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INTREEREDE

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Dear colleagues and friends,
ladies and Gentlemen,

The technological advancements of the 20th century, particularly during the second part, have been astounding and had an incredible bearing on every aspect of our life. The economic accomplishments of Western societies and the standard of living they have reached are largely due to technological innovations and their introduction into the different sectors of the economic system. They have afforded important and often dramatic benefits in almost every domain, including transportation, production, health services, education, and entertainment.

The impact of many technologies has infiltrated into each and every facet of our life. To mention just one example, only two decades ago, when I was working on my doctoral dissertation I had to painstakingly go a hundred times over the text to ensure that it is complete. Once it had gone to the typist changes were extremely costly and often required retyping the entire manuscript from scratch. Ten years later, with the introduction of personal computers and word processors, it has become possible to make any correction or modification one wishes without any real trouble. Not only have word processors facilitated the task of writing a manuscript, they have really transformed it into a different type of task. Indeed, computers have become an essential and indispensable component of the work place and, according to estimates, during the coming year more than 3 billion guilders will be spent in the Netherlands on new computing equipment by the private and public sectors. Similarly, computers have become a major tool for education, play a crucial role in different segments of the service sector, and are becoming an integral part of an increasing number of households.

What is particularly remarkable is the increasing pace at which new technologies are being discovered and implemented. The rate of change and innovation and the flow of information are growing exponentially, often to the point that people have difficulties in remaining updated. Many visions that were considered as a fiction only a century ago have become a reality and the limits for further advancements are difficult to assess.

Universities and institutes of technology have been playing an important and crucial role in these developments, which are considered to be a primary component in maintaining the present economic growth. Whereas the function of such universities in a technological

society may seem to be self evident, the role of the social sciences in such universities is probably less obvious. What could be the possible contributions of the social sciences to a technological institution? More specifically, what could the relevance of an experimental cognitive psychologist like myself be, and what can he offer to an academic technological environment? I would like to use this unique opportunity to reflect on these questions and share with you some of my recent thoughts.

Before I start to answer these questions I would like to make two introductory remarks regarding the fundamental presuppositions underlying the field of cognitive psychology. First, experimental psychology has been dominated during the past three decades by the so called *human-information processing* approach. A major impetus to the rise of this approach, even if implicit, have been the advancements in information technology and in particular the development of computers. In this context, implicitly or explicitly, the computer has been adopted as the most suitable and natural metaphor of the human mind. The link between the mind and the computer has ostensibly become so close that intelligence has been attributed to both, with the difference that the latter has been qualified with the term artificial.

Whether *artificial* intelligence is the most *natural* way to study the human mind remains an open question, if only for the fact that 'natural' and 'artificial' are far from being compatible terms. It is certainly not my intention to underrate the contributions of artificial intelligence to the cognitive sciences. Indeed, many insights have been gained from artificial intelligence, specifically in areas such as problem solving and expert systems. Nonetheless, conceiving of the human mind as an ultra mighty computer led to a heated debate. As John Searle has noted, there are two camps holding different views with regard to the role of the computer in studying the mind. The so called *weak* version of artificial intelligence views the principal value of the computer in the study of the mind as merely a tool, albeit a very powerful one. Proponents of the *strong* version of Artificial Intelligence have a much bolder assertion: They claim that an appropriately programmed computer is synonymous with the mind. Thus as Searle noticed, "In strong AI, because the programmed computer has cognitive states, the programs are not mere tools that enable us to test psychological explanations; rather, the programs are themselves the explanations".[1]

The issues involved in the controversy regarding weak and strong artificial intelligence are complex

[1] *J. Searle "Minds, Brains, and Programs". The Behavioral and Brain Sciences, 1980, vol 3,*

and intricate and it is not my intention to elaborate on them here. Suffice it to say that my personal stance is unequivocally behind that of Searle who, in my opinion, presents convincing arguments against the strong position of artificial intelligence. Furthermore, although the issue is clearly far from resolved, even the most zealous advocates of the strong view would admit that it will take a very long time until their vision can be materialized. Meanwhile, we may use the potential benefits of artificial intelligence in studying the mind while not abandoning the more traditional methods of the social sciences in general and of psychology in particular.

Let me add a point to which I will return at the end of my talk. To this date, most of the work on artificial intelligence has been almost exclusively limited to cognitive tasks. According to Webster's dictionary, cognition refers to the faculty or the process of knowing or perceiving. Following the common usage, cognition does not encompass the passions in the broader sense of the word, including emotions, motivations and moral issues. The claims of strong artificial intelligence regarding these facets are even weaker and remain on a rather abstract level. Furthermore, and without undermining the achievements embedded in the work of researchers such as Schank or Newell and Simon, even at the cognitive level the achievements should not be overstated. The recent claim made by the late Allan Newell[2] alleging that we have reached the point of a unified theory of cognition seems to me premature, and is more a reflection of wishful thinking rather than a reality.

The adoption of the human-information processing paradigm and its association with the computer metaphor warrants an additional remark. It concerns another basic premise underlying much of the social sciences, namely that of rationality. The idea of a rational organism or a rational agent has been central to most of economic theory during this century and has, at least implicitly, been endorsed by other branches of the social sciences. The rational agent is assumed to be guided solely by the cognitive architecture in which the canons of logic and mathematics serve as the fundamental building blocks or, if you want, serve as the operating system.

It is of course accepted that the cognitive system is error prone. Due to limitations in both memory and processing capacity, the cognitive system does not always operate optimally. Simon, for instance, proposed that the system is not geared to achieve maximization, and has

[2]. *A. Newell, Unified Theories of Cognition, Cambridge, MA: Cambridge University Press, 1990.*

coined the term *satisficing*, which supposedly offers a better description of human behavior. Satisficing implies a criterion that is less than optimal and yet satisfies the most essential needs or desires of the decision maker. There is accumulating empirical evidence, specifically in the decision making literature, suggesting that human behavior is often incompatible with some basic premises underlying the description of a rational agent. As a consequence, the assumption of rationality, even if viable under certain limiting conditions, has been seriously questioned.

The presupposition that behavior is controlled by an information-processing setup combined with the assumption of rationality provides a perfect match with the underlying principles of technology. Indeed, information technology has been the most dominant and influential component of the technological revolution, and this technology is based entirely on rational grounds. Thus, there is a clear link at the most fundamental level between cognitive psychology, or, more broadly, the cognitive sciences and technology. How can this link be further utilized in practice? There are a large number of applications of which I would here mention only a few.

One of the most noticeable applications can be found in the field of cognitive ergonomics or what is often referred to as human factors, which deals with the problems of human-machine interactions. The field emerged during World War II specifically to meet the demands from pilots in the cockpits of military airplanes. The two major and related problems concerned the division of attention among different tasks, and designing the different required operations such that the cognitive load would be minimal. Ergonomics has since then grown to be a field that stands on its own. Its major domain is the study of humans' interface with their environment. It aims to assist in the design of new technologies such that they would be compatible with the capabilities of human beings and their limitations. Indeed, the significance of compatibility between input and output has long been recognized by students of human performance. Engineering psychologists have discovered that responses to visual displays of information are faster and more accurate if the response structure is compatible with the arrangement of stimuli. Thus a response to a pair of lights will be faster and more accurate if the left light is assigned to the left key and the right light to the right key, rather than an opposite assignment. Similarly, it is easier to control a square stove with four burners with a matching square array of knobs than with a linear array.

The introduction of new and more

complex technologies places growing demands on the users in terms of learning to utilize these technologies in sensible and optimal ways. People often develop mental models, a kind of a simple theory, of how certain devices work and use this mental model as an operational guideline. Unfortunately, these models are often inaccurate, or in the worst cases totally wrong. We are all familiar with the scene in which people continue to push the lift button vehemently, obviously to no avail. It seems as if they are trying to wake up the homunculus that is responsible for operating the lift, exactly as they honk the horn to remind the driver in the car in front of them that the light has turned green. Psychologists can try to identify these mental models and assist in two ways, either by helping to modify the design of the device so that it is more compatible with existing common mental models, or alternatively by developing appropriate instructions that will help people to get rid of faulty models.

Designers of technological inventions usually assume, implicitly or explicitly, that humans are logical and sensible creatures. We may let human beings enjoy the benefit of the doubt, yet, as John Locke noticed already in his *Essay on Human Understanding*, "all men are liable to error". The psychological study of human errors and the circumstances under which these are likely to occur can lead to design improvements that may not only save costs but also increase safety and reduce the probability of an accident.

Up to this point I have briefly mentioned some domains in which the knowledge accumulated in the psychological sciences can be of enormous value to a technologically-geared society. It can assist and expedite the interaction between humans and their technological environment, help identify the needs and preferences of individuals and of society at large, and aid in designing newly-introduced technologies so that they will become more compatible with humans capabilities. In addition, based on principles of cognition and learning, educational methods can be developed to facilitate the comprehension of the underlying principles of technological devices and their operation. In all the examples and applications I have mentioned up to now, and the list is far from being exhausted, the gains to be made from the interaction between the psychological sciences and technology are transparent and direct. However, I believe that the social sciences in general, and psychology in particular, have additional important functions in any technologically-oriented institution. Although these functions are not always immediately apparent, they are nevertheless highly important. Evidently, because the potential

gains of these functions are not always direct and measurable, they have often been overlooked and underestimated. I will elaborate on two issues which I hope will suffice to clarify the message.

The introduction of all the technological marvels (be it supersonic airplanes, television and VCRs, microwaves ovens, fax and e-mail, and the list seems to be endless) has certainly advanced our standards of living. But whether the comforts afforded by all the technological spectacles have made our environment a more "fulfilling" place to live in remains an open question. Technology has undoubtedly solved many of our daily problems, yet at the same time it has created numerous new ones. The belief that all problems will eventually be solved by an appropriate technological breakthrough is not only naive but may also be dangerous: It creates an illusion that can never be made true. In a recent book entitled *How to Want What you Have* psychologist Timothy Miller observes that "people spend their lives honestly believing that they have almost enough of whatever they want. Just a little more will put them over the top; then they will be contented for ever". As Miller notes, this is a built-in illusion. A similar illusion is created by the technological paradigm: Just some more new gadgets, faster computing facilities, some additional improvements in operating devices, and all the problems will be solved. We will be contented for ever.

The approach taken by technology to solve the problems and ailments of society is often too narrow. Problems and their corresponding solutions can be viewed from more than one perspective. In this regard I would like to briefly mention some recent work by Jerome Bruner. A pioneer in the systematic study of problem solving and thinking, he published in the mid fifties a book entitled *A Study of Thinking*[3] which was one of the precursors of the cognitive revolution in psychology and remains a classic to this day. Approximately twenty years later, Bruner realized that there is more to cognition than pure rationality. Specifically, Bruner proposed that a distinction be made between two modes of reasoning that he termed the "*paradigmatic*" and the "*narrative*", and which he claimed are fundamentally different.

The paradigmatic mode is what we usually refer to as logical reasoning (in the broadest sense) and which at its most developed level fulfills the ideal of a formal, mathematical system of description and explanation. It is characterized by strict requirements of consistency and non-contradiction and constitutes a fundamental building block of the rational approach. We know quite a great

[3] *J.S. Bruner, J. Goodnow, and G.A. Austin. A Study of Thinking. New York: Wiley, 1956.*

deal about this mode and, over thousands of years, have developed a powerful set of devices, of which logic, mathematics, science, and most recently information science are its most advanced manifestations.

We know less about the narrative mode, which is more diffused and vague, though its existence cannot be denied since it is often reflected in our gut feelings. This mode deals with experiential facets that are subjective in nature and hence is more qualitative and difficult to quantify. It is this mode the use of which leads to good stories, gripping drama, and believable historical accounts. One essential difference between the two modes concerns the time dimension: The paradigmatic mode is universal and timeless whereas the narrative context is temporal and context-bound. A second important difference between the two modes concerns the establishment of truth: The paradigmatic mode employs formal verification procedures and empirical proof. In contrast, in the narrative mode it is not exactly truth that is established, but rather what Bruner terms truth-likeness or verisimilitude. There is little in the paradigmatic mode, specifically as it is reflected in science and logic, that corresponds to narrative poetic episodes. Falsifiability, as proposed by Poper, may be imperative for the appropriate conduct of science, but believability is the essence of well-formed narrative. Applying criteria of falsifiability to a narrative empties it of its content.

Bruner's main point is that each of the two modes provides its own way of ordering experience, of constructing reality, of organizing representation in memory and of filtering the perceptual world, and as such each merits its own status. Rational considerations (in the broadest sense) are processed solely by the paradigmatic mode. But as Bruner points out, the narrative mode has its own virtue and plays an indispensable role in our daily life. Most important, though the two modes are not necessarily contradictory, they are irreducible to one another.

In short, without undermining the importance of rational and analytical thinking, it remains the case that other considerations represented in the narrative mode may often prevail. Extending somewhat Bruner's definition, I include in the narrative mode the facet of passions. Behavior is frequently either partly volitional or totally non-volitional, even in situations characterized by substantial deliberation. Although we usually hope that in the case of a conflict between reason and passion the former will reign, we should not understate the latter. For immediate behavioral decisions, emotional feelings may compete with knowledge and regulate actions in a direct manner. From an evolutionary

perspective, emotions ensure survival by eliciting adaptive responses like protection, destruction responses, or reproduction. There are situations in which we explicitly hope that emotions will play a role. As a good colleague of mine pointed out, "would we want important decisions to be made in cold blood?". The revulsion of calculating the value-of-a-life is an example, despite the fact that sometimes such calculations are inevitable.

The fundamental assumptions of rationality have recently been challenged by myriad controlled experiments on judgment and choice. Starting with the ingenious research program of Daniel Kahneman and Amos Tversky, and followed by numerous other researchers, a wide range of behavioral violations of the rationality assumption has been documented in both the economics and psychological literature. Generally speaking, these violations can be divided in two categories, which following Bruner's classification I will term paradigmatic and narrative.

Examples of the first type, the so called paradigmatic violations, are abundant: People make systematic errors in estimating probabilities by wrongly integrating available information, or sometimes by ignoring it all together. They make intransitive choices, as for instance stating a preference for one gamble over the other and yet willing to pay a higher price for the unchosen one, the so called *preference reversal* phenomenon. Sometimes they even reject options that are clearly dominant on any possible dimension. The common denominator to these, and to many other similar violations, is that they are cognitive or perceptual in nature and mainly result from the use of heuristics and strategies that are supposedly developed to overcome capacity limitations in both memory and information processing. Evidently, the evolution of the human mind is slower than the evolution of computers.

The narrative type of violations is of different nature. These violations stem from the fact that people take into account considerations other than profit maximization or, more generally, utility maximization. These considerations include emotional, motivational and ethical considerations. For instance, several studies have shown that considerations of fairness, though irrelevant to rational economic analysis, may play an important role in the decision process and explain results which are anomalous in a perfectly rational world. As an example, consider a car dealer who is raising the price of a popular model by 200 dollars because of a temporary shortage in the production of this particular fashionable car. The majority of subjects in a study conducted by Daniel Kahneman and his collaborators[4] believed this rise to

be unfair. Another group of subjects were told that the dealer was originally selling the car at a discount of 200 dollars and had canceled the discount because of production shortage. The majority of subjects in this group found the move acceptable, although from a normative rational viewpoint the two problems are identical. Inconsistent and suboptimal choices resulting from such considerations can be justified, but the justification is obviously not based on common rational grounds.

I would like to devote the remainder of my talk to a specific source of human suboptimality in decision making. I have chosen this particular case for two main reasons: Its generality, and the important implications it has for both individual behavior and the society at large.

A well-documented phenomenon in the psychological literature on both animals and humans is the so-called *positive time preferences*. Evidently, animals and humans have a strong and pervasive preference for immediate over delayed rewards. For example, in a recent experiment conducted in collaboration with Peter Roelofsma, we asked subjects which of two options they would have preferred: an immediate payment of $f$ 100 or a delayed payment of $f$ 110 in four weeks. Economic wisdom based on the canons of rationality would unequivocally prescribe the second option. In fact, on a yearly basis, the second option offers an annual interest of more than 100%, a gracious return according to any standards. Nevertheless, as it turned out, 82% of our subjects expressed a preference for the first option.

A general and elaborated framework to account for the preference for immediacy is provided by the *Matching law* that was originally formulated by the late Richard Herrnstein. A basic phenomenon in this context is what Herrnstein termed *melioration*, which is the tendency to choose that alternative with the currently higher yield in utility. The important point is that the process is characterized by a failure to take the effect of current choices on future yields into account. Let me use an example borrowed from Herrnstein to clarify the nature of melioration and its consequences.

Consider a hypothetical consumer, call her Mrs. Technol, who is following a strict diet that consists exclusively of hamburger and caviar. Let us further assume that both are obtained free of charge, so that Mrs. Technol can consume an unlimited amount of caviar and hamburger. How should Mrs. Technol determine her exact diet? Every time she has to make a choice between the two

[4] *Kahneman, D., Knetsch, J.L. and Thaler, R. Fairness as a constraint on profit seeking. Entitlements in the market. American Economic Review, 1986, 76, 728-740.*

options, she will tend to prefer the luxurious caviar. However, as we all know, the consumption of even the most luxurious types of food can only be carried up to a certain limit. The consumption of foods and goods tend to saturate. The more of the caviar we consume the less attractive it becomes or, alternatively, the marginal utility from consuming a unit of caviar constantly decreases. In fact, a major appeal of luxurious items is indeed their rarity.

In choosing between the two types of food, a rational consumer - that is, a utility maximizer - would take into account not only the current utility of each type of food, but also the negative impact of current caviar consumption on the utility derived from future caviar consumption. Thus, a rational consumer should self-ration caviar consumption such that its utility is always greater than that of hamburgers. The utility of consuming caviar, say once a week, is so much larger than the utility of consuming it daily, that overall the consumer will achieve more by consuming the caviar less frequently. In practice, however, Mrs. Technol will probably tend to be a meliorator, in other words, she is likely to ignore the impact of caviar on her future tastes and consume caviar to the point where its current or marginal utility is equal to (matched with - hence the matching law) the current utility obtained from hamburger consumption.

Melioration and the matching law are based on widely established laboratory results and are applicable to a vast variety of non-laboratory settings. Melioration can be represented as a sort of local maximization in which certain indirect effects are ignored or underweighed, and as such it deviates from normative rational prescriptions. Note that melioration is also a type of partial maximization, but the maximization is only in the short run. It overlooks a long-run perspective and thus reflects a myopic approach.

It is certainly not the case that melioration always overrides. There are situations in which matching and rational maximization converge to the same solution. However, when matching and maximization make diverse predictions, behavior is often (but not exclusively) closer to matching than to maximization. One lacuna in the matching law, as formulated by Herrnstein, is that it does not take uncertainty into account. As I have elaborated elsewhere, the greater the uncertainty involved, the more likely it would be to lean toward matching, and such behavior might, under certain circumstances, be judged as sensible. To take an extreme case, a patient with a terminal disease would be better off by adopting a short-sighted view and follow a matching strategy. We should however be careful not to use the uncertainty argument as a justification for any

myopic behavior. The problem is that people often have difficulties in coping with uncertainty. Myopic behavior is an escape from uncertainty but it does not offer an adequate solution.

What are the implications of melioration and the matching law? At the individual level it portrays human behavior as often being guided by short-term considerations. In extreme cases, like for instance drug consumption, such behavior may result in very grave consequences such as addiction. But even without going to such extreme cases, shortsighted behavior may frequently lead to suboptimal outcomes. Evidently, self control, a topic that has recently attracted much attention from psychologists, is a key concept in the evaluation of rationality, though our knowledge in this regard is very limited indeed.

Almost three decades ago, psychologist Walter Mischel and his collaborators launched an ingenious research program on self control. In the classical setting of their experiments, children aged 4 to 6 were invited individually and placed in a plain room, where a gentle torment then begun. "You can have this marshmallow right now", the experimenter said placing a marshmallow on the table in front of the child. "However, if you wait while I run an errand, you can have two marshmallows when I'll get back". Whereupon the experimenter left for a few minutes.

As you can imagine, this was not an easy test for those youngsters, and the results of these experiments did not yield a homogenous picture. Some children grabbed the sweet right away and consumed it immediately. Others had shorter or longer deliberations before they gave in. Finally, there was a group of children who were able to stand the temptation all along and, as promised, got their hard-earned reward. The most interesting insights from these experiments were obtained many years later, by the time these children had reached high school[5]. A survey of the children's parents and teachers revealed that those children who as four year olds had demonstrated self control by having the fortitude to hold out till the experimenter returned, generally grew up to be better adjusted and were more popular, adventurous, confident, and dependable teenagers compared to those who gave in to temptation. Even on the scholastic aptitude tests which students in the United States take when applying to university, the self-controlled group outperformed significantly compared with the rest.

The failure to delay gratification, or

[5] *Mischel, W., Shoda, Y., & Rodriguez, M.L. (1989) Delay of gratification in children. Science, May 1989, 933-938.*

alternatively the lack of self control, is mainly a result of motivational and emotional factors, although cognition may also play a role. The important point to emphasize is that rationality (driven by the cognitive mode) is at best a necessary but not a sufficient condition for optimal behavior. Self control, the ability to be in command of our emotions and motivations is as important for the optimalization of our well being. Indeed, there is a growing realization that intelligence in its broadest sense encompasses more than just cognitive capabilities, and some psychologists these days are even talking about an emotional measure analogous to the traditional IQ, which they refer to as EQ, the emotional quotient. Although difficult to quantify, an important ingredient of EQ is self control and the ability to delay gratification.

Incidentally, this ability is certainly of the utmost importance for the conduct of science. The image people often entertain of important scientists, being born as super thinking machines may be somewhat distorted. Without undermining the intellectual competence of these scientists, one may wonder why natural talent seems to ignite in some and not in others. It is here that the marshmallows come in handy. Distinguished scientific achievements require painstaking work, in which the temptation for partial and incomplete gratification can be mastered. It is this skill, which often does not show up in traditional IQ tests, that may often be crucial.

The potential losses that may result from a myopic or short-sighted view, are not limited to the behavior of individuals and equally apply to decisions and policy making by small or large organizations. I will briefly mention here two specific implications that are of special relevance to the academic environment.

One is directly related to the conduct of science and the way it is practiced. During the past 20 years there has, in most western countries, been a gradual yet unmistakable and consistent shift in preference towards applied over basic research. Although the two are not necessarily contradictory, and in fact are often complementary they are, in several respects, nevertheless of a different nature. I would like to elaborate on one dimension on which the applied and basic perspectives take diametrically different stands. This is the time dimension.

I should make it clear at the outset that I strongly believe that both applied and basic research should at the end yield some benefits for the welfare of individuals and society. What remains open concerns the sort of benefits and the time span within which these benefits can be

harvested. Applied research by its nature poses questions that are addressed at a specific problem and that usually have to be solved within a pre-specified temporal schedule.

The specificity of the problem implies that whatever the results of the corresponding applied research, their generalizability is limited at best. Because of the tacit expectations for demonstrated results within prespecified time limits, the corresponding research is often shallow and lacks a broader perspective. The emphasis is on producing quick results that, at least in the short run, will be acceptable and satisfy predetermined expectations. Moreover, the production of results ('quick and dirty' as they may be) is essential for obtaining future grants. In a recent scientific program on the BBC that dealt with environmental concerns, a scientist was interviewed on the issue of global warming. In his opinion there was an insufficient amount of reliable evidence to support the conjecture of global warming. The many arguments to support his position are immaterial to the present discussion except his answer to the last question. When asked at the end why serious scientists persist in maintaining that global warming is real and constitutes an actual threat, he responded that if they had abandoned their claim they would have lost all their funding. The point I am trying to make is simply that those who are responsible for research policy often adopt a myopic perspective and in turn sway practitioners of science to follow the same route. The long term perspective receives low priority or is altogether ignored.

Clearly, the picture is not as bleak as I may have portrayed it. Nevertheless, there is a distinct pressure from those who provide the funding for applied research to see their returns as soon as possible. As is the case with any other investment, those who invest in research have the right to expect appropriate returns. However, as with most investors, there is an increasing trend to search and look for fast and rapid profits, those investing in research not excluded. I conjecture that during this century there has been an ever-increasing tendency toward what seem to be demonstrations of impatience associated with a short-sighted view. Like some of the children in Mischel's experiments, we often lack the tolerance to wait even a few minutes before consuming the marshmallow.

My conjecture is not that we have, by some evolutionary process, become intrinsically more myopic. Rather, I suggest that modern life characterized, as I have already mentioned, by an ever increasing pace of change, has altered our time horizon. The many changes that were imposed on us by wanted and unwanted technological innova-

tions, and specifically the swiftness by which they occurred, have gradually changed our perception of time. We are in a continuous race against time accompanied by rapid changes in which what was new only yesterday is, by today standards, considered ancient. Consequently, I suggest that, in order for us to adapt to the new pace, our time horizon has contracted. Indeed, some evolutionary psychologists have recently questioned whether there is not a fundamental mismatch between our genetic makeup and the swiftly changing modern world in which we live.

Returning to my main point, I suggest that because of our contracted time perception, we tend to be more myopic and less patient. Unfortunately, this short-sightedness has also recently infiltrated into much of basic research. Here too there is a growing pressure to produce results within limited and preplanned periods. But research and the search for knowledge can be planned only up to a certain point. It is impossible to provide assurances as to when an investigation will be completed and will yield the proper outcomes. Science is the search for what is yet unknown and is, by definition, associated with uncertainty. If you will, it is a kind of gambling, albeit calculated gambling, and as I have tried to point out calculated gambling on the long (and not the short) run. A typical example of such a far-sighted view is exemplified in Herrnstein's research program on the matching law stretched over a period of three decades.

The short-sighted view characterizing research has also slipped into the education system. Students search for courses in which the immediate benefits in terms of usability and applicability are transparent, or alternatively choose courses that are easy enough so that they can secure a high grade without much effort. The system obviously inspires such a behavior by placing restrictions and encouraging short-term goals. But the aim of higher education should, in my opinion, stretch beyond the acquisition of specific skills. Higher education should aim to train students to develop critical and innovative thinking, and furnish them with the ability to analyze problems from multiple perspectives. Our current education system is too geared to supplying students with skills intended for limited specific goals, often taught in a mechanical and technical manner, and overlooking the importance of productive and critical thinking. The computer metaphor pops up again in this context: The production of good computers and the preparation (note, I am not using the word production) of qualified and constructive students should not be based on the same guidelines.

The second application of meliora-

tion and the matching law, on which I want to draw briefly, is in explicating the behavior of individuals and organizations with regard to environmental concerns. Whether global warming is real or not is still an open question, and likewise many issues regarding environmental protection remain controversial. Nonetheless, there are very few who doubt that we are gradually depleting our natural resources and systematically degrading their quality. Individuals and governments alike, although alarmed by the potential calamities encapsulated in the degradation of our environment, pay lip-service to the issue, yet maintain behavior and policies that are clearly myopic. Indeed, the matching law provides in my opinion an accurate description of a society in which matching, namely the optimalization of current hedonistic needs, dominates the long-run perspective. Technology often contributes to this trend either by supplying us with instruments and goods that will satisfy our short-term desires, or alternatively by imposing new developments on us that are rarely evaluated on the basis of their long-term consequences.

Again, the picture is not altogether bleak. Take for instance the introduction of new medical drugs into the market. Most countries maintain rigorous and often prolonged procedures for investigating not only the effectiveness of the proposed drug in curing the specific ailment for which it was designed, but also for testing possible side effects of these new drugs before they are allowed to enter the market. Why are we so concerned about possible future side effects before we are willing to use a specific drug, and yet so unwilling to pay attention to the possible side effects of our current consumption habits? More generally, what are the necessary conditions required to trigger our long-term judgment and evaluation? This is a basic psychological question, the study of which will yield high dividends both for individuals and society as a whole.

In closing, I would like to return to my original question, namely what can a psychologist contribute to a technological environment like this university. In his classic, "The Character of Physical Law", Richard Feynman emphasized the importance of deriving different formulations for the same physical law, even if these formulations are mathematically equivalent. Such diverse formulations evoke different mental models and can help us make new discoveries. Broadening and generalizing Feynman's idea, I think that cognitive psychologists can offer technology students insight into a different perspective, introduce them to formulations that are different from those they are used to, and expose them to types of problems not all of which can be resolved by

technological means. Enriching students with multiple mental models from different perspectives will hopefully result in preparing well-rounded engineers, who will be attentive to individual and societal needs, and will be able to find the right balance between short run and long run considerations.

Ladies and Gentlemen,

I would like to use this unique occasion to acknowledge all those from whom I have learned in all these years, and whose knowledge and wisdom have influenced my perception of the world. I apologize to all those whom time constraints prevent me from mentioning them explicitly.

My parents were certainly the first to mold my attitudes, judgments and opinions. Like any teenager, I screened and redefined their values (sometimes in a rebellious way), yet I hope that at least some of the essence has remained.

I completed my undergraduate school at the Hebrew University of Jerusalem and was lucky to attend the lectures of some superb teachers. Among the most influential was Amos Tversky who comprised a rare combination of an outstanding scientist and an eloquent and stimulating instructor. He not only inspired my interests in the field of decision making but also taught me how to enjoy it.

Of all my teachers at graduate school, two had a special impact on me. During my first year in graduate school I attended the course of Steve Maier on the topic of animal learning. I had no intention to specialize in this field and until this day I am not sure why I elected it. What I am certain is that I never regretted it for a moment. Beside being the first one to introduce me to Herrnstein's matching law, I was staggered by Steve's depth of analysis and the broad applications he was able to draw from observations that initially seemed to be of little importance.

I owe my biggest debt to Charlie Lewis, an outstanding teacher, a marvelous colleague, and a dear friend. An endless source of knowledge and an unusual statistician, he has assisted me with valuable advice throughout my entire career. Most important, he has consistently offered a model of a scientist for whom honesty and integrity are paramount.

Baruch Fischhoff and George Loewenstein, both from Carnegie Mellon University, frequently provided me with constructive criticism and novel ideas. Both were always supportive, even in times of despair, and despite the geographical distance remain to be close friends.

Since my arrival in the Netherlands fifteen years ago, the list of those to whom I am indebted has lengthened. Herman Bouma and Don Bouwhuis from IPO were marvelous hosts on my first visit here. It was

the unusual hospitality that I received at IPO that served as a major attraction to come back to this country.

Much of the research during my first years in the Netherlands resulted from a fruitful collaboration with Willem Albert Wagenaar. One important lesson that I have learned from this collaboration was to appreciate a person with whom I often had deep disagreements.

Discussions with Jan van Bolhuis, a colleague and a good friend, have always been stimulating and enriched my intellectual arsenal. Nancy Brenner has skillfully refreshed my rusty knowledge in philosophy and during our lengthy conversations I rediscovered its close links with psychology. Joe Brenner has always provided the right advice at the right time, and I am grateful for his continuous support.

I certainly had some difficulties in adjusting to my new environment in Eindhoven. Notwithstanding some differences in opinions I was gratified by the continuous cooperation for which I would like to thank all my colleagues in the department and in the faculty as a whole. Though time does not permit me to mention a long list of names, I would specifically like to thank Cees Midden for his support and encouragement which did not go unnoticed. Although our faculty has gone through tremendous turbulence during the past two years, I nonetheless believe that we are gradually getting on the right path. I hope to be able to contribute to the further determination of this path in the years to come.

Last but not least, I would like to express my deepest love and gratitude to those who have accompanied me in all the ups and downs inherent in navigating the ship. Although it goes without saying, Mira, Yonatan, an Talia have enriched my life in more than one way.

Ik heb gezegd!

Gideon Keren was born in 1942 in Jerusalem, Israel. After attending the 'Hebrew Gymnasium' High School in Jerusalem, he went on to study Economics and Business Administration at the Hebrew University in Jerusalem, where he earned both a B.A. and a M.B.A. degree, respectively. He went to the U.S.A. where he received in 1975 his Phd. in psychology from the University of Illinois at Champaign Urbana.
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