Experts and technology: Do's & Don'ts

As technological innovation progresses, people are increasingly seeing tasks that were once performed by humans shifting into the domain of the machine. Are we inevitably going to reach the state where technology can perform and take over any human activity? And even if it were possible, do we want to reach this state? Leaving aside the moral, philosophical, and social aspects of this trend, what is the most efficient and productive way to use technology, in terms of its interactions and in relation to humans?

We live in a world where technology is increasingly 'taking over' from humans, particularly in activities that are considered mundane. However, in more sophisticated tasks, such as in biometric identification, which relate to a core human cognitive activity, technology faces interesting challenges. We have seen, time and again, that the great promises and aspirations of new technologies fail to deliver and live up to their expectations. One reason for this is the underestimation and dismissal of the sophistication and complexity underlying human ability.

The role of such technology, which can be characterised as 'cognitive technology', is to undertake mental and cognitive activities previously performed by humans (*Dascal & Dror, 2005*). In the case of biometrics, this relates to one of the most basic human cognitive abilities – identification of each other. This ability is well rooted and justified by evolutionary and survival needs to constitute a critical human cognitive ability. Indeed, humans are very good at identifying each other and possess distinct brain regions which specialise in such tasks (*Dror & Stevenage, 2000*).

Although all humans excel in identifying each other, this ability is limited to specific types of information, such as facial features. Other types of biometric identification, such as fingerprints, DNA, ear marks and handwriting require specialised training and experience. These types of biometric identification require human experts who have attained highly skilled expertise.

As technologies advance and infiltrate human cognitive abilities that were once solely the domain of human experts, we need to consider the advantages as well as the potential pitfalls of using technology in these areas. The need for using technology is clear, but its role and interaction with human experts (and its implications) has been relatively neglected. Such an examination is critically needed in order to understand which roles are best left to humans (if any), and what is the optimal way to integrate the technologies; thus optimising the development and usage of such technologies.

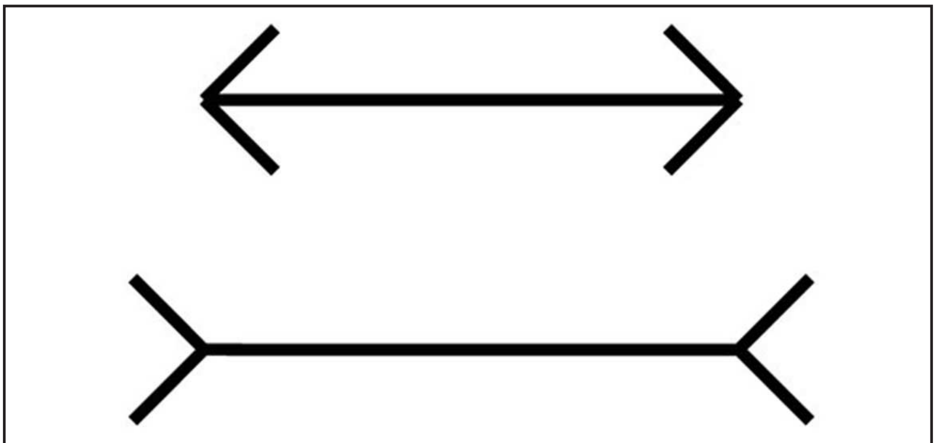

Figure 1.

Strengths and weaknesses

To answer these questions and to start composing a list of *do's and don'ts* in technological ventures it is first necessary to consider the relative strengths and contributions of human experts, as well as their weaknesses and vulnerabilities. This, of course, has to be considered in light of the strengths and weaknesses of the competing alternative technologies. Where do human strengths complement technological weaknesses, and where do the human vulnerabilities need 'technological' assistance, if not replacement altogether? Let us briefly consider some elements in human cognition and expertise so we can properly begin to evaluate these questions.

Human cognition is an active and dynamic system. Rather than perceiving and processing information passively, letting the incoming data drive the system, humans actively interpret information. We use our past experience and expectations (to name but a few) to organise, interpret, and evaluate what we see and perceive from the environment. In fact, much of what we see depends on us and our cognitive system rather than on what is really out there (*Dror, 2005*).

In this sense we impose our conceptions and perceptions on the world rather than it on us. This creates a great vulnerability to distortions at all stages of cognitive information processing, from simple 'automatic' perception to more demanding active decision making. Even when we make simple perceptual judgements, our system interferes with the data and may create misperceptions and distortions. See, for example, the two lines displayed in Figure 1.

Although the top line looks to us as shorter than the bottom line, both lines are in fact identical in length. Thus, we incorrectly perceive and judge the length of the two lines. The cognitive system not only has the potential to distort the incoming data, but it can also add information and

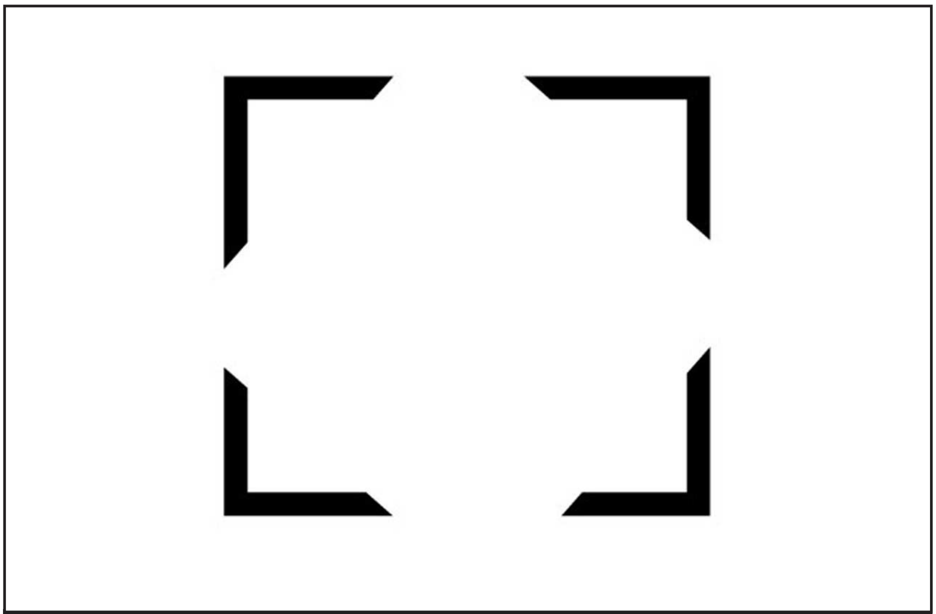

Figure 2.

make us perceive things that are not actually there. For example, in Figure 2 most people see an imaginary white square on top of a black square.

These phenomena relate mainly to the perceptual level. However, even more alarming and dangerous distortions may occur at the cognitive and psychological levels. Wishful thinking, state of mind, self fulfilling prophecies, and confirmation bias are examples of such distortions and they all derive from the very architecture of the human mind.

Take for example how emotional state can affect how humans evaluate biometric information. In a recent experiment conducted in my research laboratory we found that people are more likely to judge a pair of fingerprints to be a match under an emotional condition (*Dror, Péron, Hind, & Charlton, 2005*). In the study we presented fingerprints within different contextual backgrounds. Some prints were presented within highly emotional contexts and were accompanied with graphic photos from horrific crime scenes.

The same pairs of fingerprints were more likely to be judged as a match when they were presented within an emotional context than when they were presented in an emotionally neutral condition. The effect of the context was most apparent when fingerprints were partially missing and ambiguous (see *Dror, Péron, Hind, & Charlton, 2005*, for details).

In real life

We wanted to see if such cognitive and psychological influences would affect real fingerprint experts in their everyday working routines and environments. We set out to collect data from fingerprint experts from our data base of expert fingerprint examiners that had agreed to volunteer in our research. The volunteer experts come from a variety of fingerprint laboratories and forensic science institutions from different countries (including the United Kingdom, United States of America, The Netherlands, Israel, and Australia). During the data collection the experts are not aware that they are actually taking part in a psychological research experiment.

To obtain a very reliable measure to examine contextual affects we examined how fingerprint experts may evaluate the same pair of fingerprints under different contexts. Thus, we collected pairs of fingerprints from archives, going back to fingerprint-based positive identifications made five years ago. We then presented the same fingerprints again to the same experts but now provided an external extraneous context that strongly suggested that the fingerprints were not a match. Unknowing that they had previously judged these very fingerprints as a match, in the new extraneous context, most ofalmost all the fingerprint experts now judged the fingerprints to be a non-match (*Dror, Charlton, & Péron, 2005*). Thus, context infiltrated the experts' 'objective' and 'independent' judgements: although the fingerprints were identical on both occasions, the experts made differing, indeed conflicting, decisions.

This experimental data illustrates the vulnerability of humans, even highly trained and experienced experts, to cognitive and psychological effects that can influence and even distort their perceptions and judgements. This clearly points to a weakness in human expertise and makes the use of technology appealing.

Non-bias technology

Technology is not only superior in its ability to compare vast amounts of information without error, but it is not susceptible to such psychological and cognitive vulnerabilities. Recently a number of fingerprint experts from the United States Federal Bureau of Investigation (FBI) positively, but erroneously, identified an innocent Muslim man as a terrorist bomber (for details, see *Stacey 2004*). Using current biometric technology, an Automated Fingerprint Identification System (AFIS), the fingerprints from the bombing scene were compared against millions of fingerprints stored in data bases. The most likely matches were highlighted by the AFIS technology and then provided to human fingerprint experts, who then made a positive match to one of the highlighted fingerprints. However, when the human experts judged the fingerprints, psychological and cognitive contextual elements distorted their judgements and gave rise to an erroneous identification match.

Interestingly, technology may have played an indirect part in this erroneous identification. Many of the psychological and cognitive effects are most pronounced when the identifications are more difficult and challenging (such as when some information is missing or ambiguous). Because of biometric technology it was possible to compare the fingerprint from the bombing scene against millions of fingerprints. Such powerful comparisons – at least in quantity – being made across vast amounts of data is likely to result in finding similar fingerprints by pure coincidence. The similarity of the fingerprints highlighted by AFIS makes the task of the human experts especially challenging (*Ashworth & Dror, 2000*). This similarity creates greater opportunity for the external extraneous information to make a substantial and perhaps critical influence.

Intuitive humans

The underlying human cognitive architecture is the root of such distortions and influences. However, this same architecture is also what underlies the extraordinary ability of human experts, those abilities that are lacking in technology. If we take fingerprints as a case study, the technology can make good identification when the fingerprints are clear and intact, but when the matching gets to be more complex, when the process of identification needs to be active and dynamic, then human experts are needed.

This situation in fingerprint identification is also apparent in other biometric measures, for example in face identification (*Dror & Shaikh, 2005a*). The need for human expertise exists in almost all cases that are special and not 'run of the mill', straight forward comparisons. In fingerprint identification it is not only when fingerprints are partial and distorted, but also under other tricky situations, for example, when you need to compare fingerprints taken from a juvenile and compare them against adult fingerprints.

Hence, the root of some mistakes derives from the same abilities of human experts that enable them to excel. Those abilities that allow them to make 'leaps' based on intuition and experience; when a hunch and tacit knowledge can guide their thinking and investigation; when human experts can use and combine multiple levels of information in parallel (such as holistic characteristics and piecemeal feature components, *Smith & Dror, 2001*).

A combined approach?

Technology is very advantageous and offers many opportunities, but it too has vulnerability. Its inherit inflexibility, tunnel vision, and passive information processing, to name but a few, can easily lead it astray. It seems then that both human expertise and technology both possess very strong and crucial elements, however, both also have weaknesses. Thus, rather than conceptualising them as competing and fighting for supremacy, it is better to find the best way for their integration and cooperation.

The key to constructing the most efficient and effective system is through understanding the characteristics of human cognition and technology, and then to integrate the advantages that each has to offer. Through the correct balance a mutually complementary contribution can be achieved.

Based on knowledge and understanding one can then start to construct a list of *do's and don'ts* when trying to develop technology in areas of human expertise. Based on a few points raised in this paper, one can start compiling such a list. It would suggest, to begin with, do consider the weaknesses of human experts and how technology can complement them; do develop a system that integrates technology with humans so they work together in a cooperative partnership; do not overestimate technology; do not hastily think of disposing the human experts and replacing them with technology.

These initial thoughts on the *do's and don'ts* when considering technology and human expertise only relate to one aspect of development and integration of technology. Other equally important aspects that must be considered relate to the user of the system. For example, consideration on how to train humans to operate and work with such cognitive technological systems (*Dror & Shaikh, 2005a*) should be made, and how to design the technology with the proper tools and utilities in a way that is most effective and needed by humans (*Dror & Shaikh, 2005b*).

In addition to all of these, one needs to consider how humans will need to make decisions based on the technological system, especially when decisions will be made under time pressure and will involve risk taking (*Dror, Busemeyer, & Basola, 1999*).

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