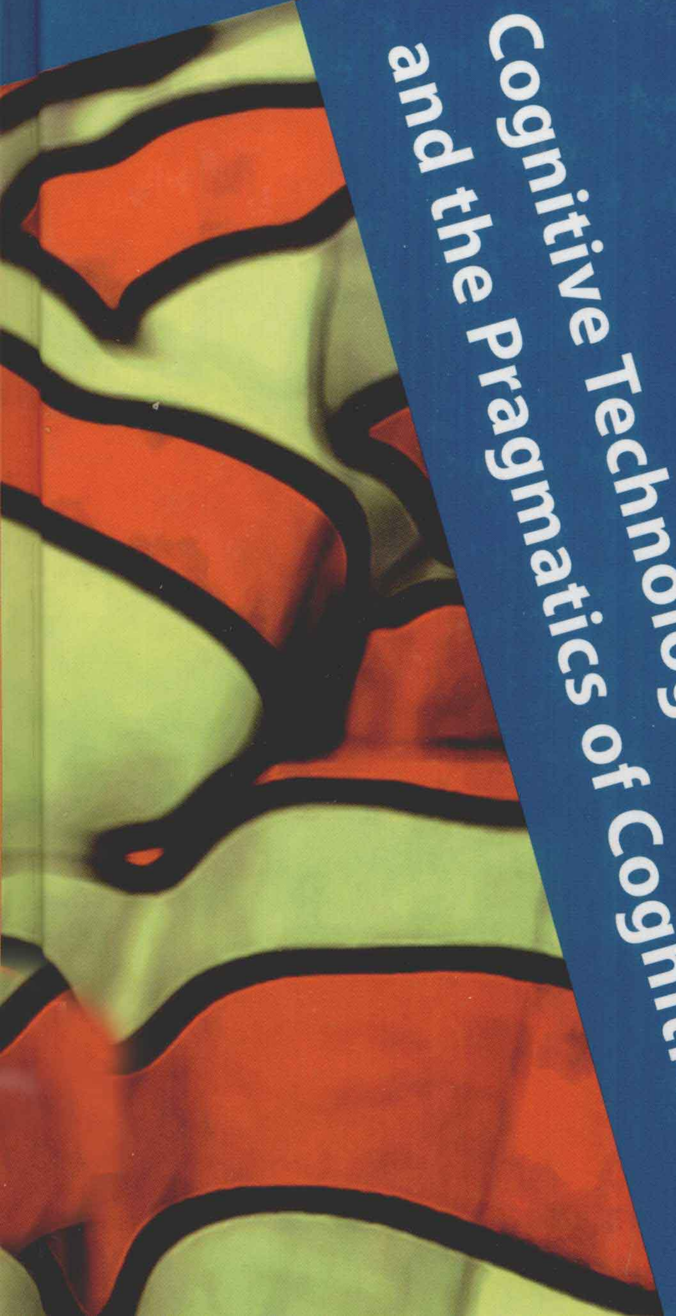
Itiel E. Dror (ed.)

Cognitive Technologies and the Pragmatics of Cognition



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Cognitive Technologies and the Pragmatics of Cognition

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I dedicate this book to my four L's and my one and only S.

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Jim Turner is a postdoctoral research fellow working with The Open University's International Centre for Comparative Criminological Research. He recently completed a PhD at The University of Westminster that sought to use knowledge gained from perceptual research to improve the construction of facial composites using the E-FIT system. His work on using minimal face stimuli has since been incorporated into the development of the latest version of E-FIT.

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The authors are part of The International Centre for Comparative Criminological Research at The Open University. Recently they have been involved in two U.K. Home Office projects to investigate using computer technology to make the most of identification evidence and to study the visual identification of suspects. Their background is in applied cognitive psychology, particularly with regards to eyewitness evidence.

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Table of contents

Gold mines and land mines in cognitive technology

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Technology has long played an important role in human activity. However, with technological advances we are witnessing major changes in the role technology plays. These changes are especially revolutionary in two senses: First, new technologies are playing greater than ever roles in human *cognitive* activities. These activities include: 1. New levels of cognitive interactions between people. These interactions, both quantitatively and qualitatively, are at an intensity and scale that allow new forms of cognition to emerge, such as distributed cognition. 2. Technologies that cognitize with us, thus playing an active part in our cognitive processes and constituting themselves as inherent components in human cognition. 3. These new technologies do not only cognitize with us, but they also cognitize for us. In this sense they go beyond supplementing human cognition; rather than playing a facilitating role they actually take over and replace certain aspects in human cognition altogether.

Whether these technologies give rise to new forms of cognition, such as distributed cognition, or they cognitize with us and for us, these technologies mark a fundamental change in the role they play in human activities. Such technologies are best termed *cognitive technologies* (Dascal and Dror 2005).

The second sense in which these technologies revolutionize their role is that they are actively affecting and changing human cognition itself. In the past when they were predominantly a tool to aid humans, they had a minimal role in shaping cognition. They only played an instrumental role in executing the product of human cognition. Now, with increasing emergence and use of cognitive technologies, they are more integrated in the cognitive processes themselves. As such, they play an active and constituting part in human cognition. Since human cognitive processes are adaptive, dynamic, and pragmatic, they do not work in isolation from cognitive technologies. These new technologies affect and shape cognition.

As new cognitive technologies emerge and with their wider integration in human activity, they influence and change the very way we think, learn, store information, communicate with one another, and a host of other cognitive processes, thus changing the nature of cognition and human activity.

This new emerging field of cognitive technology is of great interest and importance. Its implications are all encompassing; they raise academic and scientific questions, as well as practical issues of how best to develop and integrate these technologies in the workplace and at home. They also introduce social, moral, and philosophical issues. It is time to investigate and consider the broad issues surrounding cognitive technologies. Technological innovations are very fast and the rapid changes they introduce are followed by legal, social, and other slower responding systems which try to consider and adapt to the technological impacts. Cognitive technologies, as I will try to illustrate, offer a great potential across many domains. However, their power and intrinsic influence on human cognition can be detrimental and harmful. Thus we need to understand and carefully consider the *gold mines and land mines in cognitive technologies*, as I explicate below.

To consider cognitive technologies, I will focus my examination of its impact mainly on two broad and fundamental domains: The first is data exploration and investigation, and the second is learning and training. Data exploration and investigation, from initial design of the methodology for collecting the data and the actual data collection, to its exploration, analysis and interpretation have all been profoundly affected by cognitive technologies. The gold mines of these technologies are that they offer great opportunities for data explorations and investigations that have never existed before. For example, in psychological experiments we can relatively easily design complex methodologies that involve experimental design to collect response time data from participants. In the past the apparatus for such experiments would require months if not years of work, but nowadays this can be achieved in a matter of days if not hours.

The data collection itself has also been affected by new technologies; nowadays using multiple computers or web based studies, hundreds, if not thousands of participants can contribute to data collection within a few hours. Even in domains that do not rely on human data, new technologies enable the collection of huge amounts of data with great efficiency. A variety of data mining technologies allow efficient exploration of vast amounts of data in very little time. In the past a great deal of effort and time was needed to collect and explore such amounts of data. Once the data has been collected and initially explored, its further analysis and interpretation is relatively trivial. Statistical packages and other software enable us to analyse and visualize data to uncover interesting patterns in a matter of minutes, if not seconds.

These examples illustrate the great power and abilities that new technologies offer; a gold mine, no doubt. However, they also introduce some potential land mines that we need to consider. Too often such technologies are embraced without fully considering (and taking countermeasures to) the problems they introduce. For example, the ease of collecting data and its analysis have reduced the investment in planning and thinking. With cognitive technologies it is so easy to carry out these activities that rather than thinking carefully how best and most appropriately to do things it is more straight forward to just adopt a 'trial and error' approach than to consider things in depth. Using this approach, for example, when you design a study rather than investing thought whether (for illustrative purposes) to expose a stimuli for 100 or 150 milliseconds, you are more prone to use one of them and 'see how it goes' because you know it is very easy to modify the exposure time. Similarly, when you analyse the data, because you are not computing the statistics by hand, you can run a variety of models and use different statistical approaches with great ease. This leads many times to not carefully considering which is the best approach, but just to try one, and if it fails, then to try another. The problems with such impacts of cognitive technology are not limited to possible distortions in the correct and scientific procedures and results (such as an increase in false positive statistical significance findings as a result of multiple testing), but has far reaching implications to the level and depth of thought put into these data investigations.

Such land mines introduced along with the gold mines offered by cognitive technologies are not limited to data investigations in the scientific domain, they are equally applicable to other domains. For example, moving from the laboratory scientific inquiry to the 'real world', we can see these implications in the forensic world of fingerprint identification. Although fingerprint identification has been around and used in courts for over a hundred years, it has been revolutionized in the past few years with the introduction of new technologies. These technologies have affected all aspects of fingerprint identification, from using scanners rather than ink to collect fingerprints, to their digitization, and the introduction of mobile devices that can do these and other functions. But most interesting and revolutionary is the introduction of the Automated Fingerprint Identification System (AFIS). These technologies enable us to take a partial or distorted fingerprint left at a crime scene and compare it against a very large set of fingerprints stored on a database. In a matter of seconds AFIS will provide the closest matching prints for a human expert to consider. AFIS offers great power, and indeed many crimes have been solved because of these new technologies, including old unresolved cold cases.

However, as we have seen in the domain of scientific inquiry, such gold mines introduce land mines. In the forensic fingerprint identification domain, the gold mines AFIS has produced have also brought about dangerous land mines in the form of erroneous identification. With the introduction of very large databases and the ability to search them via AFIS, there is now a high likelihood of finding very similar 'look alike' fingerprints by pure coincidence (Dror, Péron, Hind, and Charlton 2005). Thus, the criteria threshold for concluding an identification needs to be adjusted to the use of such powerful technologies. The erroneous Mayfield case illustrates the practical and real land mines that are introduced with these technologies. Using AFIS Mr. Mayfield was selected as a suspect in the Madrid bombing. Three fingerprint experts at the FBI examined the fingerprints of Mr. Mayfield and they unanimously and independently misidentified him as the Madrid bomber (Stacey 2004). The important point here is that the erroneous identification of Mr. Mayfield was in part because of the powerful technology of AFIS. This technology enables us to search very large databases, and thus will result in finding very similar fingerprints by pure coincidence. When such similarity exists, it is much more likely to make erroneous identification (not only in fingerprint, but in any other pattern recognition task, such as aircraft identification, see Ashworth and Dror 2000).

The last domain that I want to use to illustrate gold mines and land mines in cognitive technology is learning and training. Technology Enhanced Learning (TEL) has been used to facilitate and improve one of the cornerstones of cognition and human activities: Acquiring, storing, and using new knowledge. TEL has been taking an increasing role in almost all learning environments. It is used in a variety of informal and formal educational environments, as well as in many commercial, industrial, and governmental settings. Since these cognitive technologies are having a growing use and impact in the area of learning and training, it is important to consider some of the gold mines along with the land mines they introduce. These will further illustrate the general issues associated with cognitive technologies.

First, in general, for learning to be successful it must conform to the architecture of the mind. For example, this means training must take into account constraints on information processing capacity. Information during learning need not be reduced to fit the limits of the cognitive system, rather the information must be conveyed in ways in which the system can easily acquire and store it. This can be accomplished by using the correct mental representations and engaging the cognitive system on its own terms. Doing so will not only enable quick and efficient acquisition, but the knowledge gained will be better remembered and will have an impact on behaviour. Using TEL offers great opportunities to build efficient and effective learning programs, but the powers that TEL provides may also overwhelm the human cognitive system. Thus, they bring to the forefront the need to make cognitive technology fit and work well with the architecture of cognition (Dror 2005).

Second, when we consider specific technologies (and their usage) we need to examine what they offer as well as what they may limit. This applies to a variety of TEL in which we need to understand how the use of electronic boards and visualization tools, e-learning, synchronic vs. a-synchronic remote learning, blackboard, simulation and gaming, interactive videos and virtual realities, and other specific TEL environments affect learning and the learner. Lets take an example of a very basic and widely used tool: PowerPoint. An increasing number of learning and training presentations are provided via PowerPoint. This TEL specific tool offers a gold mine in terms of presenting information in a succinct and clear fashion. It enables us to present multi-media and complex information in an easy manner that simplifies learning. However, the use of PowerPoint has also had a detrimental affect on learning. This tool has been used many times in a very limited and expected format, resulting in boring and ineffective learning. It is not the tool itself, but the way it is used. This is a fundamental point across cognitive technologies: they offer great opportunities, but also have vulnerabilities. These gold mines and land mines are highly dependent on how we utilise these technologies, rather than on the technologies per se.

Third, and finally, TEL needs to be considered and understood in light of learning objectives: not only the acquisition of information, but also the ability to retain and use it. Learning, in all its stages, depends highly on the learners paying attention and being engaged. Learning technologies offer real opportunities in this regard. Beyond specific TEL tools, such as simulation, gaming, and interactive videos, which are designed for this purpose, all TEL enable us to promote a great deal of active learning. For example, providing control to the learners helps to achieve active and motivated learners, and when they are involved, participating, engaged, and interacting with the material, then learning is maximised. It is maximised because it activates and correctly taps into the cognitive mechanisms of learning, such as attention, depth of processing, and other cognitive elements of learning. TEL enables us to shift from merely exposing the learners to the material, to transforming the learning environment.

In terms of control, the learners can be given control over the presentation format of the material. Because learners have different experiences, cognitive styles, etc., they may have preferences for the way the material is delivered (for example, visual vs. auditory, text vs. diagrams, etc.). Giving them control over the format of presentation not only gives them control but also optimises and tailors the learning to the individual learner. At a more basic level, learners can control the pace of learning (e.g., when to move on to the next item/page, and whether to repeat a section before moving on to the next). Thus, this illustrates that TEL can help to establish active and motivated learners, and bring about engagement, involvement, participation, and interaction. These are all critical ingredients for achieving effective and efficient learning.

However, as with other cognitive technologies, TEL can have detrimental affects. It can hamper learning by utilising its powers to provide too much to the learners, and thus end up making them passive. For example, memory is probably one of the most important dimensions in learning because learning most often is aimed at conveying knowledge to the learners so they retain and remember it. TEL can hinder memory by its very nature and merit. One of the appealing elements of technology is its ability to provide information in a very effective way; many times by taking the burden off the learners. However, if not done properly, reducing the effort and work involved in learning is not necessarily good (Bjork and Linn 2006). It may promote 'spoon feeding' the material, which makes the learners more passive and decreases their depth of processing, leading to reduction in retention and memory of the learned material. The use of TEL does not only affect the efficiency of how we acquire and retain information, but it is changing how we learn and what learning is all about.

I have used data exploration and investigation and Technology Enhanced Learning to illustrate cognitive technologies and to exemplify the gold mines and land mines they introduce. These opportunities and pitfalls are --of course-- not limited to these two domains that I have used for illustrative purposes. Mobile phones are highly used technologies that have transformed how we communicate with one another, the language we use, how we access and store information, and so forth. Like the other cognitive technologies I have discussed, this device offers new and great opportunities, but also can have a variety of detrimental affects. Cognitive technologies are growing, both in terms of new technologies emerging and also in terms of their wide usage in a variety of human activities. It is thus important to consider their full impact. What we need to understand is that cognitive technologies are no longer just aids in helping humans achieve their goals, but that they are becoming so engrained into the cognitive process that they affect it and who we are.

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Making faces with computers

Witness cognition and technology*

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Knowledge concerning the cognition involved in perceiving and remembering faces has informed the design of at least two generations of facial compositing technology. These systems allow a witness to work with a computer (and a police operator) in order to construct an image of a perpetrator. Research conducted with systems currently in use has suggested that basing the construction process on the witness recalling and verbally describing the face can be problematic. To overcome these problems and make better use of witness cognition, the latest systems use a combination of Principal Component Analysis (PCA) facial synthesis and an array-based interface. The present paper describes a preliminary study conducted to determine whether the use of an array-based interface really does make appropriate use of witness cognition and what issues need to be considered in the design of emerging compositing technology.

1. Introduction

Despite the recent advances made in physical and photographic identification, the eyewitness continues to play a central part in police investigations. That witnesses tend to be somewhat less than reliable has become a phenomenon well documented in research (for example see Cutler and Penrod 1995) and, as a result, juries are warned against placing too much store in witness testimony in both UK and US courts. Perhaps the most important information that an eyewitness can supply is that relating to the identification of the perpetrator, but unfortunately this form of evidence is just as prone to error, if not more so, than more general forms of information about the crime.

Of key importance are the cognitive processes involved in encoding, storing and retrieving the face of the perpetrator. There is little, if anything, that can be done to improve the encoding and storing stages of this process, beyond only using witnesses who got a 'good look' at the time of the event; so it is the retrieval