Chapter 4
A Cognitive-Semiotic Model to Capture Knowledge Dynamics at the Individual Level

4.1 Introduction

The previous chapter discussed the I-Space of Boisot in relation to the aim of the present study to understand what actually happens to the knowledge of people who undergo organizational change. Although the I-Space model puts forward some intriguing tools to identify and understand knowledge dynamics within organizations, we argued that, for our purpose, the I-Space did not suffice [see also table 3.1]. The I-Space takes on an organizational perspective and we argue for an individual, cognitive-semiotic perspective for understanding knowledge dynamics. Whereas Boisot discusses the potential of the diffusion of certain knowledge the model that we will present aims to capture the essence of knowledge itself and the dynamics of that knowledge. In other words, Boisot focuses on the dynamics of certain knowledge within a population, whereas the present study focuses on the dynamics of knowledge within a person – or an organization when the knowledge of the individuals is added up – changing the knowledge, not its degree of diffusion. As we shall see in the present chapter, this results in swapping the diffusion dimension for a dimension on sensory knowledge. This choice is founded in the cognitive semiotic pillars of our model.

Leading up to the presentation of our cognitive-semiotic model, we discuss its two foundations in cognitive science and in semiotics [4.1]. We present the three dimensions of our model, namely the sensory dimension, the coded dimension and the theoretical dimension [4.2]. We then add the dynamic aspect to these three dimensions resulting in a new space, the knowledge space or K-space [4.3].

4.2 A cognitive-semiotic approach to knowledge

In understanding the knowledge dynamics of organizational innovation, in particular at the level of the individual, it seems reasonable to take a cognitive perspective; cognition is often described as information processing. But cognition does not take into account the nature of the signs and symbols that underlie
discussions on mental representation, while semiotics, as the study of symbol and sign structures and interpretation, does. In combining cognitive science and semiotics – a combination to which some refer as psychosemiotics [Posner, Robering, & Sebeok 2005] – a very powerful team arises in understanding knowledge dynamics [van Heusden & Jorna 2001], reasoning [Shank 1998], learning of humans [Cunningham 1998; Smith 2000] and studying the mind in general [Smythe & Jorna 1998; Bouissac 1998]. This team is no coincidence. In fact, they share historic roots [Bouissac 1998].

Whereas the cognitive side focuses more on the mental processes and structures, enabling solid empirical research, the semiotic side is fundamentally based on the symbol and sign structure approach with an emphasis on semiosis [sign understanding, the concept coined by Peirce]. The common interest that these two disciplines share is that both have signals, signs and symbols as a central concern [Michon, Jackson, and Jorna 2003]; they differ in the fact that semiotics does, and cognitive science does not actually explain the nature of the sign. For pragmatic reasons we will refer to this common interest as representations [Jorna, 1990; van Heusden 1994: 30]. The combination of a cognitive approach and a semiotic approach to representations forms the foundation of our cognitive-semiotic model. We argue that our model can account for the dynamics of knowledge in innovation processes, in particular the dynamics in knowledge that the individual within the innovation process undergoes. In the following section we elaborate on the two fields of cognitive science and semiotics separately.

4.2.1 Cognitive science

Cognitive science is a relatively new discipline; it is the factor that connects disciplines that deal with cognition. Besides cognitive psychology and experimental psychology the roots of cognitive science can be found in linguistics, artificial intelligence, neuroscience, epistemology, logic [Michon, Jackson, & Jorna 2003], cognitive neurology, and philosophy [Nersessian 1992]. One of the typical issues within cognitive science in concerned with how knowledge is represented [Simon and Kaplan 1993], for example procedural knowledge and declarative knowledge [Jorna 1990]. Among the methods that are used in cognitive science to gather data are protocol analysis, content analysis, AI and computer simulation, meta-analysis, philosophy, logic, and semantics, but also experiments and physiology. Pylyshyn [1993] argues that the key characteristic in which cognitive science differs from the more traditional cognitive psychology relates to its influences ‘by both the ideas and the techniques of computing’ [1993: 51], which are used for
the ‘imitation of certain unobservable internal processes’ [1993: 53]. Simon and Kaplan describe cognitive science as ‘the study of intelligence and intelligent systems, with particular reference to intelligent behavior as computation’ [1993: 1]. Representations can play a key role; cognitive science studies how they are formed and changed.

Simon and Kaplan [1993] appoint intelligent behavior to be the core subject of cognitive science; it ‘is adaptive and hence must take on strikingly different forms in different environments’ [Simon 1980 in Simon and Kaplan 1993: 38]. Thus, Simon argues that human cognition is dynamic and when used this cognition changes. Simon continues to say that

On a longer time scale intelligent systems make adaptations that are preserved and remain available for meeting new situations. They learn. There are many forms of learning. One important form is the accumulation of information in memories and the acquisition of access routes for retrieving it. Learning changes systems semi-permanently and hence increases the difficulty of searching out invariants [Simon 1980 in Simon and Kaplan 1993: 38; italics not in original].

The above implies that the ability to adapt is an important aspect of intelligence and human cognition, accumulation being an important form of adaptation. This accumulation enables more complex forms of cognitive activity.

In trying to explain and predict human intelligent behavior three levels [stances, Dennett 1971/1978] can be distinguished: the design stance, the physical stance and the intentional stance. Dennett [1971] illustrates these three stances in using the example of a chess-playing computer. When we play a chess-playing computer we can adopt different strategies to predict the moves of our opponent. The first strategy involves the design stance. In using this strategy we rely on our knowledge of how the computer is designed, including how it is programmed. Knowing this we will be able to foresee the responses to any move that we make just by following the computational instructions of the program. This stance relies on the notion of function. That is, ‘a design of a system breaks it up into larger or smaller functional parts, and design-stance predictions are generated by assuming that each functional part will function properly’ [p.88]. Dennett notes that design-stance predictions can be made at several different levels of abstraction. Essentially, using the design-stance we ‘make predictions solely from knowledge or assumptions about the system’s functional design,'
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irrespective of the physical constitution or condition of the innards of the particular object' [p.88].

The second stance is the physical stance. This stance bases its predictions on 'the actual state of the particular object' [p.88]. This is worked out by 'applying whatever knowledge we have of the laws of nature' [p.88]. This stance can predict malfunctions of the system.

The third stance is the intentional stance. This strategy is used when the computer is viewed as an intentional system. In this case 'one predicts behavior in such a case by ascribing to the system the possession of certain information and by supposing it to be directed by certain goals, and then be working out the most reasonable or appropriate action on the basis of these ascriptions and suppositions' [p.90, italics in original]. In explaining and predicting cognitive behavior our interest is at the level of the design stance. In the following section, which discusses the semiotic foundation to this study, the functional level of behavior will be examined, as we will see, distinguishing three types of knowledge.

In sum, cognitive science has its foundations in a variety of disciplines. It deals with intelligent behavior, such as setting adequate goals in a coherent and appropriate way and choosing relevant actions accordingly. Essentially cognitive science can be said to be the study of representations and its underlying neuronal and physiological structure. Important is the characteristic of adaptation and the accumulation principle, which is the study of the changing representations. Within cognitive science three strategy levels to explain and predict behavior can be distinguished, the design level, the physical level and the intentional level. And last but not least, cognitive science has a number of methods available to do empirical research. However, while cognitive science does not concern itself with the nature of the representation of intelligent behavior, the discipline of our second foundation, semiotics, does.

4.2.2 Semiotics: A sign process of semiosis in three dimensions

Semiotics has been described as ‘the study of the innate capacity of human beings to produce and understand [the nature of] signs of all kinds’ [between brackets not in original], but also as “the study of ‘semiosis’ or sign action, … how signs are interpreted and used to effect various ends” [Sebeok 1994 in Smythe and Chow 1998: 783]. In short, semiotics is the theory of signs. The American Peirce and the Swiss de Saussure laid the foundations for it. As modern semiotics is mainly influenced by Peirce [van der Lubbe & van Zoest 1997] we take his work as a
starting point to introduce the discipline of semiotics. Peirce argued that all knowledge is mediated, that is, there is no direct relationship between the object and the knowledge of this object [Peirce 1868 in Schuyt 1997: 156]. For instance, there is no direct relation between a book and what we know about this book. These two are mediated by a sign, the sign that we have for the book. The process of knowledge – just as every form of thinking and every form of communication – involves signs. Peirce explains this mediated relation by distinguishing three related elements in the process of thinking [van der Lubbe & van Zoest 1997]

1. the sign [or representamen van Heusden 1994] that can be perceived [the word ‘book’]
2. that to which the sign refers, the object or referent [the book itself]
3. what is evoked in the person when the sign is perceived, the interpretant [what we know about the concept of the book] – we will refer to this element as meaning

In other words, the process of thinking essentially distinguishes these three elements and together these three elements form the essence of the semiotic process. As we will see every element that is represented in our cognitive system – in the form of a semiotic sign – is made up of these three semiotic elements and each element adds a dimension to the semiotic sign. In using an example, based on van Heusden and Jorna [2001], the added value of each semiotic element becomes more tangible. This example shows how new experiences are perceived and represented in the mind, from a semiotic perspective.

The first semiotic dimension: Perception of difference

The semiotic process starts with perceiving a difference. But how does this perception come about? When we do not perceive a difference, what we experience [in actuality] is precisely the same as the experiences that we have had before [stored in our memory]. In other words, the things that we perceive are already known to us, e.g. we see a book and we have seen books before. Thus, we constantly compare what we perceive, the world around us, to what we already have experienced, in our mind. When this comparison does not add up to a difference we are still in a non-semiotic situation; memory and actuality are one and the same [Jorna & van Heusden 1999]. But now we come across something that we have not experienced [perceived] before, so our experience
and perception [actuality] differ from our memory [what is already represented in our minds], the semiotic process is triggered [van Heusden & Jorna 2001].

To illustrate the process just described, let us assume that we are at a Christmas party eating a dish consisting of different kinds of fruits. While tasting the different pieces of fruit that this new dish contains, we notice a piece of fruit with a taste unknown to us. So, we perceive a difference between what we experience [tasting the piece of fruit unknown to us] and our memory [all the types of fruit that we have tasted before in our lives]. This discrepancy is what makes us notice the taste of the new fruit. This means that, although the taste of this new fruit will always be experienced in comparison to the fruits that we experienced before, to start the semiotic process it is crucial that we not only perceive differences, but that we also perceive similarities between actuality and memory. This combination of differences and similarities is what sets off the semiotic process. Thus, we search our memory for experiences to compare to the new experience; these experiences form a framework or reference point for the new experience. Hence, when there is no common ground between the new experience and the 'old' experiences, then it becomes impossible to give this new experience a perspective making it impossible to comprehend or grasp. This becomes particularly apparent when you enter an unfamiliar discipline. For example unfamiliar with physics you come across a very complicated formula; then, you do perceive differences, but there are too many to start the semiotic process.

Returning to the Christmas party, we compare the new fruit to a different, but in a way, similar fruit that we know. Let us assume that the new fruit in fact is a piece of mango. Therefore, a similar fruit to which we can compare this new piece of fruit could be a pear. Similarities between our experiences with pears and our new experience with the new fruit [e.g. both soft and juicy fruits] together form the basis of a concept for the new fruit. The semiotic process is triggered and therefore the creation of new knowledge is started.

In perceiving the new piece of fruit [mango] in comparison to a familiar piece of fruit [pear], the familiar pear functions as a reference point to the new mango. Thus, the new experience is perceived and interpreted based on similarities between the two fruits, the old fruit [the pear] and the new fruit [the mango]. However, perceiving difference is what starts the most primitive form of the semiotic sign, the perceptual, one-dimensional sign is formed. At this first stage in the semiotic process the newly formed concept of the mango is still dependent on the presence of a context; we need the mango to be present to be able to apply our knowledge of this new concept.
From a semiotic perspective, using the three elements of sign, object and meaning, the above example of encountering a new fruit can be captured in terms of the physical, tangible mango to which the word ‘mango’ refers [object], the word ‘mango’ [sign], and our interpretation, the essence of the mango fruit [meaning]. In the first stage of the semiotic process these three aspects object, sign, and meaning are still one-dimensional, they are one and the same [see figure 4.1a]. That is, the new knowledge of the mango can only be of use in the presence the new piece of fruit [object]. The mango fruit does not have a sign yet [e.g. the word mango]. Furthermore, we cannot yet verbalize or make our interpretation of this new fruit tangible, that which is specific for the mango fruit. We cannot verbalize this because we do not [yet] know in what way the new fruit essentially differs from other fruit [meaning]; we cannot pinpoint the difference. Thus, both meaning and sign are still directly related to the object of the new fruit; the three aspects of the semiotic sign are one. As stated in the above, as no earlier experience with this type of fruit is available, no representation for this new fruit is available; the object has no representation yet.

![Figure 4.1a: The first semiotic dimension in which object, sign and meaning are one](image)

The second semiotic dimension: The need for communication

Returning once again to the Christmas party, the person to whom you are talking happens to know the new fruit that you have just tasted; he says that this fruit is called ‘mango’. In naming the new fruit we have taken the second step in the semiotic process; the semiotic sign has become a two-dimensional sign. That is, object [the actual mango] has become separated from the sign [the word mango that we use to refer to the object mango]. Now that we have named the new fruit, this second stage in the semiotic process enables reference to the new fruit without its actual presence. Hence, we can talk about a mango without the
mango being present. The sign has become a code that we use to refer to the object; the word mango functions as a code to refer to the object mango. This second dimension opens up possibilities for communication. We can replace the experiences with the new fruit mango with a code. The code is an arbitrary phrase, word or sound for our experiences. As the code [mango] replaces our experiences with the mango fruit it is important to keep in mind that the second dimension in the semiotic process presupposes the first. We cannot use a code, without the experiences that form the foundations for that code. As different people experience the same fruit in a different ways, this implies that the [same] code that people use will be used in different ways. The more abstract the concept to which the code refers the more likely this will be the case; this is often a source of miscommunication.

Thus, in terms of the three semiotic elements of object, sign, and meaning, the second dimension separates object [actuality] from sign [code] and meaning; the sign has become two-dimensional [see figure 4.1b]. We now can refer to the object mango by using the code mango. For communication this implies that other people should also have knowledge of this code ‘mango’ [as referring to the fruit]. As the code is arbitrarily chosen it should be clear that a code is therefore restricted to a limited group of people. A code is only of use when the communicating parties use the code in the same way. For instance, even though the Swedish word barn [meaning children] and the English word barn [meaning a storage] have the same spelling and they are pronounced in the same way [the code is the same] their meanings do differ. Only people can attach meaning to a code. A code loses its meaning when it is used in communication with others of outside the group [Boisot 1983: 163].

<table>
<thead>
<tr>
<th>Object</th>
<th>Sign</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>the actual mango</td>
<td>the word mango</td>
<td>the meaning of the mango concept</td>
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Figure 4.1b: The second semiotic dimension, in which the code separates from actuality
Returning to the mango example, the people that use the word [code] mango must have experience with this particular fruit. They must know to what object the word mango refers in order to communicate effectively [without the fruit being present]. We could say that the second semiotic dimension comes into play when a need for communication concerning the experience with the new fruit mango emerges. Therefore, the essence of the second dimension partly lies in sharing and communicating. Would there be no need for communication, then neither would it be likely that a need for the second dimension would emerge.

The third semiotic dimension: Understanding the essence in relation to other concepts

Let us return to the Christmas party for one last time. Joining the mango-group is a woman who happens to be an expert on mangos. She explains the origin of this fruit, its physical appearance and so on. She explains the essence of a mango, that what distinguishes a mango from other kinds of fruit. With this expertise it becomes possible to judge individual cases of fruit on their ‘mango-ness’. This is in essence the third and last semiotic dimension. When we actually understand what it is that makes a mango a ‘mango’, the second dimension makes way for the third dimension. This last dimension separates sign, object, and meaning into three different parts of a whole; thus ‘meaning’ also becomes separated [see figure 4.1.c]. Therefore, we now have the mango as an object, the word mango as a code to refer to the mango object, and conceptual content that comes with the code [and therefore also the object]; the sign has become three-dimensional.

Figure 4.1c: The third semiotic dimension, in which meaning separates from the code

The third dimension adds coherence and integration, it structures. Whereas the first dimension relies on a process of transformation [transforming the bundled
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experiences with the mango fruit], and the second dimension relies on a process of substitution [replacing the actual fruit for the word mango]. The third dimension relies on the analysis of relations or structures [van Heusden & Jorna, 2001]. The third dimension replaces the arbitrariness of [the code in] the second dimension. Hence, as we recall, the use of codes is restricted to a limited group of people. Therefore, to be able to enter the third dimension, one needs to be able to use the codes accurately as the third dimension basically structures the codes from the second dimension. So the third dimension is not accessible to just anyone. The third dimension is not based on convention, as is the second dimension, but it is based on coherence and structural qualities. In the mango example this third dimension reflects the structural differences between the mango and the pear. For example, whereas the pear has several pits inside the mango only has one big pit. Knowing this we no longer merely have to rely on experiences; we can now make a judgment based on logic and reason. When we can only judge based on experience, we might deduce from these experiences that the color of pears is just green and that the color of mangos is a mixture of colors such as yellow-orange-green. When we come across a green mango based on this judgment rule we should reason that this green mango is a pear. However, this is not correct as we came across a green colored mango. Therefore, only having a judgment rule at your disposal is not sufficient to correctly judge the given situation. But when we, besides the descriptive qualities, also have the structural qualities of the mango fruit at our disposal, then we can make an accurate judgment. When we know about the structural quality of the mango, for instance only one big pit, then we can reason that this alleged pear actually is a mango [note the similarity with possible idiosyncratic feedback during the innovation process as a possible threat to the innovation process, e.g. Leonard-Barton 1995].

So, the third dimension provides coherence and structure. Note that this third dimension is cumulative to the second as the second is to the first. Therefore, this third dimension also presupposes the first dimension: no structure or logic without codes or perception. The third dimension structures the codes of the second dimension. However, theoretical knowledge is not coded by definition [van Heusden & Jorna 2001].

In sum, when we experience something that we have never experienced before we perceive a difference, given certain similarities between the actual and memory; this perceived difference is what triggers the semiotic process. Then, presupposing the first, substitution takes place: the new experience is categorized
as a specific experience. Finally, a new type of concept is added to the categories of the second dimension; these concepts no longer refer to classes of objects, but to structural relations such as 'number' and 'cause' and 'effect'. We can now signify the semiotic process in terms object, sign, and meaning [van Heusden & Jorna 2001]. We want to note at this point that the three semiotic dimensions also parallel the differences between data, information and knowledge, in particular argued by Boisot and Canals [2004] emphasizing the role of the perceptual filter and the conceptual filter. The three semiotic dimensions, together with the empirical focus of cognitive science, will function as the foundation for our cognitive semiotic approach to knowledge.

We argue that the semiotic perspective, as discussed in the above, will function as a firm foundation in understanding organizational innovation. In distinguishing three types of knowledge parallel to the semiotic dimensions we can gain understanding of how knowledge types are mutually related and of their dynamic character.

In combining the cognitive framework with the semiotic framework, we have a solid foundation for three different types of knowledge. Van Heusden and Jorna [2001] capture this line of thought in the following way:

Our knowledge of reality is a semiotic, that is, a representational construction. Representational activities can be studied, both from a cognitive [focusing on the empirical reality of the behavior] and from an interpretative [focusing on the meaning of the behavior] perspective. As [cognitive] mental activity, this representational behavior is studied by cognitive science. As representational activity, however, the cognitive mental behavior is the object of semiotics [p.84].

Understanding knowledge from a cognitive-semiotic approach implies that the acquisition of knowledge involves three stages. In the following section we will discuss these three stages and relate them to three types of knowledge, namely sensory knowledge, coded knowledge, and theoretical knowledge.

4.3 Combining cognitive science and semiotics: Three stages in acquiring knowledge

In the following section we will present our cognitive semiotic model. Therefore, we will discuss separately each of the three dimensions of which this model
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consists, namely sensory knowledge, coded knowledge, and theoretical knowledge. As discussed earlier, the model to be presented was greatly influenced by the I-Space model of Boisot. This model also contained three dimensions, the codification dimension, the abstraction dimension, and the diffusion dimension. The codification dimension shows great parallels to our coded knowledge dimension and the abstraction dimension shows great parallels to our theoretical knowledge dimension. However, the I-Space model differs from our cognitive semiotic model on the third dimension; whereas Boisot introduces the diffusion dimension, which is, more or less, a resultant of the codification dimension and the abstraction dimension, we introduce the sensory knowledge dimension, which precedes the coded knowledge dimension.

4.3.1 Sensory knowledge

Sensory knowledge is the first type that we distinguish in our cognitive-semiotic model, based on the first semiotic dimension. As the name reveals this type of knowledge is essentially sensory and it is based on perception. Based on perception, this type of knowledge precedes the stage of coding. Note a parallel with Boisot and Canals [2004] who refer to a perceptual filter that sorts out the incoming stimuli into data as the foundation for knowledge.

Although all knowledge is personal, sensory knowledge is personal in the sense that it can only be applied. There is no mediating sign; sensory knowledge is completely dependent on its context. Examples of this type of knowledge: are, the taste of mango, the act of actually riding a bicycle, or a sense of the existence of different roles within an organization, which could be translated to the concept of ‘hierarchical structures’; these examples can all be referred to as sensory knowledge.

As this type of knowledge is not mediated by a sign, sensory knowledge can only be transmitted through imitation; in an organizational setting this could be translated to on-the-job training. Through sharing the same experience different individuals build up the same [or at least very similar] sensory knowledge based on common experience. For instance, in teaching a novice how to negotiate within an organizational setting a person with many years of job experience can show the novice how she, as an expert, negotiates. This way the novice can experience the process of negotiating. So, the novice will share the same experience with the experienced person, or rather these two individuals will experience the same situation although both with a unique frame of reference. This does not have to be a problem per sé, just as long as these two individuals...
agree on the experience as a reference. Boisot [1983] remarks that uncodified knowledge – which shares the ‘pre-codedness’ with sensory knowledge – is difficult to transmit. According to him:

Ambiguities abound and can only be overcome when communications take place in face-to-face situations. Errors of interpretation can then be corrected by a prompt use of personal feedback. Consider the apprenticeship system as an example. [p. 164]

The essence of on-the-job training is the possibility of instant feedback and calibration. This opens the possibility to highlight certain aspects of the sensory knowledge, decomposing it in a sense. So in on-the-job training the expert essentially provides the novice with a model to perceive differences. But on-the-job training also helps the expert to understand the frame of reference of the novice. This is important as the frame of reference determines the vigilance of a person. A way to highlight certain aspects of the coded knowledge is the use of metaphors, analogies and examples; these can function as a mutual reference point in the abundance of stimuli. Although the use of metaphors can be very useful, one should always keep in mind that a metaphor cannot function as a substitute. For instance, an organization is not actually an organism with all the characteristics ascribed to an organism. The purpose of using a metaphor lies in communicating some sense of sensory knowledge through highlighting some of its characteristics in using a metaphor.

As sensory knowledge is transferred from person to person the diffusion of this kind of knowledge is very limited. This puts restrictions on the time span in which this knowledge can be transferred; sensory knowledge takes a great amount of time to diffuse over a whole population.

A more complex example of sensory knowledge is the sensory knowledge of a more abstract concept such as ‘hierarchy’. One might sense differences between the statuses of different persons within an organization through, for instance, the way that these persons are spoken to. This sensing precedes being able to exactly frame the differences in the way that these persons are spoken to. This sensing refers to the sensory knowledge about the concept ‘hierarchy’. Note that in using an example to explain the essence of sensory knowledge we in fact use the very same means as described above, that is, we use this example to communicate sensory knowledge [building up of a mutual frame of reference].
When we view sensory knowledge itself more closely we can distinguish a variation in the degree of detail, from rough sensory knowledge [e.g. general knowledge of sports, such as throwing a ball] to detailed sensory knowledge [e.g. knowledge in top sports]. We need this refinement in sensory knowledge to express the great variation between the first sense of difference and the very detailed sense of difference. The refinement of sensory knowledge is also a process that is triggered by perceiving differences. For instance, when we are refining our skills in swimming we can only do this when we perceive that a certain way of swimming is better or more comfortable, only then will we choose to stick to this particular way of swimming.

We can capture the essence of sensory knowledge by summing up its characteristics and their implications. Sensory knowledge is based on perception and it precedes the coding stage of knowledge. It cannot be verbalized, only applied. Use of metaphors, analogies and examples often captures both similarities and crucial differences in a certain situation. Transfer of this type of knowledge can only be from person to person by ways of imitation and on-the-job-training, which ensures instant feedback and opportunity for calibration of skills. Finally, sensory knowledge is very dependent on its context, it diffuses slowly and it is restricted in time. In sum, one might say that sensory knowledge is knowledge that works in practice [van Heusden & Jorna 2001].

4.3.2 Coded knowledge

The second knowledge type in our cognitive-semiotic model is based on the second semiotic dimension. We refer to this type of knowledge as coded knowledge, as this dimension introduces the use of codes to which an object or an experience refers. At this point we want to emphasize the difference with Boisot’s model of the I-Space. Boisot places both sensory knowledge and coded knowledge on one and the same scale, the dimension of codification. He emphasizes that for the process of codification

... the learning required involves a gradual mastery of the codification skills themselves and an appreciation of how they attach to a specific and narrow range of experiences [Boisot 1983: 166]

So, although Boisot acknowledges that one requires a certain skill to be able to code, he does not frame this acknowledgement by using a separate dimension. As we saw in the semiotic process, the step from the first dimension to the
second dimension presents a crucial difference. To emphasize this crucial
difference we therefore split Boisot’s dimension of codification up into two
dimensions, two different types of knowledge, based on the semiotic process.

Coded knowledge introduces the possibility to communicate knowledge without
the presence of that to which this knowledge refers. For instance, we can talk
about an apple without its actual presence. This essential difference with sensory
knowledge lies in the fact that coded knowledge does not have to be applied –
through physical action – in order to be communicated. Thus, the introduction of
a code makes it possible to refer to certain knowledge. Therefore the code can
be viewed as an activation key for coded knowledge. We might say that the
[coded] knowledge has been tagged by a code. For instance, the object mango
has been labeled as the code ‘mango’. So when we talk about a mango we
expect others to know to what we refer. And the difference sensed between the
people in the organization can be labeled with the code ‘hierarchy’. So when we
talk about a hierarchical organization we expect people to know that this, among
other things, means that the different people within that organization have a
different status. Note that, although we argue that a code opens up the possibility
of communication, the actual process is likely to be the other way around. That is,
the need for communication forces the introduction of codes.

At this point we want to stress that the code represents certain knowledge. We
make no claim that the code is the equivalent of the knowledge that it represents.
Rather, the code is the key to this coded knowledge. The code can be detached
from the messenger, although the knowledge for which this code stands will
always need a messenger in order to have content. Therefore the knowledge is
not applied through specific action, as is sensory knowledge. Rather, a person can
communicate coded knowledge simply through referring to a particular code.
Using codes therefore opens a great many possibilities for communication; these
possibilities are absent for sensory knowledge. Boisot [1998] makes an essential
remark for the procedure for codification, as he calls it, in saying that it is a risky
business. He argues that if

… the strategy is faulty, the wrong data may be selected and
valuable data discarded. In an organizational context, however,
data discarded by the decision-making apparatus may actually
be retained in an implicit form, embedded in the memory of
individuals involved in the selection process’ [p. 45]
This is an important aspect of coded knowledge that we should always keep in mind in communication. The power that a code gains in possibilities of communication is at the same time its weakness. Especially in using complicated codes for communication we should always be aware of differences in the ‘data-reduction’ process, that is, the knowledge for which the code stands.

When we compare sensory knowledge to coded knowledge the first difference is their foundation. Whereas sensory knowledge is founded in perception [of differences], coded knowledge is founded in sensory knowledge and therefore only indirectly founded in perception. Thus coded knowledge is not personal in the way that sensory knowledge is [but we continue to stress that knowledge always has a direct link to people]. This has implications for some of the other characteristics. Whereas sensory knowledge can only be exercised by applying it, coded knowledge can be used in different ways. For instance, we can write it down. This makes coded knowledge less context dependent than sensory knowledge in two ways. Firstly, in referring to something with a code, such as referring to the mango, we do not need the actual mango present. In this way coded knowledge is independent of the context. Secondly, in writing down the word mango in a letter, we can communicate with someone without this person being present. So coded knowledge allows knowledge transfer without either the object of reference or the party with whom we are communicating present. This makes diffusion of coded knowledge less restricted than that of sensory knowledge, and it also takes a shorter amount of time.

There are, however, still restrictions in the use of coded knowledge as the parties who communicate the coded knowledge should all be aware of the knowledge on which the codes are based. This implies that codes can only be used in a limited group, a community. But also, one and the same code can be interpreted differently within different communities. Communication is often obstructed in that the codes that are used represent different knowledge for the different people involved in the communication process. This rivalry can be a troublesome source of miscommunication. Furthermore, we expect that this rivalry could potentially be an important inhibitory factor in innovation process. So, ‘a shared context is essential to the formulation of meaningful messages [Boisot 1983: 163]. With the increased ease of communication and diffusion the chance of miscommunication also increases, especially when the coded knowledge is not embedded in sensory knowledge, but merely copied as a code. Finally the quality of coded knowledge is expressed in the degree of ambiguity – the lower the ambiguity the higher the quality of the code and the more powerful the code.
Codes such as the alphabet notations or musical scores are less ambiguous than codes such as icons or pictograms [see Goodman, 1981; Jorna 1990].

4.3.3 Theoretical knowledge

The third and last knowledge type that we distinguish in our cognitive-semiotic model of knowledge is based on the third semiotic dimension. Whereas sensory knowledge identifies and coded knowledge defines knowledge, this third knowledge type structures, it puts the knowledge in perspective; therefore, we will refer to this knowledge type as theoretical knowledge. We can compare this type of knowledge to the abstraction-dimension of Boisot.

Theoretical knowledge refers to knowing the essence of a concept [object, or event]. Essentially understanding a concept implies that one can also determine and analyze the relations of this concept to other concepts. This understanding is therefore more than just defining the concept, which is covered by coded knowledge. Theoretical knowledge essentially structures, it structures the coded knowledge and it therefore presupposes coded knowledge. Note that coding is not the essence of theoretical knowledge; it can be coded, but it does not have to be coded [van Heusden & Jorna 2001]. Theoretical knowledge is typically obtained in education, as education emphasizes the structure and reason. Education often highly depends on reasoning and understanding how different things are related, it offers a model to structure.

Theoretical knowledge explains; it provides the answer to the 'why-questions’. This does not mean that theoretical knowledge pretends to be true or correct. Keep in mind that argumentation valid to some may be invalid to others. McCloskey [1983] points to the use of naïve theories [of motion]. He distinguishes three ways in which everyday experience can lead to knowledge [about motion] and the naïve theory is one of these ways. He shows that these models [the naïve theories], although constructed individually, can be well articulated and show consistency over different individuals. The naïve theories studied by McCloskey related to knowledge of physics. And interestingly, although similarities were found between individuals these theories showed great inconsistency ‘with the fundamental principles of classical physics’ [p.299], showing great resemblance to the pre-Newtonian physical theory. An important aspect to note about these naïve theories is that they can be very persistent and that they can lead to misinterpretation of information. So, these naïve theories can stand in the way of forming new [coded] knowledge. In the McCloskey study the students tried to fit the information that they received into their naïve [and incorrect]
theory. It is less clear how these naïve theories develop or what role they play in everyday life. Clement [1983], who uses the term intuitive model instead of naïve theory, shows that mere exposure to an established theory will not eliminate the intuitive model and stresses the importance of devoting ‘more attention to conceptual primitives at the qualitative level’ [p.335]. This is in line with the foundation of our theoretical knowledge, the third semiotic dimension, namely knowing the essence of concepts leads to structure, not the other way around. Clement seeks argumentation for their persistence in the following line of thought:

Preconceptions need not be viewed exclusively as obstacles to learning, however; they constitute micro-theories that students have constructed on their own, and should be respected as such. Because they ordinarily have some predictive power in certain practical situations, they can be thought of as “zeroth-order models” which the students possess. Some preconceptions can be built upon or modified by students in order to increase the precision and generality of their theories [p.335].

To the above statement we want to add that the persistence of the naïve theories can be explained by the fact that they are well imbedded in the knowledge of the users. In other words, the structure of these theories fits within the knowledge network of the users. So, not only are the intuitive theories well-structured micro-models, they also fit well into the existing knowledge of the persons. The above citation also emphasizes the importance of having a model in perceiving and weighing information. Thus, theoretical knowledge also provides underpinnings for choosing one alternative instead of other alternatives. As a consequence theoretical knowledge provides the possibility to take different points of view, putting things into perspective. That is, structures are multi-dimensional as opposed to coded knowledge. This means in practice that we can choose between different alternatives based on a certain coherence and reasoning pattern. In addition to the explanatory power of theoretical knowledge, it also has a predictive power. It provides a means to conduct an experiment of thought, whereas coded knowledge does not.

Boisot [1983] notes that when codification has not yet been established the process ‘remains tentative and exploratory and can only be understood on an intuitive level’ [p.166]. Johnson-Laird [2006] refers to intuitions as a possible beginning of reason: rapid and often accurate.
Chapter 4 A Cognitive-Semiotic Model to Capture Knowledge Dynamics

As theoretical knowledge structures and introduces coherence, it essentially creates its own context. Therefore, we argue that theoretical knowledge is not dependent on a context [compared to sensory knowledge and coded knowledge]. This implies that the diffusion of theoretical knowledge is even easier than coded knowledge. However, the entrance level is higher than that for coded knowledge.

Like sensory knowledge and coded knowledge, theoretical knowledge can also vary in quality, namely in its degree of abstractness. Very abstract forms of theoretical knowledge tend to be universal. Concrete theoretical knowledge is what we use in our everyday lives to make sense of things [compare the naive theories]. The degree of abstractness of theoretical knowledge is therefore related to the applicability of the knowledge; the more abstract the theoretical knowledge becomes the higher the explanatory value and the higher the predictive value. Boisot (1998) refers in his dimension of abstraction to concrete perceptual and local knowledge on the one end of the scale and abstract conceptual and non-local knowledge at the other end. Boisot grasps the essence of the abstraction process, like the codifying process, in a form of economizing on data-processing [see also the previous chapter].

We conclude this section on theoretical knowledge with an interesting quote from Johnson-Laird [2006: 414] on the importance of theoretical knowledge and its practical use.

Our ability to reason is vital. The better we reason the better our lives. We are healthier, we live longer, and we are more successful in the academy and the market place. In life we make many simple inferences, and we make them almost without realizing that we are reasoning. I described what happened when I first went into an Italian coffee bar to get a cappuccino. I had to infer that one pays first then orders at the bar. This induction was supported by a deduction – that the bar wasn’t exceptional, because if it had been then other customers would have had to make the same detour as me – to the bar, to the cash register, and back to the bar.

Now that we have characterized the three knowledge types separately we will put them into perspective.
4.3.4 Putting the three knowledge types into perspective

Polanyi's tacit knowing versus sensory knowledge

The sensory knowledge as characterized in the above shows strong parallels to the concepts of 'tacit knowing' introduced by Polanyi; he has often been used as a reference in literature on knowledge management and knowledge in relation to organizations. However, there are fundamental differences between our sensory knowledge and the tacit knowing of Polanyi [1966].

Polanyi uses the concept of tacit knowing in a functional way. That is, knowledge can be tacit in one situation, but very explicit in the next. Our sensory knowledge is 'absolute'; it remains sensory knowledge, this does not differ per situation. The following example used by Polanyi himself will show the functional use of tacit knowledge. Polanyi quotes an experiment conducted by Lazarus and McCleary in 1949, in which a person is shown different syllables. A shock is administered to this person after some of these syllables. After a few shock syllables this person will start to show symptoms of anticipating these 'shock syllables', but without being able to name them when asked. So this person cannot explicitly state which ones are the shock syllables and which ones are not. This example, to Polanyi, illustrates the structure of tacit knowledge, that is, two terms are associated: the shock syllables and shock associations on the one side and the electric shock following on the other. According to Polanyi, this connection remains tacit, because the subject's attention is focused on the electric shock [rather than on the shock syllable]. He says: 'we attend from something [the proximal term, in the example the shock syllable] for attending to something else [the distal term, in the example the shock – original in italics]'. This functional aspect of tacit knowledge gives meaning to a situation. So tacit knowledge can be seen as the knowledge that is in use in experiencing a situation, but not in focus. To emphasize that this type of knowledge is not in focus Polanyi [1964] also refers to it as 'subsidiary awareness', playing a supporting role to add meaning to a situation [as opposed to focal awareness – the knowledge which is in focus and can be verbalized].

Polanyi's functional use of tacit knowledge implies that the same [content of] knowledge can either be tacit and not in focus in one situation and explicit and in use [thus no longer tacit] in the next. Thus whether certain knowledge is tacit or not depends on the situation. The sensory knowledge of our cognitive-semiotic model on the other hand, will stay sensory in any given situation. For instance, the person in the shock syllables example has built up sensory knowledge about the shock syllables. However, this sensory knowledge will not become a different one.
type of knowledge given a different situation; it can only change when this person becomes aware of the sensory aspect in knowledge in that these shock syllables become apparent and this person will be able to name them. Until that happens will the knowledge remain sensory.

Thus, sensory knowledge and tacit knowledge are fundamentally different. The differences between these types of knowledge become apparent in transfer. Tacit knowing cannot be transferred per definition, as it consists of a combination of personal experiences that give meaning to a certain situation. Sensory knowledge, on the other hand, refers to perceiving differences. Even though this also depends on former experiences, sensory knowledge does not involve a complicated combination of experiences. Rather, like the mango-example, you have experienced something or you have not in which case you might be able to perceive a difference. When you do, then sensory knowledge is created. Therefore, we can transfer this type of knowledge. Another difference is in verbalization of these types of knowledge. Whereas tacit knowing is difficult to verbalize it is not impossible. In some situations tacit knowledge could be the equivalent of what we would characterize as theoretical knowledge. Sensory knowledge, on the other hand, by definition is impossible to verbalize. Similarities are founded in the fact that both are personal; this implies some mutual characteristics. Regarding dependency on context, to both knowledge types the context in which they are used is crucial to their interpretation.

Boisot’s codification dimension versus coded knowledge

The main difference between Boisot’s codification dimension and the coded knowledge dimension of our model lies in the essential difference of the continuum. Whereas the codification dimension ranges from ‘uncodified’ to ‘codified’, the coded knowledge dimension ranges from weakly coded [i.e. pictograms and icons] to strongly coded [i.e. formulas and musical scores]. We argue that there is a fundamental difference between coded and uncoded knowledge, which we tackle with distinguishing sensory knowledge from coded knowledge.

Boisot’s abstraction dimension versus theoretical knowledge

The abstraction dimension of Boisot pretty much equals our dimension of theoretical knowledge; its relation is accumulative to the codified dimension as theoretical knowledge is to coded knowledge. Boisot sums up the difference between the dimensions in that the codification process ‘gives form to structures’ [p.48] and the abstraction process gives structure to the codifications. The same
applies to our knowledge types. Whereas coded knowledge elicits from a need
to communicate – and therefore gives a form to the knowledge – theoretical
knowledge puts the coded knowledge into perspective – it positions the different
coded knowledge knots in relation to each other.

Schematic overview of the three knowledge types

Table 4.1 provides a schematic overview of the three knowledge types and their
characteristics.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Sensory</th>
<th>Coded</th>
<th>Theoretical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semiotic foundation</td>
<td>One-dimensional sign</td>
<td>Two-dimensional sign</td>
<td>Three-dimensional sign</td>
</tr>
<tr>
<td>Object-sign-meaning</td>
<td>O S M</td>
<td>O S M</td>
<td>D S M</td>
</tr>
<tr>
<td>Perception of difference</td>
<td></td>
<td>Need for coding</td>
<td>Essence</td>
</tr>
<tr>
<td>Context relevance</td>
<td>Situated, can only be applied</td>
<td>Not situated</td>
<td>Not situated</td>
</tr>
<tr>
<td>Coding</td>
<td>No coding</td>
<td>Coding</td>
<td>Relation with other concepts</td>
</tr>
<tr>
<td>Transfer/Communication</td>
<td>Personal/imitation, on-the-job training, use of examples, metaphors</td>
<td>Group/convention, use of jargon, no personal contact is necessary</td>
<td>Structure or reason</td>
</tr>
<tr>
<td>Learning</td>
<td>On the job training, experience</td>
<td>Books</td>
<td>Education, thought experiment, weighing of alternatives</td>
</tr>
<tr>
<td>Diffusion</td>
<td>-</td>
<td>++</td>
<td>*</td>
</tr>
<tr>
<td>Quantification</td>
<td>Degree of detail</td>
<td>Degree of ambiguity</td>
<td>Degree of abstraction</td>
</tr>
</tbody>
</table>
We will now discuss the dynamic aspects of our cognitive semiotic model, which hold a key position to understanding the dynamics of knowledge in the process of innovation.

4.4 A cognitive-semiotic model to understand the dynamics of knowledge

Peirce argued that 'signs do not simply exist but also grow' [semiosis, Smith: 5] emphasizing the dynamic property of signs. The following section will elaborate on the intrinsic dynamics of our cognitive-semiotic model.

In the above we presented three types of knowledge, which form the basic elements of our cognitive-semiotic model to be presented in this section. The essence of this model is that knowledge emerges and structurally changes during a learning process. Furthermore, this model stresses the cumulative nature of knowledge; first comes sensory knowledge, which forms the foundation for coded knowledge on which eventually theoretical knowledge is built.

As chapter 2 showed, the essence of innovation is a structural change, a discontinuity with what was before. Therefore, the cognitive-semiotic model is particularly useful to study the process of innovation in terms of knowledge, as this model presents the structural changes involved in knowledge change.

4.4.1 Accumulation of knowledge types

The nature of the three knowledge types implies that they are cumulatively related. Just as the semiotic dimensions add up, so do the knowledge types.

Starting when difference is perceived [the new taste of mango], sensory knowledge emerges. This perception of difference is essential to coding; the newly perceived is coded as a need for communication [even with oneself at a later moment] emerges. Thus, coded knowledge builds on sensory knowledge. Coded knowledge in turn is fundamental to theoretical knowledge. Hence, theoretical knowledge essentially entails the deeper understanding of a code [concept], which consequently implies relating the code to other codes. Thus, theoretical knowledge is an extension of coded knowledge, which in turn is an extension of sensory knowledge. So, theoretical knowledge entails coded knowledge as well as sensory knowledge. In this way the three knowledge types are cumulatively related.

This line of reasoning can also be applied in more detail [see figure 4.2]. Coded knowledge presumes sensory knowledge. However the sensory foundation of this
coded knowledge was built up during a previous experience, which in content was not necessarily directly related to the coded knowledge. **Perception 2**, an ‘old’ experience with the fruit pear, does not only form the basis for **sensory 1**, but also for **sensory 2**. For the build-up of coded knowledge the same applies. **Sensory 2** is the foundation for **coded 1**, **coded 2** and **coded 3**. And for theoretical knowledge the same applies, coded knowledge can function as a foundation for more than one sort of theoretical knowledge. Theoretical knowledge provides coherence and structure. So this means that **coded 2** that forms the foundation for **theoretical 1** can also form part of the foundation for **theoretical 2**.

So, one individual perception is not merely linked to one specific ‘unit’ of sensory knowledge. Hence, this would mean that a certain skill from one field of work or knowledge area could not be used in another knowledge area. In fact, we argue that this cross-founding of knowledge forms the strength of a having a broad armature of skills and experiences. Knowledge, therefore, is the complex activation of a network. Note, however, that some theoretical knowledge is needed to bridge the different work fields. Without a frame of reference it is
impossible to use particular types of knowledge in different situations, which would leave the different knowledge fields incidental and isolated.

Now that we have established the relation between the three knowledge types we will consider their dynamics in more detail in the following section.

### 4.4.2 Knowledge change

The first way that knowledge can be dynamic according to our cognitive-semiotic model is through changes within one type of knowledge [see figure 4.3]. That is, the increase of quality within a knowledge type; thus, within sensory knowledge an increase in the degree of detail, within coded knowledge an increase in the degree of coding, and within theoretical knowledge an increase of the degree of abstraction. This type of dynamics within knowledge enhances the depth of knowledge. Larkin [1983, in Johnson-Laird 1993: 486] captures differences in the quality of knowledge, [the theoretical knowledge of novices compared to that of experts] in the following:

… an important difference between the way a novice and an expert reason about a physical situation is that the novice’s model represents objects in the world and simulates processes that occur in real time, whereas a trained scientist can construct a model that represents highly abstract relations and properties, such as forces and momenta.

![Figure 4.3: Visualization of the difference between knowledge conversion and knowledge change](image)

The above example shows that even though the novice and the scientist both clearly have a model [coherence in thinking, implying theoretical knowledge], which they use to reason and to act upon, the model used by the scientist is
much richer and more advanced than that of the novice. The novice uses a more concrete form of theoretical knowledge than does the expert. The fact that the model of the novice represents [physical] objects also point to this fact [compare the abstraction dimension of Boisot].

4.4.3 Knowledge conversion

Next to changes within a knowledge type knowledge can also be converted from one type into another; this is called knowledge conversion [see figure 4.3]. Knowledge conversion occurs every time that a new dimension emerges. Thus, when the need for communication emerges and codes are made, then a conversion from sensory knowledge into coded knowledge occurs. Also, when a deeper understanding of the code leads to relating this code to other codes then coded knowledge is converted into theoretical knowledge. This, however, does not imply that the sensory and coded knowledge, respectively, decrease or vanish. The conversion of knowledge adds a dimension to the knowledge rather than replacing one type of knowledge for another type of knowledge. However, we do want to note that the emergence of an additional knowledge type will open up possibilities. The fact that it might appear that the sensory knowledge decreases when coded knowledge comes into play can be explained in that knowledge is not a ‘thing’; it is a dynamic interplay and can only show its value when in use. So, when sensory knowledge is converted into coded knowledge often the coded knowledge takes over and the sensory knowledge is used less. This decrease in use then causes the sensory knowledge to decrease; so the knowledge conversion can indirectly cause a decrease.

Theoretically, three types of knowledge add up to three combinations of two knowledge types with each two variations:

1a. sensory $\rightarrow$ coded and 1b. coded $\rightarrow$ sensory
2a. coded $\rightarrow$ theoretical and 2b. theoretical $\rightarrow$ coded
3a. sensory $\rightarrow$ theoretical and 3b. theoretical $\rightarrow$ sensory

Our cognitive-semiotic model only allows two variations: 1] sensory knowledge converts into coded knowledge [1a], and 2] coded knowledge converts into theoretical knowledge [2a]. The cognitive-semiotic model argues that knowledge is accumulated from perception to sensory knowledge, to coded knowledge and then to theoretical knowledge. Thus, change of codes leads to change of theoretical knowledge, but not the other way around; theoretical knowledge...
cannot change coded knowledge. So there is no knowledge conversion from theoretical to coded or to sensory knowledge.

Knowledge can, however, be rebuilt. Let us take the Copernicus example of refocusing from a geocentric model to a heliocentric model as an example. Copernicus suggested that the geocentric model by Ptolemy be replaced by the heliocentric model. The new theoretical knowledge represented in the heliocentric model is formed by different coded knowledge. Additionally a new structure is applied, restructuring the coded knowledge. Therefore the theoretical knowledge is rebuilt into new theoretical knowledge. The structure of the geocentric model has been proven incorrect, or rather, some of the coded knowledge did not fit the geocentric model. Therefore, Copernicus applied a new structure, which could fit the coded knowledge. This line of reasoning is in line with the intermediate position that Boisot suggests between the two polar cases of N-learning and S-learning. Boisot [1998: 94] notes:

It is possible to hold a position midway between the two polar cases presented. A shift of paradigm, for example, may involve a destruction of codified and abstract knowledge embedded in organizational processes, but leave intact the tacit knowledge base from which such knowledge is derived.


We want to note at this point that knowledge does not simply change by itself; there is always something that causes the change, which sets the knowledge dynamics in motion. Thus, in case of a misfit between data and model one could either ignore this misfit and treat the data as idiosyncratic and continue to use the [old] model [think of the naïve theories] or one could look for a new mode of coherence, a new model.

So, knowledge can be dynamic either within a knowledge type or between knowledge types; we expect that both knowledge change and knowledge conversion are processes related to innovation.

**4.4.4 Individual differences in learning**

Innovation can be characterized as a learning process as the definition by Hilgard and Bower [1975: 7] shows:
Learning refers to the change in a subject’s behavior to a given situation brought about by his repeated experiences in that situation, provided that the behavior change cannot be explained on the basis of native response tendencies, maturation, or temporary states of the subject (e.g. fatigue, drugs, etc.)

Hilgard and Bower [1975] compare the relationship between learning and knowing to the relationship between process and result. So, the result is the newly acquired knowledge, which reveals itself in new behavior.

We know from literature that people differ greatly in their learning processes [e.g. Ackerman, Sternberg, & Glaser 1989]; this results in differences in knowledge.

Therefore we are interested in the possible differences in knowledge dynamics. In this respect these differences are the resultant of a process. However, these expected differences are based on the assumption that two [groups of] individuals each have a different starting point as well. In that respect the differences are regarded as indicators. Horn [1989] frames this difference in the following way: ‘Human abilities are simultaneously outcomes of learning and determinants of learning’ [p.61]. The implication for the present research therefore is not only to establish differences in dynamics, but we need to establish differences at the points of departure, before the implementation process has started. The points of departure are the different starting points of the individuals that learn or that have to change their knowledge.

Choosing the factors that influence the relationship between knowledge and innovation we are particularly interested in the characteristics of the individual itself, as opposed to characteristics such as the working environment of the individuals or the political preferences that individuals hold. In particular we focus on factors that are directly related to the individuals’ work. We therefore want to explore the influences of working experience and that of contractual hours on the relationship between knowledge and innovation. We also include the factors of age and education, as these factors are often posed as factors of influence in studies on individuals. In the following we will discuss these four characteristics separately.

**Job experience and expertise**

Job experience stands for the amount of working experience that a person has, mostly expressed in number of years. Job experience, or the degree of expertise,
has been shown to be of great influence on how people organize and conduct their work [e.g. Mietus 1994]. However, the effect of training is expected to be more predictable for people with less experience than it is for experts [Hunt, 1999: 22]. So, in understanding the implementation of a DSS in terms of knowledge dynamics we particularly expect a difference for coded knowledge; coded knowledge is expected to increase, as the way of working will become more standardized with the introduction of DSS.

Education

We argue that education is a strong indicator for theoretical knowledge, which implies the use of models and applying structure. So, the higher the education the more theoretical knowledge a person has and the more likely that person is to perceive differences. Therefore, higher educated people are expected to show an increase in sensory knowledge in comparison to lower educated people. But also, the higher the education the more set the use of coded knowledge is. So, for the coded knowledge we expect a difference between the higher and lower educated as well.

Age

Age related differences in acquiring knowledge have been studied frequently. We therefore wonder whether younger people show different knowledge dynamics compared to older people. We especially want to relate this factor to coded knowledge as coded knowledge is expected to be the key knowledge type to show dynamics.

Contractual hours and building routine: part time versus full time

Differences between part timers and full timers have been particularly studied in relation to job satisfaction [Eberhardt & Shani 1984; Steffy & Jones 1990], job attitudes [Levanoni & Sales 1990], status differences [Jackofsky & Peters 1987], and specifically in relation to women [e.g. Nakamura & Nakamura 1983]. Feldman [1990] questions the one-directional relation of part time work that influences workers’ attitudes; rather, he suggests an influence in the opposite direction as well. That is, ‘employees who have certain job attitudes and work behaviors may gravitate toward part-time work instead of full-time work’ [p.104].

Based on our theoretical framework we argue that it is very likely that part time workers differ from full time workers in the way that they organize and use their knowledge. Part time workers differ from full time workers in the amount of
shared experience that they have with other colleagues. Another difference is that part time workers in comparison to full time workers spend much more time on communication about the status of the job. That is, they need to communicate much more about what has happened and what still needs to be done. We do want to remark here that there is a difference between part time workers that perform tasks that are autarchic [need not communicate with others, e.g. data typist] and those that work as part of a continuous process, such as nurses and secretaries. Furthermore, the type of work might differ as well between part timers and full timers, which could be an indication for the types of knowledge that one uses. We are therefore interested to explore the possible differences between these two groups.

4.4.5 Visualizing knowledge [dynamics] of innovation in the K-Space

Inspired by the I-Space we visualize our cognitive-semiotic model in three dimensions as well; we will refer to this space as the Knowledge Space or K-Space. Similar to the I-Space the K-Space enables visualization of both static situations as well as dynamic situations. Additionally, it is possible to capture both the knowledge [dynamics] of one individual as well as [a unit of] an organization – adding up the separate individuals.

Sensory knowledge is placed on the X-axis ranging from rough sensory knowledge [on the left] to detailed sensory knowledge [on the right]. Coded knowledge is placed on the Z-axis ranging from weakly coded knowledge at [at the front] to strongly coded knowledge [at the back]. And finally theoretical knowledge is placed on the Y-axis ranging from concrete theoretical knowledge [at the bottom] to abstract theoretical knowledge [at the top].

We note that, just as the I-Space, the axes are not orthogonally related as in a mathematical space. The K-Space is just as the I-Space a kind of metaphor.

Before the start of an organizational innovation process we can map the knowledge of the individual people who will be affected by the innovation. To place them in the K-Space we determine their sensory knowledge, their coded knowledge and their theoretical knowledge separately, which results in three coordinates [see figure 4.4a, each person resembling a dot]. This way we have mapped the knowledge of two persons at the beginning of the organizational innovation. Now, we can also map the desired knowledge, so can determine a possible discrepancy between the knowledge that a person has and the knowledge that this person needs to have to adequately take part in the
organizational innovation [see figure 4.4b]. When there is no discrepancy this means that the organization, from a knowledge type perspective, is ready to start the innovation process. If, on the other hand, there is a discrepancy, than this must first be eliminated.

In sum, this chapter presented a cognitive-semiotic model for studying dynamics of knowledge, distinguishing three types of knowledge. These knowledge types are essentially different and cumulatively related. We argued that this model is particularly interesting to use to study the knowledge during innovation processes, as it provides a tool to understand the structural changes that take place during this process. Furthermore, this tool can be used to evaluate innovation processes. The next chapter will focus on the domain of knowledge that we used in this study, the domain of planning.