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An Agent-Based Simulation System to Support an Approach to Brand Perception Measurement

Ivan Alfredo Mendoza Pulido

Universidad Nacional de Colombia
Facultad de Ingeniería
Departamento de Ingeniería de Sistemas e Industrial
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to me parents, who have brought me here
and to Sandy, to whom I owe almost everything now

Remember Duane Allman
Fans

ABSTRACT

A theoretical approach for measuring the brand perception of a single organisation in a heterogeneous group of persons of arbitrary size and supported by an intelligent agent based system is presented. The system is based on the interaction of two types of agents: on one side, groups of acquiescent agents modelled after a given brand's potential customers and aware of environmental disturbances produced by an organisation in form of influencing agents on the other. The relation is based on the perspective that *a person may define an organisational value by returning her own perception to the environment, an organizational value that in some way has been interiorised*. Once her perspective finds a way to the environment again, it gains new life and is able to influence other people.

The aim of the mentioned system is to evaluate the effect of the discriminated marketing investment made to expose different values of the organisation. Management aspires people to interiorise these values and to return them untouched to their peers to interiorise them later too. By making the investment aspect clear, the management may become aware of which resources are being well spent and which ones need a to be redirected to really reach their desired target in accordance to the people's response, an aspect clearly presented by the simulation process.

So, differences among the customer groups were modelled by determining their members' sensibility towards influences and the capacity to produce an active response to such stimuli. An active response in terms of the system was modelled in two ways: (i) is to return the influences back to the environment or (ii) to terminate them abruptly.

Influencing agents are also gathered by common given objectives to form groups but maintain a certain degree of independence by being more or less prone to survive in the environment. This last feature was modelled after the investment effort made by an organisation towards the penetration of own values to be perceived by the public.

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1. INTRODUCTION

The lack of data about a brand's acceptance among the members of a society raises several questions about the efforts made by an organisation to communicate corporate values. Among these questions, an external consultant may ask whether a value classification that exposes the strong aspects and presents as improving the weaker ones has been established. Also, she may ask the level of understanding attained by the organisation about the already achieved customer base or the desired extent in which that customer is to be approached.

Several perspectives have been used to solve questions related to the relation between the organisation and potential customers and their environments. Psychology and philosophy have contributed with their own theories, tailored to the marketing effort. Management, in a more traditional sense has tried to increase customer retention and satisfaction as a measure to improve markets and make them bigger.

In turn, computer science has contributed to the marketing issues on one side, by applying machine learning and other AI techniques to market data analysis, and on the other, by improving behavioural targeting or the task that tries to guess peoples' responses by following the principle of perception-reasoning-action.

The present work serves this last purpose by modelling the perception-reasoning-action process starting from analysing the granular conceptual components coming from the organisation to simulate people's perception process. Once the customer has been affected by diverse stimuli, the reasoning process is simulated as an accumulation of perceptions that inevitably results in a customer action that sometimes will benefit the organisation marketing strategy and sometimes will not.

The present works' aims are directed towards building a consultancy tool to fine-tune the management efforts of improving markets and making them bigger, under the perspective of a sole organisation facing up its customer base in contrast to a competitive landscape that considers other companies' strategies.

2. OBJECTIVES

2.1. General Objective

The purpose of this work is to obtain an approach for measuring an organisation's brand perception in a heterogeneous environment by means of an agent based simulation system that represents groups of persons and management efforts to influence them. Once this approach has been obtained the system shall become a tool for management to gain a better understanding of the firm's marketing efforts, so this activity can be guided towards more pertinent audiences.

2.2. Specific objectives

1. Characterise the people's experience-acquisition mechanisms towards perceiving a sole brand. As a result of this characterisation, several groups of persons shall be formed.
2. Propose an approach for characterising an organisation's values or marketing elements so they can be related to people's experiences and therefore be perceived.
3. Characterise people's reactions produced by the accumulation of experiences related to a brand.
4. Design and build a simulation system for the proposed brand perception measurement approach and then test it by making a series of experiments with several kinds of organisations and societies to support the proposed characterisations.

3. AN INTRODUCTION TO BRAND PERCEPTION

Brand perception is a personal process in which a subject succeeds in achieving an exclusive awareness about a number of concepts about products and/or services and the organisation that provides them. This personal process is continuously shaped by experiences perceived by the subject. Two types of experiences work in order to develop individual concepts related through time: (i) *functional* experiences in the case of a subject's judgement about the product, and (ii) *emotional* experiences related to her feelings on owning (or not owning) the specific product. In some cases, the subject is a customer but a number of different types of perception subjects may also experience brand perception without necessarily being buyers.

Several sources for these experiences are identified in the process of developing a brand perception and all of them imply a certain degree of exposure from the subject. Among these sources, advertising, reputable source reviews, previous experiences with a product of similar characteristics and previous interactions with the same company are the most enduring in the literature [Dobni and Zinkhan 1990].

Mental images as an alternative to experiences are also found in the literature as outcomes of a "mental configuration and analytical processing". In this context, external and internal factors contribute to the formation of an image in a customer's brain. The internal factors are related to personality and other subjective characteristics of a customer. Conversely, external factors are only related to the products' physical characteristics or those that can be related to concrete attributes like a product's country of origin [Koubaa 2008].

3.1. The origin of brand perception: dualism between truth and illusion

As an advantage to an organisation that seeks to gain acceptance from a group of people in a society, a potential customer must reconcile her apparent obvious truths about her previous experience of the product and organisation with the possibility of a perceptual error. From a philosophical point of view, the outcomes of a perception process are threatened by the existence of hallucinations and illusions. The problem lies outside the question of how perception can provide knowledge from the external world.

An illusion is defined as "any perceptual situation in which a physical object is actually perceived, but in which that object perceptually appears other than it really is". In illusions, the subject is not necessarily deceived into believing that things are other than they are. The subject may know that is experiencing an illusion when its happening, so she is not necessarily being deceived [Smith 2002]. The basic process to perceive an illusion is now detailed:

- When a subject is exposed to an illusion, it seems to her that something has a characteristic *C*, which the real object does not really have.
- When it seems to the subject that something has the quality *C*, then there is something else in her awareness that indeed have it.
- As the object in question is, by hypothesis, *not C*, then it follows that the subject is not aware of the real object, or she is aware of it only indirectly, as her awareness process is being mediated by an external agent.
- The subject does not have the ability to distinguish between the phenomenology of perception and the illusion. The two processes are the very same for her.
- In consequence, there is no reason to suppose that even in the case of genuine perception, the subject is directly aware of the objects.
- Finally, perception as was initially defined now acquires a new meaning.

The key point in this process is more than obvious, as the organisation must become the mediatory force that changes the customer awareness towards a better response in future buying or recommendatory actions.

In consequence, the problem with brand perception lies within the reach of the organisation’s ability to gain knowledge about customers in several areas like their ways of selecting a product, the identification of customer sources of information about products and what is important to them when making a brand decision. If the organisation successfully manages to manipulate or modify a customer perception in key areas like the ones just mentioned or influence the shape and contents of knowledge about itself, it will be able to build a closer relation with the characterised potential customer.

3.2. General concepts on brand perception

Dobni and Zinkhan start by saying that the brand image definition has changed over the years and that experts have not achieved a desired consensus on how the definition shall be operationalised yet. They say that the concept was first introduced in the 1950s and although it originally lacked a definition, it has been widely used in a “variety of technical and casual applications”. In general, they introduce the term image brand as an “embodiment” of an “abstract reality” [Dobni and Zinkhan 1990]. This very general, wide definition shall be kept in mind throughout this entire document. This reality consists in the fact that “people buy products or brands for something other than their physical attributes and functions”: this is the ultimate reason for a work like the one hereby presented, “to sell more products”.

Despite the implicit importance given to the concept in the literature, some authors state that it has been debased as a consequence of its indiscriminate application. Moreover, some authors criticise brand image related research by citing foundational research that traces definitions and justifications as a mean to determine “if a consensus is developing, both in terms of conceptualization and in terms of measurement”.

Gardner and Levy are responsible for the initial efforts of crystallising the brand image concept in the form of finding and identifying “more enduring reasons for purchase”. They were the first to identify a dualism in the nature of products: goods and services have a ‘social and a psychological’ nature and also a ‘physical’ one. After mentioning this introduction to brand image literature, a brief review on the concept is needed and three related aspects are found [Gardner and Levy 1955]:

- Names ascribed to the phenomenon
- Formal definitions
- Components

An important conclusion in a hypothetical literature review around this topic is that the words “product” and “brand” are used interchangeably, although in marketing there is an important difference between them.

3.2.1. Names ascribed to the brand image phenomenon

Also, when dealing with works that have not used the specific term ‘brand image’ when referring to the concept, it is important to state that is the “symbolic utility” name the one that derives from the concept of intangible aspects of a product evaluation. When making emphasis a product's human qualities, such terms as “brand personality”, “brand character”, “personality image” are used. Finally, “brand meaning” or “communicated messages” (by products) are used when the research focus is the attributed meanings that brands acquire from users.

3.2.2. Brand Image formal definitions

When dealing with formal definitions, a classification is produced, namely (1) blanket or very broad definitions, (2) definitions with emphasis on symbolism, (3) definition based on meanings or messages, (4) definitions with emphasis on personification and finally, (5) definitions with emphasis on cognitive or psychological elements.

The first group of blanket definitions do little to contribute with refining the understanding of the brand image concept. The contribution of these definitions lies in their expression of brand image as an abstraction. Also, they have in common the highlight on the fact that people have notions about a product that may not coincide with the product's actual physical profile: perception of reality becomes more important than reality itself.

The definitions based on symbolism deal with the meaning of symbols and their language, as they encompass many dimensions. Also, symbols are related to self-concept. But only in the 1980s, the concept of semiotics began to be related in some way to brand image. The marketplace as a container and enabler of objects claims the position of a semiotic system. Also, commodities took the place of “signs whose meaning is the consumer’s brand image” [Noth 1988]. Definitions in this group are said to be “more public” as a “social meaning or value” has to be associated by every individual in the first place, and also, since products, which act as symbols, will be used exclusively to “reinforce the consumer's self-concept”.

The third group deals with definitions based on meanings and messages: a product's “connotation or meaning” ascribed by a consumer is what really differentiates one product from a similar one, since what a brand “denotes” may not be very different from what another does. Moreover, each product has a “meaning profile” which definition relies on the past group, but in this sense, there are three different ways in which a product may have a meaning to a consumer: causality, context and similarity. These three ways come from the philosophy of meaning [Dobni and Zinkhan 1990].

The method for making meanings to reach customers can be “message differentiation”. Since functional differences among products may not be enough for a customer to tell them apart, it is necessary to attach a meaning to the product as a differentiation strategy. This message ought to imply meanings about the ownership or use of the brand. Also, the meaning may spread from an exposed customer to another by means of “interpretation”.

“Psychological meaning” is the mental position, understanding or evaluation of a product inside a consumer's mind. The interesting fact about this existential-phenomenological psychology is that it shall develop itself in a “non-random way” as the product from the interaction between a perceiver and a set of “product stimuli”. The psychological meaning will definitely be mutable in time, as experiences with the product will shape it.

Definitions that deal with brand personification are based on this practice along with associating human characteristics to brand image. One approach to the practice is to describe a product as if were a human being and assigning a personality profile to it. Also, the action of describing a customer’s personality with the product falls into this category.

This range of definitions rely on the fact that both brand image and personality can be viewed as multi-dimensional concepts that operate at a lower level in the person’s conscious activity. The definition is based on the assumption of an interaction between a consumer’s self-concept and the product's personality. But this approach has similar drawbacks as those found in defining and measuring a personality, task undertaken by psychologists, so definitions in this category couldn't be very detailed but rely on assignations of human descriptors to products as gender, age group or social caste.

The last emphasis on defining brand image is the one that uses cognitive or psychological elements. All possible cognitive or metal processes once used in psychology are now used to explain the triggering that ends in a brand image residing in a person's mind. Terms as "ideas, feelings, attitudes, mental constructs, understandings or expectations" are now determinant to the brand image success over a population.

Feelings that emerge between a product and a person arise according to this view thanks to the lack of objective measures or product attributes that locate it above the others, when product clones cannot be differentiated. In the same way, attitudes as concepts that set a brand image apart from those of similar products are more suited for measurement as instruments for this purpose have been developed in the psychology realm. The problem with this approach is a significant market share difference of products with very similar sums of their attributes, as this sum is used to measure the product's set of subjective characteristics.

3.2.3. Brand Image Components

This section covers the importance of detailing the marketing practitioner's activity from the significance of the brand image concept. Since no consensus about brand image's components has been reached, the task is regarded as complicated by some authors [Dobni and Zinkhan 1990].

Dobni and Zinkhan start by stating two somewhat similar points of view: The first, proposed by Reynolds and Gutman deny the importance of other elements beyond the physical product in brand image. This view provides the elements for "analysing" brand image or decomposing it in its constitutive elements [Reynolds and Gutman 1984]. The opposing view only accepts elements extrinsic to brand image as composing it. This perspective, enforced by Gensch divides the so called "product perception" in (1) the consumer's measurement of a product's attributes and (2) brand image, leaving it as a "pure abstract concept" [Gensch 1978].

A perspective that includes both attributes and abstractions was also proposed and supported by Friedmann. The result proposed in the vein of this trend is called "psychological meaning". It comprises (1) an attribute bundle (objective), (2) a perceptual mode that is dominant in the consumer and (3) a context in which the "perceptual process" take place [Friedmann 1986]. The psychological meaning is said to have a synergistic effect and is ascribed a "means-end chain" to explain its division in components. Two networks are "reflected" by this chain: the implication network that shall be provided by the brand experts' effort and the memory linkages [Reynolds and Gutman 1984].

3.2.4. Brand Image and Brand Associations

In relation to brand perception, several overlapped concepts arise in the literature, for example, "brand image" is defined by Aaker as ''a set of perceptions about a brand as reflected by the brand associations held in consumers' memory'' [Aaker 1991]. But the same concept is defined again as "a customer's perceptions related to a brand" [Dobni and Zinkhan 1990]. These perceptions come indistinctly from reasoned or emotional sources and are exclusively composed by beliefs. Images are the basis of beliefs as the key factors for the development of a brand image [Koubaa 2008]. Beliefs can be functional or symbolic (emotional) as the customers' experiences previously mentioned. Beliefs are also called "brand associations" relating brand perception to a semantic memory representation called "associative network model" [Aaker 1991] that explains semantic memory in terms of nodes and links.

A brand association is therefore, any sensorial perceived or internally developed concept that is linked in memory to a specific brand. Informational nodes linked to the brand node contain the meaning of the brand to a customer. These concepts are stored in memory as a certain category of assets and liabilities, giving balance to the general perceived brand meaning [Farquhar and Herr 1993].

Finally, Keller defines brand image as "the set of associations linked to the brand that consumers hold in memory"[Keller 1993].

3.2.5. Sources for experiences: ICBEs and fluency

Much of the consumer behaviour is the product of "exposure to subtle cues in the environment" according to Bargh and Dijksterhuis et al., these cues are responsible for the activation of processes in two complementary fields, cognitive and affective, but with one common characteristic, namely, the unawareness or lack of intent in the internalisation[Bargh 2002], [Dijksterhuis *et al.* 2005].

Common examples of these subtle signals are for example daily encounters between potential customers for a brand (observer subjects) and brand users (observed subjects). These encounters constitute a very important source of brand exposition for consumers. They are not part of the organisation's efforts to increase brand perception among potential buyers. Their length is brief; they occur only in passing and reject "direct communication and engagement" [Ferraro *et al.* 2008].

These events are called incidental consumer brand encounters (ICBEs). Their "ubiquitous and pervasive" nature is complementary to brand perception since exposures experienced by the *observer* subject are very common, but the brand is rarely the focal point in the encounter. Consumers are indeed influenced by ICBEs and the encounters lead to information processing about the brand and about the person using the brand [Bargh *et al.* 1992], [Fazio *et al.* 1986], [Schwarz 2004]. A defining characteristic of the studied encounters is the brand presence in the *observed* party by means of *consuming* (for example in cases such as drinking certain beverage) or *displaying* (e.g. wearing an identifiable piece of clothing).

A phenomenon called *fluency* has to be experienced by the observer. This phenomenon is essential for an effect to occur in her. Two types of fluency are mentioned in ICBE literature: *processing* fluency, or the ease with which a given stimulus is processed and *perceptual* fluency, a subtype of the first that refers to the relative ease with which people can identify stimulus on subsequent encounters or process perceptual stimuli. Only the last concept is relevant to brand perception.

Potential customers subject to an ICBE, automatically process the frequency of exposure to information. In the case of brand perception, repeated exposure should lead to increased perceptual fluency and a “more positive response toward the brand”. Therefore, under the perceptual fluency perspective, a sufficient condition for an improvement of a stimulus’ judgement is merely a repeated exposure to a stimulus [Zajonc 1968]. This condition explains the role that “frequency information” (automatically encoded by the observer) has on brand choice: perceptual fluency guarantees that experiential information in the consumer will be used as meaningful input for a brand evaluation [Schwarz 2004].

Ferraro et al. consider important to state that perceptual fluency may or may not have consequences at the level of conscious experience; moreover, its effect on consumers is optional when making explicit inferences on brands or making conscious attributions to a stimulus. In any case, repeated exposure to a brand is expected to activate a representation in the observer brain and to generate fluency so the subject will prefer that particular brand when given the choice among a set of competing options.

However, the improvement effect increases when the subject does not notice the exposure: the exposure process seems to have stronger results when the subject is not aware of the exposition to stimuli [Bornstein 1989]. Also, favourable attitudes and affective responses toward stimuli have been found when those stimuli are in a “shallow level of processing” [Janiszewski 1993], [Nordhielm 2002]. Nevertheless, in an average subject, the knowledge of having been exposed to a stimulus may attenuate its effects. In sum, “marketing stimuli processed without conscious awareness or at a shallow level of processing can result in increased favourable attitudes and affective responses toward such stimuli” [Ferraro *et al.* 2008].

The argument on ICBEs also deals with an observer’s response towards the type of person associated with the brand. This response towards a person can also moderate a positive response towards a determined brand when derived from a repeated exposure to it. Positive moderation is the result of a "clear basis for categorization" of people into defined groups. Authors cite *visual clues* as the most important mean of categorization in types like "teenagers", "females" or "athletes" [Fiske *et al.* 1999]. Consumers' responses to stimuli include affective, cognitive and behavioural types, when the exposure is studied in the perspective of the *observed* type of user. Exposure to certain kinds of persons automatically activates those responses as a result of a repeated co-activation related to the observer and the observed brand user.

But a positive response must be preceded by a conditional acceptance of both the brand and the observed subject. So, in a separate action, observers should *implicitly* process information about the users of a given brand, that is, attitudes toward these users should also be automatically activated [Bargh *et al.* 1992], [Fazio *et al.* 1986]. Automatic reactions are responsible for subsequent consumer (observer) behaviours and, more importantly, also serve an informational purpose as automatic judgements towards other people that should moderate a positive, neutral or negative response toward a frequently encountered brand. Finally, the perceptual fluency effect on the observer response may be attenuated when other relevant information is made available.

3.2.6. Brand equity

Brand equity is defined as "the added value a brand gives a product" [Farquhar 1989]. This perspective of brand equity is biased towards cognitive psychology and relies aspects if the consumer's cognitive process. It does not take into account the informational aspects of the market in which the brand is involved, although these aspects are determined by the dynamic interactions between firms and consumers.

Several concepts underlie brand equity. Consumers' brand associations and brand awareness are the key foundations of consumer-based brand equity, presented by Erdem and Swait as a complementary perspective to the firm-based, which is an approach related to signalling theory from information economics. This second view is thoroughly explained in the reviews section (**Error! Reference source not found.**). In addition to those underlying concepts, also brand loyalty and the products' perceived quality and other firm's assets as patents participate in brand equity[Erdem and Swait 1998].

"Brand Empowerment" is inferred from Keller statement who states that "ultimately, the power of a brand lies in the minds of consumers or customers" [Keller 2000].

3.2.7. Sponsorship as an example of improving Brand Image

Sponsorship is a way of achieving a better brand or corporate image. Poon and Prendergast proposed a framework for evaluating sponsorship opportunities. This framework is composed of a conative component (purchasing intention), a cognitive component (brand image) and an emotional component (brand attachment). The effect of sponsorship on consumers' attitudes and purchase intentions is greater for brands with low familiarity [Carrillat *et al.* 2005]. Also, organisations derive important benefits from sponsorships as to link their brands to objects that represent part of a consumer's extended self [Madrigal 2000].

In the context of brand image, sponsorship relies on the event/sponsor fit. If this fit is strong in the customer's mind, the sponsorship has a positive impact and becomes "the main driver of the strength of image transfer". Among other findings in their literature review, Poon and Prendergast state that a neutral sponsor's image penalises the sponsees. But synergy effects can benefit both parties and a positive image can be capitalised. The aim is to "generate a positive image transfer".

3.2.8. Brand image structure

Koubaa places the concept of "brand image" as fundamental in the marketing research field for its importance on building long-term brand equity and its role on tactical marketing-mix issues. They exemplify their view using an identification of a lack of congruency or a contradiction in specific terms related to the brand image of hybrid products, or those carrying a foreign brand but locally manufactured [Koubaa 2008].

Knoubaa's paper states that a customer's decision on acquiring a product rely on an inference that involves previous experiences along with "stored information about cues". These cues include for example, the brand or the Country of Origin (COO). The authors relate the inferring process to the classification of "human belief" as (1) descriptive, (2) informational and (3) inferential. This classification was introduced by Fishbein and Ajzen [Fishbein and Ajzen 1975].

The authors introduce descriptive beliefs as those produced by the direct customer experience with the product. Informational beliefs come from external sources of information and inferential beliefs are derived from related experiences associated to the one currently being formed. The problem with the last group is that an inference process' outcome may result in a distorted belief. Brand image is the manifestation of instances of these three groups of beliefs and will become the basis of a customer judgement about a product or brand.

Moreover, the authors bring forward the Erickson *et al.* concept of "images variables" that define concepts far away from a product's physical characteristics but that identify it in a unique way [Erickson *et al.* 1984]. These images variables are also included in the set of experiences that form the basis of an inference produced belief.

Also, a repetitive occurrence of a stimulus may affect the customer's familiarity with a certain product. Therefore, inferred beliefs on a certain attribute tend to be produced by a previously recorded belief on a related attribute. The paper mentions that brand or country images, for example, influence perceived attributes of products associated with that country or sold under a specific brand, respectively. This influence is supported with the idea that places recorded beliefs on an attribute as the cause for beliefs on some other attributes.

Moreover, they mention several interactions between images and perceived attributes like globalisation, standardisation vs. customisation strategies and the different customer's responses to appeals of brand images in different countries. These interactions also affect the inference process and should be taken into account when the organisation develops a marketing strategy. If the firm is involved in multiple markets, it should at first instance identify the national characteristics that may influence the brand image improvement strategy.

In more specific terms, the authors state that brand image comes after country image (the overall customer perception of products from a particular country). They identify country image as an umbrella that covers over and above the perception for all the products from a specific origin. So, consumers are prone to recall the stored information about the brand and the country in question so they are later able to relate the brand name to the Country of Origin to form a brand image and infer a product evaluation.

Since the economy is profit driven, customers' beliefs can be determined in basis to these persons' meanings that in turn are linked to desires, necessities and interests. To support this idea, Park *et al.* propose a set of specific "dimensions", namely: symbolic benefits, experiential benefits, and functional benefits [Park *et al.* 1986]. To adjust to this proposal, brand associations are classified into three major categories: (1) attributive beliefs that refer to descriptive characteristics of a product, (2) beneficial beliefs that refer to the personal value that a customer attaches to a product, and (3) overall brand attitude beliefs. A brand image composed of the three categories of brand associations is ideal in the consumer memory[Koubaa 2008].

3.2.9. A brand image measurement effort

Aaker presents *stochastic models of buyer behaviour* as good predictors of market share or product sales. Such presented models are based on the knowledge of individual purchase decisions (purchase histories). So he defines a brand acceptance measure in terms of purchase histories of subjects trying a new or existing brand for the first time. Uses for this measure are twofold: evaluating brand's performance and determining buyer segmentation.

The first use of the measure is to isolate individual brand acceptance or rejection decisions and then to identify the model projected trend with one of (1) a set of enduring judgements about a brand brought in by new triers, (2) a change in sample composition or (3) a temporary reaction to an unusual promotion.

The second use for the measure is to predict individual group trends when the population study is segmented according to meaningful characteristics like sex, group age, etc. Promotional efforts are then optimised by obtaining a true/false result on each group about their acceptance or rejection of the brand. Alternatively, the population may be partitioned on promotional targets, so the effect of "controllable variables" can be observed immediately.

Aaker's work introduces a measure of brand acceptance using a statistical model and studies the effect of a promotion associated with first or trial purchases on ultimate brand acceptance. The model is based on a series of purchases made by a population in discrete intervals. The expected value of the probability of purchase in a given time, over all the population is the model's mean value function or the model's prediction for a market share $E[p(n)]$. A set of binary coded brand choice decisions is then introduced to differentiate the buyers' choice (1 for the brand of interest and 0 for other brands). So a five binary digit sequence like 10111 means that the population is sampled in five purchase occasions or moments and that an specific individual decided to buy the brand of interest in all but the second occasion.

The objective of finding $p(\infty)$ for an individual is "intuitively" easier if the sequence is known. If the sequence shall be 11111 for a single individual, $p(\infty)$ likely exceeds $E[p(\infty)]$. In the same way, for a sequence like 10000, $p(\infty)$ will likely be less than $E[p(\infty)]$. Contributing to the argument, the author states that the distribution of $p(\infty)$ "can often be obtained" and that the mean of this distribution is $E[p(\infty)|x]$ being x a specific sequence of purchase decisions. This last number is the *measure of brand acceptance* for the population defined with the aim of not ignoring the always available "brand decision vectors for each sample member".

Each individual is assumed to follow a Bernoulli process, a discrete-time, binary-stochastic process. Each subsequent random variable (0 or 1) may take its value in the way a consistently unfair coin flipping would result ($p(x_i = 1) = p$). So trials are independent and the process is memoryless. To determine the process is to check if the coin is fair, given a limited set of trials. Since all individuals have different probabilities, the parameter p is distributed with Beta distribution over the population. Shape parameters for this distribution are α and β, so the expected value for the population, given a sequence x with cardinality n is:

$$E[p(\infty)|x] = \frac{\alpha + t}{\beta + n} \qquad \text{eq 3-1}$$

In this equation, t is the number of purchases for the brand of interest (the number of 1s in x). This equation implies that those individuals which generate an x with a remarkable number of ones, are more likely to have high $p(\infty)$ and to eventually "accept" the brand.

The next step of the model application is to characterise the population in terms of segmentation variables, or alternatively, exposure to promotional efforts in order to obtain the measure. This is achieved by building another model called *new-trier* in which the process that follows the first purchase is a Bernoulli process. In the model, the brand is new to the buyer, as in the case of a new brand or an unfamiliar brand to the buyer.

At $n = 0$ the first purchase occurs (the outcome shall be $p(0)$). Then, the model distributes $p(1)$ over the population with a truncated Beta distribution, so the individuals for which $p(0) = 0$ are assumed to have completely rejected the brand (the threshold for the truncated distribution is $\phi = P[p(1) = 0]$). Having those buyers discarded, the model gives the opportunity to the brand of "become ingrained as part of a family's habitual purchasing process". If the brand is initially accepted, the model allows the buyer to later reject it. At any time in the future, $p(n)$ is distributed over the population for which $p(n) > 0$ with the same Beta distribution and the same parameters. A cumulative probability of rejection (acceptance) is used. This value increases geometrically through time at a rate of γ from its initial value ϕ. So, $P[p(n) = 0] = \phi + (a - \phi)(1 - \gamma^{n-1})$ with $n = 1, 2, \ldots$

Aaker then states that his measure is just a "transformation of the brand choice vector" x based on a model like the *new-trier*. The transformation for the Bernoulli model was just the number of ones in the sequence. If a more detailed model is used, the results will be "more sensitive and refined".

3.2.10. Brand Equity as a Signalling Phenomenon

Erdem and Swait propose a signalling perspective for brand equity. Authors argue that the "imperfect and asymmetrical information structure of the market" motivates the role of credibility as the primary determinant of consumer-based brand equity. Credibility is a modifier that on the endogenous products of the dynamic interactions between firms and consumers. A market's informational aspects are determined by the interactions between firms and customers. The asymmetrical and imperfect informational structure of the market is considered when analysing brand equity from the perspective of the firm. Signalling theory from "information economics" is the basis for this view [Erdem and Swait 1998].

The mentioned authors specify content, clarity and brand credibility as the defining characteristics of a signal. Market signals include for example, educational signals in job markets or quality signals in more generic markets. In the same way, the pair advertising-price is also a signal in generic markets. “Marketing mix” elements are considered quality signals emitted from the firm to the consumer: advertising, warranties and retailer choice are among them.

Signalling can be viewed in the context of the consumer when the firm approaches to them, or in the context of firm-to-firm signals. Only the first kind is explained further in the context of quality signals.

The signal purpose is twofold but always refers to the consumer: signals should (1) increase the perceived quality of a product and (2) decrease the information costs and the perceived risk. These two purposes finally increase the expected utility, a concept also defined by [Farquhar 1989]as “the added value a brand gives a product” [Erdem and Swait 1998].

3.2.11. Metacognitive Experiences in Consumer Judgment and Decision Making

Human judgement theories assume that a subject forms judgements on the basis of *declarative information* (attributes) that keeps a relation to the target and that is available to the mind in the moment of the judgement [Higgins 1996], [Wyer and Srull 1989]. The declarative information concept relates with information that a subject can speak about, and is contrasted with such learning as riding a bike or dialling a telephone number once again when several other dialling attempts have been made. In consequence, a consumer should evaluate a product more favourably as more positive attributes come to her mind: more positive declarative information available about a product [Schwarz 2004].

However, other processes are also relevant in the judgement formation like metacognitive experiences, defined as the “ease or difficulty with which a piece of information can be brought to mind or the *fluency* with which new information can be processed”. Metacognitive experiences act also as sources of useful information and people use them as resources in judgement forming and decision making.

One of the consequences of the influence of metacognitive experiences on decision-making is a deviation of decision predictions, provided only the accessible declarative information. For example, “consumers have been found to like a product less, the more positive attributes they brought to mind” as found by [Menon and Raghubir 2003] and [Wänke *et al.* 1997]. Also, as more reasons a consumer finds to making a choice between brands, she will be more likely to defer it [Novemsky *et al.* 2003]. Other more banal examples are that people find “more likely to endorse a statement as true” as a consequence of the colour of the printed text, when colour makes easier to read, people believe in it more readily. The same happens to text that rhymes [Reber and Schwarz 1999], [McGlone and Tofighbakhsh 2000].

A model for judgement based on content is hard to reconcile with such findings since they show subjective experiences in the thought process as qualifiers for "the implications of accessible declarative information". This means that a potential customer can judge information provided by reputable sources under the light of subjective experiences. This subjective experience influence may go to the extent that the judgement may become the opposite of what the accessible information may suggest or imply. To solve this issue, the Schwarz introduces a new idea; he states that the judgement depends on the "*naive theories* about memory and cognition". Naive theory is just a name for assumptions on what makes it easy or difficult to bring a piece of information to mind or the fluency to process new information [Schwarz 2004].

Formulations of naive theories may include "examples are easy to recall when there are many" and hence, a difficulty to obtain an example reflects a lack of them in a given set. Other example may be that "it is hard to recall things one does not pay attention to" so an example is hard to find if the subject is not familiar with the given set.

So an interrelation among four factors comes into play:

- Accessible declarative information.
- Metacognitive experiences related to the declarative information.
- A perceived informational value of the metacognitive experiences.
- The naive theories used to interpret the perceived value.

A recall experience is based on the previous four factors but the problem that the experience becomes uninformative for judgements that require other naive theory "as an inference rule", as a mediator trough a conclusion. The naive theory choosing becomes determinant when analysing a subject's conclusion as it will be very different from the one reached by another subject under similar declarative information but a different naive theory [Schwarz 2004].

Moreover, the sequentially of the four factors is mandatory: e.g. once an example cannot be found given a set, it cannot be inferred that the subject does not have good memory for instances of the given set (once a consumer cannot remember a flower shop that carry carnations, the research cannot infer that she does simply not have good memory for flower shops). Conversely, after a subject has been identified to have poor memory for instances of a given set, it no longer follows that there are not examples in the given set (once the consumer has accepted her poor memory for flower shops, "it no longer follows with any certainty" that there are no flower shops that carry carnations).

Summarising, many different conclusions may arise for different subjects under the same factors or experiences. Moreover, conclusions may be mutually exclusive. "Subjective accessibility experiences are informative […] and qualify the implications of recalled content. Moreover, people do not draw on their accessibility experiences when their informational value is called into question".

But an individual's reliance process on accessible content mediated by accessibility experiences does include another factor: the level of processing motivation that subjects bring to the task. The author states that the majority of subjects rely on accessibility experiences when processing motivation is low. Otherwise the accessible content is preferred, even if the con contents are difficult to recall. This observation supports the former assumption that subjects rely on accessibility experiences as "heuristic processing strategy" whereas they rely on accessible information as a "systematic processing strategy" [Schwarz 2004].

4. PROBLEM STATEMENT

Organizations struggle to find the extent of their ability to understand customers' actions when selecting a product or identifying the sources of information used in such processes. Attempts have been made to analyse the situation from disciplines such as psychology and management. These efforts have provided solutions that cover certain aspects of the task like characterising the customer base, identifying potential customers, targeting the advertising towards a more adequate population or redefining corporate values to make them more suited for a relatively fast changing society.

Representing those aspects in a single methodology results in a very complex system that can be understood and partially predicted by means of computer simulation and more specifically using agent based modelling. An initial approach must have visible parts of the organisation on one hand, customers and potential buyers on the other, and a measurable relationship between these two entities. This work pretends to model a system with those three big components in order to understand the interactions at a very granular level, trying to encompass the big range of actions that can be observed on either side individually and when interacting.

A brand acceptance or rejection decision prediction is the main purpose of this system as proposed by Aaker who addressed the issue of the usefulness of a model designed to evaluate a brand's performance.

As the marketplace is a container (and enabler) of objects to be "bought", it takes the form of a semiotic system [Noth 1988] that shall be analysed and classified in order to understand it, gain full access to it, and finally, make a profit from it. In order to decompose this semiotic system, a model of the composing "symbols" shall be obtained and their relationships established, in terms of themselves as whole entities and sub components that enable this interaction. A system of symbol groups to be perceived (perception cores) shall be obtained from modelling and will be used as the basis for influencing a heterogeneous population.

Also, there shall be several models of persons participating in a system like the one modelled in this work. Since consumer's responses include affective cognitive and behavioural types when exposed to stimuli, the phenomenon called fluency (or the ease of identifying and processing those stimuli) shall be modelled to replicate exposure to a brand's information [Fazio *et al.* 1986], [Ferraro *et al.* 2008], and a degree of moderation towards its products based on the "observed type of user" since exposure to an specific kind of persons may activate a customers' response [Fiske *et al.* 1999].

A method for gaining access to populations is also needed since several organisations may be in competing positions in front of a potential customer: their product may have the same objective characteristics but a “message differentiation” has to be achieved in order to make the potential customer a buyer. Ownership of the brand has to imply a “meaning” to the customer as the result of the messaging (spreading of corporate values in form of facts or assumptions) process [Dobni and Zinkhan 1990].

5. THE MODEL AND SIMULATION

This section starts by presenting some comments about the recommended modelling approach that was used in this work in relation to the relation between managers and system designers. Then the methodology for measuring brand perception is presented in terms of its components and the relations present between them. The corresponding section presents the model and simulation as an answer to the problem statement. Since the first product of this model is simulation software and this software is part of this work, its documentation (in its current incarnation as an academic and experimental tool) simply describes what the simulation does. Although the documentation should have been written by a marketing specialist rather that a simulation modeller, the text has been "management oriented toward the presentation of conclusions and recommendations", so managers can use it to make decisions.

The following is a relationships map in a simulation system problem context [Silbey 1978]: The managerial group perceives a problem in a different way as the modeller group. Therefore, two overlapping models of the same problem exist: some elements exist in both groups and some are unique to each model. Silbey remarks that the two models aim for different goals and that as the map is not the territory, the same occurs with the documentation: it is not the simulation system model.

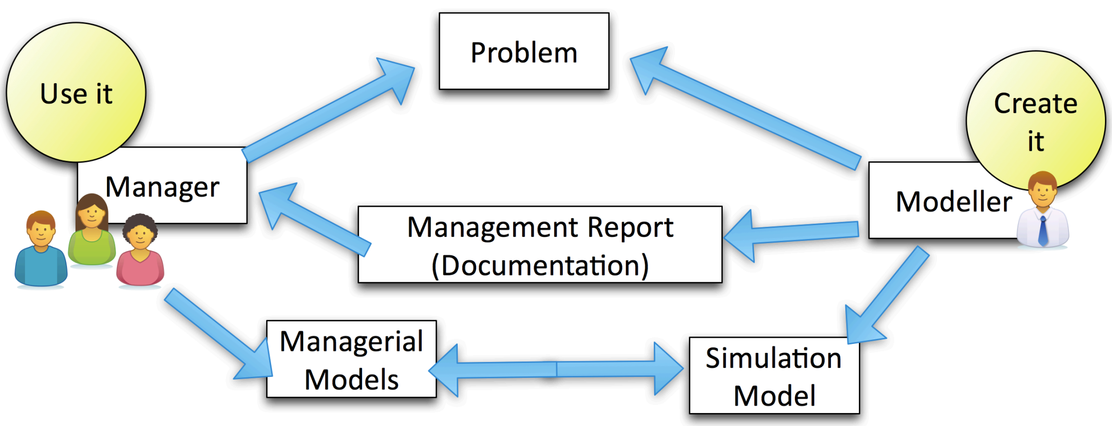

Figure 1: Modelling and simulation construction from two different perspectives. Source: the author's reproduction of Silbey's own picture. [Silbey 1978].

The presented methodology will be described as a set of static characteristics that disaggregate the system components in a model, and the simulation as the dynamic application of relation rules among those components.

The following sections give all the detail about the methodology for measuring the socio-cultural aspects of brand perception for a single organisation. The methodology is also useful to disaggregate these measures in the terms of composing cores to be perceived by a group of agents created for that purpose. The system's main objective is to "generate value" as it shall give advice on reorganising investment priorities in each of the cores.

5.1. Static entities of the system

Three static types of entities were derived by abstraction from real entities involved in the marketing process of brand perception, with the purpose of measuring it for a single organisation: population, organisational values and the various material efforts made by the organisation to reach the potential customers and persuade them to learn the values. These correspond to simulation constructs called perceiving agents, perception cores and microagents. The following section gives an approach to their design in the context of the simulation.

5.1.1. Perceiving Agents

The first breed of agents was modelled after potential customers or persons that may affect a potential customers' purchase decision. Each agent represents a person in a society. Perceiving agents work by accumulating influences and at some point in the simulation by performing an action towards the organization. This action can be positive, in this case the accumulated influences are returned to the surrounding "environment" for other perceiving agents to perceive them again.

Perceiving agents are gathered together in functional units responsible for the system's purpose of "perceiving" the brand or perceiving agents groups, a number of groups of agents exist within the simulation, each of them with a defined role like a "parent" or "high school student" for example. Each group contains an arbitrary number of agents.

5.1.2. Perception Cores

Perception cores are abstract representations of the values that the organisation may or may not want to exhibit before society. Each core is made up by *facts* or *assumptions* or *components* related to a single theme. There are a fixed number of perception cores in the system; they will have an influence on the previously mentioned perceiving agents by producing and releasing *microagents* (as they are smaller that the former agents). Each core in the system can produce a fixed maximum amount of microagents, whereas in this number will be divided according to the core's own facts and assumption's *weights* (component's weights). In consequence, there will be as many microagents *types* in the environment as facts or assumptions in the core. By having all cores to produce the same amount of microagents, a consultant can be sure that she can use a known reference frame for measuring the influence of a company value represented in a fact or assumption perceived by the public. In the next section, microagents produced by perception cores will be introduced.

To gain control on the core's performance, each component (fact or assumption) has a fixed height that will be interpreted as the time that the produced microagents will survive in the environment, hence having more influence.

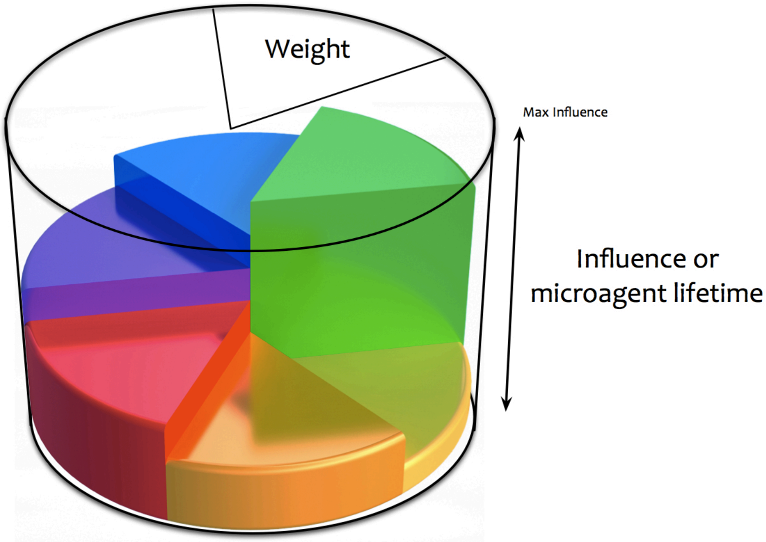

Figure 2: A perception core with six equally weighted components (same amounts of microagents released for each). Nevertheless, the green component influence is greater than that of the others. Although each component will produce the same amount of microagents (they are all equally weighted), those coming from the green component will survive longer. Source: the author.

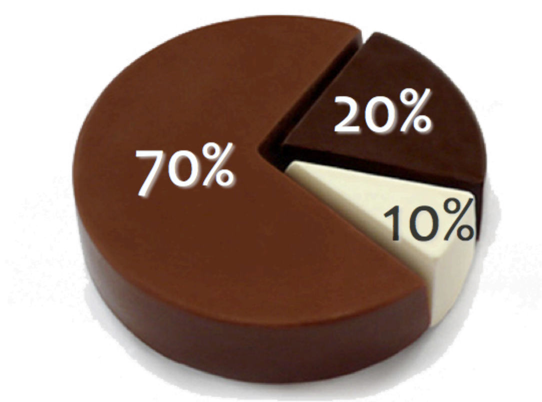

Figure 3: Another example of a perception core with three components of different weights (different amounts of agents released to the environment). Nevertheless, their microagents life span is the same. Source: the author.

5.1.3. Microagents

These are the conceptual entities produced and released by each perception core and they correspond to the hereby-introduced functional units that exert an influence on an "agent society" for the sake of a brand. Each perception core (second static entity of the system) is composed by several influential components, *i.e.*, facts or assumptions whose effect will permeate inside of the perceiving agents (first static entity) when exposed to microagents. By having a stake in the perception core, each component takes on a relative importance when calculating the overall importance of the whole core, as shown in the figure below. The larger a component weight is defined, the more microagents it can produce. The larger the height of a component is defined, the longer its microagents' permanence in the system will be. Given these two conditions, microagents are indistinguishable one from another.

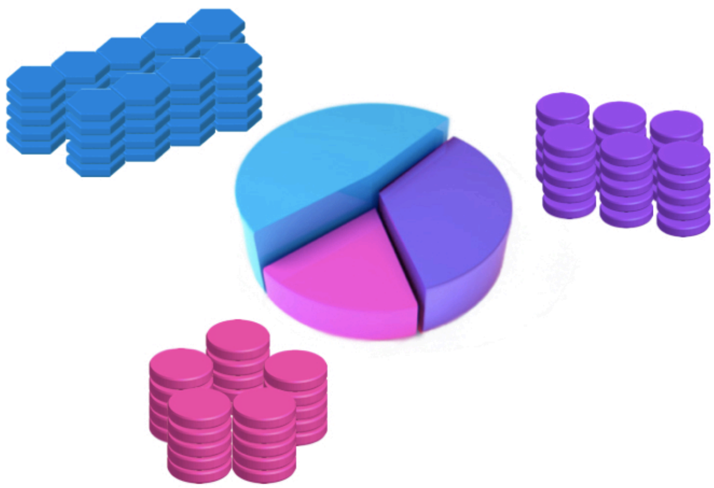

Figure 4: A perception core with three components and microagents. Their weights are roughly 45% for the blue component, 30% for the violet and 25% for the pink. The pink microagents will disappear faster and the blue ones will be longer. Coincidentally, there will be a larger amount of blue microagents, as that component is the larger. Source: the author

A core component's stake in the core is represented in the simulation system execution by a number of microagents that influence perceiving agents. Their lifetime is given by the component's height and their cardinality is fixed. Although there are people (perceiving agents) that may have an opinion (perceive) so diametrically opposed to others, influence can only take non-negative values. The negative perception (opinion against a fact or assumption) will be resolved later in the context of perceiving agents' characteristics.

Finally, perception cores produce and release microagents into the environment between fixed periods of times. This integer number is set for each core before the simulation starts, as seen in section 6.3 that deals with the implementation details of the static entities in the system.

The following is the specification of the possible values that the k^{th} microagent can store: it is an ordered pair made up by its core weight, (w) and remaining lifetime (t). The first value uniquely identifies microagents of the same species, *i.e*. those who try to influence the perceiving agents on the same fact or assumption. A simulation system execution may contain different microagent groups that share the same value of influence:

$$X_k = (w, t) \text{ with } w \in [0,1[, t \geq 0 \text{ and } w, t \in \mathbb{R} \qquad \text{eq 5-1}$$

A microagent will be present at the system until it finds perceiving agent and influents it and dies inside it (a process detailed in section 5.2.3) or until its lifetime t becomes zero.

5.2. Dynamic elements of perception or enabling agent's characteristics

The perception as a process involves all the static entities of the system. The following definitions correspond to the characteristics of the static components involved in the perception process.

5.2.1. Perception Threshold

It is a characteristic of each perceiving agent although it does not differentiate individuals from different groups. It is defined as a numeric value that models a customer's capacity to accumulate perceptions before she responds with an action or opinion. The threshold is normally distributed among the members of the perceiving agent population and makes them to *act* prematurely or late in response to a fact or assumption (actions are explained in the next sub section). The threshold of the k^{th} agent is just a real number given by the following specification:

$$u_k \in [0,1], u_k \in \mathbb{R} \qquad \text{eq 5-2}$$

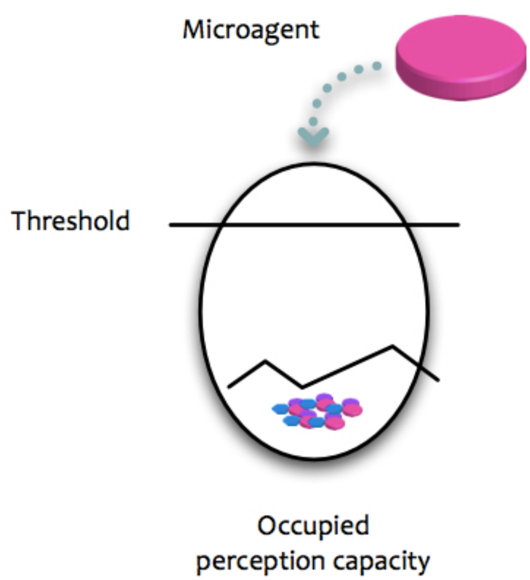

Figure 5: A perceiving agent full of microagents. Its occupied capacity has not reach the threshold yet. Source: the author.

5.2.2. Perception-inductive Channels

Channels are also characteristics of each perceiving agent. They are simply real variables that represent the impact of a fact or assumption on a target group, independently of the values carried by the latter's members. It is the same concept as a channel's "radius" that allows the simultaneous entry of a limited number of microagents. The perception channel influence results in different perception measurements from different groups when the very same kind of microagent reaches the perceiving agent.

For example, "email chains" have a negligible impact on older people, and a minimum impact (on average) on groups of suppliers, as decision makers in these groups ignore this form of information acquisition. Such a phenomenon would not happen in the case of specialized periodicals, for example. Through an identical process, the exact opposite phenomenon (high impact) would result from the perception gained from email chains over a group of recipients as the one that would represent "wealthy teenagers".

In summary, a channel is a real value of the importance given by a group of people gives to a fact or given assumption (a core component). The following is the specification of the possible values for the radius of the i^{th} channel:

$$c_i \in [0,1] \text{ with } c_i \in \mathbb{R}, i \in \{1, 2, \dots, p\} \qquad \text{eq 5-3}$$

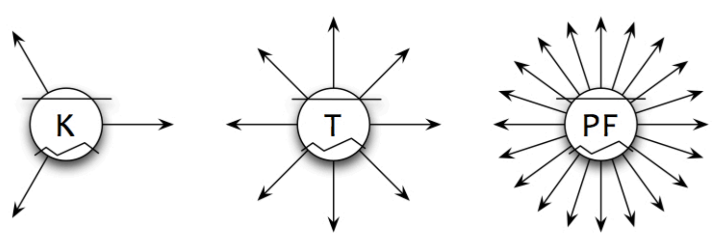

Figure 6: Three kinds of perceiving individuals with associated channels. *Kids* do not have as many channels since their social relationships are prone to monitoring by third parties, even more that those of *Teenagers* or *Pater Familias*. Notice the threshold for each kind of agent. Source: the author.

5.2.3. Actions

An action is a perceiving agent's response to stimuli from the *environment*. This environment is understood simply as the set of all static entities when the simulation is executed.

An action occurs when the perceiving agent's threshold introduced in subsection 5.2.1 is reached as the effect of the continuous exposure to microagents. This means that the agent is ready to make an impact on the environment in correspondence with its attitude to the brand. There is not such a thing as a spectrum of possible reactions from perceiving agents against (or in favour of) the organization, since only the impact of that action is relevant, not the action itself. Therefore, the microagents still stored in the recipient agent are set free, acquiring further impetus, that is, the lifetimes of these microagents return to their initial state. This constitutes a positive reaction towards the brand. Conversely, the perceiving agent may prematurely terminate the life span of all the self-contained microagents, performing a negative action towards the brand. It shall be clear that given the normally distributed nature of the threshold parameter (unique for each perceiving agent) and the uniform nature of the probability of occurrence of a microagents vs. perceiving agents encounters, actions in the system occur randomly.

Actions must exert an increasing or decreasing effect on the *overall brand image* but this issue will be discussed further when introducing the algorithmic behaviour of system processes.

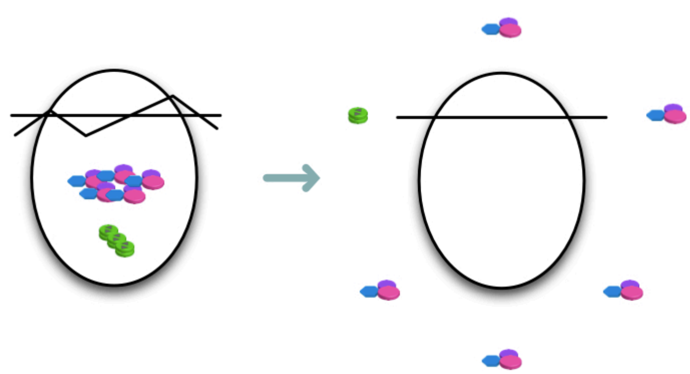

Figure 7: A perceiving agent before and after performing an action. Its perception capacity is sharper (again) after the action. Perhaps some microagents perished before being set free to the environment. Source: the author

Actions depend directly on the threshold value; therefore, this value has special significance in the formula:

$$u_k > \sum_{\forall i,j} c_i * x_j \qquad \text{eq 5-4}$$

In this equation, u_k is the perception threshold, of the k^{th} agent and c_i is the radius of the channel used by a microagent to gain access to the perceiving agent.

5.3. System Dynamic components: relations among static components

5.3.1. Perceiving agents and microagents: Influence.

This relationship is based on the concept of perception. To understand this process is necessary to explicit and rigorously define perceiving agents. The specification of the k^{th} agent is given by:

$$A_k = \{u_k, s_k, \{X_1, X_2, \ldots\}, \{c_1, c_2, \ldots, c_p\}\} \quad \text{with } s_k \in \mathbb{R} \text{ and } s_k < u_k \ \forall\, k \qquad \text{eq 5-5}$$

which means that an agent is a quadruple (4-tuple) formed by a threshold, occupied capacity (s_k), and two sets, the first containing microagents of different species inside the agent ($\{X_i\}_{i=1,2\ldots n}$) and the other containing channels used to introduce the latter ($\{c_j\}_{j=1,2\ldots m}$).

The occupied capacity is key in the role of microagents influencing perceiving agents when two individuals from the two sets relate. Occupied capacity is a function of the two sets in the perceiving agent specification and behaves as follows:

$$s_k(t) = v_1 * \text{atan}\,(v_2 * t \ \pm v_3) \sum_{i,j} w_i c_j \qquad \text{eq 5-6}$$

It is important to notice that there are two variables called t in the system: one in the microagents specification context and one in the influence context: the arctangent function of the elapsed time (with real constants associated $v_1 < 0$, v_2 and v_3) ensures that the microagent shall gain access to the perceiving agent inearly stages of its lifetime. Furthermore, the summation applies to each value of microagent weight (w_i) within the perceiving agent, whose associated radio channel has a constant value (c_j).

A graphic for an arctangent function of time with associated constants $v_1 = -1$, $v_2 = 1$ and $v_3 = 0$ is shown below. The microagent influence of is maximum at the instant at which is introduced into the environment, and decreases as time elapses.

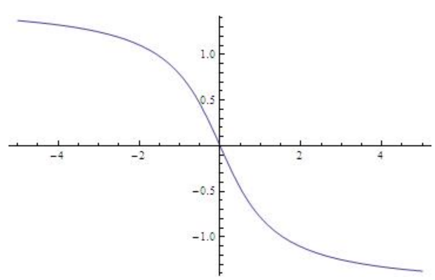

Figure 8: The occupied capacity function depends on the microagent lifetime. Source: the author.

5.3.2. Microagents and perceiving agents: Action.

When a perceiving agent reaches its threshold it must perform an action that returns the microagents to the environment. The original value of t in $X = (w, t)$ for the microagent is restored to its original value (the remaining time when it was introduced to the environment). If microagents survive inside their new environment, that is, inside the perceiving agent, they regain all their initial strength and return to the environment full of other perceiving agents (as well as competitor microagents).

5.4. System Operation

The process of defining brand value (its measurement or a theoretical adjustment through disaggregation) is composed by several steps, which are performed several times before a stop condition is met.

The resulting values in case of a measurement process experiment (values for each core assessment and the resulting overall brand image) must be closer to a single value called *convergence value*. Alternatively, an adjustment process through disaggregation should find the resulting values that reveal the system's internal behaviour on the basis of the certainty of the initial conditions and calculated cores assessments (through an instrument or an expert's opinion).

The following steps are specified in a number of management analysis (marketing) activities and simulation algorithms so the present methodology can be implemented.

1. Core identification and validation of the already found by intuition.

2. Characterization of each core: epistemological validation of each axis can be performed in this step, since a perception core characterization means finding its components and a given weight to calculate its final value. Also the microagents' lifetimes (and related variables as their weight) must be established. Common characteristics can be found in different cores, but the should have different weights in each.

3. Identification and characterization of groups of perceiving agents.

4. Identification and characterization of the *perception-inductive channels* used by each fact or assumption to reach the perceiving agents. Also, a group of perceiving agents must be associated with these channels. This may seem as a part of the previous point but channels can be identified and valued independently.

5. Simulation of a number of agents to find a measurement for overall brand perception. Alternatively, the system inner workings (variable adjustment) are found for known initial conditions and an overall brand perception final value set in advance.

6. The simulation final outcome is the perception measurement of a set of perceiving agents modelled on the basis of the firm's real environment starting with a number of beforehand-identified perception cores: a function of the weighted core assessments, or the sum of as many assessments as perception cores are defined.

5.5. Description of the simulation

On one side, the system comprises a number of perceiving agents belonging to different groups. For this model, agents can be for example "parents" or "high school teachers" or "university students". These agents are immersed in an environment that also has a number of microagents to be perceived. These microagents represent a fact or assumption (an element of influence) such as "our university was the one that first introduced the mechatronics engineering programme".

Microagents exercise their power of influence by crossing the *perception-inductive channels* associated to each perceiving agent. Agents with fewer channels will be fed with influences in a more slowly rate than those with more channels. The radii of the channels are to be normally distributed throughout the population that have them (perceiving agents with a particular channel whose radius is greater than zero), and the distribution parameters must be adjusted numerically or by the consultant.

Once influences have begun to act (microagents crossing channels) on perceiving agents, the latter begin to fill. Microagents then have two possible destinations, namely (1) their disintegration inside a perceiving agent (their influence ends forever) or (2) a return to the environment when the agent reaches its perception threshold. At this time, the perceiving agent performs an action (the nature of this action is not relevant to the system) and releases the stored microagents with new life to the environment. These newly revived microagents will perform a new influence cycle over other perceiving agents as their time of life is renewed to the same level at which they were created. An action performed by a group of perceiving agents results on a direct influence (modification of) over the n^{th} core assessment. The following equation represents an evaluation of the positive actions towards the brand. This equation does not constitute the analytical way of solving the system since it does not take into account the negative actions from the perceiving agents.

$$\mathrm{I}_n(t) = \mathrm{I}_n(t-1) + \int_i \int_j \int_k \mathrm{f}(s, c, x)\mathrm{dx}\,\mathrm{dc}\,\mathrm{ds} \qquad \text{eq 5-7}$$

The function f(s, c, x) could be adjusted numerically based on the simulation's results; the differentials s, c and x represent agents, channels and microagents. The letters *i*, *j* and *k* represent the entire group of agents, the channels associated with them and microagents that have been assimilated by individuals respectively.

In conclusion, to isolate brand acceptance or rejection decisions is a main problem stated by Aaker [Aaker 1972] when addressing the usefulness of a model used to evaluate brand's performance. This model was designed to fulfil such purpose and to be efficient enough to be implemented as a consulting tool. This shall be achieved through the use of a single interview with the adequate officers in the organisation.

6. SYSTEM ARCHITECTURE

This section presents arrangements implemented in the code that were not obvious in the previously stated model specification. The simulation was entirely written in the Java language with no external aids or libraries other that the Java Class Library. Input files are '.ini' text files that resemble a Microsoft Windows 4 configuration file and output is also written on plain text, comma separated value files. This section is divided in the same way as the system itself: packages and classes. Each package purpose, and class functionality is explained. The following is the legend for the system object oriented architecture:

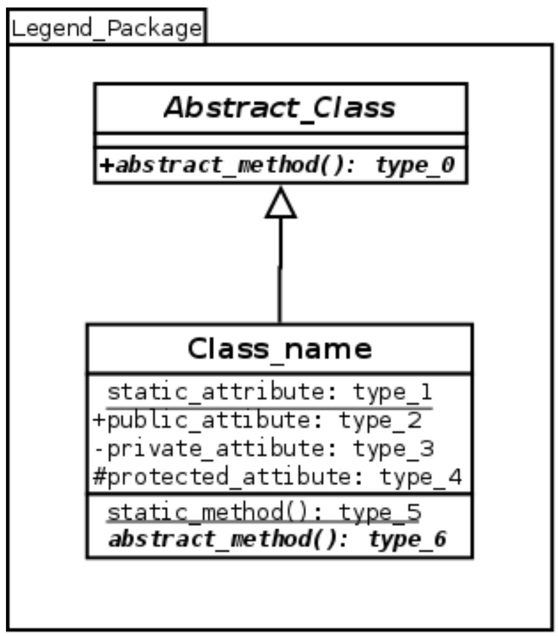

Figure 9: Legend for the class diagrams. The arrow represents inheritance. Source: The Author.

Abstract classes are presented in ***italics*** and ***bold***, as well as abstract methods. Class-scope or static attributes are underlined. Method visibility is distinguished by the bullet preceding methods' names and their return value type follows these name and a colon (:). Static methods are also underlined. Inheritance is represented by a continuous line and arrow towards the parent class (in the context of the Java language). No interface implementation behaviours were modelled for this system.

The system has four packages but just two of them are dedicated to simulation purposes. Simulation packages include `main` and `staticComps`. The other two are namely `statistics` and `util`.

6.1. The `util` package

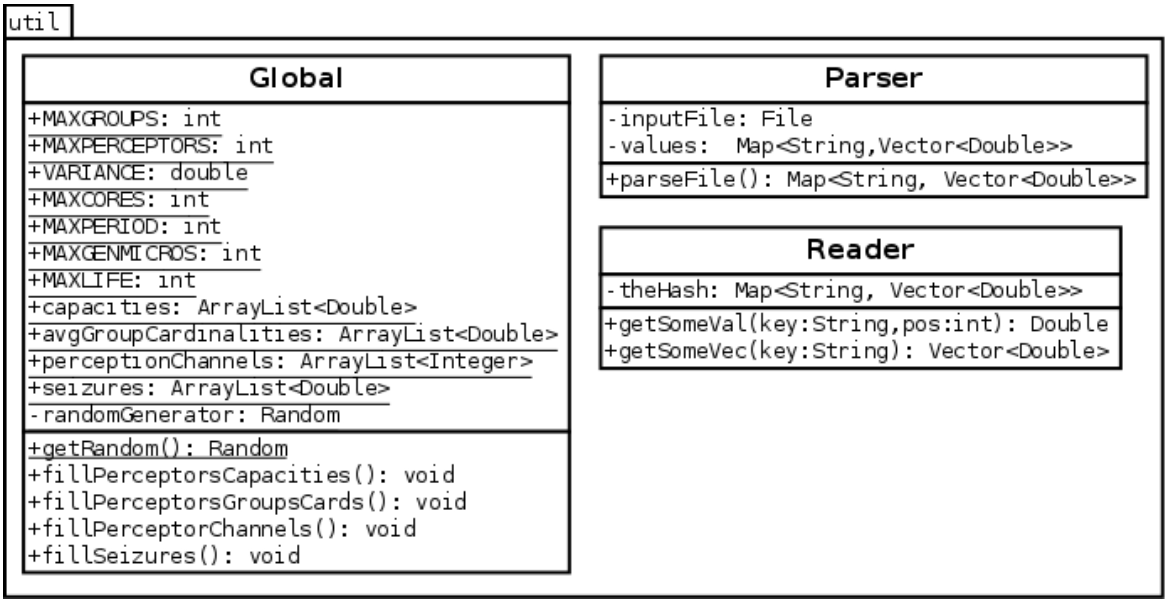

Figure 10: The `util` package

The `util` package helps mainly the system by setting up the simulation. It also provides random number generation and file access. Just three classes comprise the package: `Global`, `Parser` and `Reader`.

`Global` contains the simulation parameters, the random number generator static instance and a wrapper to access it. All the simulation parameters were declared static and public. They are listed below:

Perceiving-agent related:

- `MAXGROUPS`: a fixed integer that represents the total of perceiving agents groups.
- `MAXPERCEPTORS`: Total number of perceiving agents allowed in the system. This is also an integer.
- `VARIANCE`: variance for perceiving agents' capacities as this agent individual characteristic is normally distributed among them. As all real valued variables in the system, this parameter is declared as a double.

Core related:

- `MAXCORES`: a fixed integer representing the number of perception cores.
- `MAXPERIOD`: this integer represents the maximum number of tics that a core must wait before changing between generations.
- `MAXGENMICROS`: maximum number of generated microagents per generation. If a core has a single component, it will generate `MAXGENMICROS` microagents per generation.

Microagent related:

- `MAXLIFE`: maximum number of tics in a microagent's lifetime.

Grouped parameters:

All of the following parameters apply to each group of perceiving agents, so (in the context of the .ini file) they are stored in containers that appears as many times as the number set by `MAXGROUPS`.

- `capacities`: a double precision real number representing perceiving agent's capacity to store microagents when influenced by them.
- `avgGroupCardinalities`: divides the amount of perceiving agents in several groups, as many as the parameter `MAXGROUPS` says, so the real values in this container should sum 1.0.
- `perceptionChannels`: an integer that determines the fixed number of channels in each member of the perceiving agent group.
- `seizures`: this is the perceiving agent's probability of returning the stored microagents to the environment, hence causing a positive action towards the brand.

`Parser` and `Reader` classes are used by `Global` to obtain the parameters from a text file. The `fill` methods in `Global` just use these two classes for the purpose: The `Reader` maintains a hash table that maps the values to known names inside the application and the `Parser` access the filesystem to feed the hash with numerical single or grouped values (methods `getSomeVal` or `getSomeVec`). The following is an example of a configuration file, explained within by means of comments that follow the '!' character in each commented line:

```
!--parameters file
!for comments

[maxgroups]
3

[maxperceptors]
10

![maxcapacity]
15.0

[maxcores]
3

[maxperiod]
22

[maxgenmicros]
100

[variance]
0.5

[maxlife]
16

[capacities]
!(as many as maxgroups)
1.676661625
6.149475817
4.279913767
! kid male, mother, univ student,
kid female, father

[avggroupcardinalities]
!group members (as many as
maxgroups)
!shall sum 1
0.32990968791167974
0.30841617543632216
0.3616741366519981

[perceptionchannels]
!as many as maxgroups
3
4
8

[compcard]
!component Cardinality for each core
!as many as maxcores
5
1
6

[periods]
!as many as maxcores
0.6808100724
0.9464840561
0.2863589903

[lifetimes0]
!shall be 5
0.8423890655
0.2249085204
0.4389466300
0.9397569191
0.6121827338

[lifetimes1]
!shall be 1
0.1654011963

[lifetimes2]
!shall be 6
0.1676739167
0.3680615798
0.0967633925
0.8523119200
0.6393524301
0.8741342623

[partition0]
!5: component Cardinality, core 1
0.2830847925940466
0.08326793598525462
0.26233035844082675
0.09110132505693302
0.280215587922939

[partition1]
!1: component Cardinality, core 2
1.0

[partition2]
!6: component Cardinality, core 3
0.2822517759686204
0.0399485319178946
0.23429646697311401
0.16132341420723373
0.0905117021334082
0.19166810879972906
```

Figure 11: Parameters in an input file. Text inside [brackets] is not commented in contrast to the text that follows the ! sign. Notice that `maxcapacity` was deprecated in development.

6.2. The `statistics` package

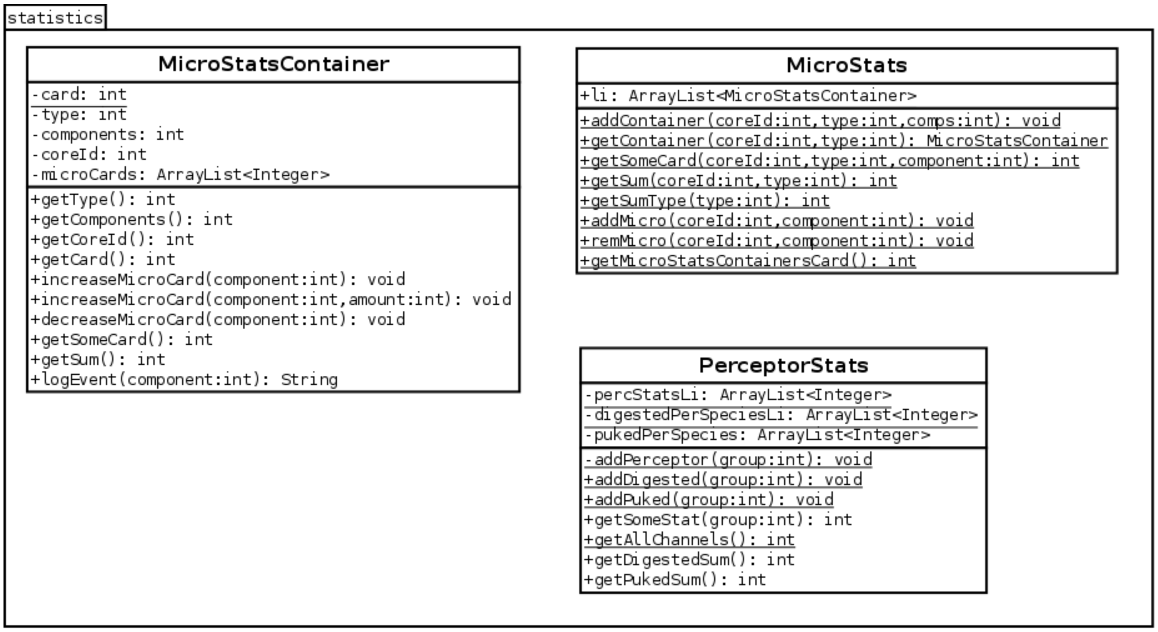

Figure 12: The `statistics` package

This package keeps times and amounts of living and dead agents and associated times for events of agent creation and deletion.

Two instances of the `microStatsContainer` are created for each perception core: one for produced microagents and one for deceased ones. Therefore, their attributes include an integer variable `type` (0 for produced agents, 1 for deceased ones) and integer attributes called `components` and `coreId` taken from the creating core. The last property is a list to maintain cardinalities of microagents (`microCards`). There is one position in the list for each component. So, as soon as a core releases new microagents into the environment, a position in this list is updated. The same occurs with deceased agents. The `MicroStats` class provides the wrapper functionality for the `microStatsContainer` instances. Its only attribute is a list of the latter.

As there are no subtypes of perceiving agents, only an instance of `PerceptorStats` is needed to maintain data on these agents. The attributes for this class include only lists of integers that count the number of created perceiving agents (`percStatsLi`), microagents that have been removed by `Perceptor` instances after “ingestion” (`digestedPerSpeciesLi`) and microagents returned to the environment, also after ingestion (`pukedPerSpecies`).

6.3. The `staticComps` package

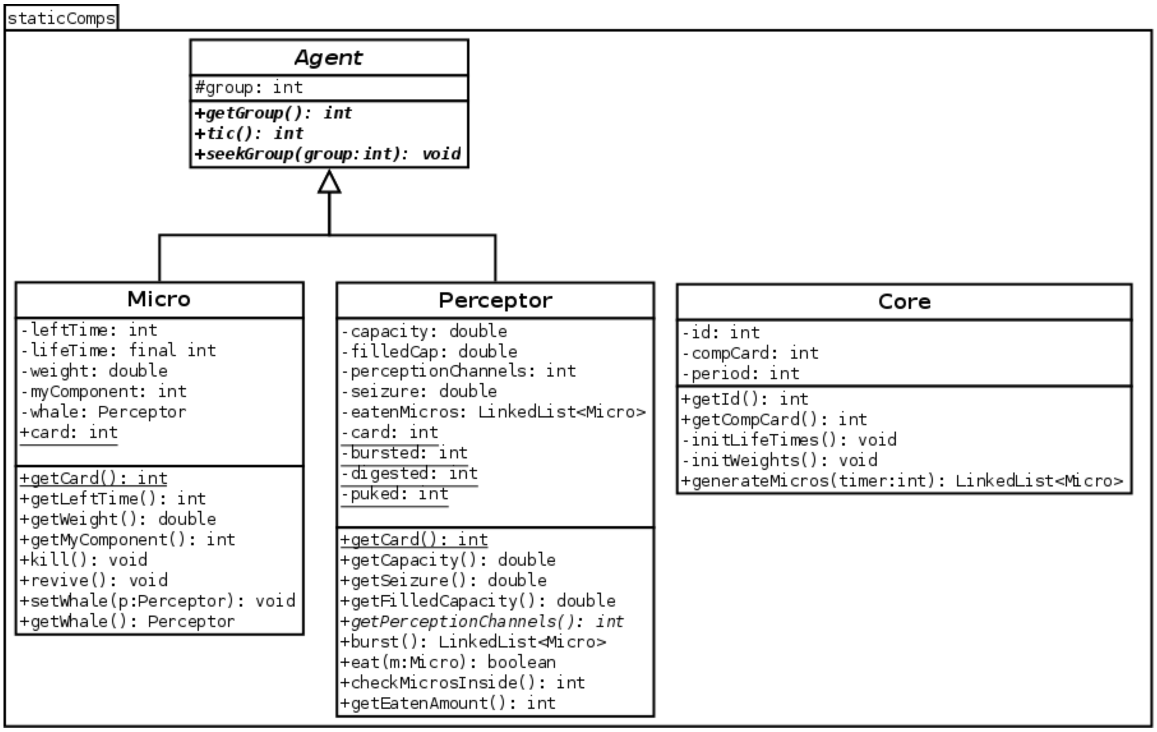

Figure 13: The `staticComps` package

The static components for the simulation are implemented in this package. There are two kinds of agents: microagents and perceiving agents. The abstract `Agent` class was created to provide functionality for the agent shared `group` property and related methods. A `group` variable defines the different agent gatherings: for example, there are as many microagent groups as perception cores (`MAXCORES`), or as many perceiving agents as `MAXGROUPS` in the simulation parameters. As soon as an agent is created, an identification tag to a group is assigned (`group` attribute). In addition, every agent must implement the `tic()` method that obliges it to perform an action every time the timer changes.

6.3.1. `Perceptor` Class:

Perceiving agents are implemented in the `Perceptor` class. Their individual attributes include a constant, real valued `capacity`, normally distributed among the members of the group. The mean value is taken from the `capacities` container in the `Global` class. The `VARIANCE` for `capacity` is the same for all groups and is also taken from parameters stored in the `Global` class. This is the limit for the `filledCap` variable that starts in zero and increases as the agent ingests microagents, using the latter's weight.

A perceiving agent also has one or more perception channels (`perceptionChannels`). This integer value acts as the number of times that a single perceiving agent will be exposed to the influence of microagents. This property's value is common for all instances of a given group. To make every single perceiving agent unique, a `seizure` value is defined for it. This value is assigned when the agent is initialised and is calculated by generating a normally distributed pseudo random number with variance 1.0 and a mean read from the `seizures` container in the `Global` class. In addition, an empty list of microagents is set up in the initialisation (`eatenMicros`).

Finally, a set of four static counters is defined. As they are static, all instances of the class will share a common value for the variable. These variables are redundant in terms of ones being the sum of others. The variables are called `card`, for the cardinality of the perceiving agent group, `burst` or the number of microagents involved in a perceiving agent's action process that may conclude in being, `digested` or `puked`. When a microagent disappears inside the perceiving agent without having completed its lifecycle the variable `digested` increases or the same happens when a microagent returns to the environment with renewed life, this is the case for the variable `puked`.

The two methods inherited from Agent class works as follows: `seekGroup` only adds the agent to a `perceptorStats` instance. As mentioned above, this happens only when the agent instance is created. The `tic` method evaluates the ingesting capacity of the agent (the `filledCap` property), letting the simulation know if is it adequate to select microagents to "feed" it.

The `burst` method implements an action performed by a perceiving agent: as the action itself is not important, only its results were modelled: that is, whether its behaviour was directed towards the benefit of the brand and hence, the organisation, by returning the influencing agents to the environment or conversely, by finishing their lives prematurely.

In either case, the `filledCap` property is set to 0.0 again, and a new list of microagents is prepared for all of them to escape. In this precise moment, a uniformly generated random number that is compared to the `seizure` property decides the faith of the ingested set. If the random number is greater, each microagent is deleted (the microagent `kill()` method), the static values `digested` and `burst` are incremented and the `perceptorStatistics` instance is notified so it may update itself.

In the other case, every microagent's `revive` method (as presented below) is called, the `puked` and `burst` values are incremented and the statistics updated, but more importantly, the newly created list is filled with the contents of the local microagent list (the `eatenMicros` property).

The complementary ingesting process is implemented in the `eat` method. This function is passed a microagent and then it simply calculates if it may fit inside the perceiving agent: the microagent `weight` property must be less than or equal to the remaining capacity (`capacity – filledCap`). If this is the case, the `whale` property in the microagent is set to a reference to this, or the very perceiving agent instance that is ingesting the microagent. The eatenMicros list is updated with the newly acquired Micro instance, the filledCapacity is effectively modified and the method returns ‘success’. If the microagent does not fit (if there is not enough space inside the Perceptor instance or filledCapacity < weight), nothing happens and the method returns ‘failure’.

The last interesting method in the Perceptor class is checkMicrosInside that not only returns the size of the eatenMicros list property, but also iterates over it to tic every ingested microagent. If this tic returns zero, the microagent’s life has ended and hence is removed from the list and the filledCap is updated.

6.3.2. The Micro class:

The Micro class implements the knowledge and behaviour of individual microagents. It has an only constant integer value called lifeTime that determines the number of timer changes the agent will withstand in the hypothetical situation that no perceiving agent eats it. A Core instance sets lifeTime when the microagent is initialised and ultimately comes from the initialisation file. Close related to this variable, leftTime is set to the same value at initialisation. The agent’s weight is stored in the real valued weight property. Just like the lifeTime variable, the creating core initialises weight.

The myComponent property tells the simulation what kind of microagent is being handled in a certain moment. Cores are composed by components and every component releases representatives to the environment in the form of a microagent. The creating Core instance sets the group property, inherited from the Agent class; the same occurs to leftTime (and hence lifeTime), weight and myComponent in the Micro constructor. Also, the whale property that contains a reference to a potential perceiving agent that contains the microagent is set to NULL at this moment. The microStates (section 6.2) instance is told to update itself and the class scope (static) cardinality variable card is increased in one. A good observer should have noticed that lifetime and myComp are synonyms.

When a staticComps.Perceptor.burst method prematurely ends a microagent’s life, the kill method in Micro is called. It simply tells the MicroStats instance to update itself, as the Micro is effectively removed by the adequate method in the Perceptor instance. A similar situation occurs when the same burst method in a perceiving agent makes a microagent to return to the environment. The leftTime is set to lifeTime again and the whale property is NULL again. Also in this case, the Micro instance is removed by the Perceptor.

Finally, the two inherited methods are seekGroup and tic. The former does nothing, as the creating core handles the group functionality, and the latter just decreases the leftTime variable. If the microagent has no more time to live the MicroStats instance is told to update itself again. If the microagent is living inside a perceiving agent, this latter instance removes the `Micro` instance, but if the microagent lives in the environment, the `Simulation` instance does the job.

6.3.3. The Core class:

The last class in the package is the `Core` class. Its properties are limited to an identification tag (`id`), the cardinality of components (`compCard`) and a `period` to wait between microagents releases to the environment. All these three are ultimately read from the parameters file and are set in the constructor. The two other properties are lists of numbers, as big as the `compCard` value: `lifeTimes` is composed by integers and will be transformed later in the individual `lifeTime` for microagents. The other list is `weights`, which contains a partition of the total core weight, so the real numbers on the list shall sum 1.0. Methods for initialising these lists are called in the constructor as well as notifications to the `MicroStats` instance to add the new core.

The `initLifeTimes` method initialises the `lifeTimes` list by taking individual values for each component of the core. These values are stored in the `Global` class and are read from the parameters file, e.g., in the `[lifetimes4]` section for the fourth core. There shall be exactly `compCard` entries in the section for the programme to continue its operation. The real value is multiplied by the `MAXLIFE` parameter (also from `Global`) and stored in the `lifeTimes` list. A similar procedure is used to fill the `weights` list. This time the `[partition10]` section of the initialisation file contains a partition of 1.0, the total weight of the tenth (and every) core.

A separate algorithm was designed to accomplish the task of generating these partitions:

```
FUNCTION partition (original: REAL, whole: REAL, parts: INTEGER, tolerance: REAL): REAL[]
        section ←whole/parts
        d ←whole
        IF parts = 1 THEN
                aSum ←CALL sum(VECTOR)
                CALL addToVector(original – aSum, VECTOR)
 ELSE
        WHILE |d – section| >= tolerance
                d ←CALL rand()
        ENDWHILE
        CALL addToVector(d, VECTOR)
        CALL partition (original, whole – d, parts – 1, tolerance)
ENDIF
RETURN VECTOR
END FUNCTION
```

The recursive partition function takes four parameters: the original length to be partitioned, the whole length to be partitioned in the present function call, the desired parts and a tolerance value that can be allowed when calculating each section. The algorithm produces a VECTOR in which the lengths of each part are stored. The trivial case occurs when the desired (or which length has not been calculated yet) parts is just one. In this case, the length is the yet-to-be-partitioned length: original – aSum (aSum is the sum of all lengths already stored in the VECTOR) and it is added to the final position of the VECTOR. That is the purpose of the addToVector function, and the sum function calculates the summation for all lengths inside the VECTOR.

The non-trivial case waits for a suitable length to be generated by the random number generator (in [0,1[). This number is suitable if it fits inside the length of a piece of the whole length yet-to-be-partitioned (|d – section|).

The last relevant method in the Core class is generateMicros that produces a list of microagents to be added to the big main.Simulation.microList list property whenever the core period is divisible by the Simulation timer (Not at all times microagents are released to the environment). The number of generated microagents is always the same (MAXGENMICROS), but the amounts depend on the weight of each component (obtained from the weights list).

6.3.4. The main package

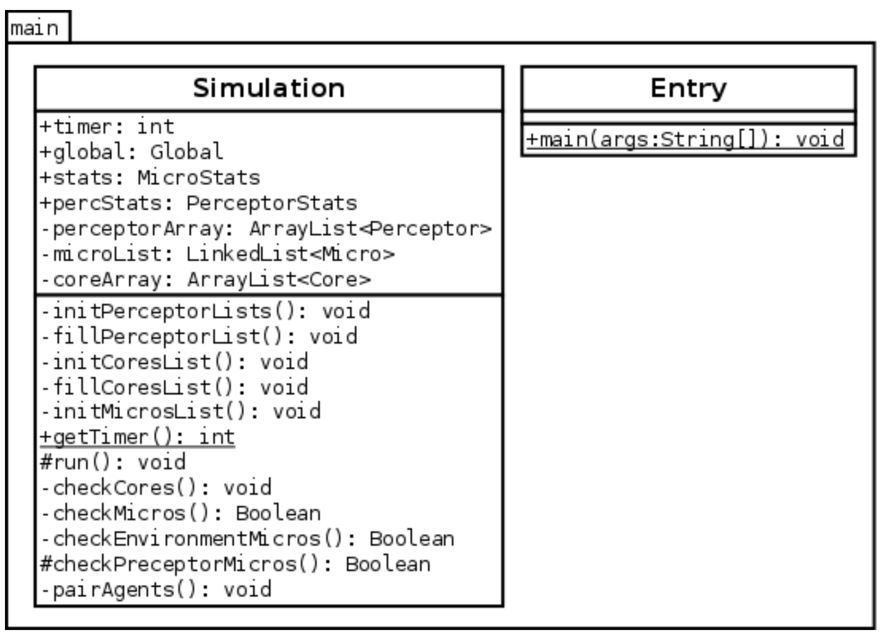

Figure 14: The main package

The main package contains a class to be used as the only entry point to the application creating a single instance the simulation class that runs all the processes that relate static components in the system.

The simulation class contains an integer time counter (timer) that will act just as a reference to all other processes in the system: it will not be used to calculate any value for the static components (perceiving agents or microagents). It also contains a Global instance to initialise the system with simulation parameters and instances of microagent statistics (Microstats) and perceiving agents statistics

(`PerceptorStats`). This class also serves as a container for all the agents in the system: an `ArrayList` structure (`perceptorArray`) was used to store perceiving agents since no instances are to be created or deleted as time passes. Conversely, a `LinkedList` structure (`microList`) is used to maintain microagents as they are continually renewed in the system. Finally, another `ArrayList` (`coreArray`) will be used to store perception cores.

As for the methods in this class, they are centred on initialising and filling data structures for static components: perceiving agents, cores and microagents. In the case of core creation, only the number of components (integer) and the period (a real in [0,1]) are needed. These values are read from the initialisation file and the period values are multiplied by the `maxperiod` parameter and given an integer value. After that, the newly created core is inserted in the `coreArray` list.

Also, a fixed amount (`MAXPERCEPTORS`) of perceiving agents are generated using a roulette wheel selection algorithm to choose the group that each one of them will join. The algorithm just takes a random number from [0,1] and looks for it in the intervals defined in the `[avggroupcardinalities]` section of the initialisation file. These intervals are stored and managed by the `Global` class. The probability of choosing a given interval *i* is just its fitness over the sum of all fitnesses.

$$p_i = \frac{f_i}{\sum_{j=1}^{N} f_j} \qquad \text{eq 6-1}$$

The method that executes the simulation process is `void run()`. It consists only in an infinite loop that increases the timer, verifies the cores, then verifies microagents and finally, pairs them with perceiving agents. The process of verifying cores and agents is handled by different methods and will be explained immediately.

```
WHILE true
        timer ← timer + 1
        CALL checkCores
        IF NOT CALL checkMicros THEN BREAK
        ENDIF
        CALL pairAgents
ENDWHILE
```

`checkCores` asks each core to produce a list of microagents and if this list is not empty, the method adds all its members to the `microList` container. The list shall be empty if the timer does not match the core `period` property.

`checkMicros` verification tells the simulation whether or not a single microagent survives in the system. Microagents can be found inside perceiving agents or in the environment. If either condition is true `checkMicros` will not halt the simulation. This method is composed by `checkEnvironmentMicros` and `checkPreceptorMicros`. In addition to counting the microagents living outside a perceiving agent, `checkEnvironmentMicros` also removes the environment microagents that have completed their life cycle by asking them whether their `tic()` method returns zero. `tic()`, in this case, reduces in one the microagent's lifetime. See section 6.3 for the agent abstract class explanation.

Finally, `checkEnvironmentMicros` returns false when there is no more microagents in the environment and the timer has passed the `MAXLIFE` mark, in order to allow the cores to fill the environment in early stages of the simulation. Then again, `checkPreceptorMicros` only asks each perceiving agent whether it has a microagent inside.

`pairAgents` deals with the process of influence. A perceiving agent "ingests" a group of microagents from the environment in the following way: First, the perceiving agent `tic()` method is called, and it answers whether the agent is able to gain `filledCapacity` by ingesting more microagents or not. Then, `pairAgents` asks every perceiving agent for the number of perception channels available for influence exposure. The agent ingests as many microagents as perception channels it has. These microagents are randomly selected from the ones still in the environment.

6.4. Guidelines for the software use

The software was built using the version 1.6.0_39 of the Java complier for Mac OS X and shall work in any Java 1.6 virtual machine. An INI and a CSV text files are used as sole input-output means for the programme. All simulation parameters are to be changed in the INI file using any text editor that uses `0x0A` (`LF`) as the newline character. In the current development version, the CSV file shows the creation, freeing (puke), deletion by timing out and negative action (from a perceiving agent) and capture (also by a perceiving agent). These events are logged along with perception core identification data, and the component. The timing is also logged and obviously first events are shown earlier in the file.

7. EXPERIMENTS

7.1. Experimentation with the Java based simulation

The first set of experiments seeks to find the microagents population situation at the end of the period. Given a fixed, perceiving agent setting (a low fluctuating society), the consultant may devise the path that a marketing investment followed after an initial release. A cost may be assigned to each microagent release according to its weight and lifetime.

For small amounts of perceiving agents, the difference between the values for 'digested' population and 'dead' population is noticeable. For 10 perceiving agents, digested microagents are about 19.35% of dead population. This means that the majority of microagents died outside the perceiving agents, so the marketing effort is about 80% lost. In the case of a hundred perceiving agents, about 74.74% of microagents effectively die inside a perceiving agent. So the marketing effort does get to the public indeed. Maybe it is not causing great impact but this issue is to be addressed in another experiment. In this regard, perceiving agents use the value in the `[seizures]` section of the parameters file to decide if their microagents *shall be released* or die.

For large values of perceiving agents population, almost all of the microagents die inside a perceiving agent. This value corresponds to approximately 94.08% of the population. A measure must be to improve the organisations value diffusion so the seizures values can be lowered to tolerable levels.

The following table shows microagents populations for a fixed set of cores and a fixed simulation time of one hundred days. Ten experiments were run for several values of perceiving agents. Since the periods and amounts of produced microagents are constant, the total number of produced microagents is always the same for all experiments. Figure 15 and Table 1 shows the situation at the end of the 100th day: 459,929 microagents were produced in all cases, experiments were run for several values of perceiving agents but 10,000,000 of them could not be simulated for memory issues.

perceptors	alive_ environment_pop	dead_pop	currently_Eaten	digested	puked	bursted
10	427690	32133.9	105.1	6219.1	3619.9	9839
100	364563.2	94251.8	1114	70451.6	33225.5	103677.1
1000	12963.3	436209	10756.7	436175.8	231755.1	667930.9
10000	0	431712.3	28216.7	431531.8	262766.9	695031.3
100000	0	431765.8	28163.2	431594.1	261184.4	692778.5

1000000	0	431714.9	28214.1	431537.3	259236	690773.3

Table 1: Experiment for populations at the end of 100 days

The following figure corresponds to the Table 1:

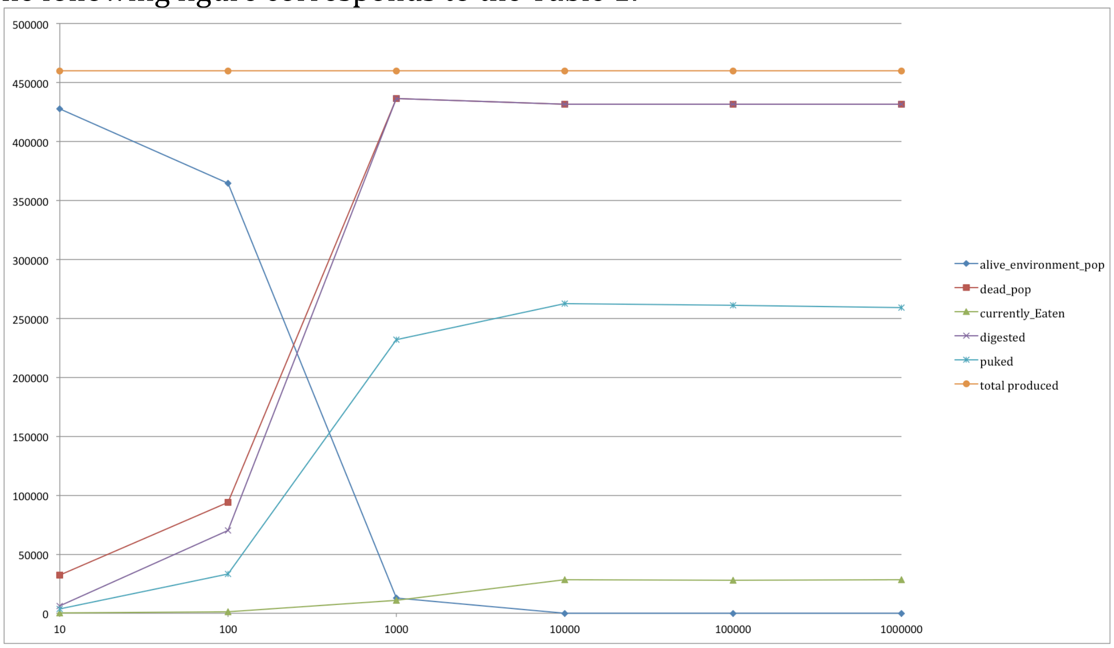

Figure 15: Chart for Table 1

The following is a screenshot of the application programme once it has finished an experiment run for the settings presented. The amount of cores, their period, component cardinality and lifetimes are presented.

```
Hi
[Global] Initialising Parser
[Parser] Parsing of .ini file completed. All internal variables initialised
[Global] All static arrays have been initialised
[SIM] perceptor list is nominal
[SIM] 10 perceptor agents correctly added to containers
[SIM] Perception cores list is nominal
Core 0. Period: 272. Components: 5. Lifetimes: 336 89 175 375 244
Core 1. Period: 378. Components: 1. Lifetimes: 66
Core 2. Period: 114. Components: 6. Lifetimes: 67 147 38 340 255 349
Core 3. Period: 149. Components: 5. Lifetimes: 173 377 357 388 96
Core 4. Period: 387. Components: 4. Lifetimes: 383 386 341 35
Core 5. Period: 132. Components: 1. Lifetimes: 79
Core 6. Period: 4. Components: 6. Lifetimes: 383 237 282 334 345 15
Core 7. Period: 5. Components: 2. Lifetimes: 157 268
Core 8. Period: 181. Components: 5. Lifetimes: 2 391 39 203 291
Core 9. Period: 393. Components: 6. Lifetimes: 311 49 91 77 70 192
Core 10. Period: 350. Components: 5. Lifetimes: 199 138 260 293 41
Core 11. Period: 203. Components: 6. Lifetimes: 259 156 313 238 340 138
Core 12. Period: 396. Components: 1. Lifetimes: 265
Core 13. Period: 146. Components: 3. Lifetimes: 258 146 59
Core 14. Period: 147. Components: 6. Lifetimes: 208 328 78 107 348 41
Core 15. Period: 217. Components: 2. Lifetimes: 242 385
Core 16. Period: 170. Components: 5. Lifetimes: 397 324 262 377 353
Core 17. Period: 61. Components: 2. Lifetimes: 133 101
[SIM] 18 perception cores correctly added to single container
[SIM] Empty Microagents list created
[SIM] Running
[SIM] No time left to run
[SIM] Elapsed time was 9731
MicroList size (alive environment pop) is: 429481
MicroList dead pop (acording to stats) is: 30339
```

```
Micros totally produced, as a result of the sum of every type: 459929
Micros totally produced, as a result of static var: 459929
Dead + alive is 459820
Difference Produced - (dead + alive) is 109
Eaten: 109
Digested 4378, puked: 5980
Burst 10358. Shall be 10358
Digested Stats: 4378
Puked Stats: 5980
perceptors, alive_environment_pop, dead_pop, produced_pop, currently_Eaten, digested,
puked, bursted
10, 429481, 30339, 459929, 109, 4378, 5980, 10358
```

7.2. A comparison with the system dynamics approach

A second simulation effort was made using system dynamics to represent the brand perception measurement methodology. The simulation consists of two major subsystems, the first one serves the purpose of separating the marketing money among the different components of each perception core and the second represents the dispersion and survival of influences (microagents) through money that has been divided by conveying it to the population segments in which the target audience has been divided. The main purpose of this stage disposition in the simulation is to compare the discriminated amounts of money invested in each core of perception with the money that survived in the form of successful marketing campaigns that permeated the perception of different types of individuals.

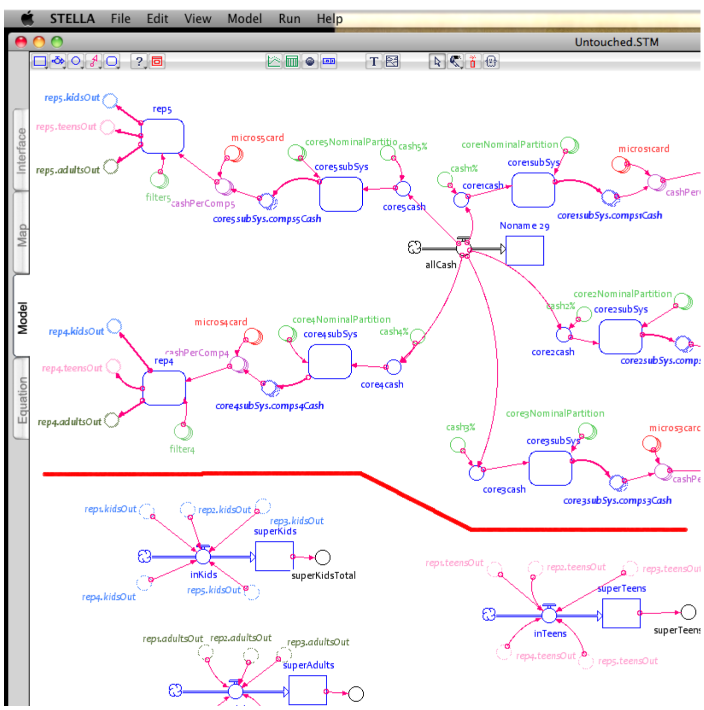

Figure 16: The two subsystems

The first subsystem divides the marketing money between the defined perception cores and their components. This money division subsystem bases its operation on a single cash flow that is shared by a fixed number of perception cores (N = 5 for this implementation). The fact that this is fixed implies a limitation on the type of simulation used (system dynamics) since a comparable system modelled using discrete event simulation could have defined an arbitrary number of axes. The same applies to the number of components for each axis, for this system this number was set at a maximum of six. The `allCash` flow of money is partitioned into auxiliary variables `coreNcash` using other auxiliary variables called `cashN` that should sum 1.0 for all N perception cores. Once an amount of money that will go to each perception core is defined, a six-position vector (`coreNnominalPartition`) is used to split and distribute this amount among all components of the perception core.

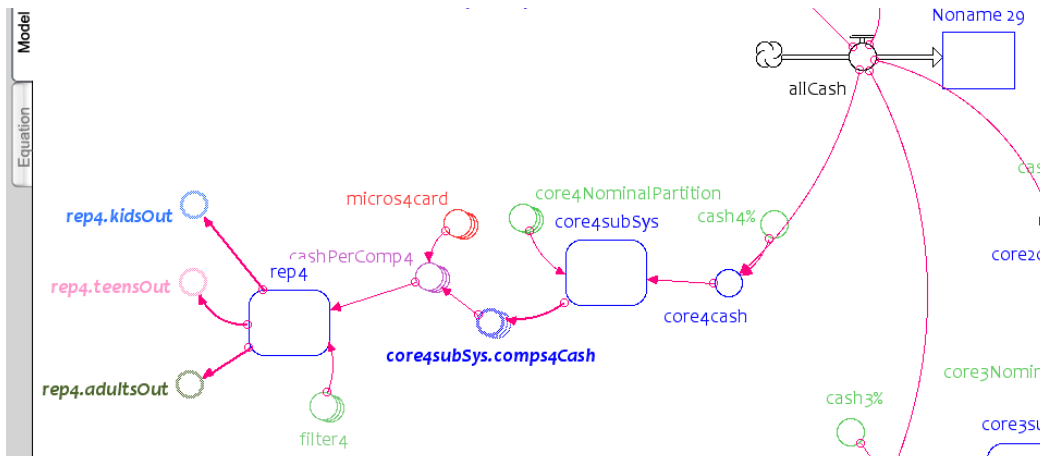

Figure 17: Detailed money division subsystem: only a perception core is shown.

This last vector and the budget division percentage allocated to each core are the `coreNsubsys` subsystem entries. This subsystem is responsible for dividing the money in a non-deterministic fashion among components of each perception core. The following table shows the percentages of the budget allocated to each perception core (fixed) and the relative importance of each component (to be randomly modified) in a first experiment brought about with this simulation.

Core percentage	0.15	0.31	0.04	0.32	0.18
	Core 1	Core 2	Core 3	Core 4	Core 5
Comp1	0.06	0.16	0.355	1	0.28
Comp2	0.18	0.18	0.303	0	0.21
Comp3	0.15	0.21	0.342	0	0.24
Comp4	0.2	0.14	0	0	0.27
Comp5	0.22	0.09	0	0	0
Comp6	0.19	0.22	0	0	0
Σ	1	1	1	1	1

Table 2: Details on the `core` subsystem for the first experiment with the simulation based on system dynamics

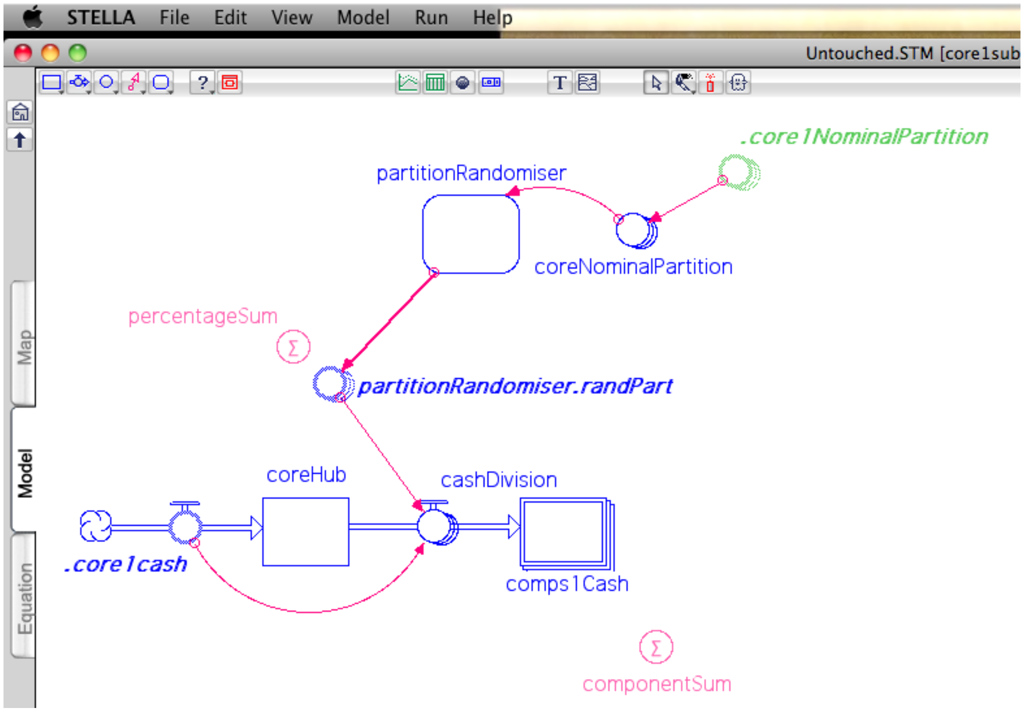

Figure 18: The `coreNsubsys` Subsystem divides the money among the cores' components

Within this subsystem there is another subsystem called `partitionRandomiser` which receives the nominal partition and modifies each of their values by approximately 4% above or below the original value. With this new partition the amounts of money received by each core component are obtained and used as the subsystem outcome. A slightly different money partition is obtained every time this component is called from the top level. If a perception core with less than six components is modelled, 0% is used as the share.

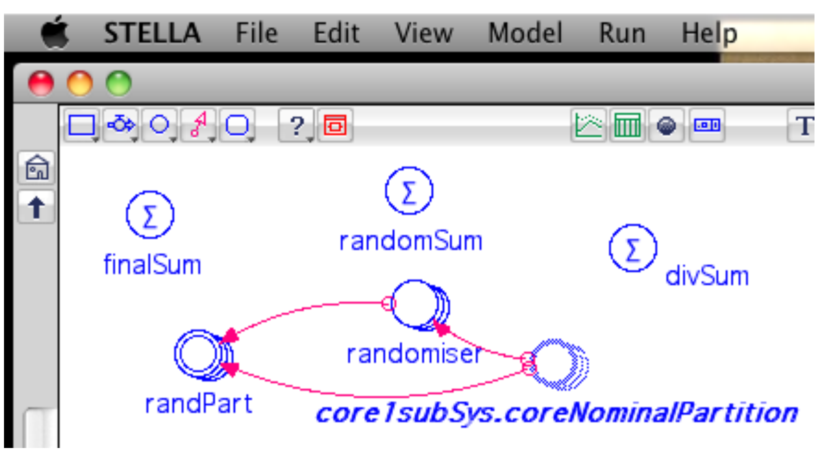

Figure 19: The `partitionRandomiser` Subsystem

At this moment, when the `coreNsubSys` subsystem exits, the microagents cardinality is important so it must be defined for each perception core so they can enter to the system. This quantity is given by the auxiliary variable `microsNcard`. In the case of having a perception core under six components, special care must be taken not to run the operation 0/0 as the money for a component that generates 0 micro agents is 0, therefore the following variable `cashPerCompN` must have a conditional branch that assigns zero in the latter case. In other cases, each of the components of this variable will contain the money allocated in a unit of time to a particular component of a core of particular perception.

The following table shows the number of micro agents produced by period for the sensing axes of the system.

	Core1	Core2	Core3	Core4	Core5		Core1	Core2	Core3	Core4	Core5
Comp1	0.06	0.16	0.355	1	0.28	**Comp1**	24	58	20	100	25
Comp2	0.18	0.18	0.303	0	0.21	**Comp2**	2	32	40	0	25
Comp3	0.15	0.21	0.342	0	0.24	**Comp3**	16	3	40	0	25
Comp4	0.2	0.14	0	0	0.27	**Comp4**	13	2	0	0	25
Comp5	0.22	0.09	0	0	0	**Comp5**	12	3	0	0	0
Comp6	0.19	0.22	0	0	0	**Comp6**	33	2	0	0	0
∑	1	1	1	1	1	**∑**	100	100	100	100	100

Table 3: Microagents percentages and amounts produced in the first experiment.

This money enters discriminated by other subsystem components called `repN` (distribution subsystem) where it is filtered so that not all micro agents can survive long enough to exert an influence on the people in the target. Along with the money, a vector containing the probability filters having a component to influence a person, are the entries in this subsystem. Money filtered and divided into components is reunited in a variable called spent accumulating which come three different flows, each directed to three different audiences: children, adolescents and adults. Each of these flows is modified by the degree of perception that may have the type of people that it is affecting.

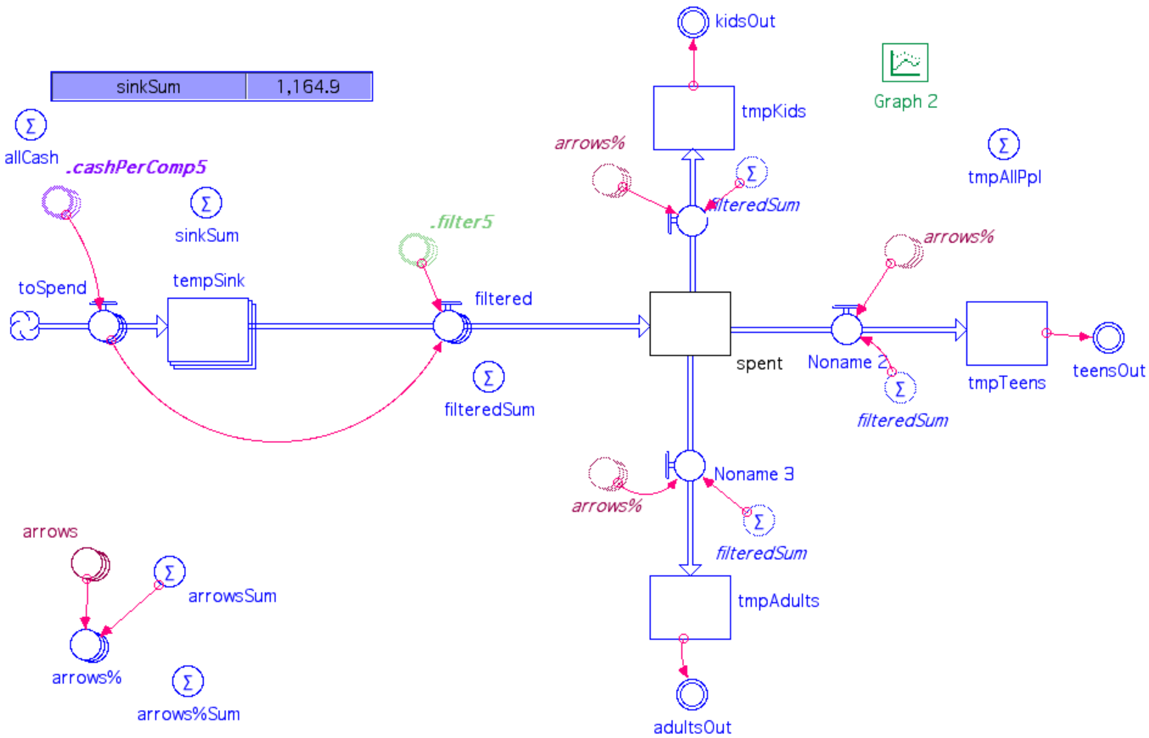

Figure 20: `repN` typical subsystem

The following table shows the filters used for each component of each axis of perception in this experiment.

	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6
Filter 1	0.56	0.58	0.08	0.05	0.84	0.44
Filter 2	0.94	0.08	0.78	0.55	0.06	0.90
Filter 3	0.10	0.66	0.12	0.30	0.29	0.65
Filter 4	0.77	0.16	0.14	0.88	0.66	0.48
Filter 5	0.46	0.46	0.65	0.93	0.64	0.24

Table 4: Filter values for all components: Although a component's value is 0.0, randomly generated filters were used for each.

This modification of the flow is related to the number of channels of information explained in the previous section and for this experiment will be 4 for children, 8 to 16 for teens and adults. The vector called `arrows` maintains these variable numbers and `arrows%` makes percentages may be used for the outflow of the stock coming spent. Thus this variable accumulation spent maintained throughout the simulation time a level of 0 and the money in full will be distributed among the three population groups keeping the analogy of money invested in marketing campaigns.
The same procedure is performed for the five axes of perception modelled in this system, obtaining as output a lot of money representing the successful marketing

activity of the company for each axis perception of each population segment analysed.

The outputs for each axis, discriminated by population segment are collected in three different flows (`Superkids`, `superTeens` and `superAdults`), so that a total known successful marketing investment (`totalTotal`) after adding, and also what is known the overall incidence of the mark on the target.

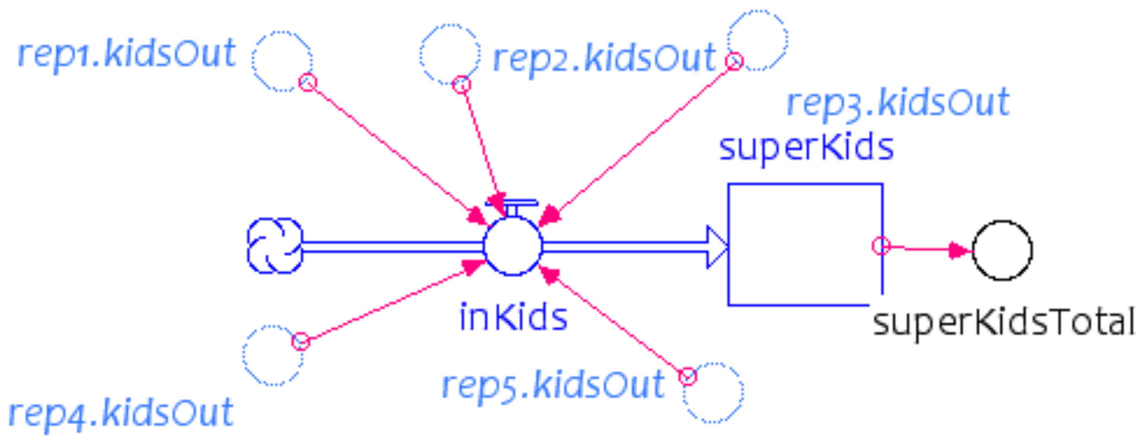

Figure 21: Microagent survival subsystem, just for kids. The `repN` subsystem output is hereby replicated.

The percentage of money received by each axis (`cashN%`) rated partitions each axis (`coreNnominalPartition`) that divides it into components and, finally, the filter that prevents micro agents immediately affect the population (`filterN`) are the modifiable parameters are under the control of the researcher in using this model. These three parameters are shown in green colour in the graphics.

Results are similar to the previously presented, as the marketing effort is partially lost in all cases. Even if the filters are set at very high levels, money is always lost when trying to reach people, no matter how open are they to acquire new information about the brand. In the first of the following graphs, filter levels are close to 10% for every core, meaning that almost 90% of the simulated microagents are lost before they can exert an influence on the three modelled groups of people. For an approximate value of $31000 M, only $8423M worth of marketing efforts are indeed accumulated inside peoples brains. This is a very optimistic view of the population since almost all the influences are well-received. The actions in favour or against the brand were not modelled as their impact would only be proportional to the median value of the good/not-good responses distribution in the population.

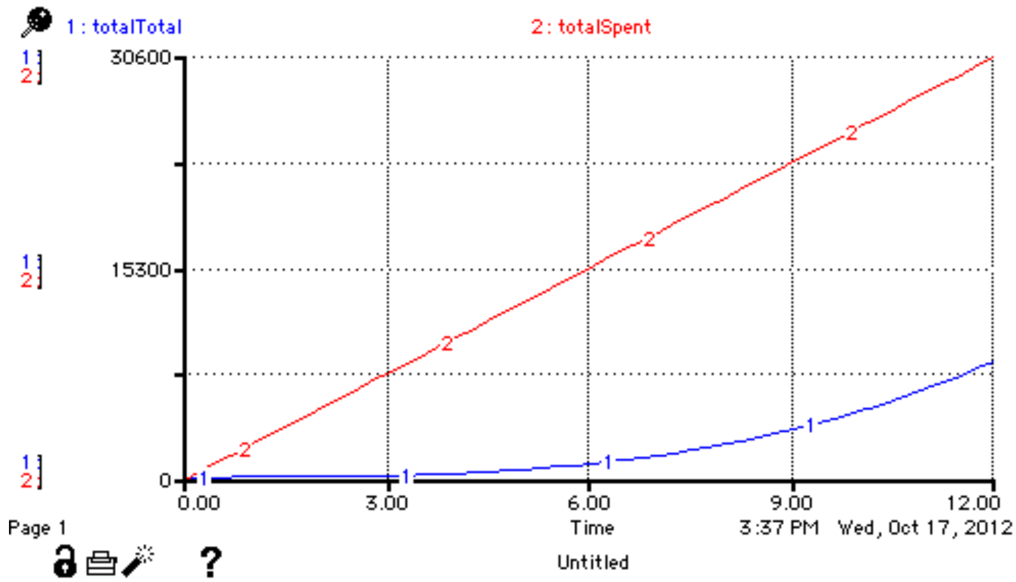

Figure 22: Although there is a big difference in the marketing budget and the well-received campaigns money, an improving trend is shown at the end of the year as a consequence of the accumulative behaviour of Stock variables in the model. Intrinsically, people start to like the brand.

Lowering the filters to allow more microagents to influence people raises the well-spent marketing money to levels very close to the total budget of the marketing campaigns. This is the beginning of a whole theorisation on how to design and maintain marketing efforts in order to not lose money as the investments lose momentum as time passes, even in short periods of time.

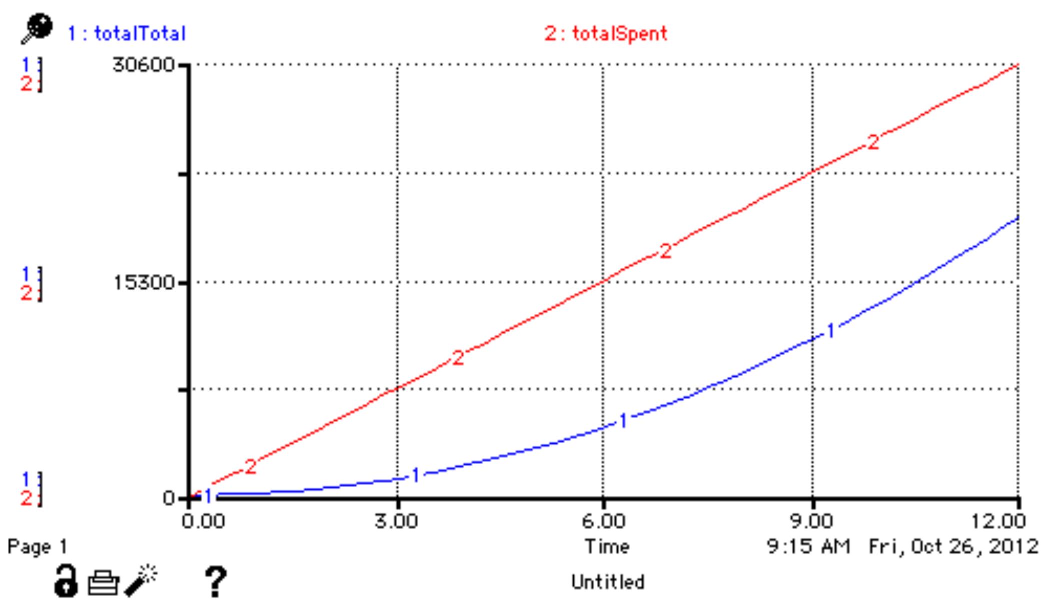

Figure 23: Filters for all the microagents are now close to 90%. This means a high influence from microagents and a small difference between the marketing expenses and the success of all the marketing efforts in monetary terms

This system dynamics approach is very useful to quickly place simulation agents and activities together and to visualise the behaviours of groups of variables but lacks in flexibility when dealing with simulation parameters that sometimes have to be hard coded so the model can be feasible only in terms of its implementation.

7.3. Guidelines for software use

Files associated with this model and simulation are to be used with the Stella simulation package. A free, downloadable version of Stella is available at `iseesystems.com`. This version allows the use of the previously created models but will not let the user modify and save any files. Files were created in the Microsoft Windows version of the software and may not be loaded by the Mac OS X version as there seems to be a bug in the naming scheme used to create auxiliary files.

For this specific model, the components drawn in green colour are to be changed by the user to adjust to a specific real-world scenario. These components include `cash`*N*`%` that contains the percentage of resources assigned by management for each perception core (notice the italicised *N*). The simulation system is hard-limited to five cores, but if fewer are needed, the value of the unused ones shall be 0.0. It is up to the user to check whether the sum of the `cash`*N*`%` values is 1.0 indeed. There is no hard check for this user's compromise, as such check would only increase the perceived complexity of the model.

The second modifiable parameter is `core`*N*`NominalPartition`, which reveals the relative importance of each component inside a core. A maximum of six components is expected for each core, a weakness when compared to the more flexible simulation written in Java. It is important to state that the sum of all components' relative importance shall be 1.0. Also, when fewer components are needed, the rest can be assigned a 0.0 value by clicking on the "converter" associated with this variable. Finally, the `filter` parameter is also user-modifiable.

8. CONCLUSIONS

The system was useful enough to determine in what areas (core components) the organisation is weak in reaching a customer base. The perceiving characteristics of the population in this organisation's task are utterly important: people are able to maintain a level of brand awareness in the short term.

The balance between the organisation's values' characterisation and classification and the size of the target population is also very important: the advertising and values promotion efforts can be measured and placed as parameters in the presented (cores and their components) system so they can be confronted with an assumed target population size. Complementing this view, the observed stabilisation of the influencing agent population values can be seen as a success in creating and maintaining a loyal customer base.

A better strategy for selecting influencing agents to be perceived by the customers is desirable for improving this system. Perception cores that represent corporate values could have different overall weights, so advertising can be targeted towards them. Also a statistical instrument can be proposed to feed the simulation system towards measuring an organisation's brand perception. Finally the system can be tailored to model many organisations competing for the same portion of society.

REFERENCES

Aaker, D. A. (1972) A Measure of Brand Acceptance, *Journal of Marketing Research,* 9, 160-167.

Aaker, D. A. (1991) *Managing Brand Equity,* New York, NY, Free Press.

Bargh, J. A. (2002) Losing Consciousness: Automatic Influences on Consumer Judgment, Behavior and Motivation, *Journal of Consumer Research,* 29, 280-285.

Bargh, J. A., Govender, S. C. & Pratto, F. (1992) The Generality of the Automatic Attitude Activation Effect, *Journal of Personality and Social Psychology,* 62, 893-912.

Bornstein, R. F. (1989) Exposure and Affect: Overview and Meta-Analysis of Research, 1968-1987, *Psychological Bulletin,* 106, 265-289.

Carrillat, F. A., Lafferty, B. A. & Harris, E. G. (2005) Investigating Sponsorship Effectiveness: Do Less Familiar Brands Have an Advantage over More Familiar Brands in Single and Multiple Sponsorship Arrangements?, *Journal of Brand Management,* 13, 50–64.

Dijksterhuis, A., Smith, P. K., Baaren, R. B. V. & Wigboldus, D. H. J. (2005) The Unconscious Consumer: Effects of Environment on Consumer Behavior, *Journal of Consumer Psychology,* 15, 193-202.

Dobni, D. & Zinkhan, G. M. (1990) In Search of Brand Image: A Foundation Analysis, *Advances in Consumer Research,* 17, 110-119.

Erdem, T. & Swait, J. (1998) Brand Equity as a Signaling Phenomenon, *Journal of Consumer Psychology,* 7, 131-157.

Erickson, G. A., Johansson, J. K. & Chao, P. (1984) Image Variables in Multi-Attribute Product Evaluations: Country of Origin Effects, *Journal of Consumer Research,* 11, 694-699.

Farquhar, P. H. (1989) Managing Brand Equity, *Marketing Research,* 1, 24-33.

Farquhar, P. H. & Herr, P. M. (1993) The Dual Structure of Brand Associations, In Biel, A. L. & Aaker, D. A. (eds) *Brand Equity & Advertising: Advertising's Role in Building Strong Brands* Hillsdale, NJ, Lawrence Erlbaum Associates.

Fazio, R. H., Sanbonmatsu, D. M., Powell, M. C. & Kardes, F. R. (1986) On the Automatic Activation of Attitudes, *Journal of Personality and Social Psychology,* 50, 229-238.

Ferraro, R., Bettman, J. R. & Chartrand, T. L. (2008) The Power of Strangers: The Effect of Incidental Consumer Brand Encounters on Brand Choice, *Journal Of Consumer Research,* 35, 729-741.

Fishbein, M. & Ajzen, I. (1975) *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research,* Reading, MA, Addison-Wesley.

Fiske, S. T., Lin., M. & Neuberg, S. L. (1999) The Continuum Model: Ten Years Later, In Chaiken, S. & Trope, Y. (eds) *Dual-Process Theories in Social Psychology.* New York, NY, Guilford.

Friedmann, R. (1986) Psychological Meaning of Products: Identification and Marketing Applications, *Psychology & Marketing,* 3, 1-15.

Gardner, B. G. & Levy, S. J. (1955) The Product and the Brand, *Harvard Business Review,* 2, 33-39.

Gensch, D. H. (1978) Image-Measurement Segmentation, *Journal of Marketing Research,* XV, 384-395.

Higgins, E. T. (1996) Knowledge Activation: Accessibility, Applicability, and Salience, In Higgins, E. T. & Kruglanski, A. (eds) *Social Psychology: Handbook of Basic Principles.* New York, NY, Guilford.

Janiszewski, C. (1993) Preattentive Mere Exposure Effects, *Journal of Consumer Research,* 20, 376-392.

Keller, K. L. (1993) Conceptualizing, Measuring, and Managing Customer-Based Brand Equity, *Journal of Marketing,* 57, 1-22.

Keller, K. L. (2000) The Brand Report Card, *Harvard Business Review,* 78, 147-157.

Koubaa, Y. (2008) Country of Origin, Brand Image Perception, and Brand Image Structure, *Asia Pacific Journal of Marketing and Logistic,* 20, 139-155.

Madrigal, R. (2000) The Influence of Social Alliances with Sports Teams on Intentions to Purchase Corporate Sponsors' Products, *Journal of Advertising,* 29, 13-24.

Mcglone, M. & Tofighbakhsh, J. (2000) Birds of a Feather Flock Conjointly: Rhyme as Reason in Aphorisms, *Psychological Science,* 11, 424-428.

Menon, G. & Raghubir, P. (2003) Ease of Retrieval as an Automatic Input in Judgments: A Mere-Accessibility Framework? , *Journal of Consumer Research,* 30, 230-243.

Nordhielm, C. L. (2002) The Influence of Level of Processing on Advertising Repetition Effects, *Journal of Consumer Research,* 29, 371-382.

Noth, W. (1988) The Language of Commodities Groundwork for a Semiotics of Consumer Goods, *International Journal of Research in Marketing,* 4, 173 - 186.

Novemsky, N., Dhar, R., Simonson, I. & Schwarz, N. (2003) Preference Fluency and Its Effects on No-Choice, Compromise, and Attraction Effects, In Novemsky, N. (ed) *New frontiers in the construction of preferences.* Toronto, Ontario, Canada, Association for Consumer Research.

Park, C. W., Jaworski, J. B. & Maclnnis, J. D. (1986) Strategic Brand Concept-Image Management, *Journal of Marketing,* 50, 135-145.

Reber, R. & Schwarz, N. (1999) Effects of Perceptual Fluency on Judgments of Truth, *Consciousness and Cognition,* 8, 338–342.

Reynolds, T. J. & Gutman, J. (1984) Advertising Is Image Management, *Journal of Advertising Research,* 24, 27-37.

Schwarz, N. (2004) Metacognitive Experiences in Consumer Judgment and Decision Making, *Journal of Consumer Psychology,* 14, 332-348.

Silbey, V. (1978) Management Oriented Documentation of Simulation, In Highland, H. J. (ed) *10th Conference on Winter Simulation.* Miami Beach, FL, IEEE Press.

Smith, A. D. (2002) *The Problem of Perception,* Cambridge, MA, Harvard University Press.

Wänke, M., Bohner, G. & Jurkowitsch, A. (1997) There Are Many Reasons to Drive a Bmw: Does Imagined Ease of Argument Generation Influence Attitudes?, *Journal of Consumer Research,* 24, 170-178.

Wyer, R. S., Jr. & Srull, T. K. (1989) *Memory and Cognition in Its Social Context,* Hillsdale, NJ, England, Lawrence Erlbaum Associates, Inc. (Psychology Press).
Zajonc, R. B. (1968) Attitudinal Effects of Mere Exposure, *Journal of Personality and Social Psychology Monographs,* 9, 1-27.