

ATGENTIVE

IST-4-027529-STP

DELIVERABLE D1.2

Status: PUBLIC

VERSION: 1.0

STATE OF THE ART REPORT

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THE AMERICAN
UNIVERSITY
OF PARIS

knowledge, perspective, understanding

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DATE: May 19 2006

Abstract

This deliverable reviews the state of the art of research related to the support of attention in systems for collaboration and learning. It presents the most relevant results in attention-related research in cognitive psychology. It introduces systems that have been designed with the explicit aim of supporting some attentional processes. It provides an overview of the specific issues related to the support of attention in educational, work, and business environments. Finally, it describes the issues and technologies related to psychophysiological measurements of attention, and to the integration of embodied agents in attention-aware systems.

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State of the art of attentive agents for collaborative learning

Abstract

This deliverable reviews the state of the art of research related to the support of attention in systems for collaboration and learning. It presents the most relevant results in attention-related research in cognitive psychology. It introduces systems that have been designed with the explicit aim of supporting some attentional processes. It provides an overview of the specific issues related to the support of attention in educational, work, and business environments. Finally, it describes the issues and technologies related to psychophysiological measurements of attention, and to the integration of embodied agents in attention-aware systems.

1 Introduction

The advent of networked information technology has radically changed our ability to access information and to communicate. Whilst once *information* was a scarce and hard to access resource, nowadays *human attention* seem to have become the scarce resource whilst information (of all types and qualities) abounds. This state of things has brought radical changes in every day's life and in particular it has had a great impact in the way we work and study. Whilst modern Information and Communication Technologies (ICT) have widened the horizons of accessible people and information, it has become obvious that we need new methodologies and tools for managing the wide range of data, knowledge, and opportunities that have become available. It is increasingly recognised that ICT, whilst providing access to information and communication, should also support human limited cognitive capabilities in the selection of the most relevant information and tasks. Such support should facilitate human attentional processes.

Current ICT tools often increase the complexity of learning and business environment and enable new interruption channels which have become an almost constant factor in many working and learning environments. Although interruptions may bring to one's attention information possibly useful for the primary (current) task, or even, in the case of simple primary tasks, facilitate task performance (Speier, Vessey, & Valacich, 2003); it has been widely reported that interruptions increase the load on attention and memory (Gillie & Broadbent, 1989), may generate stress (Bailey, Konstan, & Carlis, 2001; Zijlstra, Roe, Leonova, & Krediet, 1999), and compromise the performance of the primary task (Franke, Daniels, & McFarlane, 2002; McFarlane & Latorella, 2002; Nagata, 2003; Speier, Vessey, & Valacich, 2003) especially when the user is working on handheld devices in mobile environments (Nagata, 2003). In order to cope with these new dynamic and far-reaching environments a certain number of practices have been developed to improve the effectiveness of information acquisition and communication.

Such practices have been often explicitly stated (an online search for "netiquette" will result in a large number of such statements) and are normally accepted amongst ICT users. However, whilst the appropriate use of ICT tools by individuals may reduce the attentional effort required to the community for access and management of knowledge, ICT tools themselves represent an important mean to support people attention. This deliverable considers the research issues related to the design of systems capable of such support.

We begin with a brief summary of theoretical studies related to attention in cognitive psychology and their consequences on the design of systems capable of supporting attentional processes. We then analyse two application domains of particular interest to the Atgentive project: education and business. Finally we turn to two relatively recent technologies and the issues involved in their use as part of attention-aware systems. The first set of technologies allows system designers to take psychophysiological measures of attention-related human states. The second technologies allow designers to develop interfaces that include animated characters.

2 Attention as studied in cognitive psychology

2.1 WHAT IS ATTENTION AND HOW IS IT CONTROLLED?

Human cognitive abilities are limited in a number of ways. What we see, hear, and generally perceive around us (in the physical world) exceeds, probably by several orders of magnitude, what we are actually capable of processing. We have developed, probably through evolution, a set of cognitive mechanisms that enable us to select the information we process. Considering visual stimuli for example, Rensink (2000) describes how little we “see” compared to the stimuli on the retina. Chun and Wolfe explain that “the environment presents far more perceptual information than can be effectively processed. [. . .] To cope with this potential overload, the brain is equipped with a variety of attentional mechanisms” (Chun & Wolfe, 2001, p.273).

Although there is no one single, agreed upon, definition of attention, most researchers refer to attention as the set of processes enabling and guiding the selection of incoming perceptual information¹ (Driver, 2001, p.53; Lavie & Tsal, 1994, p.183; Posner, 1982). Chun and Wolfe (2001, p.273) propose that “First, attention can be used to select behaviorally relevant information and/or to ignore the irrelevant or interfering information. [. . .] Second, attention can modulate or enhance this selected information according to the state and goals of the perceiver. With attention, the perceivers are more than passive receivers of information. They become active seekers and processors of information, able to interact intelligently with their environment”.

¹ This hypothesis, which places attention at the root of certain cognitive activities (e.g. vision or categorisation), is the commonly recognised one, and the one on which we will base our work. Some recent studies in neuropsychology however, seem to indicate that certain high level visual task may take place in absence of attention, reporting that we can “rapidly categorize highly variable natural scenes outside the focus of attention” (Fei Fei, VanRullen, Koch, & Perona, 2002, p. 9601)

The first hypothesis on how attentional processes may work was formulated by Broadbent (1958) who proposed that selection takes place in two stages. In the first parallel pre-attentive stage, several stimuli are processed on the basis of their simple physical properties. All the irrelevant (unattended) stimuli are filtered out at this stage and the selected stimuli are passed to the second serial attentive stage, which encodes more abstract (semantic) properties of the attended stimuli. The second stage is characterised by its limited processing capabilities.

Later theories take into account the fact that there is no clear cut between attended and unattended stimuli (e.g. Lewis, 1970; MacKay, 1973)) and proposed that all stimuli are analysed but only pertinent stimuli are selected for awareness and memorisation. (e.g. Deutsch & Deutsch, 1963; Duncan, 1980; Norman, 1969).

In their studies based on the visual modality Treisman and Gelade (Treisman, 1998; Treisman & Gelade, 1980) propose that parallel preattentive processes simultaneously extract essential features of the visual stimuli (e.g. colour and orientation). The integration of the different features is then obtained applying serial attention to the location of each item. It is this serial process that binds all the elements together and produces the appropriate multidimensional percepts of objects with particular colours, orientations, etc.

This theory hints that certain searches on the visual field can be made very efficient if they only involve basic features, i.e. features that can be extracted preattentively. Several researchers in cognitive psychology have designed experiments aimed at identifying which features are recognised at the preattentive stage. In a review of such research Wolfe (2001, pp.7-8) states that “preattentive basic features are coarsely coded. [. . .] In orientation, the preattentive categories seem to be “steep”, “shallow”, “left” and “right”. In size, the categories are probably merely “big” and “small”; in depth, “near” and “far” and so forth”.

2.2 HOW IS ATTENTION AFFECTED BY THE ENVIRONMENT, PERSONAL EXPERIENCE, AND CURRENT GOALS?

There is a general agreement that attention can either be controlled voluntarily by the subject, or it can be captured by some external event. The former type of control mechanism is referred to as *endogenous, top-down, or goal-driven* attention (Arvidson, 2003; Posner, 1980; Yantis, 1998), and it is exemplified by the attention one may pay to a book while reading. The latter type of mechanism is referred to as *exogenous, bottom-up, or stimulus-driven* attention, an example of which could be the attention one may pay to a sudden noise in a quiet environment. Chun & Wolfe indicate that these two mechanisms have different characteristics, “endogenous attention is voluntary, effortful, and has a slow (sustained) time course; [. . .] exogenous attention draws attention automatically and has a rapid, transient time course” (Chun & Wolfe, 2001, p.279). Whilst exogenous stimuli may have different degree of power (i.e. certain stimuli, such as sudden luminance changes, may be more difficult to ignore) a strong interaction exists between exogenous and endogenous mechanisms (Yantis, 2000). In fact the endogenous mechanisms in place (e.g. what one is looking for in a visual field, and how this search is performed at the voluntary level) seem to determine whether one will automatically be able to ignore certain stimuli; in other words “the guidance of attention is determined by

interactions between the bottom-up input and top-down perceptual set'' (Chun & Wolfe, 2001, p. 280).

The question then arises of how top-down and bottom-up processes may interact in the environment and which role they may play in the pre-attentive and attentive stages. Treisman (1960, 1969) suggested that non-attended stimuli that are particularly significant in the current environment or personal experience could be elaborated at the attentive stage. A good up-to-date review of the main factors intervening in retaining/distracting visual attention in computer interaction is presented by Hillstrom and Chai (2006) who analyse how the direction of attention may be influenced by the distinctiveness of stimuli in the visual scene, the observer's intentions, memory of what has been attended in the past, and the perceptual organization of the display may impact on visual attention. Several recent theories relate attentional mechanisms to personal experience and current environment in an attempt to explain interference effects (delays in the processing of stimuli due to unwanted stimuli called distractors). Interference effects would be responsible for situations in which we are unable to keep attention on a target stimulus or to avoid distractors. For example, stimuli that have been actively ignored in preceding trials are more difficult to select (negative priming) (Allport, 1989; Tipper, 1985); distractors with features similar to the features currently prioritized generate more interference (Folk, Remington, & Johnston, 1992); and stimuli related to familiar and recent foci may cause greater disruption to the user's current activity (Rafal & Henik, 1994; Rogers & Monsell, 1995).

In terms of system design this implies that the impact of interruptions cannot be completely evaluated statically at design time, but it will vary and depend on recent user's activities and goals. For example, one could expect that if a user is extracting some data from an email to insert it in a spreadsheet, the notification of an email from the same sender is more likely to disrupt the work of the user than a pop up reporting on issues unrelated to recent activities.

Furthermore recent results (Cave & Bichot, 1999; VanRullen, Reddy, & Koch, 2004) have demonstrated that the simple dichotomy parallel/preattentive versus serial/attentive used to describe visual discrimination tasks may need to be replaced by a more complex model that takes into account several variables. For example, research in change blindness (the phenomenon by which significant changes in the visual field may go unnoticed) seem to imply that attentions doesn't always bind features in into complete objects representations but rather, it is highly selective and information is extracted only "just in time" if relevant to the current task (Hayhoe, 2000; Triesch, Ballard, Hayhoe, & Sullivan, 2003). It is clear that top-down and bottom-up attentional processes interact to define "what we see" and the selective nature of vision has been demonstrated by several works in inattention blindness (Mack & Rock, 1998; Rensink, 2000) and inattentional amnesia (Rensink, 2000; J. Wolfe, 1999), whilst other experiments emphasise involuntary attention-capture related to visual context (Jiang, Chun, & Olson, 2004; Wells & Olson, 2003) rather than to task. Historically, the study of change blindness has significantly contributed to the understanding of attention and its relations to memory and awareness, some reviews (Durlach, 2004; Rensink, 2002) report on the many situations in which observers fail to detect significant changes in their visual field and Simons and Rensink (2005) explain that in all these situations the localization of the motion signals that accompanied the change was impaired, which suggests that "attention is needed for

change perception, with change blindness resulting whenever the accompanying motion signals failed to draw attention" and that "these effects are even stronger when the changes are unexpected" (p. 16). See, for example, the surprising results on unexpected changes reported in (Levin & Simons, 1997; Levin, Simons, Angelone, & Chabris, 2002; Simons & Levin, 1998) which somehow contradict our naïve understanding of what would draw attention.

2.3 WHAT IS THE PLACE OF ATTENTION WITH RESPECT TO OTHER COGNITIVE PROCESSES?

Some research has aimed at building overall models of attentional processes within the frame of other cognitive processes. Grossberg (1976a, 1976b, 1999), for example, proposes a model addressing learning and conscious experience, and explains how intentions may guide attention in two ways. First, intentions reflect expectations of events that may (or may not) occur. Second, intentions help monitoring sequences of events that should take place in order to satisfy behavioural goals. In this manner "we can get ready to experience an expected event so that when it finally occurs we can react to it more quickly and vigorously, and until it occurs, we are able to ignore other, less desired, events" (Grossberg, 1999, p.12). Grossberg's theory hints that since users' attention will be focussed on information that matches their momentary expectations, understanding users' intentions (both in the sense of behavioural goals, and in the sense of events likelihood) is essential in supporting attentional processes. Furthermore, one way of directing and maintaining user focus is to act at the level of intention.

Several experiments (and common experience) reveal however that intentionality may not always result in attending appropriate events: sometimes relevant cues are ignored and irrelevant ones are attended. Kruschke (2001, 2003) explains the above phenomena stipulating that in order to achieve rapid error reduction in the selection of the cue to attend, we learn to attend to certain cues (learned attention - highlighting) and to ignore others (learned inattention - conditioned blocking). A similar model, where attention to cues that have been learned to be relevant increases, whilst attention to cues that have been learned to be irrelevant decreases, had been already proposed by (Mackintosh, 1975). We seem to apply these strategies all the time both at the macro level (e.g. we are more likely to read news coming from certain sources), and at the micro level (we disregard emails appearing on a certain colour in our client).

Multi-tasking, which regularly occurs in human activity, adds complexity to the understanding of attention allocation. How do we manage to switch our attention from one task to another? Under which conditions we can do this most efficiently? What are the effects on task performance? Based on a computational model addressing these issues, the EPIC architecture, some studies (Kieras, Meyer, Ballas, & Lauber, 2000; Rubinstein, Meyer, & Evans, 2001) have proposed that two distinguishable sets of processes control the execution of consecutive tasks: executive control processes, and task processes. Task processes control performance of the individual tasks and executive control processes control task switching. In this model endogenous control prepares, in a top-down manner, for the next task; and exogenous control, triggered by the onset of the next task stimulus,

completes the preparation for the task. The authors explain delays occurring in task switching condition by the fact that “if a switch occurs from one task to another, there is a pause between the end of stimulus identification and the beginning of response selection for the current task [. . .]. This pause is used by an executive control process whose operations enable the subsequent response selection stage to proceed correctly” (Rubinstein, Meyer, & Evans, 2001, p.770). This model seem to match several experimental results. First it models appropriately the fact that the difference in performance time for task repetition and task alternation increases with the complexity of the tasks (Jersild, 1927). Second, under the assumption that task cueing may facilitate the executive control process selecting the next task, the model explains the fact that task switching times may be significantly reduced if visual cues are provided about the task to be performed next (Spector & Biederman, 1976). Third, under the hypothesis that endogenous processes initiate preparing for the next task only if the Response Stimulus Interval (RSI) is predictable, the model explains why, under certain conditions, increasing the length of RSI decreases switching times costs only if the RSI is constant (Allport, Styles, & Hsieh, 1994; Rogers & Monsell, 1995).

The findings reported in this section have important implication on the design of attention aware systems. First, there is always a cost associated with switching attention from one task to another and this cost is related to the complexity of the tasks involved. In order to design systems that guide user attention efficiently, it is necessary to asses the parameters that define task complexity and evaluate focus switching cost on the basis of these parameters. It seems likely that both general and user-related parameters will contribute to the evaluation of task complexity (intuitively we can define the level of complexity of a task both “in a general sense” and “for a specific person”). The function mapping task complexity to switching costs seems also likely to be related to individual cognitive characteristics. Cognitive models of the user could therefore play an essential role in attention aware systems.

Second, results in task cueing in task alternation hint that systems capable of providing cues about the task to be performed next would reduce cognitive load for the users. It seems likely that, in the case of task resumption, providing cues about the context of interrupted work would reduce cognitive load. For example, in a word processor, task cues may provide information about which part of a document was last edited, and about the context in which that editing took place (e.g., after opening a certain web page and reading a certain email.).

Third, in relation to interruptions, it appears that increasing the time between attention switches will not per se reduce users’ cognitive load. A system aimed at supporting users’ attentional processes should instead allow the user to predict interruption times.

3 Overview of ICT support to attention

Several systems have been developed with the aim of supporting some aspects of user attention. These systems have been broadly classified in two categories (Roda & Thomas, 2006): attentive dispatching systems, and attention aware systems.

Attentive dispatching systems aim at presenting the user with newly available information minimising disruption to the current activity whilst satisfying informational needs; they assume that the user's current focus should either be maintained or re-established after the interruption which is always generated by the system in order to provide newly available information. Systems of this type include: the Notification Platform which filters incoming messages on the basis of their informational value and of the costs of disruption to the user (Horvitz, Kadie, Paek, & Hovel, 2003); the Priorities systems capable of predicting the urgency of incoming email on the basis of simple indicators such as the mean time and frequency with which the user responds to emails from that sender (Horvitz, Jacobs, & Hovel, 1999); and the systems proposed by Chen and Vertegaal for notifications in a mobile cell phone based on measures of "mental load using heart rate variability (HRV) signals, and motor activity using electroencephalogram (EEG) analysis", which allow to "distinguish between 4 attentional states of the user: at rest, moving, thinking and busy" (Chen & Vertegaal, 2004, p.1513).

Attention aware systems instead, whilst they may include attentive dispatching functionalities, have a more general objective. They aim at supporting users in their attentional choices reducing cognitive load and distraction, possibly helping users in maintaining a current focus or proactively proposing alternative foci that may be better suited in a given context. In general, attention aware systems adapt to certain changes in the user's cognitive state and in the environment. Further, attention aware systems differ from attentive dispatching systems in that they assume that users may not only need to be informed about newly available information, but also about information that is available but might have been overlooked; and they aim at supporting attention switches initiated by the user or by events in the environment as well as those provoked by a system notification. Often attention aware systems will need a more in-depth knowledge of the users' cognitive state, and they will need to consider a wider range of possible user's attentional foci, than attentive dispatching systems.

Several examples of attention aware systems have been proposed. The GAZE Groupware Systems conveys the attention target of people participating in virtual meetings by using an eyetracking system to "measure where each participant looks [and represents] this information metaphorically in a 3D virtual meeting room" (Vertegaal, 1999, p. 298)². The Simple User Interest Tracker (Suitor) tracks "users through multiple channels - gaze, web browsing, application focus - to determine their interests" (Maglio, Barret, Campbell, & Ted, 2000), it then finds and proposes, in a non-disruptive manner, potentially relevant information. DeepListener and Quartet are two systems that "reasons about a user's attention and intentions" (Horvitz, Kadie, Paek, & Hovel, 2003, p.58) in order to guide

² see also the follow-up system GAZE II (Vertegaal, Weevers, Sohn, & Cheung, 2003)

audio/visual dialogues with the user. Some anthropomorphic systems signal device attention with head and eye movements (Morimoto, Koons, Amir, & Flickner, 2000; Vertegaal, Slagter, Van der Veer, & Nijholt, 2001). iDict (Hyrskykari, 2006; Hyrskykari, Majaranta, & Riih , 2003) is a system that helps the user in reading electronic documents written in a foreign language by providing help to translation in a non disruptive manner. There are also systems capable of significantly reduce distraction and demand on cognitive and visual attention on the basis of a limited sensory-based knowledge. One example is the system proposed by Hinckley and his colleagues who have augmented a handheld device with sensors in order to offer functionalities "such as recording memos when the device is held like a cell phone, switching between portrait and landscape display modes by holding the device in the desired orientation, automatically powering up the device when the user picks it up" (Hinckley, Pierce, Sinclair, & Horvitz, 2000, p. 91).

4 Attention in learning

This section consists of three parts in which the relation between attention and the learning process is central. This relation is of large importance for the implementation of Atgentive in the Ontdeknet environment. Namely Ontdeknet strives to enhance the learning process of the students with the Ontdeknet platform in general and with the Atgentive agent specifically.

The three sections of our contribution deal with the following issues:

1. Section one deals with the connection between attention and the learning process. The learning process is classified in three levels: the regulation level, the cognitive level or the meta-cognitive level. These levels will be connected to the theory of attention providing us with intervention guidelines.
2. Section two focuses on the cognitive load theory. A short summary of the theory will be given followed by interventions guidelines that can be deduced from the theory.
3. Section three will deal with motivational tactics. We'll explore known ways to achieve a better motivational state in order to improve the learning process.

4.1 ATTENTION AND LEARNING: INTERVENTIONS

In this section learning theory and attention theory will be connected. Preconscious and conscious attention is to be directed at those tasks that support the learning process. The learning process can be divided in the level of regulative, cognitive and/or meta-cognitive problems. The three problems can be connected to three intervention levels in order to redirect attention to the right stimuli to continue or improve the learning process.

There has been a long history of studies how humans and animals learn to allocate attention across potentially informative cues (Trabasso & Bower, 1968). Attention is defined as *the set of processes enabling and guiding the selection of incoming perceptual*

information in order to limit the external stimuli processed by our bounded cognitive system and to avoid overloading it (Roda, 2006).

Attention is the taking possession of the mind, in a clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thoughts..... It implies withdrawal from some things in order to deal effectively with others.

William James, Principles of psychology

Attention is one of the basic cognitive processes helping humans to make sense of the world. It is often referred to as the executive controller between the three memory components, or to speak in analogy of the computer scientist, the executive controller is the executive routine in a computer program; that part of the program that keeps track of what has already happened and what still needs to be performed, deciding which activity or process should come next (Ashcraft, 1994).

Attention can be divided in preconscious attention and conscious attention. Preconscious attention supports automatic processes, which are relatively fast, parallel in nature, and for the most part outside of conscious awareness. Conscious attention can be controlled and supports controlled processes, which are relatively slow, sequential in nature and intentional (Sternberg, 1996).

4.1.1 The learning process

The learning process consists of different layers that are intertwined with each other. The distinction among the layers has been described in many ways. Nelson (1999) divided learning in two levels: the object-level and the meta-level. The object level entails the actions and behaviors of the learner and all information that is relevant for the context at hand. The meta-level is dynamically assessing the present situation. Control and monitoring information flow from the meta- to the object-level. This model is very useful to differentiate between cognition and meta-cognition.

We would like to add one level by making a division between the actions and behaviors of the learner and the information that is relevant for the task. This leads to the division into three levels: regulation, cognition and meta-cognition. Below these levels will be explained in more detail. The arrows in the graph show the heavy intertwinement of these levels.

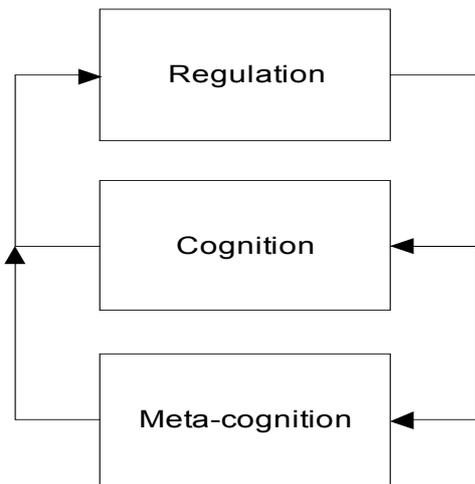


Figure 1. Classification of learning problems

4.1.1.1 Regulation

The regulation of the learning process deals with the actions and behavior of the learner at the lowest level. It supports the physical actions a learner has to perform to support the learning. A simple example of a regulation activity is moving closer to the screen to be able to better read the text.

Regulative activities are mostly acquainted by preconscious attention processes. The student will typically execute a regulative activity automatically. When the activity can not be solved automatically the learner will become conscious aware of it and probably start searching for a solution, which can be asking the teacher, searching for an online help or manual.

4.1.1.2 Cognition

Cognition deals with the content and context of the learning task. Cognition is situated between regulation and meta-cognition. It is defined as the knowledge and skills that are necessary to perform the task (Garner, 1987). A simple example of cognition is the knowledge a learner has about introductions to perform the task to introduce himself. Attention of the students at occurrence of a cognitive activity will be consciously directed at the task at hand. The first focus at a cognitive level is to assess the needed information to perform the task.

When a student is unable to assess the needed information a strategy is needed to acquire the needed information. When the student has enough self-regulations skills they might be able to assess the right strategy / process to perform this cognitive activity themselves. This is where meta cognition is coming into the picture.

4.1.1.3 Meta cognition

Meta cognition is necessary in order to understand how a task can be performed, it is situated at the high end of the learning process and has a very strong relation with

cognition as described above. The meta cognitive knowledge and skills are the ability to understand where you are in your learning process and how you should continue. It entails the follow episodes:

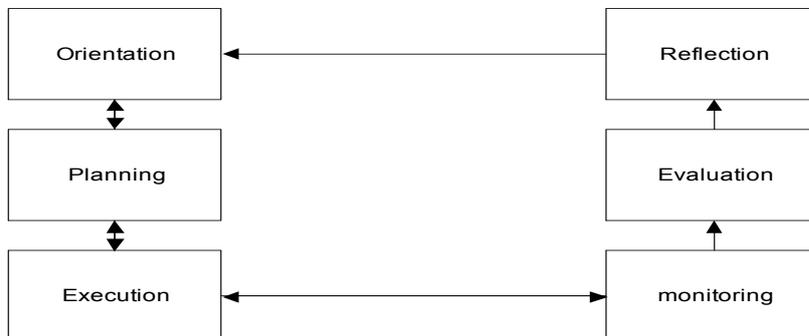


Figure 2. meta-cognition

4.1.1.4 Examples of regulative activities

- *Orientation*
 - i. What am I supposed to learn?
- *Planning*
 - i. How am I going to learn this?
- *Execution*
 - i. what am I learning?
- *Monitoring*
 - i. Am I learning according plan?
- *Evaluation*
 - i. Did I learn it right?
- *Reflection*
 - i. Did I learn the right thing?

Attention of a student dealing with a meta-cognitive activity is consciously directed at the current process they need to reflect on.

4.2 ATTENTION AND LEARNING

In essence we can distinguish between students that are actively directing their conscious attention to the learning task and the students that are not paying attention to the learning task. Teachers continually assess the student attention and come to the conclusion whether a student is directing his attention in the right way.

When a student is not paying attention, the attention of the student is directed at the wrong stimuli. This typically relates to a regulative problem. This distraction is mostly

caused by preconscious attention processes. A stimulus attracting the attention of the student typically triggers off task student behavior.

A student is on task when the attention is directed at the stimuli supporting the learning process. The student is using a conscious or top-down, goal-driven attention processes in order to learn. Cognitive and meta cognitive problems can be experienced to continue their learning. An interference in these situations situation will be directed at the conscious or top-down, goal-driven attention of the users.

4.3 INTERVENTIONS

Students experiencing problems at regulation level are faced with problems concerning the regulation of the task. Problems at a cognitive level are related to the content and context of the learning task. Meta cognitive problems deal with a lack in skills to continue the learning process in an adequate way.

The following three intervention rules can be deduced from this framework:

1. *When the student is facing a regulative problem, a simple procedural interference is necessary to redirect the attention.*
2. *When a student is facing a cognitive problem, an intervention directed at the needed information to perform the task will be needed.*
3. *When a student is facing a meta-cognitive problem, an intervention directed at the process is needed.*

4.4 ATTENTION AND COGNITIVE LOAD THEORY

Cognitive load theory explains the allocation of cognitive resources in order to enhance learning and reduce “extraneous cognitive load”. Extraneous cognitive load is believed to hamper the learning process and should therefore be reduced to a minimal level. For Atgentive the cognitive load theory can provide good guidelines towards interventions that support learning and interventions that will hamper learning on the bases of the framework of the cognitive load theory. A short summary of the theory will be given followed by interventions guidelines that can be deducted from the theory.

4.4.1 Description of the cognitive load theory

The cognitive load theory deals with the capacity of the human working memory and the best instructional design to optimize learning effectiveness. The limited working memory space should be used in the most adequate manner in the learning process. The working memory load can be affected by either the intrinsic nature of the learning task referred to as intrinsic cognitive load or by the way the tasks are presented, which is called extraneous cognitive load (van Merriënboer and Sweller, 2005). The intrinsic cognitive load is functional for the learning process and difficult or impossible to alter. The extraneous cognitive load on the other hand is not effective for the learning process and should therefore be reduced by instructional interventions. Events that increase extraneous cognitive load for example are weak problem solving methods, integrating information sources that are distributed in place or time, searching for information that is needed to complete the learning task or overloading one of the processors (visual processor or auditoral processor).

4.4.2 Interventions guidelines

The basic intervention guideline based on the cognitive load theory is: when high cognitive load is measured, an attempt should be made to reduce the extraneous cognitive load of the user. Based on the cognitive load research a number effective strategies can be named.

The effects studied by cognitive load theory and possible ways to reduce extraneous cognitive load are summarized by Sweller et al, 1998 in the table below.

Table I. Some Effects Studied by Cognitive Load Theory and Why They Reduce Extraneous Cognitive Load^a

Effect	Description	Extraneous load
Goal-free effect	Replace conventional problems with goal-free problems that provide learners with an a-specific goal	Reduces extraneous cognitive load caused by relating a current problem state to a goal state and attempting to reduce differences between them; focus learner’s attention on problem states and available operators
Worked example effect	Replace conventional problems with worked examples that must be carefully	Reduces extraneous cognitive load caused by weak-method problem

	studied	solving; focus learner's attention on problem states and useful solution steps
Completion problem effect	Replace conventional problems with completion problems, providing a partial solution that must be completed by the learners	Reduces extraneous cognitive load because giving part of the solution reduces the size of the problem space; focus attention on problem states and useful solution steps
Split attention effect	Replace multiple sources of information (frequently pictures and accompanying text) with a single, integrated source of information	Reduces extraneous cognitive load because there is no need to mentally integrate the information sources
Modality effect	Replace a written explanatory text and another source of visual information such as a diagram (unimodal) with a spoken explanatory text and a visual source of information (multimodal)	Reduces extraneous cognitive load because the multimodal presentation uses both the visual and auditory processor of working memory
Redundancy effect	Replace multiple sources of information that are self-contained (i.e., they can be understood on their own) with one source of information	Reduces extraneous cognitive load caused by unnecessarily processing redundant information

^aReported by Sweller *et al.*, 1998. taken from van Merriënboer and Sweller, 2005.

4.4.3 Task design

The first three effects are related to the instructional design of the task. This would be system dependent information that could support task selections interventions suggestions by Atgentive. When the system allows for a task selection the following rule applies:

The task selections activities should be activated when the Atgentive system measures high cognitive load. The more demanding a task is the less appropriate it is when cognitive load is high.

Less demanding tasks include the goal free problems, worked examples and completion problems.

4.4.4 Information displaying

The last three effects related to the way information is displayed to the user. This could be implemented on a system dependent level. If the system allows for different forms of information displaying the following rules applies:

The information displaying activities should be activated when the Atgentive system measures high cognitive load. The following information adjusted can be made:

- Replace multiple sources of information into a single source of information
- Replace two visual sources of information into one visual source and one spoken source of information
- Replace multiple sources of information that are self-contained with one source of information

4.4.5 Procedural and supportive information

Research of Kester et al (2001) showed that process worksheets are an ineffective way to support students, due to the high element interactivity and the split attention between task and the process worksheets. Advanced organizers which are shown to students before commencing on the task were found to be more effective (Williams and Butterfield, 1992). Kester et al (in press) found that supportive information and procedural information presented together before or during practices increased cognitive load. The best transfer results were found when procedural information was presented during the task and supported information was presented before.

This results in the following rules:

- *When the process of a task is very complex advanced organizers can be introduced*
- *When there is supported information for a task, it is most effect to show it in advance of the task execution, while providing the student with procedural information while working.*

In short a number of effective intervention strategies to improve attention and the learning process can be deduced from the Cognitive load theory. Many of these interventions are dependent on the systems usage of different task, different information modalities and the distinction between procedural and supportive information. A basic assumption is that Atgentive is able to measure the cognitive load of the user. The next section will go into this issue.

4.4.6 Measurement of Cognitive load

The measurement of cognitive load is quite a challenge and is mostly done on the bases of rating scales. These rating scales are dependent on the task difficulty and the expertise of the user. For Atgentive these measurements would both be system dependent, which means that a system independent measurement of cognitive load would be difficult. Van Gerven et al., (2004) have measured cognitive load based on the psychophysiological measurement of pupil dilation. This could be interesting to proceed on for the Atgentive system.

The results of the first test with adaptive e-learning are positive, but many questions and domains are still open for research. One important warning is in place here, reducing extraneous cognitive load is only effective if students are motivated to invest mental effort in learning process that use the freed resources (Merrienboer & Sweller, 2005). This brings us to the final part of our stat of the art contribution about motivational tactics.

4.5 MOTIVATIONAL TACTICS

The effectiveness of tutoring is frequently linked to motivational factors. Good tutors are aware of the importance of both cognitive and motivational factors. Influencing the users' motivational state (short term as well as long term) can improve their learning

process (retention). Challenging the user, giving him confidence, triggering his curiosity and giving him (virtual) control can increase his motivation (Lepper et al. 1997). In this section, we'll explore known ways to achieve a better motivational state in order to improve the learning process. It'll cover the motivation tactics from Lepper and John Keller's ARCS Model for Learner Motivation.

The effectiveness of tutoring is frequently linked to motivational factors (Naidu 2004). Good tutors are aware of the importance of both cognitive and motivational factors. Influencing the users' motivational state (short term as well as long term) can improve their learning process. In this document we'll explore known ways to achieve a better motivational state in order to improve the learning process. It'll cover the motivation tactics from Lepper and Keller's ARCS Model for Learner Motivation.

Challenging the learner, giving him self confidence, evoking curiosity and giving him (virtual) control can increase his motivation (Lepper et al. 1990, Lepper et al. 1993, cited in Vissers 2003).

The learner can be challenged by selecting problems and assignments with an appropriate difficulty level matching the learners, challenging enough, but not too difficult. Scaffolding techniques can be provided to adapt to the learners level and how familiar he or she is with the system (Winnips 2001, Van Der Stuyf 2002, Lepper et al 1997). In the communication with the learner, you can emphasize the difficulty of the task, challenge the student directly or engage a playful competition with the learner.

Expert human tutors also show great concern for protecting and enhancing the learner's self-confidence. The strategy is to maximize success and minimize failure directly or indirectly. This can be achieved by for example praising the learner, expressing confidence and commenting on the difficulty of the task in the case of failure or success.

Effective human tutors try to evoke curiosity by using the 'Socratic' and 'associative' method. Socratic methods let the tutor provoke curiosity in learners by using leading, rhetorical and sceptical questions to lead the learner to discover for himself the shortcomings, inconsistencies and other difficulties that characterize his or her own current understanding of the problem at hand. The Associative method complements the Socratic methods by putting the current problem in a real-world context.

The last category is about increasing the motivation by promoting a sense of personal control, either objective or subjective. The tutor can increase objective control by offering real choices in situations in which the learner is not certain what would be best for him, offering instructionally irrelevant choices and allowing the learners to offer their own ideas. Subjective control can be increased by creating an illusion of control by pretending to offer the student a choice or pretending to comply with a request

4.5.1 ARCS

Keller identifies a link between confidence and satisfaction (Keller 1983, cited in Small & Venkatesh 2000, Mills 2004) in his ARCS model. He specifies four essential conditions for designing instructions that motivates learning: (A)ttention, (R)levance, (C)onfidence and (S)atisfaction.

Keller proposes three methods for gaining a learner’s attention: perceptual arousal, inquiry arousal and variation. The perceptual arousal can be increased by using audio, graphics and animations, all of which provide the learner with a surprising and novel environment to explore. To increase the inquiry arousal, it’s important to pose questions to the learner or make him solve problems. Questions and problems should be challenging. To keep the learners interested, the instructions and assignments should be vary. Too much repetition fades the learner’s attention.

Also for relevance Keller identifies three methods: familiarity, motive matching and goal orientation. Familiarity can be compared with Lepper’s proposal to use associative methods. According to Keller, a learner’s motivation can be increased by satisfying a basic need, motive or value like power, achievement and affiliation. For example: make clear to the learner that his assignments will be graded and good performance will be rewarded. Closely related to the achievement in the previous point is goal orientation. Objectives and the steps to get there should be clear to the learner.

To increase confidence, learning requirements and objectives should be clear. A learner should know what is needed to succeed. Give learners the opportunity to succeed challenging tasks; this will improve the learner’s confidence. When a learner succeeds a challenging task, it should be made clear that it is the result of learner’s personal effort and ability.

(Small 2000, cited in Mills 2004) divides satisfaction into three areas: intrinsic reinforcement, extrinsic reward and equity. Intrinsic reinforcement can be achieved by explaining how the assignment / course can help the learner, while extrinsic rewards can be given through providing positive reinforcement and motivational feedback to the learner. Grading standards should be used and communicated when evaluating the learner’s performance. There should be no surprises when it comes to scoring assignments. Using a grading standard ensures equity for all learners.

4.6 CONCLUSION

Attention is directing the learning process in a sense that the stimuli that receive attention are guiding the learning process. The distinction between the different layers in the learning process can support the analysis of the situation at hand and the useful intervention. Regulative problems most likely caused by a pre-conscious of bottom up attention switch of the users while students are distracted by stimuli in their surroundings. Conscious or top-down attention shifts of the users are more likely to occur while students are confronted with cognitive of meta-cognitive problems. This defines three intervention possibilities, namely a procedural intervention following a regulative problem, a content intervention following a cognitive problem and a process

intervention following a meta-cognitive problem. Based on the assessment of the situation at hand the teacher or Atgentive can select the right intervention modus.

Lepper and Keller provide tutors and system-architects with a variety of ways to incorporate a motivational tactic and thereby improve the student's learning performance, especially in the case of remedial tutoring. Motivational factors also influence long-term attention (Roda, 2006) and for that reason it should be possible to put these factors into account when evaluating attentional decisions.

5 Attention in Work and in Business

This section presents a short state of the art of the concept of attention for an application in business and work.

“We live in an age of information overload, where attention has become the most valuable business currency”

Thomas H. Davenport and John C. Beck, the *Attention Economy*

The advent of the knowledge-based economy has radically transformed the nature of work and business in organizations. Employees, who once used in their work to fulfil only relatively routine tasks in stable environments, have now transformed into autonomous **knowledge workers** who are engaged into rich, diverse, changing and creative activities in which the processing of information is the central part of their work. Old economy's companies, which used to operate in a relatively stable situations centred on the production of large quantities of relatively small variety of goods, have now mutated into **learning organisations** (Argyris and Schon, 1978; Dodgson, 1993) operating in a continuously changing world focused on the furnishing of a large diversity of services highly customized to the needs of a multitude of customers. Today, the main factor of success of old economy companies, the optimisation of few processes, have been replaced by new ones such as the ability to rapidly adapt to open, complex, and ever changing environments (or for the “best in class” organisations, the ability to discover (Kim and Mauborgne, 2005), to shape or to invent these environments (Christensen and Raynor, 2003)) and the capacity to deal with a quantity of information of all sort. In particular some of the key elements of these organizations are their capability to listen to their customers (they have to know their customers and to interpret signals originating from them), to constantly innovate (they have to create and transform knowledge (Nonaka and Takeuchi, 1995) and not to fear cannibalisation of their own products), and to compete with others (they have to rapidly position themselves in the market, and know to reinvent themselves (Senge, 1994)).

For the employees (the now so called knowledge workers), these new conditions have translated in the acceleration of time, the multiplication of projects in which they are involved, and increase collaboration (projects now frequently involve actors of different functional and cultural horizons). They also have to process a considerably larger amount of information and sollicitation than in the past (Heylighen, 2005), originating from a multitude of sources and tools, and to interact to do their work with a variety of people, of different functions, from different organisations (both internal and external) and having a different cultural background (Nisbett (2003) researches show that it is

important to be aware of cultural differences). This interaction also increasingly includes less formal forms of communication (for instance Nardi, B., Whittaker, S, Schwarz, H. (2000) indicates that social networks have become a key source of labour and information in the information age), for which the filtering strategies are more fuzzily defined.

Yet, the human have not radically changed: people have still very limited capacities at manipulating more than a few concepts at a given time (Miller (1956) work on the short term or working memory indicates that human being have a maximum capacity to manipulate of 7 +/- 2 chunks of information) and at doing several things at the same time (Rubinstein, Meyer, and Evans (2001) have demonstrated in some experiments the high switching cost from one task to another, making multitasking a not very effective strategy when one's want to be more productive). At the organizational level, increased competition and pressure to augment shareholder value has conducted more to downsizing than to expansion of man-power: people are asked to do more with less resources and in less time.

How to address the productivity challenge in the information economy, with activities that can not be really automated and without having the possibility to increase the number of employees in the organization or their mental performance (the use of nootrope (Kher, 2006) for enhancing human performance raises many ethical issues that we do not want to address here)?

5.1 ATTENTION: THE NEW CRITICAL RESOURCE IN THE KNOWLEDGE ECONOMY

Goldhaber (1997) and Davenport and Beck (2001) believe that the element that count the most in the information economy, i.e. the one that is the most scarce and which optimization is the most critical to organization's success, is **attention**. In the context of work and business, attention is defined as (Davenport and Beck, 2001) a "focussed mental engagement on a particular item of information", and can be considered both at an individual and at an organizational level.

For the individuals, attention relates to some allocation of their brain to an activity. This brain resource is of course limited by time (usually the time that people are awake), and by some limits in the (mental) effort or cognitive load that a particular user can support. Indeed some activities are more demanding than others and can not be sustained in too long periods because of the tiredness they generate, or because they are perceived as too boring. Attention can generally be associated with consciousness: the attention of knowledge workers corresponds generally to the activity in which they are currently engaged (such as writing a report, or having a conversation). Yet, Davenport and Beck (2001) propose a typology of attention more elaborated, and that for instance distinguishes an attention that is front of the mind (for instance when someone is talking to another person) from an attention that is back of the mind (an example is the case when a person listens to a conversation whiles writing a report, or when a person is interested in a particular subject and is unconsciously filtering information related to this subject during her other activities).

For the Organisation, attention represents the number of strategic items that really have the focus of the employees that are part of the organisation. It has to be noted that, as for an individual, an organisation can only focus its attention on a limited number of items. For instance, in the domain of corporate strategy, Prahalad and Hamel (1990) suggest that in order to maintain a competitive advantage, all the activities that are not part of a company's core competency should be outsourced. The concept of "core competence", which represent key areas of expertise which intervene in the creation of new products and services and that are distinctive of this company, represent natural item candidates to be the main subject of attention for an organisation.

As indicated, the individual and organisational attentions are strongly linked. Different researches have been conducted and systems have been proposed to address the alignment of the individual goal and the company goal (and ensure that the attention of the employees is properly oriented toward items relevant to the strategic objectives of the organisation). For instance Wright and Snell (1998) propose a unifying framework for strategic human resource management addressing the fit of people and organisation. Goal alignment, appraisal or performance systems (Summers and Dahod, 2003) have also been designed as tools for helping to enforce the focus of the employees on items that are the most critical to the organisation. Still, information system helping to align the individual and the organisational attention, and more generally Human Resource Management systems remain very primitive and largely underdeveloped (Chew, 2003).

Finally, attention represents also an important element for businesses in they interaction with the external world. Organisations have to learn to manage effectively their communication to "get the attention" of their customer and of their potential business partners, since this visibility is increasingly difficult to obtain in a world flooded with information. Managing this communication represents a domain that is however well known and occupied by the media and advertising industry, even if it is facing major transformation (following the advent of the Internet). If we are not really interested here to address the communication dimension of attention that we have described, we can easily imagine that this dimension has some very visible impact on the knowledge workers: first, because they receive now an increased level of solicitation (both in quantity and sophistication) from external organisations and people aimed at trying to grab their attention. There is not doubt that they have to develop effective strategies to filter them. Second, because they will also have to learn to better develop communication skills, and ensure that their messages get the proper attention from receivers that are also overflowed by information.

5.2 NEW INFORMATION TECHNOLOGIES: A BLESSING OR A CURSE?

If the new information technologies (email, web, blogging, CRM, etc.) helping to process all this information have appeared and actually enabled this revolution, they have been unable to fully respond to the new needs resulting to the transformation of the nature of work and business and in particular of the explosion of the complexity of the world.

In some cases, the availability of the new tools for processing the information have appeared to be a cure worst than the decease that it was suppose to fix by adding to the whole complexity and creating new interrupting channels (Fried, 2005). Technology and

information overload that has resulting has even some effect on people health by generating anxiety (Wurman, 2001) and even addiction (Orlowski, 2005). In a study conducted in 2004 and reported by Clive Thompson (2005), Gloria Mark, a professor at the University of California at Irvine has found that “Each employee spent only 11 minutes on any given project before being interrupted and whisked off to do something else. What's more, each 11-minute project was itself fragmented into even shorter three-minute tasks, like answering e-mail messages, reading a Web page or working on a spreadsheet. And each time a worker was distracted from a task, it would take, on average, 25 minutes to return to that task. To perform an office job today, it seems, your attention must skip like a stone across water all day long, touching down only periodically”.

There is little chance that this situation has improved since the time this study was conducted. For instance, in the case of email alone, one of the most used today application to carry out business, the same elements that has made its success are now at the origin of endemic problems: users now complain they receive too much spam (unsolicited) email, that the email system provide little support to their work process (Whittaker, Bellotti and Moody, 2005), or that other are using it in an incorrect way (Sreenivasan, 2005). The adoption of Instant Messaging (IM) in the workplace has increased the level of interruption. Cameron and Webster (2005) mentions in a study in which interviews were conducted that “five different ways IM can be interruptive”, and that the “important concern was the tendency for IM messages to break one’s concentration while focussed on another task”. Even online social networking services, systems that help people to manage their social network such as LinkedIn or Orkut, are beginning to create dissatisfaction given the number of invitation they generate (Leander, 2004).

5.3 MANAGING ATTENTION IN THE KNOWLEDGE ECONOMY

Different solutions and mechanisms have been setup or proposed to support knowledge workers and organisations in managing all this information and interruptions, and more generally in supporting their attention.

We can distinguish different aspects in which the support of attention for people and organisations can be provided:

- The support of their **perception** (sensing the environment). The first aspect consists in the different approaches that can be used to support people and organisation’s perception. It includes the different ways to deal effectively with the massive amount of information and solicitations, and in particular sorting out the good from the useless, and “sensing” the environment without being overwhelmed by the complexity.
- The support in their **reasoning** (strategic support). The second aspect consists in the different ways to reason with the allocation of their attention (which represents a very critical resource). They include in particular the different means that help to assess and analyse the way that users and organisations manage their attention in the perspective of long term objectives (in particular the alignment of the actions and the objectives), and the

decision process of definition of lines of actions, consuming their attention, that are the more consistent with these objectives.

- The support of their **operations** (tactical support). The last aspect is concerned with the execution of multitude of activities they are engaged in, and how to avoid to be overwhelmed by the many routines tasks that tend to accumulate, the many distractions that interrupt and distract the user from completing a task, and find some rooms to dedicate to the creative tasks that have the potential to generate new value.

We can also distinguish different means that can be used to provide this support originating from different disciplines such as:

- **Communication** Sciences and Marketing. Communication and Marketing has been for a long time very interested at effective communication (how can people communicate unambiguously and efficiently) and at grabbing people attention.
- **Management** Sciences. Management has been for a long term concerned with the adoption of very effective work processes, making the best at allocating people time (and attention). Examples include the allocation of people time (and the infamous mythical person.month problems depicted in Brooks (1995)), but also the different strategies to adopt to manage interruptions, the different human resource management tools used to align people attention and the organisational attention (via incentives, and appraisal systems), or the way to motivate people (an important way to have people allocate their attention).
- **Technology**. Information technology represents one of the more important means to support people attention in the knowledge economy, since it can intervene in a variety of ways such as: the filtering, and the organization of the information (portals, community systems); the provision of communication tools (email, bulletin boards, instant messaging) and of notification mechanism (presence mechanism); but also computer based tools providing some diagnostic or some decision process support.

To these elements, we can add a set of principles contributing to attention support such as personalisation and adaptation (personalised systems increase the relevance and the impact, and minimise the distraction by intervening at the right moment), and visual representation (the information items are presented in a way –via the structuration of the space or the use of visual tags- that facilitate the identification of the important information).

In the next part of this document, we will focus on the use of technology to support attention, acknowledging that technology is a means and not an end, and that it only provides partial element of the solution. In particular, the adoption of good practice of using these technologies (for instance knowing how to send emails or post in a bulletin board properly, and without consuming inappropriately other's attention) is often much more effective that trying to provide totally automatic solutions that people are reluctant to adopt, and that often bring rigidity.

5.4 TECHNOLOGIES AND APPROACHES FOR MANAGING ATTENTION

It is always difficult, and actually dangerous, to separate the technology from the context in which it is used. Technology is an enabler of new innovative practices and not the other way round (everybody knows what happens to technological solutions that try to impose approaches that are disconnected from the social practices).

In this section, we will therefore only consider technology in the perspective of the support of innovative social practices that people and organisations will adopt because of the perceived value (although resistance to change is always present), and not as technological solutions that have to be imposed on them.

Until now, the technology had relatively little concern (and even awareness) with the support of people's attention. In particular, technological solutions have often been judged on the number of functionalities they offer, rather than their ability to easily support people's processes. In the next paragraph, we are going to present briefly some of the mechanisms that we have identified as providing more or less explicitly some form of attentional support to the knowledge worker and to the organisation.

5.4.1 Information tools and approaches (visualisation of information)

Portals, web sites aggregating in a same place different information related to a particular topic represent a good illustration of systems that support the attention of the user, and in particular its perception. The importance of the number of the items that they present is compensated by a good "information design" (e.g., amount of text on pages, numbers and types of links, consistency, accessibility, etc.) facilitating the identification of relevant information by the user (Ivory and Megraw, 2005; Beier and Vaughan, 2003).

Personalisation (Ferguson, Smith and Schmoller, 2004) has also for a long time represented an approach that has been used to improve the user experience with a portal site, both by facilitating the perception, but also the decision making process. For instance Amazon users are recognised and proposed items that are relevant to their interest. Yet, personalisation has not fulfilled yet the many expectations that this kind of systems had promised.

More interestingly, and more related to the advanced presentation of the information, we can mention new visualisation systems displaying the information according to the importance of this information and its freshness. For instance, the main portal of technological information CNET proposes the system What's Hot³, which provides a visual snapshot of which stories are the most important, making use of the size of the block (the bigger the block, the hotter the story) and the colour (bright yellow means the story was just published). CNET also proposes the Big Picture⁴, a special feature connecting the dots between stories, companies, and topics referenced in this portal. The last mechanism represents the use of concept maps, a graphical tool that enables anybody to express their knowledge in a graph form that is easily understood by others", to visualise information and knowledge (Cañas et al., 2005; Eppler, 2002).

³ CNET What's Hot <http://hot.news.com/>

⁴ CNET The Big Picture http://news.com.com/The+Big+Picture/2030-12_3-5843390.html

Finally, the use of metaphors represents an additional way that can be employed to facilitate the communication of knowledge (Eppler, 2003).

5.4.2 Community tools and approaches (tools supporting collaboration)

Collaborative portals (or virtual community systems) represents a variation of the information portals, aiming at supporting the collaborative activity of a group of people or of communities.

Different mechanisms have been elaborated to support the attention at the individual, group and community level in these collaborative portals or in socially informed knowledge management systems.

One of the most interesting idea is the notion of social translucence (Erickson et al., 2002), which aims at making the collective activities visible. Social translucence means “systems that provide perceptually based information about the presence and activity of users, thus creating social resources that the group as well as individuals can use to structure and enhance their on-line interactions” (Thomas, Kellogg, and Erickson, 2001). Practically these systems use indicators and cues that give an idea of the activities of people in the communities such as: items that are the more frequently accessed or updated, or indication of people activities (who are the people that are the most active in the system).

Other mechanisms exist such as the ordering of message threads in bulletin board according to their freshness (the threads that got the latest contribution are display in the top). People are sometime making use of this mechanism to raise the attention of the community by posting pseudo messages (a “up”) which aim is to have a particular thread of discussion going at the top. We can also mention (Amelung and Turner, 2005) some tentative to implement some notification mechanisms aimed at enhancing user awareness and cooperation in CSCWE (Computer Supported Collaborative Working Environments).

More recently, the advent of the “blogging” phenomenon (Blogs are online journals that are commonly used to chronicle the lives and opinions of their authors, and that collectively form a community space), and more generally Wiki and online social networking (Jaffe, 2005) has reshaped our perception of online communities (Blood, 2004). In this context, new mechanisms such as tagging have emerged to help to make visible the current focus of community, and therefore represent some tool of attention for the individual or the group as a whole. Practically tagging (or the related concept of collaborative bookmarking) corresponds to the explicit annotation of people postings according to the topics address in these postings, and the automatic aggregation and visualisation into some central sites (such as technorati⁵, del.icio.us⁶, or 43things⁷) taking into account their frequency of use (the most frequently used tags are displayed in bigger characters). To conclude with blog, we can indicate that they are increasingly mined so as to extract parterns of activities of the participants (for instance BlogPulse⁸ is an automated trend discovery system (Glance, Hurst et Tomokiyo, 2004)).

⁵ technorati <http://www.technorati.com/>

⁶ del.icio.us <http://del.icio.us/>

⁷ 43things <http://www.43things.com/>

⁸ BlogPulse <http://www.blogpulse.com/>

Finally, it is important that some of the most mechanisms employed are not technical, and consist in the adoption and enforcement of guideline and practices (sometime referred to as “Netiquette”) of how to behave in these systems.

5.4.3 Communication tools & approaches (tools supporting effective communication)

Different mechanisms exist in the “communication realm” that are relevant to the support of attention. For instance email includes a series of mechanisms helping to filter or organisation of information such as: anti-spamming software used to filter unsolicited emails, the possibility to indicate priorities (for instance when a message is important) or automated script (such as Outlook agents) that can be used to sort information according to the characteristic of the emails (such as the sender, the number of receiver, the existence of some particular words in the title). These mechanisms are now relatively well known not to have to describe them in detail.

In a similar way, the instance messaging software includes some mechanisms that are relevant to attention (even if in many cases, they represent a non-negligible source of distraction) such as presence (people are aware of the online presence of the other users, and to specify their activity state –available or busy). As in the previous case will not enter into the detail of these mechanisms that are relatively well known.

At a less technical level, different communication mechanisms are worth to be mentioned. First, and as mentioned in the previous section, a certain number of practices can be developed to improve the effectiveness of the communication. If we take the email alone, some behaviour in using the communication tools can help to alleviate the distracting nature of email such as: making the messages short (less is more), well identified (with a relevant title), specific (only address to a specific audience), and making an moderate use of priority.

A more interesting perspective is related to the form of the communication that has to be entertaining: many researches have been conducted in the use of narratives as an effective way to communicate information and keep the attention of the receivers. In particular storytelling, which represents a relatively informal form in which the content can be presented (as narratives, scenarios, etc.), is indeed a very effective means to propagate (McLellan, 2002), to elicit (Snowden, 2002), to capture, and to exchange complex ideas, but also to encourage collaboration, to generate new ideas and to ignite change (Denning, 2001; Lelic, 2002).

5.4.4 Tools supporting the organisation work and management practices, and more advanced tools

We will conclude this section by mentioning the different tools that have been designed with the aim of explicitly supporting the work process and management practices. We will also indicate some of the advanced intelligent approaches aiming at more deeply supporting attention.

In the first case, a certain number of tools have been elaborated to support the organization of individual or group work. They include all the PIM (Personal information manager) such as agendas that help people to get organised, but also at the group level the different planning tools that help to organize people work (with examples such as Microsoft Project). These different tools are well known and probably would deserve additional attention for informing the elaboration of the next generation attention informed tools. Yet, they remain relatively unambitious (in the case of PIMs), or not totally convincing in the case of planning tools which appear often too constraining (attention tools should favour creativity rather than bureaucracy).

As we have indicated in the first section of this document, a certain number of tools have also been invented to support human resource department to align the focus of the employees to the organizational goals (such as appraisal systems). We can even mention the case of the AttentionScape tool that was developed to directly assess the attentional level of attention of people and organisations (Davenport and Beck, 2001).

AttentionScape is a graphical tool for measuring several dimensions of attention. It allows to create generating a visual representation of how people an organisations allocate their attention according to the six attention types (The six types consist of three opposed pairs: Captive or voluntary, aversion-based or attraction-based, and front-of-mind or back-of-mind.). Yet, the use of these categories of tools remains marginal.

What about the more intelligent tools for supporting attention and in particular people process management?

The support of people activities have been one of the focus on research and application of intelligent agent for a long time (we will not consider here the application of agent technology for searching information, since they rely more on data processing techniques). For nstance, on the application side, in the early nineties, General Magic tried to develop a "personal intelligent communicator" named Serengeti Serengeti, included features such as notification of urgent messages, the ability to act upon critical information from voice mail, e-mail or pager, and the integration of personalized address book and calendar information. Automated features such as rules and filters allowed users to customize the service to meet their changing needs. Whiles not directly market at supporting the attention of the user, it appears that such a virtual assistant promised to unload the employees or managers from many distracting tasks and allow to orient their attention to activities that were more at the core of their activities.

On the research side, Maes (1994) describes an electronic mail filtering agent which 'prioritize, delete, forward, sort, and archive mail messages on behalf of a user'. The program learns by monitoring the user actions that it tried to automate. One of the stated objectives of this agent was to reduce information overload. Virtual Mattie (Franklin et al., 1996), an Intelligent Clerical Agent designed at the Institute for Intelligent Systems, the University of Memphis, was a softbot which role was to actively gather information from humans, compose announcements of next week's seminars, and mail them each week to a list that she keeps updated, all without the supervision of a human.

The result of this work can appear as relatively disappointing if we consider that companies such as General Magic have disappeared, and research on those assistant

agents do not seem to have progressed very much (researcher having move their focus to other subjects).

To conclude, we have observed in the recent years to some reviving of some research on agents specifically oriented towards the support of attention. For instance Maglio, et al. (2000) describe Sutor, a system which track user behavior, model user interests, and anticipate user desires and actions, and in particular suggest information that might be helpful to users, and that is explicitly aimed at supporting user attention (user interface designed are also studied to reduce distraction). Horvitz and al. (2003) describe the worked conducted at Microsoft on attentional user interfaces, and which are directly reasoning with the attentional concept.

It is difficult now however to evaluate the value of these research in term of outcomes integrated into producterised systems. Another potentialy rich line of research that will have to be considered is the one that we have outline previously and that is related to the support of attention in a collaborative context.

6 State of the art in psychophysiological measures

Psychophysiological measures have potential to represent continuous estimates of cognitive and emotional states of a person. It is difficult to acquire as accurate information on a competitively fine time scale and in real time with other measures (Öhman, Hamm, and Hugdahl, 2000). For example, the exact time of a reaction to a certain surprising event is more easily identified as a change in physiological parameters than using, for example, a post study questionnaire. Thus, if attention is to be continuously monitored, psychophysiological measures potentially offer a viable alternative that is less invasive and does not require intervention during acquisition.

Many non-invasive and unobtrusive physiological measurement techniques have recently been developed (Anttonen and Surakka, 2005; Lisetti and Nasoz, 2004; Vehkaoja and Lekkala, 2004). These techniques allow measurements to be taken discreetly and ubiquitously, which suggests that these measures could soon become common in everyday human-computer interaction. Affordable eye-tracking techniques, for example, using web cameras and off-the-shelf components, also show potential for wide-spread use (Hansen and Pece, 2004; Babcock and Pelz, 2004). Thus, in addition to providing data for the evaluation of systems using a small sample of users, psychophysiological measures are potential rich modalities for everyday human-computer interaction.

6.1 PSYCHOPHYSIOLOGICAL MEASURES AND ATTENTION

There are several techniques for acquiring physiological signals and extracting measures that are related to attentional processes. The following is a summary of the most promising ones.

The activity of the brain can be measured with several techniques. Probably the most feasible online measurement technique is electroencephalography (EEG). In EEG brain activity is measured with electrodes placed on the scalp. The EEG involves relatively small equipment, and the electrodes can be applied on the subject with little restriction to the position and movements of the person (compared to, e.g., functional magnetic resonance imaging). Further, wireless measurement prototypes for EEG have recently been developed (see, e.g., <http://www.cs.uta.fi/hci/wtpc>, Retrieved on February the 20th, 2006). Wireless devices allow nearly unrestricted movement and they can be employed in several contexts.

Studies involving auditory evoked response potentials (ERP), that is, brain responses associated with a sound stimulus, have shown that its characteristics vary depending on whether the stimulus was attended to or not (Näätänen, 1992; Fabiani, Gratton, and Coles, 2000). However, like most other psychophysiological measures, the ERP can reflect a multitude of psychophysiological phenomena, including emotional arousal and

cognitive activity (Bradley, 2000; Coan and Allen, 2004). Another potential measure for attention is the power spectrum analysis of the EEG, which has been used to estimate alertness (Jung et al., 1997). The level of alertness is associated with performance in tasks that demand sustained attention and fluctuations in EEG power. Further, asymmetries in the power spectrum of frontal EEG have been associated with motivational approach and withdrawal tendencies (Sutton and Davidson, 1997; Coan and Allen, 2004). Thus, measures of EEG spectrum could also be useful in estimating how engaged a person is in a task.

In addition to directly influencing brain activity, many cognitive processes, including attention, are associated with the autonomic nervous system (ANS). Thus, they induce changes in heart activity, which reflects both parasympathetic and sympathetic branch of the ANS (Öhman, Hamm, and Hugdahl, 2000). Spectral analysis of the heart rate variability (HRV) is often used to separate parasympathetic, sympathetic and respiratory influences on heart rate (e.g., Wilhelm et al., in press). In practice, heart rate variability has been used to index mental stress and cognitive load (Hjortskov et al., 2004; Chen and Vertegaal, 2004).

Electromyography (EMG) measures the electrical activity of muscles which are connected to psychological processes in several ways. For example, the activity of certain facial muscles is associated with the experienced emotional valence (pleasantness) (Larsen, Norris, and Cacioppo, 2003; Surakka and Hietanen, 1998). Using EMG it is possible to measure small changes in facial muscle activity, which would be very hard to measure with other, e.g., video-based, techniques. Most often used measures reflect the power of muscle activations. However, it is also possible to extract spectral measures of EMG. They have been used, for example, to estimate fatigue in muscles (Tassinari and Cacioppo, 2000).

The face is well represented in the motor cortex of the human brain (Rinn, 1991). Further, facial musculature system is very fine grained. For these reasons, it is probable that correlations exist also between facial EMG and cognitive states, including attention. For instance, it has been suggested that the activity of the *corrugator supercilii* muscle could be associated with large commitment of attentional resources (Öhman et al., 2000).

Also eye movements can tell much about the cognitive processes of a person. For example, gaze paths, that is, sequences of saccades and fixations, are affected by the tasks given to a person as well as her or his perception strategy. As an example of using eye movement analysis to support learning related tasks, Hyrskykari and others (2003) implemented an application that proactively responds to difficulties in reading text. As another example, Merten and Conati (2006) studied the estimation of a student's self-explanatory behavior from eye movements. They found that eye tracker data could significantly improve the accuracy of their probabilistic student model.

Some eye-trackers are capable of measuring pupil size variations in addition to eye movements. The pupil size is affected by both affective and cognitive processing (Aula and Surakka, 2002; Partala and Surakka, 2003; Beatty and Lucero-Wagoner, 2000). Eye

blink characteristics (e.g., frequency, latency, and amplitude) are also promising measures for estimating attention, as they are related to cognitive load, visual load, and alertness (Veltmann and Gaillard, 1996; Richter et al., 1998; Dinges et al., 1998).

Although there are many promising measures, the extraction of attentional information from psychophysiological signals is a challenging task for several reasons, including their context-dependency, non-specificity, and individuality (Cacioppo et al., 2000; Matthews and Wells, 1999; Ward and Marsden, 2004). Further, attentional processes are tightly interconnected with other psychophysiological processes. For example, attentional processes are modulated by emotions and vice versa (e.g., Surakka et al., 1998; Carretié et al., 2003). These challenges have previously been addressed by acquiring converging data from multiple simultaneous measurements (Chen and Vertegaal, 2004; Kapoor, Picard, and Ivanov, 2004; Lisetti and Nasoz, 2004; Teller, 2004). This approach is based on evidence suggesting that distinct patterns of physiological responses exist for different mental states, such as the tendency to withdraw or approach stimuli (Christie and Friedman, 2004).

6.2 PSYCHOPHYSIOLOGICAL MEASURES IN HUMAN-COMPUTER INTERACTION

In HCI research, physiological measures have been used in various ways. One common application has been the evaluation of interfaces based on physiological responses to HCI events, for example, difficulties in web browsing (Hazlett, 2003; Ward and Marsden, 2003; Riseberg et al., 1998). Further, computer generated displays of affect and empathy have been found to mediate these responses (e.g., Partala and Surakka, 2004; Prendinger et al., 2003). Thus, emotions can serve both as input and as output modalities in HCI (Picard, 1997).

Gaze tracking has also been used for evaluating interfaces, as the gaze provides an insight to many cognitive and social processes that are involved in HCI. For example, Vertegaal and others (2001) measured gaze direction during a multi-party conversation and found that people spend significantly more time looking at people who they listen or talk to than looking at other people. Thus, it can be said that gaze acts as contextual information, signaling conversational attention, that is, who is listening and who is spoken to. Artificial agents can use this information both to signal their own attention and to sense and react to user's attention when conversing with the user (Oviatt and Cohen, 2000; Vertegaal et al., 2001; Oh et al., 2002; Koons and Flickner, 2003; Selker, 2004). As an example, Lee and others (2002) built a statistical model for realistic eye movements based on eye-tracking data. An artificial character that used their model was perceived more natural, friendly, and outgoing than a character with stationary eyes or random eye movement. In general, as Zhai (2003, p.35) noted: "The eye gaze of a user tends to provide the context within which actions take place." This approach can be used, for example, to segment and analyze other physiological data according to gaze patterns (Chateau and Mersiol, 2005).

It has been shown that artificial characters are efficient in capturing visual attention to themselves. For example, Witkowski and others (2001; 2003) measured gaze direction while the user interacted with an agent presenting different wines. They found that people spent nearly 20% of time looking at the agent and over 50% reading the text bubble that displayed its utterances. Further, attention was mostly directed to the agent character's face, which supports the notion that people interact socially with computers and artificial characters (Nass et al., 1994). This also enables other social cues besides gaze direction, for example, proximity, to be used by embodied agents (Partala, Surakka, and Lahti, 2004). Furthermore, eye-tracking studies suggest that embodied agents can resolve ambiguities by providing conversational cues and that people follow the verbal and non-verbal instructions of an agent (Predinger et al., 2005a; 2005b; Ma et al., 2005).

In addition to evaluation of interfaces, gaze direction has been used as an input signal in human-computer interaction. As gaze tracking can be used to automatically detect the objects that the visual attention is directed to, it can be used as a basis for adapting the interaction based on the interests of the user, for example, by providing relevant and related information (Starker and Bolt, 1990; Maglio et al., 2000; Hyrskykari et al., 2003; Puolamäki et al., 2005; Qvarfordt and Zhai, 2005). As an example of another type of adaptation, computing resources can be saved by adapting the level of detail in graphics rendering depending on visual attention (O'Sullivan, 2005). Gaze is also a very efficient modality for selecting interface objects (e.g., clicking a button), especially when combined with other physiological signals that reflect the intent of the user (Sibert and Jacob, 2000; Surakka, Illi, and Isokoski, 2004).

There has been less research on systems that automatically adapt to changes in other psychophysiological parameters besides gaze. However, there is evidence that such adaptation evokes emotions and increases human cognitive performance (Aula and Surakka, 2002; Freeman et al., 1999; Partala and Surakka, 2004). For example, Predinger and Ishizuka (2005) were able to decrease the arousal of a person using a virtual character that provided empathetic feedback according to changes in the person's skin conductance and electromyographic signals that were used to index frustration.

One major challenge in developing adaptable physiology-based systems for wide-spread use has been the restrictiveness, invasiveness and cost of physiological measurement devices. However, several new wireless and unobtrusive measurement devices and methods have recently been introduced. For example, Hansen and Pece (2004) developed a web camera based eye tracking method. The accuracy of this method was sufficient for typing an average of four words per minute using 12 on-screen buttons. Other novel measurement techniques enable wireless, discreet and unobtrusive measurement of muscle activity, heart rate, and skin conductivity, for instance (Anttonen and Surakka, 2005; Teller, 2004; Vehkaoja and Lekkala, 2004). It seems almost inevitable that such wireless, wearable, and ubiquitous measurement techniques will become more common in the future, enabling psychophysiological measures to be used as a part of every-day human-computer interaction.

7 Embodied Agent for Attention: State of the Art

Information can be stored in human verbal or visual memory and it can be represented in a user interface as words or icons. Montigneaux [Montigneaux, 02] says that the great richness of visual memory completely compensate for a lack of vocabulary. He adds that when the attention is not sustained, some visual elements can be preserved, which is not the case of the semantic elements.

Understandably, humanized characters appeared inside virtual environments and just like any other objects already displayed as icons (desktop, directories, files and trash bins) human Agents are represented by geometric models, which become the own image of the user or a figure viewed from a subjective perspective. As opposed to simple objects, an Agent is given habits, attitudes and a general behavior at physical and psychological levels, which have a strong influence on the user and his attention.

Humanization process is of great value because *the way people interact with technology is the way they interact with each other* [Picard, 04]. As a result, there is a demand for interactivity and "dialog" with the application. Interactions between human beings are made of emotions and it is interesting to see how to model these emotions inside computers, as Rosalind Picard defines it in *Affective Computing* (1995).

In the next chapter, we propose to make a state of the art of Embodied Agents, of existing technologies that allow dealing with them, and to list their different components.

7.1 THE FIRST EXPERIENCES

The first Agent appeared in movies and notably in the movie *Tron* en 1982. Jeff Bridges plays a computer hacker who is split into molecules and literally transported inside his computer. Two years later, *Max Headroom*, already a show in the U.K., made its series debut on American television. Set 20 minutes into the future, the character Max Headroom is the computer-generated alter-ego avatar of television reporter Edison Carter, and can move through both television and computer networks at will. The show only lasted 14 episodes, but introduced the notion of embodied agent to millions of American television viewers.

If Max Headroom was the first avatar, he was broadcast, and there was nothing dynamic about him and we had to wait the use of these virtual characters directly on computers to really call them Agents where you could easily update what they say and what they do. We can see some of them every time we open our computer. The most tangible example is Paper Clip from Microsoft Office who is the descendant of the famous Microsoft Bob (1995). On the Web, some Agents start their mission like Ananova (2000) or Eve Solal (2000) ...

Many people considered *Ananova* as the first Agent on the net. Created to present the news on Internet and on mobile phones, *Ananova*, 28 years old 3D Agent with green hair, is able to speak in every language and provide several facial expressions. She has been designed to show confidence, seduction and credibility. She communicates with the web surfer on "face to face" as it's the standard communication for the newscasters.

The opportunities for this type of interaction are numerous and researchers looked for other domains like e-learning. Several studies have been conducted on the interaction between the learner and the Agent having a mission of Tutor or ingenious Learner.

In addition to coupling feedback capabilities with a strong visual presence, these agents play a critical role in motivating students. The extent to which they exhibit life-like behaviours strongly increases their motivational impact [Lester & Stone, 97].

Motivation is a key ingredient in learning, and emotions play an important role in motivation. *We believe that pedagogical agents will be more elective teachers if they display and understand emotions. [Elliot, Rickel & Lester, 97].* The users believe in an interactive system with an Avatar. *Human-like characterization is one good form of autonomous agents, because people are accustomed to interact with other humans. [Takeuchi & Naito, 95].*

The embodied Agents became more and more autonomous and intelligent. *Artimis*, developed by France Telecom Research & Development is able to analyze a question thanks to its voice recognition system and answer almost immediately by an embodied Agent. We can also meet Agents in different devices like PC, interactive TV, booth, set top box, mobile phones.

Nevertheless, the first interactive experiences didn't receive a success because it was difficult to mix the technological and artistic aspects. Today, we live a second stage for the Agents thanks to the evolution of the technologies. If, 5 years ago, technological brakes were important and avoided having a nice result, today it's different. The software publishers provide better solutions and efficient Agents. The Agent market is new but they start to answer clients needs. *OddCast*, a US company, claim having 4.500 clients using their solutions. Among them, *L'Oréal*, *Coca Cola*, *Chrysler*. In France, more than 10% of large companies use the Living Actor™ technology.

The networks are more powerful and the computers allow better multimedia experiences. More and more users accept interactive experience and the tools to create media data are simple and funny to use. This play aspect is a key because, in front of an embodied Agent, the user acts like he does in a video game.

7.2 FEATURES OF AN AGENT

7.2.1 Its representation

The first user impression comes from Agent's graphical aspect. His first vision will identify the Agent as having mission. In video games, Gard (2002) says that the first impression of a player in front of a virtual character determines the way he will interact. This first impression remains for the player and even involves some form of seduction. The famous Disk Doctor and Win Doctor by Symantec company, associated with Norton Utilities product, have not been chosen by chance. Here, the use of the word doctor as a metaphor, immediately expresses intelligence, knowledge, and brings confidence. This choice of words is more persuasive than Disk Helper or Disk Assistant. Furthermore, a diagnosis made by an experienced doctor is more credible and comforting than the same one made by a junior doctor. Usually, this distinction is made according to the visible age of the character, accessories like his glasses, a name or nickname given to him.

7.2.2 Its behavior

The behavior of a person carries a language as important as verbal communication. An Agent is identified by reading his body language, or behavior, which gives him a more credible mission. Hogan (1996) talks about two strategies to be convincing: make people like you and make people believe you. He says the best way to be believed is to have coherent verbal and non-verbal communication.

Many researchers consider behavior as very important in all types of communication. Too many dialogs are boring. Attention significantly benefits from non-verbal communication. An action or a joke can efficiently replace a dialog [Eco, 86].

Let us distinguish two physical parts of the Agent: face and body. Thanks to his face, the Agent uses expressions to convey emotions, generate emotions and draw attention. His body actions strongly contribute to his speech.

Eye movements have always been a topic of research. The literature is abundant on the subject and first researches have been carried out by Dr. Ernest Hidegard in the fifties. The gaze is a very important part of attention when it comes to a specific graphical area, but eye movements are also meaningful when observed in waiting phases.

The results of researches show that people are likely to temporarily move their eyes to specific positions when reminding events, answering questions, talking to themselves, feeling something, or when they visualize future events. Eye motion is therefore the basis for various interpretations and we must be careful when making use of it. Hogan is very precise in his works by defining six key positions / movements of eyes for a human. He shows that for instance, looking at an upper right location is a sign of image visualization in a previously unknown situation. Hogan concludes by saying that the knowledge of information given by eye movements is a powerful tool in many types of communication processes and influences other people decisions. An appropriate eye movement gives confidence in the quality of listening. A sustained look shows that an action is expected. During their experiment *The solar system*, Cassel and Thorisson (1999), showed that Agent's non-verbal behavior, while improving the structure of conversation, made the system better understood. The study shows active or passive behaviors, without dialog, making people understand that the system is waiting for an action. These behaviors might also hamper user interactions. For instance, movements may unintentionally let the user think that the system expects something from him. In addition, the user may wonder what he has done right or wrong when he sees the Agent blinking or performing automatic action. Consequently, we must ensure that Agent behaviors correspond to his actions. *An animated paper clip which blink any time you click on it, is perceived as a person insisting by blinking when you ask him to leave your desktop* [Picard, 01]

The behavior is not limited to eyes and in general, body language provides much information. Human beings have an unlimited range of emotions, easily understood through body language [Dimitrius, 98]. In his book, *Reading People*, he describes many states of a human easily identified in body language.

Body motion allows a character to widely occupy the scene and draw User's attention. He can show elements using his hands, move, disappear and reappear.

The rhythm of his movements is also a key factor in non-verbal communication. To make the user execute an action, he can show that he is listening by slight movements, in

contrast with more active attitudes, by having an attitude oriented toward the user, like moving a hand in his direction or by trying to persuade him through wide gestures.

7.2.3 Its voice

When voice is involved, the user better memorizes messages and in addition, he receives many data in support of his confidence in the Agent. Hogan (1996) studied the confidence in a person according to his vocal replies. He shows as a result, significant features associated with different kind of people, which can be transposed to Agents. If the Agent is a female, Hogan recommends lowering the frequency of one octave in order for the voice to be perceived as more professional, because, he says, *women having high frequency voices are considered as weak and boring*. If the agent is a male, Hogan recommends making him more powerful and respected by lowering his voice frequency of half an octave.

Other vocal parameters, among them, the rhythm of the message and changes in the intonation, give the User some confidence in the Agent and give the Agent persuasive power. A dominating character for instance, uses a faster rhythm than a submissive character.

It's not what you say, it's how you say it [Dimitrus, 98]. Dimitrus shows, in its work, how, our every day attitudes are not revealed by the words, but by the way we say them. According to him, two different dialogs take place in any conversation. The first one uses the words and the second one uses the intonation. When you ask somebody "how are you?" and you hear "very well", you do not automatically trust the answer. The tone of voice is preminent to tell you if he is depressed, anxious, excited, or something else. Where you listen to the tone, the volume, the pace and other vocal features, you enter a non-verbal conversation, where you can actually find the truth. These features are obviously less emphasized when using synthetic voices. Emotion in TTS is not as powerful as emotion in recorded speech. [Nass, 2000]. However, even with the lack of emotion carried in synthetic voices compared with recorded voices, they have the advantage of being productive.

Sounds are enabled in the majority of modern computers, though it is not always possible to play them as desired, for example in work places like open space offices. That's why the Agent speech may written somewhere in an area dedicated to the answer, like a comic strips dialog balloon.

The gaze of internet users is attracted by the text being scrolled in the balloon and it lowers the impact of Agent's behavioural language. However, it is an interesting solution. Users are more attentive to an image of a human face with the mouth animated in synchrony with speech than a simple text [Sproull et al., 96].

7.2.4 The Agent and the application

An experiment has been conducted by Lantz (2001) on Agents representing the users in a collaborative platform. By highlighting more or less these Agents, every one is allowed to speak in turn. The location of Agents in the platform and their space relationships permit to change turn-taking fluidity.

It is interesting to play with size and position of the Agent. A study by Andersen (2001) showed that the Agent should not occupy too much place and thus leave information behind him. Andersen concludes it is even better to provide a resizable Agent, which can be moved over the interface and disappears when asked to.

The first and simplest rule in film making is related to the position of the subject within the frame. It is more harmonious and dynamic not to place systematically the subject right in center of the frame (Couchouron, 04). All classical techniques of photography and cinematography may be applied to Agent visualization, even regarding viewing angles. A high angle shot tends to squeeze the character, whereas a low angle shot will have the opposite effect, which strengthens the dominating personality.

7.3 OVERVIEW OF THE TECHNOLOGIES

The first solutions were introduced in the mid-1990's, focusing on one or several components of the humanized interface, but Microsoft undoubtedly initiated the market by launching the Office companion in 1996, follow up of Microsoft Bob. The Office companion was greeted with mixed feelings but the fact that it is still available nine years after its debut in Office is proof of its success. Several companies launched their own technologies such as Inago (3D technology *Net People*), Qedsoft, Haptak (3D technology *PeoplePutty*), Nevertheless, we must acknowledge that its launch did not flood the software market with agents.

Technology had seriously evolved up to the year 2001, but that year saw a reversal of the Internet market. This brutally reduced industry marketing and communication investments in breakthrough tools that had yet to demonstrate their added value, which was the case for most agent solutions.

Thus, of the active market actors of this period between the late 1990's and early 2000's, few have survived except for several specialized companies that, at times, strongly reoriented their strategy (we will discuss this later). This was the case for VRTV Studios and Pulse 3-D. Pulse 3D had a very good 3D technology but decided to move for a Java technology due to the technical constraints of the Web (very few people accept to download an ActiveX Control necessary for the 3D technologies).

Since the end of 2003, we have observed a very strong renewal of interest in agent solutions thanks to the development of standard technologies such as Flash from Macromedia as this technology is deployed by Microsoft Explorer.

Macromedia (now bought by Adobe), with solutions enabling interface enhancement, provides third-party editors very interesting 2-D avatar publishing technology. In fact, several direct competitors of Cantoche utilize the graphic rendering engine produced by Flash in order to produce agents. They rely on a very widely deployed player (more than 95% of the world's existing PCs and Macintosh computers are equipped with it!).

For over a year Yahoo! has been offering customizable Flash avatars as a complement to its instant messaging service. IMVU (US) offers the same service. Oddcast (US) proposes its platform, VHost, which is based on Flash technology. A large number of client references are mentioned on its site, making it a very important competitor in the PC market. There are other companies comparable to Oddcast, but with a much smaller customer list, such as VRTV Studios (France) or Eficie (France), which create

personalized Flash animations. There are other businesses combining avatars and natural language such as Conversive (US). However, these companies only offer solutions of modest quality and have a relatively small client base.

By using Flash technology, the graphics quality and the behavioral performance of these avatars remain very limited and would not make it possible to fully exploit the potential of an agent in its role as a communication vehicle or in its social mission. Moreover, agents produced with Flash technology are generally limited in 2-D size to a head and shoulders shot contained in a window, which strongly restricts their use and their impact on the user.

7.4 ADVANTAGES OF LIVING ACTOR™

The Living Actor™ technology was developed entirely by Cantoche and launched in January 2002 on the Major Accounts market as a response to that market's problems with internal and external communication.

Living Actor™ represents a complete departure from existing solutions thanks to the two major and unique innovations described here:

- First (i), it uses a behavioral intelligence engine, which endows the actor with an autonomous existence, thereby allowing it to adjust its interaction to each user. This technology provides the interactive character with unsurpassed automatic behavioral and expression abilities that enable it to establish with its users a high-quality mode of non-verbal communication that is essential to the effectiveness of this communication. This computerization also makes it possible to significantly reduce the production cost of the agent's interactions.
- Second (ii), the characters can be displayed in different formats with excellent graphics so that they can be distributed throughout various types of interfaces and devices depending on their technological specifications, from PCs to mobile phones to set-top boxes for interactive television.

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