign any motivation or intention to the act observed (which obviously remains an approach that is not readily verifiable or falsifiable).

Praxeology and behaviour setting

Praxeology consists in observing people so as to record their practices (e.g. by concealed camera) but is also interested in routines (Alexandre 2003). Behaviour setting developed by Barker (1968) and taken up by Alexandre (2003) is part of the same rationale. It takes into account the study of places—places that are not special in any way, where people do not behave in original ways strictly speaking but where complex recurrent relations occur. Various types of activity are observed (going to shops, schools, health services, etc.). The ecological survey seeks to determine the importance of each of these activities in spatial and temporal terms by counting the opening times of establishments and user frequentation.

- 👍 **can be used to identify places frequented/avoided, routines.**
- 👎 **no information about reasons for action.**

The constant comparative method of analysis

This method consists first in noting observations by certain characteristics of the observed and comparing observations within each category with a possible extension to other categories (Glaser 1965). Next the different categories are compared and reasons are given that might explain the differences observed, such as the places (public spaces, etc.) being frequented by certain user categories (youngsters, parents with children, retired people, etc.) that may determine residential choice.

- 👍 **can be used to identify places frequented/avoided.**
- 👎 **indirect information about reasons for action.**

3.2 Standardized methods

These methods are used in surveys with closed questionnaires or in experimental methods. Experimental variables can be used to study what happens when a change occurs in a generally well-established, routine scenario. Individuals are confronted with projections of scenes, photos, etc. and asked to express themselves using, for example, a scale of evaluation. There is, then, no interaction between the respondent and any other person; the situation is standardized and reproducible (methodologically). However as pointed out the semantic interpretation of the formulations used risks introducing bias and may cause particular emotions in the respondent. A method of this kind may prove useful in a given context if we are looking to explore the criteria for evaluating a residential environment by proposing graphical representations (house with garden, handsome building, etc.).[37] Similarly such methods may serve to find out more about spatial practices or emotions attributed to a given situation. Thus respondents may be asked to choose from among a range of emoticons the one that best corresponds to a pre-defined situation.

Logbook

Respondents record their movements over a given period by indicating the reasons, route, lived experience, and so on of the journey. This brings the

37 For example, SOFRES surveys on the influence of neighbouring environmental factors on residential choice relied on such an approach.

individual aspects (personal characteristics, cognitive representations), social aspects (household structure, life cycle, socio-occupational position, transport facilities, and means of communication) and the spatial environment (shops, services, road access, and public transport) into relation with daily mobility practices. In this way indirect information can be obtained about the intentions associated with certain spatial practices without coming into direct contact with respondents by asking them about the reasons for making trips (Lee-Gosselin and Doherty 2005). Information about the actual decision-making process remains limited.

- 👍 **can be used to compare places frequented, routines, and means of travel, reasons for and emotions associated with the journey and so help to better understand spatial cognition (e.g. complementary to mental maps).**
- 👎 **can generate artefacts—respondents may limit their journeys or omit to mention them. They tend to associate the journey with its purpose.**

Surveys

Surveys establish a direct connection with the person and can be used to address various subjects, impressions, and so on. They may take various forms: directive survey, questionnaire (open or closed questions), observation (of behaviour, etc.). Answers may be recorded in closed forms (binary, Likert or Osgood scales, bargaining games, etc.).[38] The less directive the survey is, the more it departs from the standardized method. They are then more difficult to exploit using statistics.

As with any observation based on direct interaction between observer and observed two types of artefact may be found. The first type is the direct artefact due to interaction between interviewee and interviewer ("What do they expect? Why are they asking me this question? I don't want to come across like a…")[39] and may be reinforced by a possible realization that changes the observed's state of mind. Remember that the more closed a question is, the greater the risk of a direct artefact (Wilson 1967). It has also been observed that the context in which a question is asked, and so for example the question order, may affect the results (Easterlin 1974). The second possible bias, the *indirect artefact*, is related to the use of language (meaning of words, imitation, etc.). Textual analysis is then an interesting method when exploiting the corpus. However, analyses of both occurrence and context require semantic control by the investigator. It may be useful to have another investigator repeat the survey in order to better understand the interaction between interviewee and interviewer.

38 See table 2.
39 Cf. dissonance theory (chapter 7).

- 👍 **can be used to trace elements that come into play during journeys (cf. logbook) and when moving house. The method can include a wide variety of approaches and therefore meet varied requirements. Direct information can be collected about the reasons for action and associated emotions.**
- 👎 **direct action is subject to all the artefacts set out above, which requires great care when designing, carrying out, and exploiting the surveys.**

3.3 Individualized collection method

Commented path and the itineraries method

A path taking about 20 minutes to travel is pre-defined. Respondents make commentaries and voice recordings are made of them. The aim is to describe what they perceive along the way using all of their senses (light, sound, temperature, smells, etc.). They may stop on the way and then set off again (provided they report it) (Petiteau and Pasquier 2001). The itineraries method (Amphoux 2001) enhances this approach by proposing a route in a socio-historical context (Saint Nazaire docks, a historical centre, etc.) which takes an entire day and requires an escort with whom a dialogue starts up.

- 👍 **can be used to study the affective impact of an environment on an individual.**
- 👎 **no direct information about reasons for action.**

Mental map

It is used to give an account of the *representations* of space (visualization of an object that is absent) and its use—both perceived space and space as experienced (Lynch 1982). People are asked not just for words and concepts but to draw on paper the representations they have in their heads. By analysing mental maps it is possible to predict spatial behaviour and especially the decision-making function (Cadwallader 1979): the decision to remain or stay, the place we are headed, the path taken and how to get to the place (Gärling and Friman 2002). This also provides knowledge of representations of distance and spatial patterns.

- 👍 **can be used to compare places frequented/avoided in affective terms and mental representations of them.**
- 👎 **no direct information about reasons for action.**

Spatial reconstruction game (JRS)

This method involves the respondent positioning spatial objects (houses, trees, etc.) relative to each other, taking account of their nature for representing a type of space (city district, village, residential area, etc.) (Ramadier and Bronner 2006). It is possible to analyse the content of the representation (landmarks and environmental knowledge) and spatial structures (nature and relative positions among the elements mentioned).

- 👍 **can be used to understand mental models for representing space and by asking for an interpretation of its construction, the reasons for the choice of arrangement of the elements. It can thus inform us as to what the respondent likes or dislikes about her residential environment.**
- 👎 **individual and difficult to verify.**

3.4 Interactive methods

These methods are used to associate the observed directly with the observation. Interviewees are asked to use retrospection through which it is possible to access information about the reasons that led them to take decisions and the emotions felt when taking them. Interaction between observer and observed and communication play a crucial role. These methods are subject to the artefacts mentioned for surveys.

Interview

Interviews may take very varied forms (from unregulated to semi-directive). The more open the interview, the more individuals can direct what they have to say at content that has not been identified beforehand and feel "free". The risk is thus reduced of a predefined formulation by the observer influencing the interviewee's thinking but conversely comparison is made more difficult. Thus a large number of parameters can be revealed and enhance knowledge of the subject in question. As for surveys, textual analysis proves a valuable tool, remembering that semantic verification by the investigator remains an important feature in order to identify either confusion over words or less obvious, context-related synonymous expressions.

- 👍 **can be used to compare places frequented/avoided or migrations and to prepare questionnaires.**
- 👎 **direct contact is subject to the range of artefacts presented, which requires great care when conducting and exploiting interviews. There is no direct bridge to formal modelling, which must involve re-encoding when the interview is exploited. This step may lead to misinterpretation of certain terms. Textual analysis may prove a useful aid.**

3.5 Synthetic reflections

Each of the methods presented has its advantages and drawbacks and many of them are complementary with regard to the type of information they can be used to collect. We provide a round-up of their strengths and weaknesses in table 2.

We supplement this overview of the different methods of observation with reflections on specific aspects of a survey designed to collect the desired information about decision-making processes and the associated feelings.[40]

	Frequentation of places	Collectiv references, representations	Lived experiences	Reason for action	Emotions	Arbitration	Satisfaction	Acting out	Observed-observer interaction	Precise information	Certain information
Praxeology, direct observation	✓	✓	✓					✓	--	--	++
Mental maps, spatial reconstruction game	✓	✓	✓			✓			-	+	-
Commented path	✓				✓		✓		+	+	-
Logbook	✓	✓		✓	✓			✓	+	+	+
Survey	✓	✓	✓	✓	✓	✓	✓	✓	+	+	-
Interview	✓	✓	✓	✓	✓	✓	✓	✓	++	++	--

Table 2—Strengths and weaknesses of the different methods of observation
++ very much present
+ present
- somewhat lacking
-- almost completely lacking

Decision-making processes implement complex phenomena that are difficult to grasp. Various recent and earlier experiences may come into play, for

40 These reflections were conducted as part of the ANR ECDESUP project by a working group made up by D. Ansel (Psychology Laboratory, University of Franche-Comté), K. Chapuis (UMR ThéMA, University of Franche-Comté), A. Chauvin-Viléno (Laseldi, University of Franche-Comté), C. Enaux (ERL LIVE, University of Strasbourg), P. Frankhauser (UMR ThéMA, University of Franche-Comté), A. Griffond-Boitier (UMR ThéMA, University of Franche-Comté), M. Kastberg, (Laseldi, University of Franche-Comté), S. Mariani-Rousset (Laseldi, University of Franche-Comté), T. Ramadier (ERL LIVE, University of Strasbourg), C. Tannier (UMR ThéMA, University of Franche-Comté) and J. Valentin (UMR ThéMA, University of Franche-Comté).

example a feeling of inse Satisfaction curity or a ubiquitous audible nuisance, a bad atmosphere in a block of flats, but also an unpleasant residential environment (traffic, poor access to shops, no recreational areas, etc.). Such experiences may generate fears of reliving such situations. The reflections in chapter 1 showed the influence of social context for children constructing their spatial references. Questions relating to childhood residential background and appreciation of it may therefore help to clarify the possible influence on aspirations that guide the residential choice of adults who may wish to reproduce or on the contrary avoid similar situations. More generally, going back over the residential trajectory or at least, to limit the scope of a survey to the most recent moves, may provide insight not just into the influences of these factors when making a decision but also into how the respondent felt about an improvement in their new environment and to what extent those factors will influence any future move.

The account, which calls on introspection, may then help the individual to reconstruct the series of thoughts and actions that led ultimately to a decision, a series of which the actor is not necessarily aware or at least has not explicitly formalized as being the sum of elements that led to the decision. During an interview, individuals while relating their latest move of home, highlight decision-making mechanisms and reveal the toing-and-froing between the various stages: factors that impel them to leave and possible disagreement among family members, diverse uncertainties and the time required to reach the decision, the various possibilities (or otherwise) available for a new place of residence and the requirements to be taken into account, arbitration among family members, visits to accommodation, difficulties or hesitations in reaching the final decision. It is important, then, to resituate individuals at the right times: for example, to understand whether there is agreement about moving house, individuals have to be taken back not to the active phase of the removal but before it, to when they were thinking about whether a move was opportune or not. Without this, in a survey, a somewhat general formulation of the type “At the time of moving, was there finally agreement among the people involved in the final decision?” leads to virtually nothing but positive answers, which can be explained, among other things, by an unwillingness to reveal dissonance within the family. This example illustrates the importance of the language used in a particular stage. Going back over the stages in the decision-making process may be one way of reducing the risk of an “over-optimistic” synthetic evaluation (remembered utility) highlighted by Kahneman (1997) (see above). In addition, it makes it possible to reconstruct in part at least the variations in evaluations (instant utility) during the decision-making process and explore the significance of the various stages for reaching the final decision.

Making such decisions in a potentially conflict-ridden situation can cause a degree of stress. It is possible to “recreate” such an environment of "decision-making stress" via bargaining games. To investigate family disputes, it is possible to use a *sociogram* which is a graphic representation of the various household members or others involved in the decision to move. This enables the respondent to visualize the protagonists and award them points (positive or negative) depending on the weight they exerted in reaching the final decision.

Emotions felt when making a decision may be explored by asking the respondent to associate emoticons with a situation, which provides a comparatively standardized reference. Emoticons have the advantage that they dispense with language and refer unambiguously to basic emotions like anger, disgust, fear, joy, sadness, or surprise. Obviously the methodological reflections put forward by Vermersch (1999), set out above, are to be taken into account in such an approach just like the precautions concerning the way questions are formulated.

In order to get as close as possible to the language used by respondents and the meaning given to certain notions, it seems useful to conduct preliminary interviews before the questionnaire design is finalized that allow wide scope for interviewees to express themselves. A textual analysis will make it possible to analyse certain words used by respondents and integrate into the questionnaire turns of phrase typically used in a given context.[41] In addition, such interviews may reveal factors that have not been identified by the investigator(s) and may be involved in decision-making.

Notice that the use of various types of encoding in the form of scales and so on (see table 1) and the statistical exploitation of a survey can provide results that are sufficiently quantifiable to be integrated into a formal model of the decision-making process.

In drawing on events that have already taken place, the proposed approach seems similar to the *revealed preference* method. At the same time, respondents are led to talk about the time the decision was made, which refers more to the *stated preference* approach (cf. chapter 9). However, ours is more of an explanatory approach, which stands apart from the more descriptive approach that is often used in surveys designed to identify the preferences that determine residential choice.

4. Conclusion

Some in-depth methodological and epistemological reflection has enabled us to highlight the strengths and weaknesses of the different observational methods in the social sciences. Even if the results obtained by direct observations such as surveys and interviews do not readily lend themselves to mathematical or computerized formulation and are subject to bias arising out of direct contact between observers and the observed, the use of such methods is inescapable.

41 An example is the way respondents often use the expression "what *finally* brought us to…" when speaking of their definitive choice of place to live.

Indirect observation does not provide information about the reasons that prompt individuals to act, the emotions assigned to such a decision or the collective and personal references that come into play. Moreover, it seems impossible to observe individuals *at the time they make their decision* to change their place of residence. Accordingly the only way to explore such a situation is to invite people to use introspection to enable them to reconstruct the stages in the process and identify the thoughts and emotions associated with it. This may be facilitated by creating a similar situation, even if the stakes are obviously not comparable. It seems that the risk of bias, even if it cannot be ruled out completely, can be reduced by suitable approaches. Resort to certain methods of encoding means the results can be used in the modelling context contemplated.

Preferences, Utility, Choice, and Attractiveness

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1. Introduction

The purpose of this chapter is to specify what is meant by preferences, utility, choice, and attractiveness in the context of daily and residential mobility. These notions will be addressed from the angles of economics, geography, and psychology. We are interested in the process of choice leading to a decision and action with spatial consequences, primarily in terms of residential mobility even if factors pertaining to local daily mobility such as modal choice and route choice are evoked. Each discipline has developed specific but fully complementary approaches to these thematic areas. Schematically, psychology deals with the decision-making process itself, economics attempts to forge a connection between preferences and choices and examines the consequences of choices, while geography looks into the way choices are constructed in a spatial context and the spatial structures that follow from them.

Even if group references are evoked, we shall emphasize individual behaviour in choice and decision-making in this chapter. From this point of view, the notions of preferences, utility, choice, and attractiveness are interdependent. Choices procure essential information about individual preferences. Preferences are expressed about the characteristics (notably spatial ones) of alternative choices and are translated into utility functions in number terms. The utility of an option derives from the individual's characteristics, the preferences expressed by the individual for a set of attributes and from the characteristics of the option itself. Choice is supposed to be the expression of those preferences, even if it cannot be reduced to them and does not reflect them entirely,

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especially because it is expressed under physical, budgetary, social, and other constraints. The individual decision fits into space and leads collectively to spatial modifications.

Discrete choice models used in economics are useful in that they deal with choices relating to a limited series of mutually exclusive options whereas conventional models, which are based on continuous spaces of goods, require their own specific axiomatics (essentially convexity of space). Yet in the geographical world, space is not necessarily convex and real estate is characterized by a geographical setting that cannot cater for composite spatial characteristics (a house with a bedroom in southern France, a terrace in Tuscany, a living room in Paris, and so on). Discrete choice models deal with decision-making on an individual level for a finite set of alternatives and turn up results that can be used for studying the behaviour of groups of individuals. Based on the utility of each alternative, maximization calculations can be used to reproduce supposedly rational behaviour to identify collective preferences associated with the choices made. Rationality refers to both the capacity to choose the most satisfactory option and the means to achieve this end. Such rationality is assumed to be objective when the decision-making process is adapted to the aims the individual has set herself and subjective when the individual considers her choice technically appropriate but without it leading to an optimal choice.[1] In the case of such subjective rationality, it should be observed that the information available and the uncertainty related to choice play an important part. Behaviour may therefore be characterized as rational in a context in which information is limited or in an uncertain situation, even if it leads to poor anticipation of the consequences of the choice. Besides, as psychologists point out, rationality is invariably limited if only because individuals have restricted, non-deterministic capacities for choice (cf. chapter 8), especially when the choice relates to spatial characteristics that are by their nature difficult to appraise. The complexity of the decision-making process and the work relating to an understanding of it will be evoked principally in this chapter. They shall also be addressed in a different form in chapter 10. After introducing the notions of preference and utility, we shall address the way the process of choice can be modelled, and then reflect on the resulting attractiveness of urban spaces.

2. From preferences to utilities

2.1 Methods for collecting preferences

Two methods are classically used for studying individual preferences. Economists usually resort to the *revealed preferences* technique developed by Samuelson, which consists in collecting indirect information about choices made. This

1 It may, however, be choice rationalization in a second-rank optimum context.

method rests on the assumption that behaviours observed are good indicators of individuals' preferences. It can highlight, through surveys and modelling approaches, the significant characteristics having determined the choice made. But this method rests on an elaborate axiomatics that turns out to be very restrictive (Mas-Colell et al. 1995). In particular it requires the investigator to make a sometimes incomplete selection of the relevant attributes for characterizing the alternatives under study. This is compounded by the problem of defining the set of choices, which we shall address later. In addition, for the residential locations observed to reveal individuals' preferences clearly and directly, the economic market must be working "properly", as Francescato (2002) states: "these premises might deserve consideration IF residential environments were a part of well-functioning markets in which a menu of true choices were available to all consumers and IF by understanding purely economic decisions it were possible to also understand the overall relationship between people and their home environment". This argument relates also to a geographical question that individual preferences cannot be revealed unless the spatial pattern so allows. It is impossible to reveal certain preferences for a given spatial characteristic when it is distributed relatively evenly for all of the alternatives under consideration. In this case, choice cannot express what are very real preferences of individuals and that would have been relevant in another spatial context. To address this type of spatial effect, geographers may propose a set of measures of the spatial distribution of the characteristics under study.

The *stated preferences* technique rests upon an estimation of individuals' preferences based on intentions made about hypothetical scenarios (Louviere et al. 2000). Respondents may also be questioned about the determinants of choices they have made in the past (cf. the concept of retrospection described in chapter 8). These methods a priori provide more certainties for the definition of behaviour since they can be used to work on the basis of clearly identified attributes and a set of controlled choices (scenarios). However, certain limits may be mentioned. First the proposed scenarios may be incomplete or even unrealistic. Second individuals are not always aware of the attributes that motivated their past choices or of the respective role of each of those attributes. Thus a discrepancy is often observed between stated preferences and actual behaviour (Gärling and Friman, 2002). This discrepancy between revealed and stated preferences can be explained as much by the theoretical nature of the questions and choices proposed in the form of scenarios, which are necessarily simplified compared with reality, as by a misinterpretation of the preferences revealed by choices. It is therefore worth using both methods together, although the heterogeneity of the results thus obtained makes them difficult to interpret.

In environmental psychology, the distinction between revealed and stated preferences crops up in the concept of decision-making, when the emphasis lies either on behaviour (preferences evaluated—and therefore revealed—with respect to places frequented, lived in) or on individuals' evaluations of places: it is then the cognitive (environmental evaluation) or affective (measurement of environmental preference) dimensions that are at issue and from which stated preferences result. The first approach is a frequentist one, that is, preference is measured from the object, the place frequented for example; the second is individual, in which the preference measurement relating to the evaluation process is made by the subject herself (evaluations and beliefs associated with places frequented, cf. chapter 10). Environmental preference measurement in psychology relates to analysis of the relationship of the individual to space. Although close to the probabilistic approach developed in cognitive psychology, the measurement stands apart from environmental evaluation because it is envisaged in a more affective than cognitive dimension. Thus unlike the geographical approach that purports to identify preferences for given places among greater sets of places, environmental preference corresponds to an "affective distance" from a place that is to be categorized according to the individual.

2.2 Utility, an economic concept

Neoclassical consumer theory has introduced an approach aimed at modelling consumer behaviour. This approach arises from the empiricist and naturalist strand of thought in the English-speaking world in the late eighteenth century, of which John Stuart Mill and Jeremy Bentham are the illustrious representatives. Bentham (1789) wrote: "By 'the principle of utility' is meant the principle that approves or disapproves of *every* action according to the tendency it appears to have to increase or lessen—i.e. to promote or oppose—the happiness of the person or group whose interest is in question." By this approach individuals can evaluate the satisfaction procured to them by consuming such or such an option and then selecting the one that seems the most satisfactory to them. The utility of an alternative flows from preferences that are expressed, depending on each individuals' characteristics, about the attributes of the alternative choices taken into account. Utility corresponds to the satisfaction procured by consuming a good or service. By this approach, therefore, each individual disposes of a utility function enabling her to arrange in order the various alternatives on offer in a situation involving choice. The choice must comply with the rules of consistency, that is, the preference for a good may be represented by a utility function if it is complete (available alternatives are fully known, comparable, and systematically evaluated), transitive (if A is preferred to B and B to C, then A is preferred to C), and if the preference for A over B corresponds to utility of A > utility of B. The process of choice is then deterministic (Mas-Colell et al. 1995) and rational inasmuch as comparison of the utilities of each alternative enables the individual to choose the one with the highest utility (maximization of utility).

If an individual is able to assign utility to each alternative, this means that utility is measurable; we then speak of cardinal utility. It is considered that consumers are able to compare, by measurement, the satisfaction procured by consuming different goods. Cardinal utility therefore expresses the degree of satisfaction an individual derives from consuming a good in quantitative terms. From cardinal utility, it is possible to infer the marginal utility corresponding to the increase in utility procured by the increase in a characteristic of a good, all other characteristics being equal. The total utility function relating the quantity of characteristics associated with a good and the utility perceived by the individual is increasing and concave, reflecting the consumer saturation phenomenon. Thus marginal utility is always positive but it is decreasing because each extra unit of a good contributes less than the previous one to the increase in utility.

Unlike cardinal utility, ordinal utility introduced by Vilfredo Pareto, is based on the fact that it is difficult if not impossible for individuals to measure utility precisely and independently. Choices offered are classified by an order of preference and not by a quantity index. Under the ordinal approach, there are considered to be several subjective utility functions enabling individuals' order preferences to be respected. So there is not just one but several measures of utility that correspond to individual preferences. In accordance with this definition, an indifference curve can be drawn along which the utility of one alternative remains constant, but with variable characteristics. Taking by way of example distance to the city centre and size of accommodation, it can easily be understood that the two characteristics can offset one another (from the consumer's standpoint we speak of a trade-off) without that affecting the utility associated with the housing considered. This means that several combinations of characteristics (baskets of goods in economics) are possible and the characteristics can be substituted one for another to a greater or less degree; it is a compensatory approach. When substitutability is perfect, the relation is expressed by an indifference curve (one unit of X is equal to one unit of Y, figure 1a).

If substitutability is reduced,[2] the straight line turns into a convex curve (figure 1b) because it is assumed households have a preference for balanced combinations of characteristics (housing of respectable size at an acceptable distance from the city centre).

Convexity arises from an essential axiom in preferences, the taste for compromise. If one is relatively indifferent between X and Y, then one prefers any combination of X and Y to X and Y alone. The quantity of good X that must be substituted for good Y to maintain constant utility is the marginal rate of substitution. This rate, which is not constant, is therefore a measure of the way in which, in the margin, one product is substituted for another so that the

2 The CES (constant elasticity of substitution) and Cobb-Douglas functions may be used to formalize such utility functions with reduced substitutability.

consumer's satisfaction remains identical. In the case of a convex curve, marginal utility is decreasing, that is the utility procured by the increase of one unit for one given characteristic is less than the utility procured by the previous unit. For example, the consumer is ready to lose a lot of X in order to get a little Y when there is very little Y present initially. The indifference curve may, in particular instances, be L-shaped when no further substitution is possible. We then speak of complementary characteristics; this is the case for example for the number of rooms in a house and its floor space, which are not really trade-offs insofar as it would be useless to buy a house with many rooms if the floor space were not increased as a consequence.

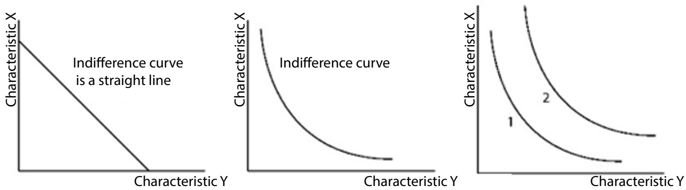

Figure 1—One way of representing satisfaction in economics

While cardinal utility can be used to develop mathematical tools such as the notion of marginal utility, total utility, and point of satiety (point beyond which utility begins to decrease), ordinal utility (via the decision maker's indifference curves) seems much closer to reality for the psychologist or geographer and therefore more suitable for representing individual behaviour. Fuzzy utility makes it possible to reconcile the realism of the ordinal approach and the mathematical power of the cardinal approach (see chapter 10).

In economics, whichever the type (cardinal or ordinal), utility is maximized under a powerful constraint, budget constraint, which weighs very heavily especially in the case of residential locational choice. An indirect utility function represents the maximum utility that can be achieved under price and income conditions. In figure 1c, any combination of characteristics X and Y situated below indifference curve 1 is financially possible, but the maximization of utility under budget constraint leads us to move as close as possible to the curve. If the available income increase without prices being changed, the range of possibilities increases and corresponds to the set of alternatives situated beneath curve 2. In microeconomics indifference curves and budget constraint are used to develop consumer demand curves, which correspond to a product's attractiveness for consumers. In the case of residential mobility, such attractiveness is expressed for housing in its environment and is reflected spatially (cf. section 3).

2.3 Characterization of alternatives

In the context of residential mobility, the characteristics of the alternatives taken into account in individuals' choices are numerous and it is difficult to identify them exhaustively. Traditionally, on the basis of individual and household attributes (accommodation occupation status, socio-occupational category, income, age, family composition, social and family relations, etc.) the evaluation of a property rests upon the attributes of the housing (number of rooms, floor space, rent, price, etc.) and the characteristics of the environment (land prices, accessibility of urban services, facilities in neighbourhood, environmental quality).[3]

For environmental attributes, a distinction may be drawn between the characteristics of the site (built forms, density, social composition, reputation, etc.) and the situation (relative position, distance from…, access to…, etc.). Some authors claim there is a hierarchical choice process between site and situation (Dieleman and Mulder 2002): individuals supposedly restrict their choice to spaces meeting their situational needs and then settle on a choice with respect to the site characteristics of the housing in question. Functional attributes supposedly then take precedence over attributes associated more with urban and social form. From this perspective, a distinction may be made depending on the distance involved in moving home. Over short distances, situation takes precedence over site and there is even a comparison with relative accessibility associated with the previous accommodation. Conversely, the greater the distance away, the more difficulty the individual will feel in evaluating the relative position of future housing in all its dimensions (distance to work, to urban amenities in the broad sense). In this case, activity spaces must be reconstructed from scratch and cannot be inherited from the former location. The individual will then tend to simplify the choice process by evaluating only what is directly visible in the space of the site (densities and diversity of urban amenities) without making a precise evaluation of the situation of the new housing. These thoughts, based on characteristics associated with choice options, raise the question of the process of choosing implemented by individuals.

3. Processes of choice

The evaluation process leading to the choices individuals make is studied in economics by disaggregated modelling and more specifically by discrete choice models. These models make it possible to work on the choices made by each individual and they apply in a very relevant way to the context of mobility. In the context of daily mobility, they may apply to the choice to make a journey, the choice of destination, mode of transport, and route. As concerns residential

3 See also chapter 2.

mobility, the stages modelled will essentially be the stages of the choice to move out and where applicable the choice of future housing.

Whichever the stage of choice studied, discrete choice models rest on a methodological organization that makes it possible to break down the choice-making process that we shall address more specifically in the remainder of this chapter:

– the choice of performing an action or not;

– the individual's decision-making processes and rules that lead to the use of very different models;

– identification of individual preferences, that is, characteristics of relevant alternatives in decision-making.

These behavioural parameters make it possible to determine each individual's utility function. This stage usually involves the attribution of a choice probability to each potential option based on the parameters selected in the utility function.[4] The aggregate of these probabilities may make it possible to identify the attractiveness of urban spaces (e.g. itineraries, favoured residential locations).

3.1 Choosing to perform an action

In the case of residential mobility we find, as mentioned, a choice to move out and a choice of destination. For the decision maker, these two stages imply a comparison between the available alternatives which represent a subset of existing housing.[5] In the choice to move out, the comparison involves the housing occupied and the set of potential alternatives for determining a propensity to residential mobility. Intra-urban migration models integrating willingness to move (Brown and Moore 1970) compare the utility of the housing occupied with that of other housing, which may also be addressed in the form of push-pull factors of choice used by Weidlich and Haag (1987) for modelling the probability of moving house (cf. chapters 6 and 7). Ettema et al. (2011) base their study on optimal utility that the household estimates from its knowledge of the property market. The household decides whether or not to move by comparing the optimal utility with the utility of its current situation. When the decision to move is made, the household looks for housing whose utility approximates as closely as possible the optimal utility. Most models of residential mobility consider push and pull factors sequentially, that is they are successive and independent (Benenson 2004, Fernandez et al. 2005). A single model operating on the basis of a single process would in theory be more relevant for representing spatial decision-making: "In many cases, it appears more realistic to consider

4 Notice that Tversky proposes a fundamentally different approach since he assumes the existence of utilities associated with action from which the choice process can then be analysed.

5 We give details of the question of the set of choices in section 3.3.

the decision to move, the search, and the choice of alternatives to be integrated parts of one and the same process" (Gärling and Friman 2002). Even so the data necessary for such formalization are not always available, which explains why the two components (push and pull) are usually modelled as separate and successive phenomena. When a household is not satisfied with its residential situation (push factor), it decides to move and looks for housing in keeping with its expectations (pull factor). These two-stage (decision and choice) or three-stage (decision, search, and choice) models can be used to identify all the stages of a spatial decision from the intention to move to the actual removal.

Comparison between the housing occupied and the remainder of the housing stock may correspond to "information monitoring" based on the opportunities that may turn up without a decision to move actually being taken. In this case, the level of requirement for the new housing will tend to be high; it is the attractiveness of the new housing far more than the lack of satisfaction with the one currently occupied that is decisive. However, if the decision to move has been made, an active search for housing is on and will more likely lead to residential mobility, even if the new housing procures a comparatively limited utility gain. The active search for new housing can be explained by the fact that the current residential location has become unsatisfactory (loss of utility of the housing occupied) under the impetus of an unfavourable change in the housing and its environment, and/or the willingness to adapt the housing and location to new needs and new household preferences (change in household composition, retirement, change in income, new place of work, change of places frequented, etc.). In the models by Devisch et al. (2006), a lifetime utility allows the household to anticipate its needs depending on expected utility and events that may occur over the course of a life.

For Van Ommeren et al. (1999) residential career and place of employment must be associated in order to determine the propensity to move. Thus people who feel dissatisfied with the housing they occupy but who at the same time hope to change jobs tend to delay their residential mobility. In this sequence, they clearly give precedence to job seeking, which is at least a temporary brake on moving house. By this logic, it will be noted that propensity to move house must be determined in a broader dynamic framework than that restricted to a single place of residence. Weidlich and Haag (1987) also examine the evolution over time of the characteristics and attractiveness of places. Combined with individual preferences, the dynamic utility of spaces, explained in part by socio-economic characteristics, may or may not promote residential mobility. This changing attractiveness of places is also dependent on individuals, as shown by Van Ommeren et al. (1999) in their work on predicting behavioural mobility as a function of the double residential-workplace location. Their dynamic search model, which is also a model of the length of occupation of housing, shows the loss of interest in certain places depending on changes in work place location.

As highlighted in chapter 2, the main reasons for moving are somewhat variable but generally related to the housing characteristics (size and comfort), willingness to move from communal to individual housing, to become a house-owner and to environmental characteristics, usually related to a deteriorated environment that households wish to leave rather than the environment of the place they move to (Dieleman and Mulder 2002). All of these factors vary with the household's characteristics, its earlier experiences and its life-cycle position. For example, high-income households pay more attention to the attributes of the residential environment (landscape, social grouping, etc.) than do other types of households (Fernandez et al. 2005).

While it is comparatively straightforward to list the determinants of residential mobility, the question of the triggering factors, time scales, and threshold effects leading to such mobility is more problematic. Emotions as factors engendering decision-making over relatively short periods were discussed in chapter 4; they are to be compared with factors involved in the propensity to act over the long term (phenomenon such as the gradual deterioration of landscapes). From another perspective, the context of choice may act as a brake on residential mobility. When the range of choice is poorly known or when there are very many alternatives and a fortiori when those alternatives tend to be similar, which may imply uncertainty, individuals tend to postpone making a choice and wait for a change in available alternatives. Tversky and Kahnemann (1991) speak of risk aversion, which corresponds to fear of negative consequences of the choice. This factor acts as a brake on the decision to move home because it may engender a pessimistic attitude in households. This type of behaviour will emerge more easily in the case of residential mobility when the housing currently occupied remains satisfactory; it provides, in this case, a reasonable expectation solution, pending the advent of a less uncertain context of choice. Certain psychological factors and in particular identity-related factors, such as affective investment or attachment to where one lives, may also adversely affect propensity to act even in the case of relative dissatisfaction with the housing occupied. The economists' opportunity cost measures what the individual gives up when making a choice. To minimize that opportunity cost, individuals try to evaluate the pros and cons of each option as best they can to make the best possible choice. In geographical space, a distinction can be made between places that individuals know, because they live there or go there often, and unfamiliar places which may be chosen even so. Between these two extremes lies a whole range of places that are more or less familiar and for which the evaluation will rest on more or less concrete, ideal and represented criteria. The more uncertain the situation appears to the mind of the decision maker, the less controlled the opportunity costs will seem to be, which will serve as a brake on the choice to act. From the geographical perspective, it seems important to distinguish the move that involves a complete change in where one lives from the move that is to be made within the region of origin.

3.2 Methods for evaluating alternative choices

In neoclassical economics, each rational individual has a utility function allowing her to order the various alternatives available on the basis of her preferences with no possible error. For de Palma and Thisse (1989) the process of choice is deterministic because the alternative with the greatest utility will systematically be chosen. But this is not realistic because individuals' responses are highly variable. This has prompted psychologists to criticize the determinist (and so highly positivist) approach of economists and to propose a probabilistic approach in modelling choices and decision-making. As de Palma and Thisse (1989) specify, two different rationales must be told apart: "in the first it is assumed that the *decision-making rules are random* and utilities deterministic (Luce, Tversky). In the second it is assumed that decision-making rules are deterministic but that *utilities are stochastic* (McFadden, Thurstone)".

These two approaches may be implemented via discrete choice models with the introduction of a chance event. For McFadden (2001) the chance event may correspond to errors inherent in the modelling such as overlooking potentially discriminatory variables or the inability to analyse individual behaviour. In this event, the agent may decide with all certainty but on factors that are not observed by the model maker. De Palma and Thisse (1989) note that an individual's mental state cannot be known and predicted at the time the decision is made.[6] If we use the interpretation whereby the stochastic character of decisions is due to the model maker, we shall turn to random utility models. For example, in Thurstone's approach it is assumed that the individual is made up of a number of different *homines economici* each obeying the axioms of neoclassical theory. Depending on her state of mind, the individual selects one particular *homo economicus* and then behaves rationally in accordance with the corresponding deterministic utility (de Palma and Thisse 1989). As those authors emphasize, economists modify this hypothesis by assuming it is possible to distinguish between different groups of individuals and that for each group it is possible to define utilities that are in principle equal for all individuals. However, because the observer cannot know all the factors determining the choice of these "standard individuals", "noise" is introduced and follows a Gumbel distribution around the deterministic utility attributed to the group. However, if it is considered that the chance event is related rather to individuals' lack of objective rationality, then probabilities shall be interpreted cognitively. We then speak of imperfect knowledge of alternatives, fuzzy preferences, evaluation errors due to

6 This line of argument is reminiscent of the thinking in chapter 8 on the question of the decision-making process referring to a mental process that cannot be observed directly.

information filtering, changing states of mind, and uncertainty of future events engendering aversion to risk. Precedence is then given to random decision models. Luce (1959) assumes in particular that the probability of choosing an alternative A_i, belonging to a subset of alternatives A already chosen initially from a wider set, is independent of that set. Tversky (1972) models the choice process explicitly via a sequence of decisions that progressively eliminates aspects by selecting one modality among all possible ones. This is conditional reasoning.

In both categories of model, the maximized utility hypothesis is maintained but it applies to the perceived cost of alternatives, which challenges the objective rationality of behaviour.[7] Although choice probabilities are specified for each alternative, this does not exclude a choice that would lead to reduced utility even if the probability associated with it is lower (limited rationality). In all cases the question arises of the behavioural rules leading to stochastic choices. In order to analyse an individual's choice and make a connection with her preferences, let us describe in detail the main two families of stochastic models identified above.

Random utility models

Random utility models are an extension of the neoclassical economic approach because the stochastic choice results from a process of optimization of a stochastic utility function. We have seen above that the decision-making rules are deterministic and utility includes a random error term. In McFadden's multinomial logit model, errors are assumed to be independent and to follow a Gumbel distribution. In point of fact, the alternatives are wholly independent of each other and consequently so are the random variables. This does not challenge the existence of a chance event but it does mean that errors are predictable because they are relatively homogenous from one person to another. Only the deterministic component of utility is therefore mobilized in the model's operation. The model's ability to reproduce the choice actually made is classically measured by the maximum likelihood statistic, which can highlight individuals' preferences for certain characteristics of the alternatives. Because of the generally additive form of utility, the choice among the potential options is compensatory; a trade-off is found among the relevant attributes for maximizing individuals' utility, that is, for choosing the option that procures them maximum satisfaction. This compensation means that two options presenting very different characteristics may have the same utility as was evoked at the beginning of this chapter. In the case of residential mobility, the compromise may bear, for example, on prices and environmental attributes.

Most random utility models rest on the assumption that non-significant alternatives are independent. This independence of irrelevant alternatives (IIA)

7 Which relates to subjective rationality referred to above.

assumption used in the multinomial logit model implies that the alternatives are entirely independent of each other and above all that the decision-making context plays no role. Yet psychologists have demonstrated that the context of choice does influence decisions. It is equally unrealistic to assume that the ratio of choice probabilities of the two options depends solely on their utility and is independent of the other alternatives: the error terms of the utility function are partially correlated. Thus although the IIA assumption is very useful for formulating the logit model, it is also its main weakness and has rightly been widely challenged. Timmermans and Golledge (1990) have identified three main categories of models escaping the IIA rule. In the first category, the utility error terms are not assumed to be independent and identically distributed; the difficulty then lies in specifying the distribution of these terms and above all in interpreting it in terms of behaviour. The second category of model takes the similarities among alternatives directly into account in specifying utility. The third category works on the basis of a hierarchical decision-making process, which may be very complicated with variations in the hierarchical structure within the population under consideration. The models in these last two categories can be used to generalize the multinomial logit and are part of the generalized extreme value (GEV) family of models.

GEV models can be used to model situations involving choice with correlated alternatives. This is the case of the nested (or hierarchical) multinomial logit model proposed by Ben-Akiva as early as 1973 (Ben-Akiva and Lerman 1985). The underlying hypothesis is that the choice process of individuals works hierarchically with similar alternatives gathered in clusters forming a decision tree that is supposed to conform more closely to observed behaviours (Kim et al. 2005). The decision-making process of individuals involves a clustering of possible alternatives depending on the degree of similarity among them. This process is expressed preferentially when individuals are faced with complex situations of choice, which is largely the case in mobility.

The hierarchical structure may also be used to reproduce the chronological process of decision-making involved in the context of residential mobility: (1) the choice of whether or not to move (as evoked above); (2) the choice of geographical location (e.g. city centre, suburbs, periurban); (3) the choice of housing type (social housing, private housing; purchase or rental; individual or collective housing; and so on); (4) final choice of housing according to its specific characteristics. These choices are sequential but also recursive in that a lower level may influence the decision made at a higher level; we consider, then, the interactions among the different stages of spatial decision-making (Fischer and Aufhauser 1988). The further down the hierarchy we go, the more similar are the alternatives with ultimately a degree of spatial autocorrelation because the same types of housing will be sought in spaces exhibiting rather similar environmental characteristics. At this fine level of the hierarchy, the context of choice becomes more uncertain but it becomes possible to identify preferences very precisely when individuals are able to pick and choose between these alternatives. This hierarchical approach by Onaka and Clark (1983) must not conceal the questions about the structure of the nested logit. How many hierarchical levels should be used? In what order? Does the choice of type of accommodation take precedence over the choice of location as Quigley (1976) asserts? Conversely, should precedence be given to spatial clustering that rests on having environmental characteristics in common as in Onaka and Clark (1983)? In this case, what scale should be adopted? How should space be discretized? Should fuzzy bounds be used? Should we work on the basis of nested scales? Can disjoint spaces but with the same characteristics be introduced into the same cluster? These questions remain unanswered and are related in part to the specific character of the nested model for which each alternative belongs to a single grouping, which is open to criticism. In addition, in hierarchically structured models, some clusters are progressively eliminated and the alternatives composing such clusters are therefore not evaluated individually. And yet some of those alternatives may exhibit greater utility than the alternative finally selected, which may lead to irrational choices. To correct for this, Pellegrini and Fotheringham (2002) propose weighting alternatives by the probability of being evaluated. The cross-nested model allows one and the same alternative to belong to several non-exclusive clusters depending on probabilities that have to be defined. The clustering is done, in the domain of route choice, on the basis of shared network elements. For residential choices, this could correspond to neighbouring locations depending on the scale considered, or characteristics of the housing or the environment that are shared without there being any spatial proximity (e.g. same distance to centre and same price per square metre).

Other models applied more specifically to path choice maintain the multinomial logit model structure and propose a correction for the deterministic part of utility. The path size logit rests on detecting shared portions of itineraries between options within clusters and reduces the utility of each option when it shares many similarities with the other alternatives. The C-Logit measures the degree of similarity between alternatives. This similarity is also calculated on the basis of shared characteristics but correction of the utility function rests also on costs of unshared attributes. The initial corrective term is applied to paths two by two and is used to compare the utility of each of the attributes common to the alternatives with the utility of the two alternatives together. This model has an interesting theoretical aspect because it can be used to work on distinctive factors that may prove more relevant for analysing the choice made.

Random decision models

In the case of situations of complex, uncertain, or even risky choice, which is the case in residential mobility choices, individuals' rationality is debateable, which may lead to suboptimal choices (Swait and Adamowicz 2001). True, with increased complexity, individuals make an extra effort to answer a question, which gives access to a finer and therefore more interesting interpretation of preferences for the model maker. But generally, beyond a certain threshold, a degree of complexity is reached that it is difficult for the individual to manage. Psychologists claim that humans are unable to deal with more than seven evaluation criteria at a time. So with increasing complexity characterized notably by the number of alternatives and attributes and by the correlations among them, choice strategies tend to become simplified.

Kahneman and Tversky (1979) claim that to understand certain situations of complex choice and make the decision-making easier, individuals may resort to "heuristics", that is, reasoning allowing the problem to be simplified and uncertainty reduced. Certain non-compensatory choice models have been proposed in which only part of the information is considered and trade-offs are excluded (Gärling and Friman 2002). Tversky (1972) proposed a model of elimination by aspects which works sequentially according to a decision-making rule laid down a priori. In this model, individuals successively examine alternatives according to choice characteristics that are ranked by order of importance. This makes it possible to gradually eliminate the irrelevant alternatives depending on the minimum levels of satisfaction. Luce's (1959) choice axiom does not refer to an optimization process either. It establishes connections between probabilities of choice defined on the basis of distinct actions. For example, the probability of choosing the car among other modes of transport will be equivalent for two choice processes that are clearly differentiated sequentially; selection of motorized form (car and bus) from a broader set of options, then choice of car to the detriment of buses or selection of individual modes (car and foot) then choice of car.

There are also other methods of simplification by the decision maker. In dominance structuring theory (DST), certain individuals attempt to avoid compromises implying giving up on things they do not wish to. This may concern household members whose preferences are sometimes contradictory in terms of residential location for example. Thus a decision maker may deliberately minimize the attraction exerted by some attribute characteristics and ascribe more value to others in order to create the illusion of a choice made without arbitration and therefore without renouncing. This strategy can reduce cognitive dissonance and may be perceived as a rationalization process. Differentiation and consolidation theory rests upon the idea that the utility of an alternative may be increased cognitively either before (differentiation) or after (consolidation) the choice is made in order to avoid any post-decision regrets (Svenson 1992).

To evaluate this type of heuristics it is possible to use two contradictory criteria relating to a more global form of rationality than that evoked previously. Choice strategies can be apprehended as the outcome of a compromise between the cognitive effort required for decision-making (depending on the complexity of the choice, time available to choose, capacities of the decision maker) and the quality of the results obtained. In this case, the individual acts when the more or less long-term interest she derives from an act is much greater than the internal resources she must devote to the act. Without any cognitive effort, the choice is random. With greater effort, there is an increased probability of choosing the alternative with the greater utility. This cognitive effort depends, of course, on the person involved. Respondents vary widely in their ability to process information. The lesser that ability and the more limited rationality is, and so the more errors are committed in comparing choice options. This may lead to very different choices even when individuals have the same preferences (de Palma et al. 1994). The cognitive effort is dependent also on the object about which the choice is made. The higher the cost involved or the more it is a medium- to long-term choice, which is the case with residential mobility, the greater the cognitive effort will be. Conversely, with route choices, the effort is lesser because the stakes are lower. Besides, even in the case of residential choice, the search time for new housing will be very variable from one household to another (Fischer and Aufhauser 1988). This parameter needs to be taken into account in modelling because it will have consequences for choice optimization.

Compared with this double criteria evaluation, non-compensatory decision strategies of random decision models require far less effort than random utility models with compensatory strategies, but they do not perform as well. It is difficult to come down on one side or other of the fence concerning the advantage of one method over the other, but it can be observed that either one may be more relevant depending on the context and the type of choice under study. Some models propose combining economic and psychological approaches (Swait and Adamowicz 2001). This makes it possible to take complexity into account to define the efforts that must be put into the decision-making process and ultimately to measure individuals' ability to choose. Notice also that connections can be made between random utility models and random decision models despite them having different properties. Thus Luce's model establishing a connection between the utility of an alternative and the probability of choice is equivalent to McFadden's multinomial logit model (de Palma and Thisse 1989). The nested logit model is very similar to the elimination-by-aspects model because neither verifies the IIA property. In addition, random utility models increasingly often include a non-compensatory stage consisting in eliminating irrelevant alternatives ahead of implementing the model properly speaking; in this they can be likened to Tversky's elimination-by-aspects model and Luce's choice axiom model. This stage makes it possible to define a reduced choice set (de Palma et al. 1994), said to be realistic, that then makes it possible to optimize the working of the random utility model to identify individual preferences finely. This approach must be approximated to the psychologists idea that there is a maximum number of alternatives that individuals are able to evaluate simultaneously.

3.3 Choice set and context

Definition of the choice set in random utility models

In mobility choice models, the definition of choice set is well separated from the process of selecting the most relevant alternative (Prato 2009). In the case of residential mobility, the choice set is all of the potential locations considered by households. It covers a more or less reduced part of the residential supply set in a given space and must include the chosen option. Unlike the process of alternative choice, the definition of the choice set is not compensatory, that is, some unwanted characteristics, identified as the most important factors of choice, lead to the definitive exclusion of certain options from the evaluation process, often deterministically (routes longer than a certain limit, municipalities not considered for residential location)[Prato 2009]. Here we find the expression of a preference with which to exclude certain unrealistic options, which then makes it possible to analyse precisely the preferences of households in modelling choices.

Determination of the choice set rests on individual preferences but also on constraints (e.g. financial constraints for residential locations) and on earlier experiences (residential history). When evaluating possible residential destinations, a household does not evaluate and compare all of the city's possibilities. There is therefore a difference between the total number of alternatives (universal choice set) and the number of alternatives available and evaluated by each individual, and the choice context must generally be restricted (Ettema et al. 2011). This stage is often performed by the modeller depending on her knowledge of the study population and the hypotheses made.

The definition of the choice set involves selecting a series of alternatives and it must contain the alternative actually chosen by the individual being observed, conditional upon a restrictive enumeration of potential options. The finite choice set must be realistic, reasonable in terms of alternatives selected and above all relevant, which cannot be measured as easily. In studies of mobility, the choice set is more or less easy to define. For transport mode choices, alternatives are restricted and well-known. However, whenever choice relates to space (choice of route, destination of a journey, future housing), there are a lot of potential options exhibiting overlapping characteristics among which a selection must be made.

In the case of residential mobility, the restrictive enumeration should relate to aspects associated with geographical location, housing, and residential environment and it will be dependent on household characteristics (cf. chapter 2). In practice, the reduction of the choice set will often be dictated by the housing available and by budget constraint. The choice set may also be defined depending on the location of the workplace or more specific factors pertaining, for example, to the coherence of the choice. In the highly specific case of route choice, the alternatives selected must necessarily include road sections that take one closer to the destination. In the domain of residential careers, the reasons for moving must be taken into account. For example, in the case of households looking to move closer to the city centre, only housing closer to the centre than the former location is considered. The characteristics of alternatives taken into account for defining the choice set may also vary greatly from one individual to another. Some approaches make it possible to determine specific choice sets depending on a categorization of the population.

Serious errors in understanding the choice process may arise at this stage, which explains why much current research relates to the effect of the choice set and irrelevant alternatives on the results of modelling. The various studies made along these lines are rather contradictory, even if it is generally recognized that information processing varies with the number of available alternatives. Individuals compare precisely the alternatives when the set of choices is small whereas they use simplified decision-making rules when there are too many alternative choices.[8] This often leads to individuals forming small choice sets in accordance with simple rules (de Palma et al. 1994; Swait and Adamowicz 2001). Even accepting that the factors for defining each individual's choice sets are clearly identified, there is still the question of differences of perception among individuals. If the definition of choice sets rests on rational and measurable hypotheses such as the housing price to income ratio, a number of individuals will be looking at identical choice sets. Yet there is a good chance that the alternatives really considered in an evaluation are dissimilar, especially because individuals have widely differing knowledge of the territories involved.

To take into account these individual differences which lead to very variable perceptions of alternatives, it is possible to use a stochastic approach that makes it possible to correct an initial choice set. In concrete terms, the choice set generation by a deterministic approach on the basis of relevant criteria will be supplemented by a probabilistic selection of the alternatives (e.g. by a Monte-Carlo method). A doubly stochastic approach may also be implemented on the basis of the utility function of the choice model: the relevant alternatives are selected by varying their attributes stochastically, which reflects the differences in individuals' perceptions, and by modifying the utility function parameters, corresponding to the supposed differences in preferences from one individual

8 Cf. random decision models.

to another. This method is most interesting but it rests on assumptions about individuals' preferences, which implies the risk of selecting irrelevant alternatives (Prato 2009). It must be noted too that there is a thin dividing line between the characteristics involved in the definition of the choice set and the characteristics involved in the choice of one alterative among those selected. It is not always easy to clearly distinguish truly non-compensatory characteristics from characteristics that may be compensatory. The approach based on the concepts of relative utility and relative interest proposed by Zhang et al. (2004) can circumvent this difficulty. It contrasts with more classical choice models in which all the alternatives selected are considered homogenous and equivalent. In actual fact, individuals or groups are more interested in (or know better) some alternatives than others. The characteristics of these options therefore have greater weight when calculating utility. Accordingly, the greater the interest in an option is, the more its characteristics are taken into account , which affects the choice; the parameters associated with relative interest are estimated in the modelling phase. This method is valuable insofar as it abolishes the boundary between the stage of selecting relevant alternatives and the stage of evaluating those alternatives.

The choice context, an approach inspired by psychologists

Several studies have identified the way in which decision-making is dependent on the choice context. This context may correspond to earlier choices and individuals' evaluation of the effects of those choices. Clark and Mulder (2000) examine the first residential choice by young adults by analysing the reasons for them leaving their parents' home and their choice of location. They show that this first actual choice is potentially foundational and may determine the residential career. In the specific case of interregional moves associated with a change in employment, Da Vanzo (1981) suggests that the first residential choice is likely to be of little relevance in terms of utility, because of lack of knowledge of the place they are moving to, and this gives rise to rapid residential relocation (repeated mobility phenomena). Similarly, itineraries used after a relocation into a new city often follow the main thoroughfares before people venture off them; choices are progressively refined giving access to new spaces to frequent. Tversky and Kahneman (1991) recall that context may correspond to the characteristics of the social group of reference and they evoke the influence that the representation of the car exerts over the choice of mode of transport in various groups. The notion of relative utility proposed by Zhang et al. (2004) can be used to determine the utility of alternatives relative to each other. In addition to alternatives in the choice set, relative utility may also refer to alternatives chosen in the past or by other individuals (social group influence).

This more social choice has been developed particularly by Páez et al. (2008) who recall that few models in geography and economics have formalized the influence of social interactions on decision-making. The theory of externalities in economics shows that an individual's potential consumption depends on her own capacities but also on the choices of other individuals, whether consumers or producers, which may affect the quantities of a good available, prices, and so on. Externalities may affect the producer's output and the consumer's choice set (technological externalities) as well as the costs of inputs or goods (pecuniary externalities). Continuing the theoretical foundations we have evoked, little work has been done on incorporating social relations into the utility function.[9] Thus behaviour and choices are described on an individualistic basis and depend solely on the attributes of alternatives and on the individual in the situation of making a choice. For example, there is no allowance for the influence of social networks on residential location choice. And yet, affective and family ties frequently emerge as determinants of residential location in surveys. These ties are often described by the affinity potential among group members and by interactions among different groups. Páez et al. (2008) propose a discrete choice model for comprehending the influence of social relations and spatial location on individuals' decision-making. The generation of different random social networks with low and high degrees of clustering makes it possible to test social influence on residential locations. Despite the low impact of the clustering coefficient, the results show that allowance for social interactions can improve the relevance of the results obtained.

This direct allowance for social interactions may be supplemented by an indirect approach in which space will play an intermediate role. For example, on the simple question of population densities introduced as a preponderant factor in the utility functions of the models of Weidlich and Haag (1988), the more inhabitants there are in a given district, potentially the more urban amenities (shops, public services, public transport, etc.) but also congestion, neighbourhood nuisances, etc., there will be. These externalities highlight an indirect, positive or negative dependence among the individual choices made. Stigmergy (referred to in chapter 7) shows that individuals exchange information by modifying their environment. Accordingly individuals' choices and strategies lead to a change in the environment and spatial patterns, which eventually has a feedback effect on individuals. Evidence of this can be seen in the phenomena of gentrification—the process of working class parts of town being taken over by middle and higher classes—or neighbourhood decay—the process by which the most deprived populations are concentrated in certain areas as a result of migratory movements of the less deprived categories towards more favourable locations.

9 Two examples are set out in chapter 6.

4. Attractiveness of spaces

Attractiveness relates to place. We leave behind individual preferences for the preferences of a social group identified through the places it frequents, where it lives, or the paths it takes. By Condorcet's paradox, there is tension between individual rationality and group rationality; preference transitivity, for example, is often called into question on a communal scale. More generally, although individual coherence exists, group coherence is less obvious; hence the impossibility of establishing a social ordering of options of choice. Arrow (1951) confirmed Condorcet's paradox by showing that it is impossible to aggregate individual preferences in such a way as to identify social preferences, from which stems the difficulty in generalizing across space the results found by the various choice models presented above. By measuring the strength of attraction of a place, attractiveness can be used to ask the question of the spatial convergence of choices, their aggregation, and their materialization through residential flows even if it must be noted that a priori the variables characterizing individual behaviours and the variables describing attractiveness of spaces are incompatible (Sanders 1992).

4.1 Attractiveness as a spatial notion

Consideration of group references through attractiveness comes back to the notion of "mean field" in physics. The influence of other agents on an agent's choice is global; for each spatial unit, it can be modelled by an attribute vector. In line with this rationale, Weidlich and Haag's (1987) model provides elements for comparing the utilities of different spaces (cardinal ranking of utilities) with associated occurrences of migration. Individual behaviours such as the propensity to migrate or the dissuasive effect of distance are assumed to be identical within a group. The choice to move results from comparison of the attractiveness of the region or cities of destination compared with the region or cities of origin, weighted by a global mobility factor that describes the propensity to migrate (cf. chapter 7). This attractiveness is measured by a dynamic utility affected by the changing characteristics of spaces and the socioeconomic context. Individuals and society interact via inter- and intra-urban migration effects on the spatial pattern. There is both a contribution of the individual to the group, with the spatial and social pattern changing under the effect of migrations, and a group influence on individuals through the socio-economic pattern of spaces (cf. chapter 6). For example, the attractiveness of a region is in part a function of its population because it will potentially have more urban amenities (shops, public services, public transport, etc.) but with a saturation parameter when densities become excessive (negative externalities). This model is similar to the notion of spatial interaction used in geography to describe relations between places depending on their relative positions and respective weights.

Spatial interaction therefore defines the attractiveness of a place that is not absolute but relative, that is, determined with respect to one or more other places. It can also be defined as the difference in evaluation between a place *i* and a place *j*. The weight corresponding to the differential in attractiveness of place may be described on the basis of very varied characteristics, potentially all of those arising from individual utility functions (housing characteristics, accessibility to services, shops, work, etc.). Besides this notion of weight, the spatial distribution of these characteristics is also of interest. The attraction of a place, if it is intrinsic, is also to be considered in the very specific framework of its territoriality and of the multiple scale spaces into which it fits. Everything hangs on the comparison of spaces with each other and the attractiveness of a place goes along with its negative double for which it exerts, if not repulsion, at least a deficit in terms of perception and usage. In this spatial valuation/devaluation mechanism, one of the major questions relates to spatial patterns. These lines of questioning fit in with the theme of spatial choice context. For example, on an individual level, the more complex the choice, the greater the variability of preferences and probability of choices. When there is a dominant alternative that differs from others from the individual perspective, the choice is plainly less uncertain (Swait and Adamowicz 2001). This observation emanating from the modelling of choices can be extended to the attractiveness of space. Places with relatively similar housing and that stand little apart from other spaces define uncertain choice sets with great variability of choice probabilities. Along similar lines, models of choice of destinations calculate accessibility among all potential choice options. The closer together these are and the more endowed with similar attributes, the more readily they can be substituted. They belong to the same large cluster, whose probability of being chosen is lower than might be expected; conversely there will be overexposure of alternatives in small clusters. If a parallel is drawn with the nested logit model, multiplication of similar or fairly similar offers will decrease the utility of these alternatives and therefore the attractiveness of the associated spatial clusters. Conversely, the existence of specific offers, which are rare because clearly differentiated from others in given spaces, will engender a redistribution of the utilities of each alternative and, from that, the potential attractiveness of certain places. These examples demonstrate the importance of what is called urban arrangement, arrangement being understood here in the morphological (the form of the city), social (distribution of social categories), and functional (distribution of population and activities) senses.

4.2 Models of economic and spatial potential

In order to comprehend the notion of attractiveness, it is helpful to look more closely at economic and spatial potential models. Such models, to which spatial interaction models can be added, are based on the characteristics of places and their relative positions in a given space. In the gravitational model, which is a particular form of the family of interaction models, flows between two zones i and j are directly proportional to the product of the masses of each zone and inversely proportional to the distance d_{ij} between them. Being more general, interaction models consider the relative position of a place in interaction with n other places characterized by a certain mass, that is, a certain drawing power. On these principles, the models proposed by Wilson make it possible to determine residential location; they rest upon entropy maximization and make it possible to evaluate the most likely evolution of a spatial system (Wilson 1998). In these models, the attractiveness of a place is characterized by what is on offer in a zone and by a decreasing exponential term featuring the cost of distance. Generally, this maximization is done under a double constraint on origins and destinations that controls the flows leaving and arriving in departure and destination zones. The entropy model does not rest directly on the microeconomic postulates of individual behaviour but an equivalence can be established between the aggregated approach of interaction models and the disaggregated one of behavioural discrete choice models (random utility models). The maximization of entropy in the double constraint model that makes it possible to estimate migratory flows corresponds to the maximization of likelihood of individual behaviour in logit models (maximization of the utility function taking account of transport cost) [Anas 1983]. This equivalence with behavioural models is important because spatial interaction models[10] have long been criticized as being poor on theory.

Under the entropy principle inherited from thermodynamics we are not interested in the state of each component (study of each household leaving one zone to settle in another zone), which information is anyway imperfect and incomplete, but rather in the number of components sharing a common state. There is an aggregation in space of micro-geographic patterns on a meso-geographic scale. We refer therefore to the number of households leaving one zone for another, and each zone can be characterized by attributes that can potentially account for these migratory phenomena (population density, number of jobs, shops, access to location factors, etc.). These models do not integrate the complexity of human behaviour but must make it possible to estimate the aggregate effects of such behaviour. Although the attractiveness of a location can be measured by the straightforward sum of individual residential mobilities, the factors that generate that mobility are more difficult to analyse because there

10 It should also be pointed out that these models are penalized by their unrealistic IIA property (Fotheringham and O'Kelly 1989).

is an incompatibility between the micro-geographical level of individuals and the meso-geographical level of neighbourhoods. On an aggregate scale, individual preferences tend to offset each other, making the analysis of individual decisions of little use for understanding what makes spaces attractive. Indeed, some seemingly attractive locations could be characterized by repellent effects on the level of individual behaviours.

The analysis of complex systems by synergetics is designed precisely to deduce the properties of a macroscopic system from its microscopic components (Sanders 1992). It rests upon the similarity at macroscopic scale between human and physical systems. This model therefore integrates individual decision-making levels. In the synergetic approach, the system dynamics is described by differential equations as a function of the size of cities and the rates of individual transition (removals). These rates of transition from one place to another depend on both the multidimensional proximity (geographical but also economic, social, and cultural) between the two spaces and the attractiveness of the destination, the advantages it holds especially with respect to the place of origin (cf. chapter 7), the formulation of which is analogous to utility theory, which allows resolution by a discrete choice model (Haag 1989). The starting point of the reasoning introduced by Weidlich and Haag (1987) in their migration model inspired by synergetics is similar to that of discrete choice models. Those authors begin with the assumption that there are utility functions that depend on group membership. They suppose that the circumstances in which a decision is made are not predictable a priori. Weidlich (2006) emphasizes that changes "effected by individuals should be described by a probabilistic process which may or may not happen, so that the individual 'freedom of decision and action' is not restricted". However, this probability is not modelled through a notion of "noise". We model the change in probability of finding an individual in a place, and this probability changes with the difference in utilities, which are deterministic and identical for members of a group, of living in the current location or another location (push-pull effect, cf. chapter 6), and with a propensity to migrate. As de Palma and Thisse (1989) emphasize, neither the Luce-Tversky nor the McFadden-Thrustone approaches initially include a utility maximization principle. Such a principle is implicit in the Weidlich-Haag approach because the rates of transition describing the changes in probability depend on the differences in utility between the alternatives. Maximum transition therefore occurs for the greatest difference in utility. These dynamic models highlight the change in attractiveness of urban spaces in light of their socio-economic characteristics and the associated mobility flows.

Sanders (1992) shows the stability of a given spatial pattern that tends to be self-replicating. There is a general relation between the attractiveness of a city and its size, which may easily be highlighted by a multiple regression. The residuals of that regression represent the specific attractiveness of a city, i.e. its "preference" and can be interpreted as the outcome of the specific perception of it by migrants. To characterize this perception, it should be compared to the attributes of the city in question. The attractiveness of a space lies ultimately in its ability to attract residential flows on the basis of specific attractors (jobs, shops, green spaces, services, etc.). Competition between zones is established in terms of attractiveness of mobility flows and frequentation of services available in the zones. This positivist approach to attractiveness is criticized, though, because it ignores the social and psychological aspects. On this point, Weidlich (1991), cited by Sanders (1992), notes the marked difference between the reductionist point of view of physicists for whom the properties on a micro scale explain those on a macro scale, and the holistic point of view of psychologists and sociologists for whom scales are clearly separate (a complex pattern exists of itself and cannot be reduced to the sum of its parts).

4.3 A psychological and social approach to attractiveness

In environmental psychology, the notion of individual/environmental congruence in the transactional system approach seems similar to the notion of attractiveness. This congruence refers to the environmental qualities that make it possible to achieve the planned actions and purposes that are important to the individual. The idea is that individuals look for places that optimize, maximize the attainment of their needs, purposes, and intentions in order to maintain an acceptable level of satisfaction. Gärling and Friman (2002) take for example the hypothesis that an individual's degree of residential satisfaction depends on the degree with which the housing chosen, including its residential setting, facilitates the adoption of her life style. The social and symbolic dimension is also considered because this individual–environment relation also depends on environmental significations. It is therefore through the diversity and complexity of significations that environment becomes a support for the individual's affective, cognitive, and behavioural welfare. In summary, congruence is a state of the individual–environmental system within which the individual attributes to the environment a set of meanings that procure her a coherent, familiar, and reassuring vision of the world and of the functional competencies required to achieve her plans and deliberate activities.

Socially the attractiveness of a space may be studied directly, on the scale of the individual (for example housing close to friends and family) and indirectly on a more aggregated level, that of the social environment of the neighbourhood. On this level, attractiveness is determined by a process that arises from shared preferences (environmental, type of housing). It will thus be observed that the attractiveness of a place is often stronger for some types of households (students, couples with children, high fliers, etc.), which reflects to some extent households' residential careers over their lifetimes. Differences in preferences over time mean that the utility a household attaches to a location changes over the course of time, and that is reflected, when financially possible (Hedman et al. 2011), by residential mobility enabling them to find a coherent location. The type of population in districts therefore tends to be comparatively stable and homogeneous. Neighbourhood characteristics are reproduced by households' selective mobility (Hedman et al. 2011, Dieleman and Mulder 2002). In theory residential movements may change the social composition of a district but most of the time they reproduce the pre-existing situation. The differential attractiveness of spaces for certain categories of population remains stable. Residential mobility makes it possible to retain a degree of social and spatial continuity. More rarely, but the phenomenon is no less striking for that, residential mobility may lead to social and economic changes (gentrification, decay)[Pellegrini and Fotheringham 2002, Hedman et al. 2011].

4.4 Attractiveness, local development and planning

Economic base theory holds that it is monetary income "captured outside" that determines regional development. This productive base must be supplemented by a residential base that stipulates wealth need not necessarily be created but rather captured. The development of an area depends therefore on how attractive it is for productive activities but also on the comparative residential advantages it offers the population so that they settle there. Residential economics is related to the location of households and subject to their residential satisfaction. Local policies pay particular attention to this component of economic development that leads to competition among territories on the basis of their residential attractiveness. For planning, it is crucial to know residential preferences in order to assess the possible consequences of local policies and adapt them for the purpose of attractiveness: environmental amenities, new housing, and optimal location of facilities are among the potential attractors brought to bear. In this perspective, the notion of marginal utility is valuable because it can be used to study to what extent variation in one characteristic influences the value of the utility assigned to the alternative under study. This impact is notably dependent on the quantity of this characteristic initially present. An obvious connection can be made with certain environmental attributes used to improve urban spaces and whose effects on individuals can be measured. A connection may also be highlighted with the marginal willingness to pay that corresponds to accepting to pay more for housing in order to increase the value of some of its characteristics. Ultimately this can lead to asking what it that makes one location more attractive than another. What needs to be changed to modify individual behaviour? What is missing in an abandoned place compared with a more attractive place?

The attractiveness of certain types of housing and certain spaces, apart from the characteristics directly associated with them, is also dependent on a more general economic, sociological, and urban context that cannot be directly taken into account through individual preferences. The economic context directly affects the share of their budget that households can give over to housing. The financial context (inflation, lending rates, and duration, etc.) directly influence the housing market and getting on the property ladder. Local and national policies on housing may modify the global pace of new building and social housing. In classical economics, migrations are associated with disequilibrium between supply and demand on the labour market. Market regulation, the percentage of vacant housing, and so on have a non-negligible influence on the way individual preferences are reflected by residential mobility at the collective level (Fischer and Aufhauser 1988). Moreover, changing lifestyles and changing housing expectations of successive generations are reflected by a greater need for space and increased attention to the social composition of the neighbourhood. All of these components influence the housing market.

5. Conclusion

In this chapter we have taken an interest in choice, in individuals' underlying preferences, and the aggregated spatial consequences of choices. While certain questions remain unanswered as to the relevance of one or other method of choice modelling, it will be remembered that choice models arising from economics and psychology can be used to analyse the decision-making process of individuals. The definition of the choice set, the role of context, the choice to perform an action, and the choice of relevant alternatives have been addressed and show the diversity of stages needed to understand choice, for all types of mobility. To each class of model there correspond behavioural hypotheses that ought to be explored. It seems that, to date, less progress has been made on knowledge of group preferences than on exploring the way in which process of choice works.

Many questions remain about individual and group preferences. How do spatial constraints and especially the geographical context act on the identification of preferences? What are the differences between preferences (positive and negative stimulations) and aspirations? Does choice accurately transcribe preferences when the budget constraint is strong and requires a restriction of choice set of some individuals? In choice modelling, allowance must also be made for decisions leading to a *status quo* insofar as this is valuable information. For the time being, this topic is addressed only in terms of restraints on action and not specifically as the result of a choice signalling preferences for the space already occupied.

Conversely, it is noteworthy that some of these choice models, especially those with stochastic utility, are now used with a view to prediction. In terms of daily mobility, they are increasingly included in traffic forecasting models, whereas a few years ago, only deterministic approaches were used. Nowadays, the behavioural approach makes it possible to better understand aggregate phenomena (Prato 2009) despite restrictions relating to individuals' limited rationality in terms of cognitive capacity and information available.

Any spatial decision, even an individual one, leads to a change and engenders a spatial dynamic. Through the accumulation of spatial decisions, this dynamic is translated in terms of attractiveness. Attractiveness is dependent on the attributes of place and the characteristics of available alternatives but it is difficult to make a connection with preferences identified in choice models. Knowing how many people will choose a particular location does not produce collective information about the attributes of those attractive spaces. Varied preferences may lead to concordant choices while identical preferences may lead to divergent choices.

Now, group behaviours with respect to mobility influence the spaces in which they are differentially implemented. Thus the characteristics of places may change through changes in the preferences of individuals reflected by choices that are spatially materialized and shared by the group. Attractiveness, which signals the explicit transition to the spatial and therefore to the collective, inevitably raises the question of urban patterns, changes, and planning. How can local and residential mobilities be channelled? By diversification or, on the contrary, homogenization of urban spaces? Should the attention we give to places be given a ranking in terms of centrality and accessibility that make city spaces differ in their importance? These questions relate to spatial differentiation and interactions among places and they refer back to the understanding of individual and group choice behaviours.

Determinism, Probability, and Imprecision in Decision-Making

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1. Introduction

This chapter looks into the decision to move house and the way in which the decision can be formalized by integrating the reflections from the previous chapters. The fact is that the decision-making process is seldom considered in the context of mathematical modelling of residential mobility. The modelling approaches set out in chapter 9 rest essentially on the concept of preferences and investigate the way in which individuals set about classifying criteria or alternatives with respect to residential choice. Now, *choice* as it is considered in chapter 9 is not to be confused with *decision-making* that marks the transition to action. For example, an individual may decide to move house so as to get on the housing ladder. She looks, then, at her preferences in terms of choice of housing and next decides whether to buy a particular place. However, the same individual could equally well observe her preferences, rank them in order, and determine her utility functions without for all that finally deciding to purchase a place.

In the preceding chapters, we saw that the decision to move home is a complex one and includes various components such as residential choice criteria (chapter 2) as well as personal experiences and collective references (chapters 3 and 6). We also observed that emotions play a non-negligible part in decision-making (chapters 4 and 5). These research results shall be included in our reflection. It should be emphasized that in this chapter we do not set out a completed model but we wish to indicate some avenues for modelling by way of methodological reflections and epistemological considerations.

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Our starting point is to assume that we have results from a survey conducted along the lines of the protocol set out in chapter 8. This survey enables us to identify all of the people in the decision maker's entourage who have had a say in making the decision and to ascertain the main reason(s) for leaving and the conditions that prompted the choice of a new place to live (chapters 2 and 8). We wish to formalize the results of this survey so as to use them in a simulation model. However, what household members have to say when they talk about their discussions concerning moving home or not are often nuanced: "he was clearly for moving", "she was fairly much for/against the move", "it was becoming impossible to live here".[1] In this case, the answers are not just in binary language, marked by a 1 (*for* moving at the end of the year) or 0 (*against* moving), but are also ternary (the third solution not being excluded: decision to move after a birth, separation, death and so on). It is possible to include such semantic values in a model. In particular, the membership function of a fuzzy set (Zadeh 1965, 1968) can be used to determine a value *between* 0 and 1. A decision maker can thus know precisely how much importance an individual assigns to the various components characterized by fuzzy evaluations, for example, the work to be done on the housing, the quality of the residential environment, or the distance to travel to get to work.

Information may be imperfect because of two opposing factors of imprecision and uncertainty. Imprecision relates to imprecise or fuzzy appreciations (preferences in economics) whereas uncertainty concerns the nature of an event and the knowledge we have of it. Imprecision relates to the content of a proposition, whereas uncertainty refers to its truth in conformity with reality. The more closely we seek to specify the content of a proposition, the more we tend to increase its uncertainty. Let us take the example of a household looking for an apartment with certain specific characteristics: six rooms, three bathrooms, two garages, south-facing, swimming pool in a stylish antique building, and in the city centre. There may well be no such place!

The uncertainty of information is intimately bound up with time and its measurement, hence the commonplace use of probabilities. Statistical methods and in particular probability theory provide a way of measuring or rather of estimating what happens in time and space and of projecting those estimations so as to make better decisions.

Let us recall, however, that it was no simple matter to introduce probability into the sciences. August Comte's positivism dismissed any probabilistic approach. "Unlike eighteenth century mathematicians like Bayes or Enlightenment theorists like Condorcet or Laplace, for whom probability theory was famously 'common sense reduced to calculation', or even his near contemporaries like Poisson, Comte did not believe in the computation of probabilities" (Engel

1 Testimony of this sort was collected in surveys conducted as part of the ECDESUP project.

1999, p. 3). Comte's positivism explained the world via classical determinism. Towards the end of the nineteenth century, this point of view was nuanced by the works of Boltzmann[2] and Maxwell, who were to promote the use of probability theory in thermodynamics.

Poincaré also criticized classical determinism by challenging Newton's celestial mechanics in his 1889 paper on the three-body problem and the equations of dynamics. He challenged the very idea that a model, however precise it might be, could predict the future. He showed in particular that if certain physical values cannot be calculated, they cannot be predicted and that certain events predicted by mathematical models cannot occur in physical reality. Poincaré's objections influenced mathematical logic, set theory, and the intuitionism of Brouwer and his successors. Poincaré also showed that, under certain conditions, three bodies obeying Newton's universal gravitation have a trajectory that is highly dependent upon initial conditions. It would therefore be impossible to determine the future of this body exactly because the slightest disturbance in the measurements would irremediably entail a marked difference in trajectory. Notice, however, that these arguments do not challenge determinism in itself but predictability. Thus a system governed by mathematical chaos is perfectly deterministic, but unpredictable because its evolution is wholly irregular and completely dependent upon its initial state.

So long as we are not interested in very small objects, classical physics can make a number of predictions that are confirmed by observation and experience, and the ideas of trajectory and movement remain valid. However, quantum mechanics shows that the notion of trajectory is no longer applicable at the atomic scale, which fundamentally calls into question the concept of predictability. It is, from then on, only possible to indicate the likelihood of certain events occurring, for example, the passage of a particle through a certain location. Probability is then represented as a wave function. This function is a mathematical object called a "state" that changes over the course of time depending on the interactions among particles according to Schrödinger's equation. The connection between this "state" and experiment arises from the fact that classical physical quantities are represented in quantum mechanics by quantities related to experimental devices. Quantum mechanics gives rise to predictions that are confirmed by experiment and observation in many domains, both in the exact sciences and in the human sciences such as economics and geography.

There can be seen beneath the surface, as it were, a "non deterministic quantum mechanics" opposed to the fully deterministic systems of random phenomena. In the social sciences, the value of using a probabilistic approach was highlighted by John Stuart Mill who admitted "the existence of laws that

2 Boltzmann, among others, deduced the second theory of thermodynamics (law of entropy) by statistical reasoning. Through his thinking, which was inspired by British evolutionary theory, he in turn influenced the Vienna Circle (cf. chapter 8).

are merely statistical generalizations relating to the statement of special circumstances" (Engel 1999, chapter 8). This point of view departs clearly from a deterministic concept and is already closer to a generalization of the probabilistic concept as it appears in quantum mechanics, without a direct connection having been established between the two ways of reasoning.

This leads us to look into the nature and function of expected utility as first formulated by Daniel Bernoulli and the pioneering approach in terms of axiomatic systems and representations of expected utility by von Neumann and Morgenstern (1953). If the formalism of quantum mechanics can be a predictive tool in a probabilistic sense, the values measured do not depend solely on physical entities but also on the experimental context implemented for measuring them. Quantum mechanics is considered a generalization of "classical" computation of probabilities, and this generalization stems from the fact that a well-defined state can give rise to several results. Considering the decision to move house, insofar as we know that individuals' preferences are not always fully defined and may be indeterminate by "superimposition of determined preferences", it is important to seek out whether there is a connection between the preferences determined previously and formalized by fuzzy set theory and the probability measurements from quantum mechanics.

This leads us more generally to study the composition and interpretation of a probability measurement depending on its mathematical structure.

The purpose of this chapter is to present, in a first part, the classical probabilistic approach as traditionally used in decision-making in economics, when choosing a place of residence, for example. In a second part, we show that the contributions from quantum mechanics and fuzzy set theory generalize the probabilistic approach and address the question of choice from a particular angle. The fact that, in quantum mechanics and in the context of fuzzy set theory, we suppose that agents' preferences are imperfectly defined and that we take account of ternary logic (Reichenbach 1949, Zadeh 1965) leads us to rethink decision-making mechanisms, in a final part.

2. Classical probability in decision-making— Models of choice in a deterministic universe

After a brief reminder about probabilities in the history of gambling, we shall study the impact of probabilities in decision-making. We consider in succession objective probabilities and von Neumann and Morgenstern's theory, and then subjective probabilities applied to Savage's theory. Finally, we shall examine the development and scope of such decision-making theories. More specifically, we shall discuss models such as those of Allais (1953), Kahneman and Tversky (1979), and so-called rank dependence theories.

2.1 Probabilities in the history of gambling

The study of decision-making in the face of risk is inseparable from the history of probability theory and gambling in the sixteenth and seventeenth centuries. The Grand Duke of Tuscany questioned Galileo as to why, when throwing three dice, the total 10 comes up more often than 9. The chevalier de Méré, philosopher and man of letters, asked Blaise Pascal: "Which is the more likely: to roll at least one six in four throws of a die or to roll at least one double six in throwing two dice 24 times?" Pascal not only provided solutions, but also came up later, in his *Pensées*, with a probabilistic argument known as "Pascal's wager". The use of his calculation of the "wager problem" enabled him later to evaluate the probable weight of an uncertain situation (its "expectation" as Huygens was to say) and so to make a "rational" decision. These problems were implicitly solved by calculating mathematical expectation based on linear processing of results (random variable additivity).

Another very fashionable game in the eighteenth century, recounted by Nicolas Bernoulli in a letter to his friend Pierre Raymond de Montmort[3] in 1713, involved tossing a ducat.[4] The coin was tossed until it came down "tails". If it came down "tails" on the first toss, the player received 2 ducats and the game ended. If not, he threw the coin a second time. If "tails" came up, the player won 4 ducats and the game ended. If not, he played a third time and won 8 ducats if "tails" came up on this toss, and so on. In this, when "tails" comes up on the n-th throw, the player wins 2^n ducats. The problem is easily resolved in terms of mathematical expectation of gain which is infinite in this game![5] What intrigued people at the time was that no one wanted to pay more than a few ducats to have a go at the game. This problem was much discussed by Daniel Bernoulli, the cousin of Nicolas, and also by Buffon, d'Alembert, Cramer, and other philosophers, because it brought to a head a problem of mathematical expectation and a problem of metaphysical expectation!

It was Daniel Bernoulli who gave the first explanation of the paradox that was dealt with (using the case of a bounded lottery) in the Transactions of the Academy of Saint Petersburg and is hence known as the Saint Petersburg paradox:[6] "People evaluate money in proportion to the utility they can derive from it". This means that by substituting its utility function for the mathematical expectation of a gain, Daniel Bernoulli was the first to propose a representative

3 Pierre Raymond de Montmort (1678–1719), French mathematician elected to the *Académie des Sciences* in 1716, was interested primarily in the calculation of probabilities.

4 A gold or silver coin of the time.

5 By positing X: the random variable of gain, the probability distribution is: {2,1/2; 4,1/4; 8, 1/8; 16, 1/16,…} and the expectation of gain is:
$E(X) = 1/2 \times 2 + 1/4 \times 4 + 1/8 \times 8 + \ldots = 1 + 1 + 1 + \ldots = \infty$

6 The paradox lies in the contradiction between the theory that prescribes an infinite wager and common sense that prohibits it.

function of preferences in which a not necessarily linear treatment of results appeared. In his expected utility model, utility does not necessarily grow at a constant rate.[7]

In economics, an individual's marginal satisfaction, that is, the gain in satisfaction derived from consuming an extra unit of a good, is not necessarily constant. The increased satisfaction provided by an extra one euro gain is not necessarily the same if one initially has 1000 euros or if one has nothing. The result is that the utility of goods (including money winnings) is assumed to be increasing, but at a decreasing rate both in certainty and a fortiori in uncertainty. It took the Saint Petersburg paradox for people to really become aware of this.

Daniel Bernoulli was inspired by the behaviour of businessmen of the time to solve the gambling problem, but other suggestions have been made (Jallais and Pradier 1997). Condorcet and d'Alembert criticized Bernoulli's choice of gain-transforming function which appeared too arbitrary. Condorcet used a function consisting in maximizing the gain by limiting the risk to a given level. Laplace also used this criterion at the same period for estimating the country's population by sample surveys. He minimized the cost of the survey while limiting the risk of error. He was also the first to introduce the concept of intervals of confidence. D'Alembert's theory of hypothesis testing proposes transforming probabilities rather than gains.

2.2 Probability in economics and decision-making

The theory behind von Neumann and Morgenstern's decision-making and objective probability

The question of gambling was to interest French mathematicians from Poisson to Poincaré throughout the nineteenth century. The convergence of a priori and a posteriori definitions of mathematical expectation (asymptotic mean) was to make the calculation usable in many applications of economic life. Insurance, for example, deals by nature with random phenomena and from the outset

7 Taking the example of the "Saint Petersburg paradox" and associating a utility function with it, it can be seen that individuals do not necessarily process the results linearly.
Let X be a random variable with probability distributions:
L(X) = {2, 1/2; 4, 1/4; 8, 1/8; 16, 1/16…},

$$EU(X) = \sum_{i=1}^{n} P_i u(x_i)$$

Let u(x) be a utility function that is increasing at a decreasing rate:
$\forall x \in R+: u(x) = \ln(1+x)$
EU(X) = 1/2 x u(2) + 1/4 x u(4) + 1/8 x u(8) + …
EU(X) = 1/2 x ln3 + 1/4 x ln5 + 1/8 x ln9 + …
Expected utility is a countably infinite number of terms. This sum is bounded. For example, by taking a boundary strictly less than:
ln5 = ln(1 + 4) = u(4), it can be seen that: EU (4) < u(4) (0.732 < 1.6)

provides a field of application for the calculation of probabilities insofar as the aim is to compute insurance premiums with certainty.[8] While marine insurance contracts have existed in the modern "simple i.o.u."[9] form since the fourteenth century, the question of the evaluation of life assurance contributed to many actuarial mathematical developments.

Borel field or sigma algebra

Sigma algebra is any family $\mathfrak{F}$ of part $P(E)$ such that:
(1) $E \in \mathfrak{F}, \text{et } \varnothing \in \mathfrak{F}$;
(2) for any monotone sequence of elements of $\mathfrak{F}$, $\{A_i\}$ is a monotone family. We have:

$$\lim_{i \to \infty} (A_i) \in \mathfrak{F}$$

This last property can be broken down into:
(a) $A_i = A_i + 1$, we then have an increasing sequence:

$$A_n = \left(\bigcup_{i=1}^{n} A_i\right) \to \lim_{i \to \infty} A_i \in \mathfrak{F}$$

(b) $A_i \supseteq A_{i+1} \Rightarrow A_n = \bigcup_{i=1}^{n} A_i$ therefore $\lim_{i \to \infty} (A_i) \in \mathfrak{F}$

Emile Borel[10] returned subsequently to Pascal's wager by emphasizing that the utility of a chance event should not be confused with its mathematical expectation. Purchasing a lottery ticket does not really change the life of the purchaser, he explains, whereas if she wins, however rare that event may be, her life will be changed completely. He shows that it is just as rational to pay to buy risk (lottery ticket) as it is to pay to avoid it (insurance premium). We saw earlier that the expected utility of a random variable is a countable infinite sum of terms. This sum is bounded. Moreover, we know also that the paradoxical character of choices vanishes if it is accepted that decision makers set about the not necessarily linear processing of results by using the utility function. While this procedure seems fairly handy, the nature of the utility function felt by the decision maker for the monetary outcomes remains to be defined, knowing that the function is defined to the nearest strictly increasing transformation in

8 The insurance premium is the amount to pay to insure against an accident. The size of the premium varies with the likelihood of the accident and the monetary evaluation of the damage incurred. A distinction is draw between basic premiums, which correspond to the mathematical expectation of the accident, considered until the seventeenth century as "the fair price of risk" and premium loadings that include management components contingent in the insurer's organization.

9 Private contract promise to pay.

10 Emile Borel (1871–1956), mathematician, professor at Paris faculty of sciences, member of the Academy of Sciences, specialized in the theory of functions and probabilities. He was one of the pioneers of measure theory and its application to probability theory. It is to him we owe the concept of the Borel tribe.

a context of certainty in microeconomics. In their book on economic behaviour and game theory, von Neumann and Morgenstern (1953) set out the foundations of expected utility both in terms of an axiomatic system and according to the representation theorem. By this theory, individual choice behaviour in the presence of uncertainty is described by the selection of a lottery[11] (or a game) among a set of acceptable lotteries, each being characterized by an objective probability distribution. The selection is determined by the decision maker by comparing different lotteries considering their expected mathematical utility, that is, in the discrete case, the sum of the utilities of the outcomes weighted by the corresponding probabilities. The decision criterion is the maximization of expected utility.

Objective probability that is based on a Borel field or a sigma algebra (cf. box) must comply with the usual axioms of probability calculation (additivity, summing to unity, conditional probability axioms, etc.). To illustrate this problem, we take the example of the choice of a decision maker faced with a choice of investing in apartments with equivalent characteristics but located in different places. The decision maker may choose on the basis of the criterion of distance between her place of work (noted 0) and the two potential apartments noted A and B (in terms of lotteries, this would amount to choosing between two lotteries A and B). For each of the home to work commutes, three states of nature can be identified (event or modality for geographers): free-flowing traffic, heavy traffic, or congested traffic. We know that we can have probabilities associated with the states of the traffic from statistical studies of congestion on itineraries 0A and 0B. The utility of the consequences of choosing apartment A or B therefore corresponds to the utility related to the consequences of congestion of the routes. The different possibilities are summarized in the following table.

Utilities/States of nature: (events, modes)	**Free-flowing traffic**	**Heavy traffic**	**Congested traffic**
Utility of consequence *A*	100	70	15
Utility of consequence *B*	90	55	10
Probability associated with journey 0*A*	1/3	1/3	1/3
Probability associated with journey 0*B*	3/4	0	1/4

The expected utility of choices *A* and *B* according to the state of nature "traffic", respectively noted $EU(A)$ and $EU(B)$ is:

11 A lottery is defined as a function that associates with each outcome of a given set the probability of the outcome occurring.

$EU(A) = 100 \times 1/3 + 70 \times 1/3 + 15 \times 1/3 = 61.66$
$EU(B) = 90 \times 3/4 + 10 \times 1/4 = 70$

Maximizing expected utility leads the investor to choose apartment *B*.

Beneath this apparently straightforward decision-making rule lies a rigorous axiomatic construction. The restrictive character relates both to the characteristics of the utility function and to the characteristics of the axioms to be observed to ensure a coherent choice. Von Neumann and Morgenstern's (VNM) axiomatic system is valuable in shifting from a spot choice to a continuous choice function. The utility function obtained must transcribe the same order as classical individual preferences. Let there be lotteries L_i and L_j:

if $\forall$ L_i and L_j, we have: $L_i \} L_j$, then $E[U(L_i)] \geq E[U(L_j)]$.

The "preference/indifference" symbol noted } for ranking lotteries must be dissociated from the usual "greater than or equal to" noted ≥ that applies to numbers. If the properties of symmetry and transitivity obtain for the relation ≥, the same is not true for the relation } included in the VNM axiomatic system. The outstanding points of this axiomatic system are the following.

– The first axiom establishes the existence of a total pre-order over the consequences of a choice. It means that the decision maker can always express an order of preference or indifference over the set of outcomes or consequences. It is, in a sense, an axiom of comparability or "forced choice" postulating that preference or indifference relations are transitive.

– The order and combination axioms are of interest for establishing preference relations, integrating probabilities associated with each of the consequences. More specifically, the lottery associated with a preference relation is defined as a function for which a probability is associated with each outcome.

– The continuity axiom is a technical hypothesis required for representing the order of preferences by the continuous utility function, contrary to the other axioms which are logical hypotheses introducing by this fact the requirement that the decision maker behaves rationally.

– The final three axioms set out the preference combination algebra. The commutative axiom indicates that the order of gains in a lottery is of no importance. The reduction-of-lotteries axiom implies the property of preference distributivity. The substitutability axiom implicitly entails the independence of preferences on the consequences of choice. This final independence axiom amounts to saying, for example, that the order of preference between two lotteries Li and Lj will remain the same if each is combined in the same proportion with a third Lz. Now, as seen before in gambling, combining one lottery with another is very different from adding two variables; in particular, if the amounts at stake are high, the new combination may lead the "player" to revise her order of preferences.

Savage's decision theory and subjective probability

When states of nature are future states whose conditions of occurrence are not identical to those that gave rise to the states observed with which they can be compared, we can no longer base our reasoning on objective probability.[12] Savage (1972) sharply criticizes probability defined as the limit of the relative frequency of observations. When the sample size tends towards infinity, he substitutes subjective probability for it. Subjective probability measures an individual's belief in the truth of a proposition. The decision to move house fits in perfectly with this logic. The individual is not sure, for example, that commuting conditions will always be the same in the future. New technologies that are currently unknown may fundamentally change travelling conditions.[13]

Subjective probability was developed by de Finetti (1937) and then taken up by Savage in constructing the behaviour of economic agents faced with uncertainty. Subjective probability rests on a number of axioms that must be in tune with the usual rules of traditional calculation of probabilities. It seeks to reduce the duality of frequency and likelihood. In order to unify these two conceptions, Savage establishes rules of correspondence between them and shows that probability, like relative frequency, is just a particular case of a more general conception. It rests on the principle that an unknown magnitude may be estimated by comparing it with an objectively known magnitude. The decision maker compares random "state"[14] variables with various events whose probability she knows objectively. Subjective probability must respect a number of properties, of which we recall the independence of probabilities compared with the selected judgement criterion. Raiffa (1973) explains this independence axiom (or substitution principle) by considering two lotteries: "If a lottery is modified by substituting for one of its prizes another prize, everything else remaining fixed, and if you are indifferent between the original prize and its substitute, then you should be indifferent between the original lottery and the modified lottery" (p. 62).

Subjective probability is based on the information held by the decision maker at a given point in time. This means that any random event (as defined previously) can be probabilized. Any newly relevant information leads the decision maker to modify the probabilities set out before. This modification is consistent with the conditional probability theorems and in particular Bayes' theorem. The subjective probability depends on the information held by the decision maker. That information cannot readily be measured: it is within her experience,

12 This is dependency that is explicit in time and that modifies the states of nature and their number.

13 Thus a street that was calm before cars were invented may have become very noisy since then.

14 The technique applies only to discrete random variables; it becomes more complex with continuous ones.

control, and memory; she is the sole judge of the value she attributes to this probability. She can be helped, though, by proposing binary reference lotteries. More specifically, when the decision maker refers to a given lottery, her attitude towards risk with respect to this lottery is revealed by the comparison between expected gain related to the lottery and the certain monetary equivalent of this lottery. This equivalence is represented by a specific number corresponding to the maximum sum the decision maker accepts to pay to protect herself from the obligation to accept this lottery. This sum may be likened to an insurance premium. In parallel to the attribution of a subjective probability to a state of nature, the decision maker evaluates the utility of the hypothetical consequence of an act that must obey the order of her preferences. She is then in a position to calculate, for each act, the sum of conditional consequences weighted by the probability of the state of nature coming about. The decision is rational if the option chosen maximizes the expected utility function. It is referred to as subjective expected utility (SEU).

Evolution and scope of probabilistic decision-making models

As in gambling, the appearance of new "experimental paradoxes"[15] shook the dominant model. Allais' paradox was later to give rise to other theories such as Kahneman and Tversky's or rank dependent expected utility theory.

Allais (1953) asked Savage some twenty questions, the following two of which make up what is called "Allais' paradox".

Do you prefer situation *A* to *B*?

Situation *A*	**Situation *B***
Certainty of receiving 100 million	10% probability of winning 500 million
	89% probability of winning 100 million
	1% probability of winning nothing

Do you prefer situation *C* to situation *D*

Situation *C*	**Situation *D***
11% probability of winning 100 million	10% probability of winning 500 million
89% probability of winning nothing	90% probability of winning nothing

Savage chooses *A* and *D*. In terms of expected utility, we should have:
$B > A$ and $D > C$. Savage's choice is therefore contrary to the results of expected utility.

15 Scientists speak of experimental or empirical paradox when a model proves incompatible with the facts, that is, theoretically impossible results are observed empirically and this divergence cannot be ascribed either to the logical structure of the model whose internal consistency is guaranteed, or to the quality of the tests (Walliser 1995).

Savage recognizes his mistake. For him, the theory cannot be refuted, it follows that the economic theory is no longer descriptive but normative.[16] Allais subsequently refuted empirically (by observations) that the theory is normative. The contradiction in choice stems from failure to observe the independence axiom. Weakening the VNM/Savage axiomatic system would make it possible to eliminate the contradictions observed. We saw earlier that the solution to the Saint Petersburg paradox involved non-linear processing of results. Buffon (1707–1788) suggested that individuals ignored small probabilities. He was to be followed in this by Allais and the psychologist Edwards in the 1950s who looked for not necessarily linear processing of probabilities. Allais' paradox therefore started up the debate anew. In the 1960s a few psychologists, including Kahneman[17] and Tversky (1979), took an interest in Allais' paradox. In their prospect theory they proposed an intuitive function for the random variable Ψ (probability transformation function), an initial wealth W, and a specific utility function (distinct from expected utility). This theory unfortunately ran up against the problem of non-observance of stochastic dominance, but it led Quiggin (1982) to propose that the transformation of probabilities relates not to simple probabilities but to cumulative probability. This made it possible to set aside any refutation of first-order stochastic dominance.[18] This is how rank dependent expected utility (RDEU) theories were born. RDEU theories present, after a fashion, a weakening of the expected utility axiomatic system insofar as they take into account not just a deformation of pay-offs through utility functions but also a transformation of probabilities.

Although these latest decision-making theories prove compatible with observations, they are far more complex to apply than expected utility theory. So even if expected utility theory does not provide sufficient epistemological foundations, it is still widely used because it is so easy to use.

We shall show in what follows that integrating imprecision both within the utility function and in the measurement of states of nature enables us to define a fuzzy expected utility that can be readily applied. Both the weakening of the expected utility axiomatic system due to fuzzy set theory and probability measures such as they are taken into account in the context of quantum mechanics are valuable in providing sufficient epistemological foundations. The resulting fuzzy expected utility can narrow the gap between descriptive theories that cannot be easily applied and normative theories that are convenient to use but are undermined by a number of counterexamples.

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16 Positive economics uses objective or scientific explanations of the working of the economy, contrary to normative economics which rests on prescriptions or recommendations.

17 Psychologist Daniel Kahneman won the Nobel Prize for economics in 2002.

18 Dominance means that "in all circumstances" the outcome achieved from a random variable X will be better than the outcome achieved from random variable Y (Gayant 2001, p. 33).

3. Probalities in quantum mechanics and fuzzy set theories—Towards non-deterministic choice models

Our objective now is to show that quantum mechanics, which rests upon a generalization of probabilities, makes it possible to supplement the epistemological foundations of decision-making through the introduction of an experimental approach that is complementary to normative approaches in economics. We also wish to show that quantum logic is intimately related to ternary logic and so joins up with fuzzy set theory. This makes it possible to model not just information that is not always predetermined by probability theory, but also to characterize the decision maker's imprecise behaviour.

3.1 Probabilities in quantum mechanics

The notion of probability in classical physics

The notion of probability is used in physics in the context of reflections on the estimation of errors. The value of using a probabilistic approach to describe observational errors in astronomy was highlighted by Jacob Bernoulli (1713) without deviating from deterministic logic with respect to the laws of physics. As we have seen, it was only in the late nineteenth century that theoretical physics resorted to a probabilistic approach in the context of developing a theoretical concept to explain thermodynamics. However, this theoretical concept does not call into question either causality or determinism. The idea is that it is simply impossible to know at any given moment the position and velocity of some 10^{23} particles contained in a box the size of which is on our scale of observation.

Axiomatic system of classical probability (Mittelstaedt 1972)

This is mathematically defined by the following axioms:

A1: Probability is a real, non-negative function $w(x) \geq 0$, which is explained for all elements x of a Boolean lattice L_B.

A2: If ∩ ("and"; association) and ∪ ("or"; exclusion) are the lattice operations and if n is the *zero* element, the following relation is valid for both elements $x, y \in L_B$ for which $x \cap y = n$:
$w(x \cup y) = w(x) + w(y)$

A3: For elements $x_1, x_2, x_3 \dots x_i \dots x_k \dots \in L_B$ for which the relations $x_i \cap x_k = n$ are valid two by two for any i, k, we have:
$w(x_1 \cup x_2 \cup x_3 \dots) = w(x_1) + w(x_2) + w(x_3) + \dots$

A4: If $w(x) = 0$, then $x = n$

A5: If e is the unit element of the lattice then $w(e) = 1$

Probability theory then serves essentially to establish a connection between the microscopic scale of particles and the macroscopic scale by counting microscopic patterns that correspond to the same macroscopic pattern.

This type of reasoning can be illustrated by the idea that any two people swapping positions in a crowd does not affect the overall state of the crowd. A familiar result of such reasoning is the second theorem of thermodynamics which states that the entropy[19] in a closed system increases until a stationary state is attained. The stationary state corresponds to a uniform distribution of particles within the closed system. However, the existence of constraints of different kinds may induce other types of stable distributions; such constraints may be introduced in the form of Lagrangian multipliers which are also used in economics.

The notion of probability in modern physics

Although the notion of probability complies strictly in thermodynamics with the logic formalized later by Kolmogorov, this is no longer so in quantum mechanics. The results of observations of particles on the microscopic scale have endangered the reasoning of classical physics. The introduction of a consistent and satisfactory interpretation in terms of logic has required a rethink of a number of postulates concerning physics and the mathematical tools used for formalizing it (chapter 8). Here we are interested in certain consequences of probabilistic formalization that might be valuable when modelling the decision-making process, without wanting to come down on one side of the fence about a direct link between the quantum microscopic scale and the psycho-neurological context involved in decision-making.

Let us consider, by way of illustration, a monochrome beam of light passing through two slits cut in a non-transparent screen based on Young's experiment (figure 1a, b, c, and d). The light is recorded on another screen positioned some distance from the first. On this screen diffraction patterns are observed confirming the wavelike character of light. Now, if we project a beam of microscopic particles—electrons, for example—onto the same device the same effect can be observed, which is in contradiction this time with classical physics. The particles should go through the slit on straight-line trajectories and we should observe not an interference pattern, but instead a concentration of particles in two spots on the recording screen as if we were spraying water through a plate with two holes in it. Therefore electrons behave like waves: they are not precisely located objects; they fill all of space in the way electromagnetic light waves do.

19 It should be recalled that various approaches in the social sciences use the notion of entropy, such as Wilson and Clark's models or urban sociology, which introduces segregation indicators based on the concept of the entropy of a mix.

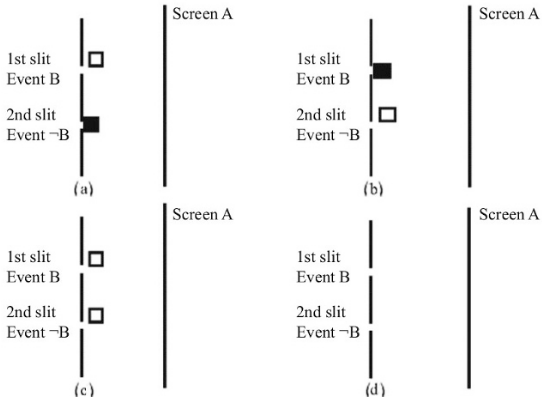

Figure 1—(a), (b), (c) and (d): The four arrangements of Young's experiment[20]

By reducing the intensity of light in the first experiment until it becomes very low, we no longer record a continuous flux, but individual flashes, corresponding to the behaviour of particles hitting the screen one after another.[21] These flashes are not, however, located in two spots as should be observed for "classical" particles. If recorded over a long time span, it can be noticed that the distribution of their traces on the screen corresponds to the interference pattern observed initially. This leads us to suppose that the particle goes *at the same time* through both slits, which is counterintuitive. This interpretation is confirmed by the fact that we observe a completely different image on the screen if we close one slit, that is, if we force the particles to go though a precise place. There is therefore an interaction between the two slits in the sense that they jointly determine the event of the passing of the particles through one or other of them and so influence the law of distribution observed on the recording screen. These results are fundamentally troubling and this effect is referred to as wave-particle dualism. They show that it is ultimately impossible to predict the specific place on the screen where the next particle will be recorded.[22]

20 Either one of the slits is obstructed (figures a and b, black square) and the passage of one particle is recorded (the white square represents the recorder) or the passage through both slits is freed up and the passage of particles is again recorded, or it is not recorded. In all four cases, the diffraction image is recorded on the screen. According to quantum mechanics the four arrangements give different results. For example, recording the passage of particles as in (c) gives a different image on the screen from that generated by arrangement (d) [Bitbol, 1999, p. 62-66]. The negation sign, therefore $\neg A$ means "not A".

21 These particles of light are called photons in quantum mechanics.

22 Which does not mean there are not singular but unpredictable cases in which a particle goes though one slit only.

Such results lead to a fundamental rethinking of the formal framework of quantum mechanics, which has prompted much debate. The generally recognized framework is based on the "Copenhagen interpretation" developed mainly by Bohr and Heisenberg to which other scientists such as Dirac and von Neumann contributed. By this approach, a distinction is made between variables that are "commensurable" and others that are not. For commensurable variables, also called "objective" variables (Mittelstaedt 1972), we obtain strictly the same results in whichever order we proceed: if we measure first property *A* and then property *B* or first *B* and then *A*, the results are unchanged. This is no longer so for "incommensurable" variables, because measuring one variable destroys the information obtained by the previous measurement.

Particular attention is paid to the interaction between the measuring instrument and the object measured. This interaction is the subject of complex reflections only the consequences of which are indicated here. Even if it is possible to abstract away the measuring instrument and consider the variable to be observed, it is impossible to predict the result of a measurement but only to indicate the probability of measuring one value or another. In the two slits experiment, the interaction between the measuring instrument and the object being measured directly affects the object being measured as shown by the difference when switching from two slits to one. The experiment makes it possible even so to determine a precise value (such as the location of the flash): at this time the system is said to be "prepared". We then speak of "objective" information. Let us emphasize that the measurement of a property of one particle may also influence that of another particle in another place if the two particles were in interaction at some point in time. Such "quantum entanglement" was long thought "absurd" but was confirmed by experiments first conducted at the *Institut d'Optique d'Orsay* (France) between 1980 and 1982 and confirmed since by other laboratories.

The peculiarities of interactions between a quantum object and its environment have fundamental consequences for the probabilistic formal framework of quantum mechanics which has been referred to as "quantum logic". These consequences were highlighted by Mittelstaedt (1972).

Axiomatic system of quantum probability (Mittelstaedt 1972)

The proposition concerning variable *A* forms, relative to operations $\wedge$, $\vee$ and $\neg$[23], a near-modular, sigma-complete, ortho-complementary lattice L_q. For the purpose of introducing a quantum probability, we define a real function $p(A)$ defined for all $A \subseteq L_q$ which is consistent with the following axioms:[24]

A$^{(q)}$1: For any element $A \subseteq L_q$ the function $p(A)$ has the property $0 \leq p(A) \leq 1$

A$^{(q)}$2: $p(\Lambda) = 0$ and $p(V) = 1$

23 A true proposition is designated *V* and a false one Λ.

A$^{(q)}$3: If $\{A_i\}$ is a sequence with $A_i \rightarrow \neg A_k$ then

$$\sum_i p(A) = p\left(\bigvee_i A_i\right)$$

A$^{(q)}$4: For any finite sequence $\{A_i\}$ it can be deduced from $p(A_i) = 1$ for all $A_i \subseteq \{A_k\}$ that $p(\bigwedge_i A_i) = 1$

A$^{(q)}$5: If $A \neq \Lambda$ there exists a p with $p(A) \neq 0$; if $A \neq B$ there exists a p with $p(A) \neq p(B)$

Notice that this lattice is no longer Boolean as far as its logical values are concerned. The axioms correspond to a generalization of axioms **A1** to **A5** because we obtain the results of classical probability for Boolean lattices. For Boolean lattices, axiom **A$^{(q)}$4** is a direct consequence of axioms **A1, A2, A3**, and **A5**.

The fundamental difference between the two forms of logic is that in classical probability, there is an equivalence between the two propositions: $A \leftrightarrow (A \wedge B) \vee (A \wedge \neg B)$, which is still valid for commensurable variables, whereas in quantum logic there only remains the implication $(A \wedge B) \vee (A \wedge \neg B) \rightarrow A$, while the reverse proposition $A \rightarrow (A \wedge B) \vee (A \wedge \neg B)$ cannot be proved.

This logic corresponds to the two-slit experiment: if—which we do not know—the particle goes through one of the two slits, it will be present on the recording screen but we cannot claim that it passed through one of the two slits because it may have "passed through both slits".

For probabilities associated with the double-slit experiment, the formalization of quantum mechanics is described by the relation:

$$w_\varphi(A) \geq w_\varphi(A \wedge B) + w_\varphi(A \wedge \neg B)$$

where the equality sign corresponds to the commensurable situation of both measures, which is the equivalent of the classical situation. Taking account of the interaction $w_{\varphi(int)}(A)$ between the two slits and the locus A, we obtain the following formulation:

$$w_\varphi(A) \geq w_\varphi(A \wedge B) + w_\varphi(A \wedge \neg B) + w_\varphi^{(\text{int})}(A, B)$$

which is not consistent with classical probabilistic theory.

Let us now consider the dynamic aspect of this formalization. In the formal concept of quantum mechanics, the state of a system is represented by a state vector. The description space is formed by a system of orthonormal coordinates in which each axis corresponds to a potential measurement value (modality), (cf. Bitbol 1999). The projections of the state vector on the axes, and therefore its components, correspond to the statistical weight of values, and therefore to the probability of observing them.[24] The measurement causes a “reduction” of the state vector: it is “projected” onto the axis corresponding to the measured value and its length is divided by one so as to ensure the probability is normalized (“renormalization”).

The fundamental difference between commensurable and incommensurable observables is also found in the formal framework. For two commensurable variables A and B, the modal coordinate systems are identical.

By measuring a value A_i, we are certain that the system is also in a precise state B_j. Accordingly, $A_i \wedge B_j$ is therefore true. This is no longer the case for incommensurable variables because their two coordinate systems are no longer identical, one is related to the other via a rotation (figure 3). Thus, after measuring a value A_i, the state vector is parallel to the axis corresponding to that value, however, it is not parallel to one of the vectors corresponding to values B_j. We can only know the probabilities of measuring one or other values B_j through projections of variable B on the axes of the system of coordinates. Thus the proposition $A_i \wedge B_j$ is no longer true, but “indeterminate” or “unknowable”, according to Reichenbach’s observations.

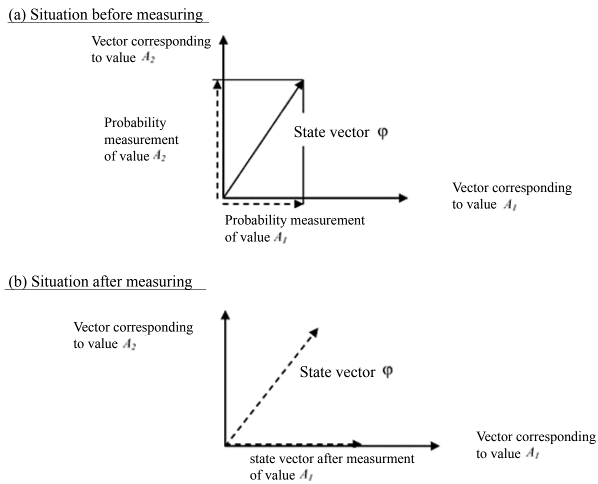

Figure 2—State vector: before and after measuring

24 Which is reminiscent, in terms of its logic, of correspondence factor analysis. However, for reasons specific to quantum mechanics, the projections are complex values and only multiplication with the complex conjugate value yields the probability value.

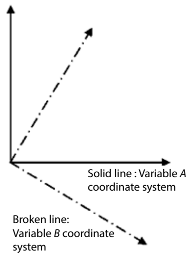

Figure 3—Coordinate system of non commensurable variables A and B

It has recently been proposed that the decision-making process be described using "quantum formalization" (Zwirn 2009). The formalization is illustrated on the basis of two decisions to be made concerning two questions of different kinds, *A* and *B*. The two decisions come immediately one after the other, to dispense with consideration of the dynamics that determine a change in the agent's attitude with respect to alternatives over the course of time.[25] For each question, a choice must be made among *n* alternatives that are ranked by an ordinal principle. A coordinate is assigned to each alternative as in quantum mechanics. The agent's mental state is represented by a state vector the projections of which on the axes correspond to the statistical weights assigned to the various alternatives. When the decision is being made, the vector is projected onto the axis corresponding to the alternative chosen by the agent, which corresponds to the measurement process in quantum mechanics. The authors distinguish between situations in which decisions "switch" ("commensurable" and therefore compatible variables) or not ("incommensurable" variables). For the first type of decision, it is assumed that they do not mutually influence each other and so the order in which they are made does not affect the final result. In this case, the coordinate systems are parallel. Accordingly, a projection on one axis corresponds to specific alternatives of the two questions and there is no mutual influence. However, for decisions of the second type, the fact that a decision has been made for one question will influence the choice of alternatives for the second question because their coordinate systems are not orthogonal. A projection on one axis of question *A* does not therefore correspond to an alternative of the other question and the projection made by the first decision becomes a state vector whose statistical weights for the alternatives of the second decision are unknown, through projections on the axes of the coordinate system of question *B*. The formalism highlights, as in Young's experiment, that the probabilities of

25 In quantum mechanics as in physics in general we have a dynamic equation describing the change in probabilities over time. This is Schrödinger's equation.

choosing one of the alternatives in question B depend explicitly on the decision first made for A, and that the probabilities assigned to the alternatives of B are different if the agent has not first decided on question A.

3.2 Probability and fuzzy set theory: towards non-deterministic and imprecise models of choice

The purpose of this section is to introduce the concept of the fuzzy set in terms of behaviour in the presence of risk and to seek out a fuzzy measurement that can adequately characterize the problems of risk and uncertainty (chapter 7). To do this it is important to consider first the axiomatic underpinnings of the various measures of risk and utility. Fuzzy expected utility and the resulting axiomatic system (Mathieu-Nicot 1990)will not be set out here as our purpose is primarily to make a comparative analysis of the different measures with those proposed by quantum mechanics and to show of what interest they can be in modelling choice and decision-making.

Fuzzy measures in a random (risky) universe

Probability measures

The axiomatic system of probability measures (cf. box in section 2.2) rests on $P(E)$ sigma algebra or a Borel field. It is the space on which the definition of probabilities rests (also called Borel-Kolmogorov space).

Notion of Borel semi-field

Borel semi-field defined on a lattice: a "Borel-semi field L" is defined as follows: given a fuzzy set reference frame E and a family Ψ, $\Psi \subset LE$, generally, L is represented by a lattice.
Ψ shall be called "Borel semi-field L" if it has the following properties:

1) $\varnothing \in \Psi; E \in \Psi$

2) $(A \in \Psi, B \in \Psi) \Rightarrow A \cap B \in \Psi$

3) $(A_1, A_2, \ldots, A_i, \ldots) \in \bigcup_{i=1}^{n} A_i \in \Psi$

The pair (E, Ψ) is a "Borel semi-space L" composed of a set E, that may be finite or not, and a Borel semi-field Ψ defined on a lattice.

The probability of additivity implies that:

$$\forall A, B \in E : P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

The probability of an event is the quantification of the degree of likelihood with which that event will occur. It is a positive or zero value and it is higher when the event is more probable.

By complementarity, it is known that the respective probabilities of an event and its opposite are equal to unity.

$$\forall A \subseteq E : P(A) + P(\overline{A}) = 1$$

The property of additivity is so obviously a matter of common sense that no one would think of challenging it. And yet in some instances in the human sciences, be it in economics, geography, or psychology, such postulates can be too restrictive. This is why, when describing individuals' real behaviour, it seems necessary to alleviate such properties. Fuzzy set theory, which no longer leans on binary logic, but on n-ary logic, draws on a more general axiomatic system such that the particular case of binary logic can be found. The approach consists in replacing the additivity property by that of monotone inclusion.[26] Moreover, the complement no longer exists in fuzzy set theory and instead of imposing a pseudo-complement Zadeh (1968) and then Sugeno (1974) introduce as a starting set a Borel semi-field on which to define the measure.

Probability of a fuzzy set

With D the set of alternatives/actions, we can define a fuzzy set H:

$$H \subseteq D$$

$\mu H_j(s)$ is the fuzzy measure of H_j.

For all states of nature noted s, the probability that a state of nature should occur is noted: $P(s)$. The probability of a fuzzy set H_j is written:

$$P(H_j) = \sum_{s=1}^{s=j} \mu H_j(s) \cdot P(s)$$

The probability of the fuzzy set H_j no longer rests on a Borel field but on a Borel semi-field noted Ψ. The complementary element no longer exists and the property of additivity is replaced by monotone inclusion. We thus find analogies with Mittelstaedt's quantum probability. Both have the same properties as Choquet's capacity[27] as shall be seen later.

26 The property of monotone inclusion: $A \in \Psi, B \in \Psi$
$A \subseteq B \Rightarrow v(A) \leq v(B)$

27 Given (E, A) a probabilizable space, a Choquet capacity is a measure:
$M: A \rightarrow [0,1]$ that confirms:

It is possible to check that the probability measure is indeed a particular instance of the Sugeno fuzzy measure and that a Dirac subset of measures[28] is itself a particular instance of the probability measure. The ordinary (non-fuzzy) set is of course part of the fuzzy set H that makes it possible to introduce a whole range of appreciations between the certain probability of an event occurring ($P = 1$) and that of it not occurring ($P = 0$). Shafer (1976) was led subsequently to define credibility and plausibility measures.[29]

Axiomatic system of additive measures

1. Probability measures

The axiomatic system of probability measures rests on $P(E)$ sigma algebra or a Borel field. It confirms that the three properties are satisfied.

Thus P is a mapping of $P(E) \rightarrow IR$ such that:

(1) $P(E) = 1$

(2) $\forall A_i \subseteq E \; P(A_i) \geq 0$

(3) $\forall A \subseteq E, \forall B \subseteq E, A \cap B = \varnothing \qquad P(A \cup B) = P(A) + P(B)$

The probability of additivity implies that:

$$\forall A, \mathrm{B} \in E' : P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

Properties (1) and (2) yield:

$$\forall A \subseteq E \qquad P(A) + P(\overline{A}) = 1$$

2. Fuzzy set probability

The probability of a fuzzy set rests on a Borel semi-field noted Ψ and the following three conditions must hold:

(1) $v(\varnothing) = 0, v(E) = 1$

(2) Monotone inclusion property: $A \in \Psi, B \in \Psi, A \subseteq B \Rightarrow v(A) \leq v(B)$

(3) For any countable family $\{A_i; i \in N$ part of $E\}$

$$\nu\left(\bigcup_{i=0}^{n} A_i\right) \leq \sum_{i=0}^{n} \nu(A_i)$$

---

(1) $C(\varnothing) = 1$

(2) $C(E) = 1$

(3) $\forall A, B \in A, A \subseteq B \Rightarrow C(A) \leq C(B)$

28 A Dirac measure is a measure supported by a singleton and of mass 1. It is worth 1 if an element belongs to a given set A, and 0 otherwise.

29 They correspond to super-modular and sub-modular functions, respectively.

This evaluation must also satisfy the additional condition of Kaufmann (1997):

$$\forall\, A \in \Psi, \forall\, B \in \Psi, v(A \cup B) + (A \cap B) = v(A) + v(B)$$

3. Shafer (1976) credibility measures

Shafer's credibility function noted *Cr* satisfies the following properties:

(1) $Cr(\varnothing) = 0 \qquad Cr(E) = 1$

(2) $\forall\, A \in P(E), 0\, Cr(A) \leq 1$

(3) $\forall\, (A_1, A_2, \ldots, A_n) \in P(E),$

$Cr(A_1 \cup A_2 \cup, \ldots, \cup A_n) \geq \sum Cr\left(A_1 \cap A_j\right) + (-1)^{n+1}\, Cr(A_1 \cap A_2 \cap, \ldots, \cap A_n)$

4. Plausibility measures, Pl

Plausibility satisfies the following axioms:

(1) $P_1(\varnothing) \qquad P_1(E) = 1$

(2) $P_1(A_1 \cap A_2 \cap, \ldots, \cap A_n) \leq \sum P_1(A_i) - P_1\left(A_i \cap A_j\right) + (-1)^{n+1}\, Cr(A_1 \cup A_2 \cup, \ldots, \cup A_n)$

Thus the plausibility of $A \subseteq E$ is: $P_1(A) = 1 - Cr(\overline{A})$.

5. Lambda fuzzy measures, gλ

The axiomatic system of $g\lambda$ rest on $P(E)$ sigma algebra, thus for

$$\lambda \in]-1, \infty) \text{ we have } g\lambda : P(E) \rightarrow IR + \text{such that}$$

(1) $g\lambda$ € $= 1$

(2) $\forall A \subseteq E, \forall B \subseteq E, A \cap B = \varnothing$ for $\lambda > -1$

$g\lambda(A \cup B) = g\lambda(A) + g\lambda(B) + \lambda g\lambda(A) g\lambda(B)$

(3) When E is not finite, $g\lambda$ also satisfies condition (3) of the $S\,\lambda$ fuzzy measures (of Sugeno [1974]):

$\forall$An € $P(E)$, $\{An\}$ is a monotone sequences and $\lim\limits_{n \to \infty} \nu(A_n) = \nu \lim\limits_{n \to \infty} A_n$

Thus for λ values, the $g\lambda$ measures become:

for $\lambda = 0$, probability measures:

$$g\lambda(A \cup B) = g\lambda(A) + g\lambda(B)$$

for $-1 < \lambda < 0$, credibility measures:

$$g\lambda(A \cup B) \geq g\lambda(A) + g\lambda(B) + \lambda g\lambda(A) g\lambda(B) > 0$$

for $\lambda > 0$, plausibility measures:

$$g\lambda(A \cup B) \leq g\lambda(A) + g\lambda(B) + \lambda g\lambda(A) g\lambda(B)$$

Credibility measures

Shafer's credibility function noted *Cr* is expressed as:

$$Cr(A \cup B) > Cr(A) + Cr(B) - Cr(A \cap B)$$

Cr(*A*) is interpreted as a degree of belief with respect to an element *x* of *E* belonging to *A*.

Moreover we have $Cr(A) + Cr(\overline{A}) \leq 1$, which means that an absence of belief about an element *x* belonging to *A* ($x \in A$) does not entail strong credibility about the same element belonging to the contrary event ($x \in \overline{A}$).

Plausibility measures

Plausibility *Pl* is defined as:

$$Pl(A \cup B) \leq Pl(A) + Pl(B) + Pl(A \cap B)$$

Since the property of monotone inclusion of a fuzzy measure cannot be used to determine the measure of the union of two disjoint subsets, Sugeno defines a particular measure, the λ fuzzy measure, which has the characteristic of generalizing additivity thereby making it possible to find the previously defined measures depending on the λ values: probability of fuzzy and non-fuzzy events $\lambda = 0$, credibility ($-1 < \lambda < 0$), and plausibility ($\lambda > 0$).

Figure 4 recapitulates the connections between the various measures.

It can thus be observed that probability measures are particular instances of plausibility, credibility, and fuzzy λ measures. Accordingly, whatever is probable is both credible and plausible, but what is plausible or credible is not necessarily probable. These are all fuzzy measures (property of monotone inclusion) defined on a Borel field. When the axiomatic system of fuzzy measures rests on a Borel semi-field, the scope of fuzzy sets becomes stronger and makes it possible to define fuzzy measures of fuzzy events.

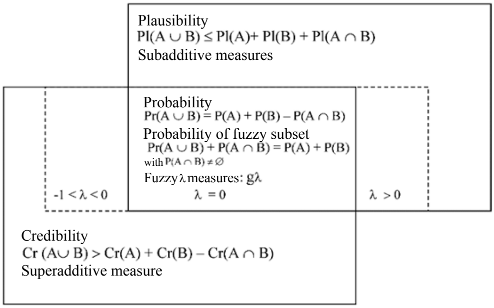

Figure 4—Representation of Sugeno's fuzzy measurements, except for Dirac measurements

Several analogies can be noted between the axiomatic system of fuzzy measures and the axiomatic system of quantum probability (Mittelstaedt 1972, Bitbol 1999). Thus the fact that it is not possible to claim that the particle goes through slit 1 (true or false) or slit 2 (false or true) [cf. boxes in section 3.1] prompted Reichenbach (1949) to propose introducing a ternary logic distinguishing not just the logical modalities "true" and "false" but that admits a third modality "indeterminate" or "unknowable". He also proposed adapting logical operations to this hypothesis by representing them in the form of a table (Reichenbach 1949). This is therefore a ternary logic that is also found in Jaffray's theoretical approaches to "ambiguity" (Wakker 2011). Moreover, the axiomatic system of RDEU theories and Kahneman and Tversky's prospect theory suggest, even if it is not always clearly defined in prospect theory, that both rest on a Choquet capacity which itself is a weakened form of the axiomatic system of probabilities!

Fuzzy utility

We know that consumer preferences are not always defined. The consumer's own behaviour (preference, indifference, or aversion to risk) may also influence the appreciation of it. This leads us to define her utility function no longer on a total pre-order but on a fuzzy total pre-order.

The fuzzy total pre-order axiom

Let $\underline{\mathrm{H}}$ be the set of alternatives/actions made possible by technical reasons. The fuzzy total pre-order axiom is stated as:
There is a fuzzy total pre-order on the set $\underline{\mathrm{H}} \subset \underline{\mathrm{D}}$ of actions. The set $\underline{\mathrm{H}}$ has the structure of a fuzzy total pre-order if the fuzzy binary relation confirms:
(1) reflexivity:

$$\forall (d_1, d_2) \in \underline{\mathrm{H}}^2,\ \mu\Re(d_1, d_2) = 1$$

(2) transitivity ∨∧

$$\forall (d_1, d_2);(d_2, d_3);(d_1, d_2) \in \underline{\mathrm{H}}^2$$
$$\mu\Re(d_1, d_3) \geq \underset{d_2 \in H}{V}[\mu\Re(d_1, d_2) \wedge \mu\Re(d_{2,}\ d_3)$$

The fuzzy utility obtained expresses the degree of imprecise preference on the consequences of an act or choice. The decision maker's choice criterion is materialized by the notion of preference relative to various alternatives/actions noted $\underline{\mathrm{D}}$. This preference is reflected by a binary relation noted $\preccurlyeq$ defined on set $\underline{\mathrm{D}}$ and such that for the alternatives $d_1 \in \underline{\mathrm{D}}$ and $d_2 \in \underline{\mathrm{D}}$,
$d_1 \prec d_2$ is read: "d_2 is preferred to d_1"
$d_1 \sim d_2$ is read: "the alternative/action is indifferent to the alternative/action d_2".

In an imprecise context, the preference or indifference field $(\underline{\mathrm{H}},\ \Re)$ has the property of totality. The totality condition means the decision maker must always know how to compare two actions in terms of her preferences.

More specifically:

$$\forall (d_1, d_2) \in \underline{H}^2, \mu\Re(d_1) \geq \mu\Re(d_2) \text{ ou } \mu\Re(d_2) \geq \mu\Re(d_1)$$

However, we have $\mu\Re(d_1, d_2) = 0$ if $(d_1, d_2) = \varnothing$ (from the definition of the fuzzy measure $\mu(\varnothing) = 0$). This is the non-comparability hypothesis. This hypothesis is not constricting, contrary to classical theory which requires complementarity. This axiom is useful in that it states that the decision maker's choice behaviour in an imprecise or fuzzy context may be rationalized by a fuzzy total pre-order noted $(\underline{\mathrm{H}}, \gtrsim)$. It should be specified here that the rationality employed in the fuzzy case is far less rigorous than that used in traditional decision theory inasmuch as the decision maker can contemplate several alternatives during the choice process, as is the case in quantum mechanics.

Towards models of non-deterministic and imprecise choice

Decision-making in the context of residential choice

Let us return to the example of a plan to purchase a place to live depending on its location. The choice of location depends on the levels of traffic.

Let $\underline{S}$ be the set of states of nature characterizing, for example, access to the workplace.

$$\underline{S}\{S_1, S_2, S_3, S_4\}$$

Let (S, φ, μ) be a Borel semi-space where φ is the family of fuzzy sets. H_j represents a (fuzzy) set of 10 places to live in all (apartments or houses selected and already satisfying a number of characteristics, such as the number of rooms, an energy performance certificate of at most *D*), belonging to a housing stock (non-fuzzy). μ is the measure (valuation) of this fuzzy set given the nature of the traffic and confirms axioms 1 to 3 of the Borel semi-field.

φ also confirms axioms 1 to 3 of the Borel semi-field.

$$\varphi \subset {}_{L(S)} \qquad L = [0, 1]$$

H_j/S	s_1	s_2	s_3	s_4
$\mu_{H1}(S_i)$	0	0	0	0
$\mu_{H2}(S_i)$	0,2	0,7	0,2	0,1
$\mu_{H3}(S_i)$	0,4	1	0,2	0,3
$\mu_{H4}(S_i)$	0,2	0,7	0,3	0,1
$\mu_{H5}(S_i)$	0,4	1	0,3	0,3
$\mu_{H6}(S_i)$	0,2	0,7	1	0,1
$\mu_{H7}(S_i)$	0,6	1	0,3	0,3
$\mu_{H8}(S_i)$	0,4	1	1	0,3
$\mu_{H9}(S_i)$	0,6	1	1	0,3
$\mu_{H10}(S_i)$	1	1	1	1

Let P be a probability law on S. We assign to each s_i a probability that describes:

$\underline{S}$	s_1	s_2	s_3	s_4
$P(s)$	0,3	0,1	0,2	0,4

$$\sum P(s) = 1$$
$$\forall H_j \in \Psi, \forall s \in \underline{S}$$
$$P(H_j) = \sum_{s=1}^{s=j} \mu H_{j(s)} \cdot P(s)$$

$P(H_1)$	0
$P(H_2)$	0,21
$P(H_3)$	0,38
$P(H_4)$	0,23
$P(H_5)$	0,4
$P(H_6)$	0,37
$P(H_7)$	0,46
$P(H_8)$	0,54
$P(H_9)$	0,6
$P(H_{10})$	1

$P(H_i)$ represents the mathematical expectation of fuzzy events by the probability law P. It is called the fuzzy event probability.

The measure μ may be a weight, a value assigned depending on quantitative criteria: floor spaces, number of rooms, number of bathrooms. However, this measure may also reflect the agent's preferences. This numerical translation of preferences then corresponds to the utility of this subset. And when the agent's preferences become imprecise ("that agent may be ready to give up a balcony, or to have a few square metres less in the kitchen for an extra bathroom, etc."), the resulting utility will be fuzzy. Of course, a check is made in each case that the classical and fuzzy utilities verify respectively a total pre-order and a fuzzy total pre-order.

The expression for the fuzzy expected utility of a fuzzy decision becomes:

$$\cup\left(H_j\right) = P\left[\cup\left(H_j\right)\right] = \sum_{s=1}^{s=j} \mu H_j(s_i) \cdot P(s_i) = \sum_{s=1}^{s=j} \cup\left(H_j, s_i\right) \cdot P(s_i)$$

Interpretation of decision-making in the residential choice context

Mental aspects and predictability of decisions

As de Palma and Thisse (1989) pointed out, in psychology, "choices are almost always comprehended in a *probabilistic* fashion", meaning that the same person will not always make the same decision when faced repeatedly in similar circumstances with the same choice (Luce 1977, Thurstone 1945). A person's reaction to a given situation does not seem strictly predictable, but predictable only by means of "probabilistic laws" (chapter 8). As de Palma and Thisse (1989) observe, "an individual's behaviour may change depending on outside factors without his preferences as to characteristics being altered. From this perspective, the process of choosing is intrinsically probabilistic". Let us recall in this respect the findings of research referred to by Kahneman et al. (1997) showing the change in how a comparable experience is evaluated depending on circumstantial parameters such as the maximum values of an emotion felt or the way the experience is lived out. Thus, de Palma and Thisse (1989) stated, "[i]t seems therefore that real choice behaviours reflect fluctuations inherent in the action-evaluation process". And indeed an individual who is compelled to make a decision may also make it spontaneously, in conjunction with a strong impression or emotion, without mobilizing all of the criteria she had previously. This effect is strengthened if the person has only incomplete information, as shown by work done in neurology (chapter 5).[30] Recent research reportedly shows besides that decisions are made in the brain before they become "conscious", that is, controllable by the individual (Smith 2011), which prompts some investigators to call into question our free will.

In this context, a reflection made by Heisenberg (2009) seems interesting. He points out that animals faced with situations they have never encountered before develop original strategies that do not reproduce some "standard"

30 See also the theoretical work by Jaffray who investigated the consequence of a lack of information on alternatives when making a decision. Shortage of information may induce uncertainty about the possible consequences of a decision and therefore about the risks incurred (Wakker 2011).

behaviour in a deterministic way. For Heisenberg, decision-making involves both predictable components and random components that might be compared with “mutations”.

Predicting the choice in decision-making therefore only seems possible through limited information. If it is merely a shortage of information accessible to the observer, the situation would be similar to that in classical thermodynamics. This prompted Weidlich and Haag (1983, 1988) to introduce a dynamic model describing changes in an agent’s attitude using a classical probabilistic approach (chapter 6, 7, and 9). In this approach, utility functions determine the variation of a probability over time through the master equation, the differential equation describing the time variation of a probability.

However, taking account of a mere shortage of information does not seem sufficient for modelling decision-making itself. For so long as the person is not forced to act, therefore so long as there is nothing at stake, she may have a more or less sharp or fuzzy mental representation or opinion about the various evaluation criteria or alternatives (and so no fixed idea about the ordering of preferences for some particular criterion that might favour one apartment rather than another). When making a decision, the individual may be forced to make choices that are likely to be subjected, as seen, to circumstantial phenomena. The decision made does not become an observable reality until the person engages in some motor action by expressing the decision verbally or, for example, by signing a purchase deed for an apartment.

We have seen that in quantum mechanics, the state of the system appears, before the measurement is made, as an “inconsistent mixture” of potentially observable values (modalities). The system is not in a precise predictable state.[31] It is only at the moment “the result is displayed” that the certainty of a value becomes “objective” (for example, the recording of a precise place of a photon on a screen): this is the idea of “system preparation”. The system is no longer in an imprecise state but in a new precise state that is the starting point for its future evolution. Remember that the gain of information thus achieved at the same time destroys all the probabilistic information about the other potential states that we had before the measurement was made. In our case, this means that the decision has fundamentally changed the person’s position—she will now be confronted with the consequences of the decision. This is why the formalization of the decision-making process by Zwirn (2009), which refers to the description of the measuring process in quantum mechanics, seems interesting.[32]

31 We do not refer here to the counterintuitive phenomenon of the Einstein-Podolsky-Rosen paradox, the existence of which was confirmed by the quantum eraser. This experimental device varies the results of an experiment depending on a filter that another element of the system passes only at a later time; the future seems to influence the current state. This discovery has triggered much reflection and speculation that we shall not go into here.

32 Without us claiming here that it is a “quantum phenomenon”.

Let us now consider the factors involved for someone deciding to move home, basing our claims on the results concerning the decision-making process in a fuzzy and quantum "context" on the one hand and on various evaluation criteria on the other.

Decision-making process in a fuzzy quantum "context"

The decision to move home may correspond to a desire to improve current living conditions, but it may also be the direct consequence of some other decision, for example to change one's place of work. It then becomes a necessity, which does not detract in any way from the following points.

The individual appraises one or more places to live. This evaluation is a synthesis combining various types of criteria. For each alternative, she has precise information (rent, number of rooms, etc.) but the evaluation criteria may be imprecise (too far away, too noisy, not enough shops, not green enough, troublesome neighbours). They often have fuzzy bounds; she accepts "about 300 m", "a certain level of noise', "certain services more or less absent". These imprecisions make the overall evaluation difficult because there may be offsetting effects. Having better access to nearby shops may make up for having a little further to travel to a playground, and so on. Some criteria may be attainable conjointly, others may be all but incompatible. For example, it is possible to have a detached house with two bedrooms and a garden, but it seems unlikely one will be able to live in the countryside and have a bus to the city centre every 10 minutes. Ultimately, some criteria are "more or less" compatible.

To appraise the current situation, the person has her experience, which is not necessarily the case for a future place to live. The information she has is usually incomplete because she does not often know exactly where she will settle down. For example, she cannot readily evaluate whether contact with her future neighbours will be good or not. Perhaps she also wonders about the possible construction of a housing estate further on that might lead to more traffic in the street.[33] The probability of an event may then be fuzzy but, depending on the degree of belief, we may also calculate credibility or plausibility measures.

Remember too that the evaluation of criteria is dictated by the lived experiences of individuals and by their collective references (chapters 1, 2, and 6)[34] and that a person may be subject to negative affects that curb decision-making

33 Research in neurology shows that humans tend to discount events they suppose might happen in the remote future and concentrate on evaluating what they perceive as imminent risks (chapter 4).

34 Results in experimental psychology show that the duration of an experience has less influence on the a posteriori evaluation of it than what people go through during the final part of the experience. Thus, for example, the unpleasant recollection of troublesome neighbours over a long period of time may be of comparatively little influence on the evaluation if it was followed by a brief pleasant spell once the neighbours had moved away (Kahneman et al. 1997).

(situation of risk that causes stress, fear of losing advantages, etc.) [chapters 4, 5, and 6]. Conversely, the person may act spontaneously because delighted by an apartment ("just fell in love with the place").

A range of approaches for formalizing and explaining choice

For the purpose of modelling the decision to choose a place to live, a set of alternatives (and so of places to live) can be considered that the person in question is aware of. Each place has its own attributes (size, distance to shops, etc.). The individual compares the alternatives while taking account of the evaluation of the attributes and the importance she attributes to them.

This approach is reminiscent of the method proposed by Tversky (1972) in which a number of alternatives (places to live in our case) are considered, each of which is characterized by certain criteria that are evaluated separately by a weight or utility (de Palma and Thisse 1989). Tversky then progressively eliminates alternatives by referring to the presence or absence of a selected character, independently of the other characteristics. On this basis, he calculates the probabilities of choosing one of the alternatives. Thus the decision is made on the basis of a probabilistic approach, whereas the utility functions (criteria) are deterministic (de Palma and Thisse 1989).

The model proposed by Thurstone (1945) obeys a different logic. He assumes that people embody a number of *homines œconomici* each of which is rational, but has a different order of preferences. In a decision-making situation, the individual will choose one particular *homo œconomicus* depending on her state of mind. This is represented by a random term in the utility function (de Palma and Thisse 1989). This model obviously takes more account of an individual's spontaneous reaction, but says nothing about the formation of the reference frame (that is, the *homines œconomici*).

We suggest that the evaluation of the various criteria should make allowance both for imprecision in the evaluation (for example, the distance from shops) and for having imperfect information about certain criteria. As research in neurology has highlighted, such imperfect information often prompts individuals to "fill the gap" by using an intuitive evaluation based on emotions. It will therefore be useful to include this aspect in modelling.[35] It is also known that when an individual decides on something, the factors in play are not all equally important. Modelling the variety of factor weights would make it possible to tell imprecise preferences apart. Lastly, because certain criteria are varyingly compatible, it would be possible to introduce a formalization, as in quantum mechanics, to distinguish "commensurable" variables from those that are not. The position of the coordinate system corresponding to an evaluation criterion

35 One thinks for example of degrees of membership of a fuzzy set relative to certain emotions.

relative to the position of a coordinate system corresponding to another criterion (therefore the angle between the two systems, cf. figure 10.3) could correspond to the degree of compatibility of the two criteria.

The resulting utility function could be schematized by a convex or concave curve of varying thickness symbolizing preference, aversion, or any other arbitration between the different choice criteria.[36]

4. Normative or descriptive choice model. Can we speak of a deterministic or non-deterministic universe?

Before looking at normality and the descriptive capacity of the choice model used, let us first recall a few points about the nature of risk and uncertainty in order to ascertain whether the universe under consideration is deterministic or not.

4.1 Nature of risk and uncertainty

In the early twentieth century, many authors took up both philosophical and economic questions about risk and uncertainty. Since we cannot be exhaustive here, we shall give precedence to the views of Knight, Keynes, and Hayek. All three dismissed the idea that individuals have perfect knowledge: they acknowledged that individuals find it difficult to make forecasts in an uncertain context delimited by two poles. The first pole is the computation and choice of the consequence of an act that is guided rationally by objectives (maximizing well-being or profit). The second pole pertains to the authors' conception of human behaviour, which is reflected by intuition, rules of life in society, and the perception of chance (Knight 1921, Hayek 1973, Keynes 1936, Moureau and Rivaud-Danset 2004).

In *Risk, Uncertainty and Profit*, Knight (1921) draws a distinction between a risky decision-making situation and an uncertain decision-making situation. In this respect, the Bayesian principle stands out from classical processes by the acceptance of a subjective assertion of probabilities by transforming an uncertain situation into a risky one. This distinction may cause confusion because it seems to link uncertainty and risk to the integral part of chance alone, and also to probability measures. More specifically, an environment is said to "risky"

36 Frankhauser et al. (1998) formalizing the "possibility" that a place to live be chosen:
$\mathrm{DIFF}^{\gamma}\,[\mathrm{MIN}\,(X_1, X_2,\ldots, X_n)] + (1 - \mathrm{DIFF}^{\gamma})\,[\mathrm{MAX}\,(X_1, X_2,\ldots, X_n)]$
with $\mathrm{DIFF} = \mathrm{MAX}\,(X_1, X_2,\ldots, X_n) - \mathrm{MIN}\,(X_1, X_2,\ldots, X_n)$, and $\gamma \geq 0$.
The individual attributes to each criterion a degree of membership of a fuzzy set corresponding to her evaluation. To synthesize the evaluations of all the criteria, the gap between the best and worst evaluated criteria is considered. If the gap is wide, the individual tends towards a "pessimistic" attitude, and so a weakly synthetic evaluation, because ill-at-ease. In the opposite case, the individual tends towards an optimistic attitude (and therefore a highly synthetic evaluation).

when the economic agent is unaware of the state of nature to which the decision applies, but is capable of defining a law of probability covering all states of the world. Knight speaks of random perspectives in this case. The environment is said to be uncertain when the individual does not know the state of nature and is no longer able to define a probability law. Knight then speaks of uncertain perspectives. A situation is said to be risky, for Knight, when objective probabilities are available. They may be either mathematical probabilities or frequentist probabilities. The former (number of favourable cases/total number of cases) are calculated a priori, as in gambling games in which chances are equal. The latter (induced from experience) are calculated from a large number of observations of events that are repeated with a certain frequency. A situation is said to be uncertain when it is considered unique and therefore cannot be reduced to a set of similar cases. These are unclassifiable, novel situations whose properties are unknown.

In his *General Theory*, Keynes (1936) emphasizes, like Knight, that it is impossible to make forecasts for want of knowledge and he refers to situations of ignorance or absence of scientific basis on which to construct probability distributions as situations of radical uncertainty. However, apart from the unforeseeable character of the future, Keynes underscores in *A Treatise on Probability* (1921) the complexity of situations that place the decision maker before a multiplicity of possible choices and value judgements that cannot readily be ordered. This was to lead Keynes to give precedence to the inductive method of economic agents, based on the formulation of judgements and opinions that are probable but not certain and to emphasize the weight of expectations.

Hayek too thinks that individuals can have only partial knowledge of the decision-making domain because of the complexity of economic activity. To anticipate the consequences of their acts, they rely on customs and social rules. Hayek (1973) objects to the influence of Cartesian thinking[37] which associates reason and certainty: "Since for Descartes reason was defined as a logical deduction from explicit premises, rational action also came to mean only such action as was determined entirely by known and demonstrable truth".

Integrating this complexity, quantum mechanics is valuable in providing predictions that are confirmed by experiment. When waves are introduced (electrical or magnetic waves), unlike trajectories of bodies that are determined by "forces" or "fields", the notions of "trajectories" for a wave function and movements change over the course of time and are determined mathematically, via the generalization of probabilistic formalism. Integrated probabilities characterize a risky decision-making situation (Dirac measure in a Hilbert space), however, the resulting preferences are no longer considered pre-existent and

37 Unlike Pascal, who shows that the truths of reason and the truths of faith are not of the same kind, Descartes makes God the keystone of his rational construction. He sets humans at the centre of all thought and studies them by the rational method, applicable to all areas of knowledge.

revealed; instead they are determined in the decision-making process. A decision-making situation can be likened to the measurement of an observable having specific eigenvalues. The decision-making system is determined by an appropriate Hilbert space, with the chosen dimension of space (the initial set on which the axiomatic system is defined) having to correspond to at least the number of possible choices.

Where observables are associated with decision-making situations that are commutative, i.e. the outcome does not depend on the order in which the subsequent decisions are taken, quantum theory comes down to the classical Bayesian system. We obtain a probability distribution over the various alternatives as prescribed by RDEU models. However, when decision-making situations are no longer commutative, i.e. the outcome depends on the order in which decisions are taken, differences arise resulting from probabilistic interferences. This would make it possible to model decision-making situations in which preferences are indeterminate. Fuzzy set calculation would make the application comparatively easy.

The upshot is that to model a decision maker's behaviour when confronted with residential choice, it is just as important to explain the different measures that can be associated with the various predictable alternatives as it is to explain the actual decision-making process; hence the importance of examining the place and nature of the probabilities used in the decision-making mechanism. It is the axiomatic system on which a measure rests that can then explain, within the theory, the semantics of risk, uncertainty, and imprecision that derive from it.

4.2 Normality and descriptive capacity of a choice model

Expected utility theory appears on the whole to be a normative theory, meaning that it seems desirable to comply with it when making decisions under risk. However, as Pradier (2004) observes, "a few Americans nonetheless think that the theory also has descriptive virtue" by accounting for actually observed behaviours. For Savage (1972), expected utility theory gives insight into why people are at one and the same time inclined to purchase lottery tickets at a price exceeding the mathematical expectation of gain and take out insurance at a price that exceeds the mathematical expectation of loss (concave then convex utility function). After questioning Savage on his choices, Allais was to ask the same question of people having to make decisions and who might be thought "reasonable". Nearly 40 per cent of people made the same choices as Savage: A and D. The outcome is that respondents' choices contradict theory, as they select lotteries that give results that are lower than expected utility in all states of the world. Savage's theory imposes constraints that are not rational, then. RDEU theories are more promising because they are compatible with stochastic orders.

The alternative theories of Kahneman and Tversky (1979) and Markowitz (1959) were to be abandoned insofar as first-order stochastic dominance is not verified. To improve his model, Markowitz integrated quadratic utility functions. For their part, Kahneman and Tversky transformed prospect theory into cumulative prospect theory, which is an example of RDEU theory.

Although the latter account for the choice A and C in Allais' counterexample by means of a weakening of classical expected utility (a distortion of pay-offs through the utility functions and a transformation of probabilities), the decision-making functions obtained become far more complex and so difficult to use. Because stochastic orders are very incomplete order relations, it is difficult to classify lotteries by this criterion. This explains why expected utility theories are still used, with the use of arithmetic means making them flexible and easy to apply. Should we therefore accredit Buffon's view that science should guide the ignorant, and it is a lucky thing that it is normative?

When the excluded middle is introduced into expected utility theory, we define a fuzzy expected utility theory of which classical utility theory stands as a particular instance. Despite the many possible values of the criteria allowed by fuzzy set theory, fuzzy utility theory is none the less a normative theory. However, the adoption of quantum formalism ensures it an experimental value besides (for example, through the possibility of generating ternary values). The introduction of fuzzy utility makes it possible to model individuals' decision-making behaviour. This means that the theory is descriptive too.

5. Conclusion

The applications of decision theory take on renewed interest in times of crisis, when people dream of imposing a centralized decision to remedy market disorder, thus proving the well-founded character of central co-ordination. From an individual point of view, the expected utility model has largely asserted itself in the human sciences, particularly in all areas of economic theory since the second half of the twentieth century. It lends itself still today very conveniently to a large number of applications in finance, theory of the firm, agency theory, insurance, and environmental economics even if its experimental character has been called into question.

The application of quantum formalism and fuzzy set theory to decision theory is not intended as a claim that the choice expressed results from a decision that has some physical quantum or fuzzy foundation. The quantum contribution to the theory is aimed at the analogous relation between decision-making and probability measurement. The quantum outlook provides a far more general and experimental explanation than probability theory as classically applied in decision-making. It applies exclusively to states of nature to which probabilities pertain. It does not, however, provide an answer to the decision maker's behavioural quirks with respect to classical theory. Such behavioural anomalies may be modelled in part by fuzzy set theory by means of a fuzzy utility function. The connection between quantum formalism and fuzzy set theory is that they envisage a third solution and not an exclusively binary language. Both use a far broader measure of probability thanks to the property of monotone inclusion, with the additivity property arising as a particular instance of this. The application of fuzzy set theory to both the utility function and probability measures leads to greater precision in the choices made, without overburdening computation.

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