Virtual reality and cognitive processes

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Abstract

The relationship between our actions and their perceivable results is ruled by what we call the laws of nature. It is general understanding that our actions act upon real objects which react according to the laws of nature what then can be perceived. Virtual Reality Facilities (VRFs) simulate the action-perception relationship in a physically correct manner but whithout involving real objects or real events. Just the same do mathematical models of nature (physical theories). So it stands to reason that VRFs can be considered as analog models of nature.

If a physical theory is false its predictions cannot be verified. If a VRF were false we would have strange and unusual perceptions as if different laws of nature would be valid. It is suggesting to say that we would fail to survive in nature when using a false mathematical as well as a false analog model. However, from the most elementary false VRF, Kohler's (1969) prismatic spectacles showing the entire world upside down, we know that we can get well used to this phenomenon without losing our moving competence. So, an analog model of nature can be useful even if it is not 'true'. What we need, therefore, is a theory on the useful interpretation of perceptions which is not based at their truthfulness. Such a theory first of all has to reply the question what criteria useful perceptions have to meet if not truthfulness. This, in turn, will provoke the question what the difference is between real and virtual reality, if 'real' cannot refere to the truthfulness of what we see. Such a theory on useful perceptions, once it is found, can be verified by means of appropriate VRF experiments, i.e. we can check which perceptual modifications are whitin our adaptive possibilities and which are not. It will be shown that the Theory of Cognitive Operators (TCO) (Diettrich, 2001) is a good candidate to solve this problem. We will deal with steady-state simulations of unusual visual patterns as well as with the simulation of high speed phenomena by means of a relativistic flight simulator. We will not consider dynamic effects due to time transformations t' = f(t).

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http://www.univie.ac.at/cognition/books/virtual/

Introduction

Classical thinking is based on the assumption that our perceptions can contribute to mastering nature only if they are correlated to nature either structurally (depicting realism) or functionally (constructivism). In either case, therefore, it holds that our perceptions and the theories we derive from them are statements on the world in the sense that in an entirely different world also our theories about the world must be entirely different.

This is equivalent with the view that there is a clear distinction between perception and action: *perception*, by means of which the world generates our knowledge (i.e. by means of which we get information on a predefined and independent outside world), and *action*, by means of which we operate on the world. This view is difficult to hold in physics (particularly in quantum mechanics) where measuring (i.e. perceiving) is itself a kind of acting which may well affect the objects concerned. Measuring is carried out by measuring devices acting as operators on the objects in question. Measuring results, i.e. what we 'see', is defined as invariants of the measurement operators. This means that there is no essential difference between acting in the literal sense and acting by means of a measurement operator. It was a far reaching decision of physicists to accept, as far as possible, objects, features or other theoretical terms only if they can be defined by means of a measurement process. This was triggered by painful experiences showing that the usual protophysical definitions, based on day-to-day experiences, may not be suitable to describe microscopical or relativistic systems. As we can neither measure a property nor act upon the object in question without the preceding application of defining operations, we can conclude: all we see and do is a matter of interaction between three different kinds of operators - defining, measuring and acting operators. In other words: what a perception is going to tell us, or what an acting will bring about depends on how the object perceived is defined. Under these circumstances it is not a surprise that we can get accustomed to Kohler's spectacles though they present to us a 'false' picture of the world, because the term 'false' and 'true' are explained only within the context of a given definition of the 'world'. To get accustomed to Kohler's spectacles only requires an appropriate redefinition of what we see. It is as with a cryptographically encoded text. We cannot say the text must be 'false' just because it is unreadable. Appropriate decoding might well transform it into something we are used to understand. The key point for better understanding virtual reality we have to deal with, therefore, is:

The relationship between action, perception and definition.

Acting (be it acting by our self or acting by other subjects or systems) means everything which modifies perceptions. Acting can be acting in the literal sense such as modifying a physical object and by this changing what we see of the object as well as acting by means of our locomotion limbs and by this changing the perceptions concerned due to perspective phenomena. The only direct access we have to objects are perceptions. It is **not** necessary to say that perceptions are perceptions ‘of’ something or that perceptions would tell us something about matters which ‘exist’ independent from our perceiving them. Then we can use the notion of operators acting on perceptions and transforming them into other perceptions. As this way of thinking is largely infected by what physicists experienced (particularly in subatomic reasons) we will propose here to apply a formalism which is quite similar to the successful theoretical tool physicist would use in quantum mechanics:[1]

φ, χ, … be normalized vectors in Hilbert space and represent perceptions.

O, P, ... be Hermitian operators in Hilbert space and represent operators acting on perceptions.

λ_i (i=1,2,..) be the (real) eigenvalues of Hermitian operators.

Let us consider all the perceptions φi (i = 1,2, …) which are invariant under the action of an operator O:

(1) $O\varphi_i = \lambda_i \varphi_i$

We will call the set of eigenvectors φ_i of O the O-representation if any perception ψ can be described as a linear combination of the φ_i :

(2) $\psi = \sum \alpha_i \varphi_i$

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[1] The terms used here can be explained as follows: Our 3-dimensional space can be considered as a vector space if we replace the 3 rectangular coordinates x, y, z by three vectors in arbitrary directions (but not in the same plane). Any triple of such vectors can be used as a reference frame. A Hilbert space is a vector space of infinite dimensions. The vectors can be represented by certain independent mathematical functions. Hilbert space operators are mathematical terms which act on these functions. Those functions which are not affected by an operator except by multiplication with a number λ are called eigen-functions and λ the eigen-value of the operator. Two operators, the space operator Q and the momentum operator M have been found so that the results of space and momentum measurements are eigen values of Q and P respectively. There is a correspondance principle saying that the operators for the other observables have to be composed of the operators Q and P in the same way as the classical obeservable is composed of the classical variables for space (x, y, z) and momentum (p_x, p_y, p_z). We will apply here a cognitive correspondance principle saying that perceiving has to be understood as a measurement process of the cogntive apparatus by means of cognitive operators, and that the results of perceiving, i.e. the regularities identified, are eigen functions of cognitive operators.

Formula (1) can also be read in another way: if the φ_i are defined by another Operator N, which commutes with O (i.e. ON = NO), then (1) represents a measurement prozess and the λ_i are the possible measurement results. This relationship is symmetric. Both O and N can be defining or measuring operators respectively. In the O-representation we can measure by means of N, and in the N-representation we can measure by means of O.

If N and O do not commute (NO ≠ ON), then N will transform a perception φ (which is eigenvector φ_i of O) either into another eigenvector φ_j of O or into a perception φ' which is no longer an eigenvector of O at all. In this case we will call N an acting operator rather than an measuring operator. The same applies for the opposite direction. *So, whether an operator can be used for action or measurement depends on whether it will commute with the operator defining the object in question.*

To make this point clearer let as pose the question as to whether our walking limbs are acting or measuring operators.

In a 3-dimensional world furnished with objects which are defined as invariants of spatial transformations, locomotion is an measurement process (when walking around an object the various views perceived will inform us on the objects shape, i.e., we will 'measure' the shape). For someone who sees the world in two dimensions, however, locomotion is an acting operator because it modifies the shapes concerned. What does that mean?

To see the world in 3 dimensions allows us to distinguish between the (visible) reduction of size due to physical compression and that one due to enlarged distance. But we cannot say that our space of visual perception is 3-dimensional because the world itself is 3-dimensional in character, and that apes which do not see the world in 3 dimensions were unable to jump from tree to tree, and, therefore, could not belong to our ancestors as Konrad Lorenz (1983) said. It is easy to show that appropriate and successful survival strategies could well be based on 2- or 4-dimensional perception spaces, independent from how many degrees of freedom are actually available. This goes as follows:

With a 2-dimensional perception we would not know the phenomenon of perspective. Things are small or things are big, but they don not seem to be small or big due to their different distance. Distance to the observer belongs to the third dimension which is excluded here. But objects, nevertheless, would shrunk in size if we use our legs to go backwards and they would enlarge their size if we go forward. So, with a 2-dimensional perception we would come to a world view according to which not only our hands and mechanical tools can modify objects but also our legs. So walking limbs were acting operators. This must not lead to the conflict mentioned by Lorenz. With such a perception, an ape may well be able to jump from branch to branch. The only thing it has to learn is that it has to grasp the branch envisaged just when its size and position achieved certain typical values. If the perceived size of a branch will have doubled after three steps, the ape must know that it will arrive at it after another three steps and then has to grasp. If it has learnt to do so it may well survive and an external observer would find no difference between the moving strategies of such an ape and those based on a 3-dimensional perception. So, whether walking is a measuring or an acting operator depends on whether the objects in question are defined as invariants of 3- or 2-dimensional transformations. (It is evident that physical theories based on the inborn world view that objects could be 'deformed' not only by means of our hands but also by means of our walking or jumping legs would have no similarities with the theories we are used to use).

We can explain this by another example: Let us imagine locally fixed plants that have eyes and can see and think and which may have acquired a 2-dimensional perception. They would tell you that they have smaller and bigger companions. For us this would be due to different distances, but not for these plants. As soon, however, as they learn to communicate and would tell each other what they see, they would find out that what is small to one observer, might well be big to another one. After some perplexity they may construct a theory of relativity of size, saying that size is nothing absolute but depends on the relative position of observers - difficult to understand for someone who is used to live in a 2-dimensional perceptional space. Exactly the same happened to physicists when empirical evidence forced them to construct the theory of special relativity saying that time intervals are nothing absolute but depend on the relative motion of the observer - difficult to understand for someone who is used to live in a Newtonian world. (By the way, this analogon can be even extended: the (relativistic) limitation of all speeds in the 3-dimensional case ($v<c$) corresponds to the limitation of all lengths in the 2-dimensional case, as these can be defined only by means of the aperture $\alpha < 180°$).

The question whether certain modifications of visual perceptions should be interpreted as a perspective (or geometrical) phenomenon or as a phenomenon of physical action, is well known from another case in physics: the orbits of planets could be considered as the effect of explicit gravitational forces (the physical solution) as well as geodetic lines within a 4-dimensional space (the geometrical solution as proposed by the theory of general relativity). As all this is just but a different interpretation of the same observations we cannot come to a decision on empirical grounds nor was adaptation or selection relevant when cognitive evolution of primates had to decide whether to see the visual world in 2 or 3 dimensions. In other words: perceptional spaces and systems of categories are purely descriptional systems which may tell us something on how we see the world but nothing on the world itself. So they cannot be the outcome of adaptation to the world. *From this it follows that our epistemology cannot be a natural (i.e. external) selection epistemology (as advocated by Campbell (1973)).*

But, could it not be possible that our epistemology is an *internal* selection epistemology? i.e. that certain elements of our epistemology are easier to realize than others and therefore are selected in the course of our cognitive evolution? The spatial shape of objects we describe in 3-dimensional perception, for example, is something nobody has ever seen. All we see are 2-dimensional projections on the retina of our eyes. The spatial character of perceived objects is a cognitive artefact which requires a lot of internal arithmetical efforts to be realised. In 2-dimensional perception, however, things are as they geometrically appear. So, from the mathematical point of view, two dimensions are privileged with respect to three dimensions. On the other hand, 2-dimensional perception requires an explicit physical theory on the correlation between what our legs are doing and what wee see. In 3-dimensional perception this is solved implicitly. The correlation concerned is a matter of geometrical perspective comprised in the notion of 3-dimensional spaces. The fact that our cognitive evolution ended in three dimensions rather than in two may not be due to mathematical economy (which, of course would favor 2 dimensions) but rather due to a very general principle: cognitive evolution tends to take away approved experiences from explicit description and to put it into implicit description, i.e. into the special character of the metatheory concerned. Then, the regularities we found are no longer a particularity of the 'world' (which may well be different in a different world) but the 'logical' consequence of the metatheory we use. The most prominent example for this is Noethers principle showing that the conservation laws in physical mechanics (energy, momentum etc.) which govern everything in the world of mechanics can be derived from our space/time perception (conservation of energy results from the homogeneity of time, conservation of momentum results from the homogeneity of space, etc.). So, the laws of nature have an ontological character only if our cognitive variables such as space and time were ontological. But these variables, as we have seen, are human ways to see the world, i.e., they are human specific constructs.

Most people when hearing that reality may not be really real would argue that ignoring the existence of tables, trees, traffic lights or what ever we find in our environment were sheerly unacceptable. Of course - but these are objects or facts which we can, at least in principle, alter or displace according to what we intend. Let us call this 'actuality'. By contrast, we will speak of 'reality' if something should be neither ignored nor can it be modified by what ever we may do. According to classical thinking this would apply in strict sense only for the laws of nature. So, disputing the ontological character of reality is reduced here to saying that there will be no definitive or objective laws of nature. This is strange enough, but it is evident that this view has no solipsistic consequences which people sometimes see when realism is disputed in general.

Cognitive Operators

Up to here we implied that the operators we spoke about were physical operators, i.e., measurement and acting operators in the literal sense or limbs for locomotion etc.

Further to these we will define *cognitive operators* which are implemented physiologically somewhere in our brain and which transform certain states of our sensory apparatus into what we call perceptions. The invariants of cognitive operators are the regularities we perceive. So, these phylogenetically acquired human specific cognitive operators are the definition operators for all the regularities we see. Insofar as we condense observed regularities into laws of nature, these laws also are human specific rather than objective. For phylogenetic reasons all men acquired the same cognitive operators and, therefore, will see the same regularities and, therefore, will identify the same laws of nature. This is why they succumbed to the temptation to call their common experiences as the result of something real, i.e., which is not specific to human beings.

This also holds for causal laws: causal laws describe the effect of actions, be it human actions or interactions of physical systems.

(2) $O\varphi = \varphi'$

If O is the acting operator concerned the causal law describes the transformation $\varphi \rightarrow \varphi'$. O is the cause, the transformation is the effect. But φ' does not depend on O alone but also on φ and by this on the definition operator defining φ. In other words: there are no universal laws. Any law describing the effect of an operator has to refer to the operator defining the system upon which the operator will act. For example: as we have seen, the law that locomotion will deform physical objects will hold in a 2-dimensional world but not in a 3-dimensional one. And the law of energy conservation depends on our mental time metric generator.

Physical extensions of perceptions

Typical of most empirical sciences is the use of instruments and measurement devices (measurement operators) by means of which we extend the range of natural perception in ways similar to those we use to extend our inborn physical capabilities by means of tools and engines. By means of microscopes we can look into smaller dimensions and by means of radio detectors we can identify electromagnetic waves our body has no natural means to perceive. We know that there are measurement devices, for example in quantum mechanics, bringing about results which do not fit into our classical world picture. The question will arise as to when a measurement can be described within the classical world picture and when it will require novel, non-classical approaches.

We will speak of *quantitative extensions* if the inborn perception operators (i.e. the phylogenetically acquired definition operators) and the measurement operators commute in the sense of operator algebra. In this case both operators will have a spectrum of invariants (i.e. eigenvectors) which can represent each other. This means that the results of the measurement operations can be presented in the terms of invariants of the inborn cognitive operators, i.e., in terms of our classical world view.

We will speak of *qualitative extensions* if the inborn perception operators (or the defining operators constructed later on in the course of scientific development) and the measurement operators do not commute. Then the results can no longer be presented in a classical manner and would require new, non-classical theories. As the set of possible measurement devices is, in principle, unlimited, it can never be excluded that qualitative extensions of previously established operators will provoke modifications of the previously established world view and of the theories associated with it. So there will never be a definitive world view and there will never be a definitive 'theory of everything'. No objective laws of nature will ever be formulated. Those laws that we have, we have 'constructed' in a human-specific way in the course of human evolution. They never will converge towards a definitive set of laws except within the context of a limited set of operators, i.e., if we desist from further experimental research exceeding these limitations. What we actually do when we do science is to construct a world that we then believe we analyse by means of quantiative extensions. In other words: analytical in the sense of deepening our knowledge is characteristic of science only within quantitative extensions. The idea that science were analytical in this sense has left a deep imprint on our thinking and provoked endless efforts to explain quantum phenomena by means of improved and perfected classical theories – until it became evident that these were vain attempts.

Our world picture

Any set of operators acting on perceptions with an unambiguous separation of measuring from acting operators constitutes what we call a world picture. (We discussed the case how our world picture has to be modified if locomotion were taken as an acting operator). An equivalent possibility to define the term world picture is to say that it represents the total sum of our physical metatheories. One of the basic metatheories in classical physics is that physical systems have independent and well defined properties (such as spatial position and momentum) which can be measured independently. The quantum mechanical analogon is: the independency of the properties of a physical system is itself a property of the system depending on whether the Hermitian operators in Hilbert space representing the measuring devices concerned commute or not.

Our classical world picture, to which we are subject in day to day life, is the result of phylogeny. The question will arise as to what prompted cognitive evolution to come to what decision. Let us try the following approach:

In case of a physical measurement (which is an action, of course) the result, in physical parlance, is the invariant of the measuring process. In other words, we use the invariants of a process to describe the effect of just that process, i.e., we describe the covariants of an operator by means of its invariants. This can be generalized into the cognitive area. The actions by means of which we explore the world can be considered as measurements (i.e., as perceptions in the broadest sense). Results of measurements (or, as one could say, the results of our experiences) then are views of the world and theories representing what we call the unchangeable and, therefore, the objective world (i.e., what is invariant under all our doing and acting). If we look however for the covariants of our action, i.e. what changes under the influence of our actions, we have to refer to what we said about the relationship between the covariants and invariants of measuring processes: the effect of action can be described only in terms of the invariants of action, i.e., in the terms of our world view.

If this is true, then the elementary categories of our perception must be the invariants of our most elementary action operators. But what are the most elementary action operators? They are not, as one might think, our hands and the tools guided by hands. They are, rather, our legs. By means of a few appropriate steps, we can change the environment of the room we are in into the environment of a blooming garden. Of course, we could achieve the same also by using our hands if we employ them to the necessary reconstruction work. But this is troublesome and time consuming. So, one of the most important human-specific operators is locomotion. Our world view, as a result, must be based on the invariants of this operator - and this is indeed the case. The most elementary descriptive category of our world view is the identity of extended objects and spatial structures defined as an invariant of locomotion. This was first expressed by Piaget (1970). (This argument does not determine whether spatial structure is 2-, 3- or 4-dimensional).

This provokes the assumption that, from a phylogenetic point of view, the categories of description can be understood only through their capability to cope with the covariants of certain operators. From this it follows that evolution designed the cognitive phenotype in order to extend the action possibilities of the organic phenotype rather than to explore the world.

The construction of visual patterns

We discussed the construction of perception so detailed in order to make it quite clear that the sensorial input may trigger perceptions but does not determine them. Particularly we cannot derive the causing input from the resulting perception. Even if there were an objective outside world and even if the sensorial input had something to do with the structure of this world - the perception which the input may bring about does not allow to draw any conclusion concerning the causing world. What we call the world and all we say about this world is a human specific artefact.

A consequence is, that certain inputs may bring about perceptions which are physically not understandable:

1. nearby objects may produce different inputs to the two eyes due to the eyes distance. They will not result into two different and overlapping pictures. Our brain rather will transform them into one single 3-dimensional picture.
2. standing in front of two parallel and endles lines we will see them converging at the right as well as at the left horizon. Consequently they must be curved in an opposite manner. But nothing of this can be seen.

There are artificial distortions which, after a while, will be compensated by the cognitive apparatus:

3. there are spectacles with different lenses for the two eyes, one for short- and one for long-distance focusing. They do not lead to visual conflicts.
4. Kohler's prismatic spectacles showing the world upside down which, after a while, generate the usual upright perception. (The question will arise as to what will happen if only one eye is subject to a prismatic lense).

Our visual experiences are based on classical mechanics. When moving at speeds near to that of light we will be confronted with relativistic phenomena which conflict with what we are used to perceive. In order to see if this is a phenomenon which as well can be mentally compensated, we will propose a relativistic flight simulator. (For practical reasons the speed of light will be put at 200 Km/h).

For the time being it must remain open if something similar could be constructed by means of which we may become cognitively familiar with the world of quantum mechanics by raising the Planck constant to a 'macroscopic' level.

The relativistic flight simulator as VRF

We will deal with the relativistic flight simulator for two reasons: (1) to use it as a VRF example and to see explicitly the visual phenomena of the special theory of relativity (Diettrich, 1989) and (2) to see to what extend we could get used to these phenomena in the same sense as we can get used to Kohler's prismatic spectacles. A flight simulator is a mashine which simulates the perceptions we will have if we would fly with a plane over a geometric landscape. It is relativistic, if the necessary transformations follow the laws of special relativity rather than those of classical mechanincs, which is relevant only for very high speeds. (The reader not so much interested in technical details may jump directly to Fig. 3)
x, y, z, t and x', y', z', t' be the coordinates of two reference frames moving relatively to each other uniformly with v parallel to the x-axis. Then is (according to the Lorenz transformation)

$y = y'$, $z = z'$ and

$$(1) \qquad x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}; \qquad t' = \frac{t - \frac{v}{c^2}x}{\sqrt{1 - \frac{v^2}{c^2}}}$$

From this it follows that a resting distance ($x_2 - x_1$) will be in the moving system

$$(1b) \qquad x_2' - x_1' \;=\; (x_2 - x_1)\sqrt{1 - \frac{v^2}{c^2}} - v(t_2' - t_1').$$

and a time interval in the resting system t_2 - t_1 will be in the moving system

$$(1c) \qquad t_2' - t_1' \;=\; (t_2 - t_1)\sqrt{1 - \frac{v^2}{c^2}} \;-\; (x_2' - x_1')\frac{v}{c^2}.$$

The distance we measure in (1b) depend on how we define t_2’ and t_1’ . We have two possibilities: either we put them equal (i.e. the measurement will be done by the moving observer at the same time) or we will put the signal times so that they will arrive at the same time at the observer independent from how distant they started, i.e. we define t’ by means of the running time

$$(2) \qquad t' \;=\; \frac{1}{c}\sqrt{x'^2 + y'^2 + z'^2}$$

This is what we need when considering visual perceptions. A visual perception is defined by all the light signals which arrive at the observer at the same time.

Eliminating t in (1) and replacing t’ by (2) we will get with y’ = y and

z’ = z

$$(3) \qquad x' \;=\; \frac{x - \frac{v}{c}\sqrt{x^2 + y^2 + z^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

In order to construct the general pictures of moving objects following from (3) we have to be aware that visual (and photographic) pictures result from 2-dimensional central projections.

In Fig. 1 be B the focus of a camera, ξ and η the coordinates of its focal plane and r the focal distance. We could have chosen as well the human eye and its retina instead of the camera and its focal plane. As we want to design and observe pictures we use the former representation. x, y, z be the coordinates of the object space with their origin in B.

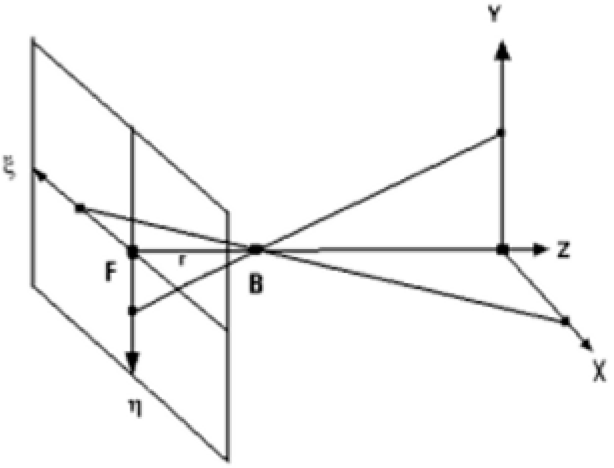

Abb. 1

Then we have $\eta = r\frac{y}{z}; \quad \xi = r\frac{x}{z}$

The vanishing point for all straight lines orthogonal to the focal plane will be F’ = F = 0. In order to see at the photograph the same as in the object space the observer has to put his eye in B, i.e. at distance r over F.

Putting this into (3) we will get

$$(3a) \qquad \xi' = \frac{\xi - \frac{v}{c}\sqrt{\xi^2+\eta^2+r^2}}{\sqrt{1-\frac{v^2}{c^2}}}; \quad \eta' = \eta$$

The vanishing point F ($\xi_F = \eta_F = 0$) transformes to F’ with

$$(3b) \qquad \xi_{F'} = \frac{-\frac{v^2}{c^2}r}{\sqrt{1-\frac{v^2}{c^2}}}; \quad \eta_{F'} = 0$$

As we have to look at the picture from point B in Fig. 2, the displacement of the vanishing point corresponds to a rotation by the angle α with $\sin\alpha = -v/c$.

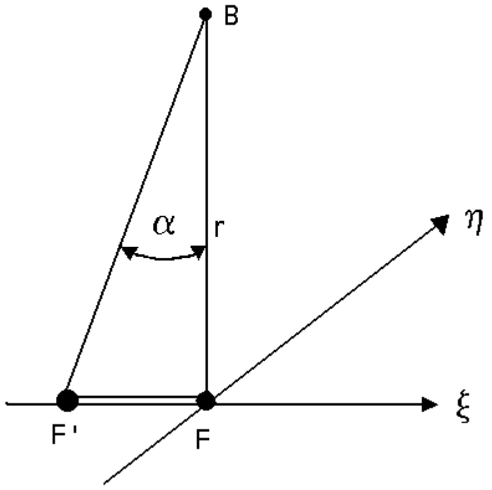

Fig. 2

$$F' - F = \frac{-\frac{v}{c}r}{\sqrt{1-\frac{v^2}{c^2}}}$$

In Fig. 3 an example has been constructed. If the observer keeps his eyes at distant r over the Point F he will see the picture of a road 5m below and leading to the vanishing point F which is paved with stones of 1,3m x 1,3m. If he moves with v = 0.8c he will see instead the curved pattern leading to point F'.

In order to understand that the displacement of the vanishing point from F to F' corresponds to a rotation as shown in Fig. 2 we must remember that with central projections the parallel displacement of a straight line in the object space will correspond to a rotation in the focal plane because the vanishing pont remains invariant. Conversely a parallel displacement in the focal plane corresponds to a rotation in the object space.

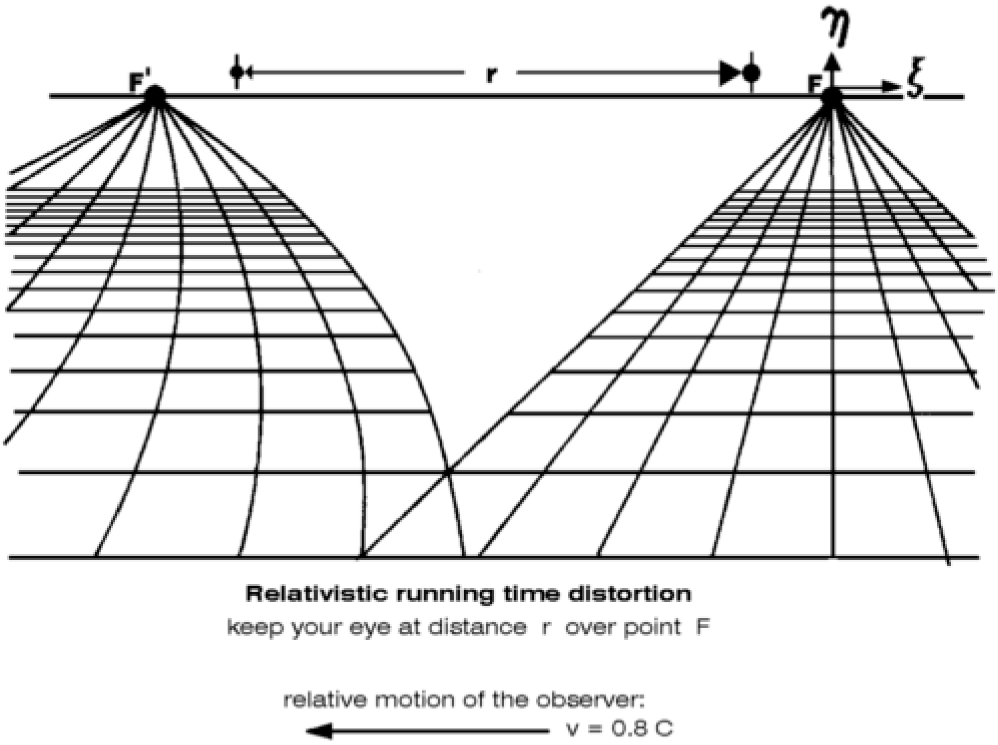

Fig. 3

The right side of Fig. 3 shows a street leading to the point F at the horizon. If we move from right to left with a speed of 80% of the speed of light, we will see instead the left part of Fig. 3. With objects of dimensions small compared with their distance the relativistic moving effect will manifest in nothing but a seeming rotation. This has been found by several authors (J. Terrel, 1959; R. Sexel and H. K. Schmidt, 1979) and provoked the question as to whether one could say that relativistic effects are visible at all.

Here we have to specify what we really mean by ‘visible’. Visible we will call a relativistic effect if it is impossible to simulate the perception by means of classical mechanics (i.e. by means of the Galilei-transformation: rotation, displacement, moving) in the same sense as we can simulate the transformation of a circle into an ellipse just by rotating its axis. (We will not deal with the question if special relativity will manifest dynamically). From this it follows that at least with small objects in great distance there is nothing typically relativistic as the visible effect can be simulated by a sheer rotation. Different is the situation for extended objects such as the roads in Fig. 3. The curvature of the vertical road lines seems to be a relativistic effect. But it is not necessarily. It is first of all a purely classical running time effect. This can be seen if we repeat our calculations on a classical basis, i.e. by starting from $x_2' - x_2' = (x_2 - x_1) - v(t_2 - t_1)$ instead from (1b). The result (which is not shown here) is very similar to the left part of Fig.3, but the road is broader. Unfortunately this can not be compensated by changing the flying hight because the vertical structure (other than the horizontal ones) remains unchanged. So Fig. 3 describes really a visible relativistic phenomenon.

Rewriting these calculation with replacing the constant speed v by a vector being explicitly time dependent $v \rightarrow v(t)$ we can construct a relativistic flight simulator by means of which we could experience the relativistic effects when flying through the skyscraper streets of Manhattan. (For practical reasons we should reduce the speed of light to, say, 200km/h). This can be used to see to what extend these effects are subject to mental accommodation. (Even if accomodation will work we have to be careful: with $v = 0.3c$ the optical Doppler effect will switch all red traffic lights into green ones!)

The limits of accomodation

In section 3. we stated that the representation generated by a defining operator P can be replaced by any other representation as long as the defining operator P' commutes with P. As the measurement operators M used in the P-representation will commute with P, they will commute also with P'. If M are cognitive operators the perceived regularities are the invariants of M. From this it follows that we will identify the same regularities in any representation generated by commuting operators. The defining operator of our kinematics is the Galilei-transformation (or Lorentz-transformation in relativistic cases). Our cognitive apparatus therefore will 'survive' (at least after a certain time of accomodation) in any representation which can be derived from the normal representation by means of a transformation which commutes with the Galilei-transformation. These are all the 3-dimensional continuous function transformations and regular reflections. This is confirmed by the examples we mentioned in section 7 (such as Kohler's spectacles). It seems that the case where the two eyes are subject to different transformations (such as spectacles with different focus for the two eyes) is comprised as well. The first criterion for accommodability is no doubt an unambiguous relationship between action an perception. If the same action will bring about different perception no meaningful interpretation is possible. However, we will expect, that non-continuous transformation (which will not commute with Galilei-transformation) will not allow accomodation. This concernes kaleidoscopic spectacles cutting the field of vision into irregular pieces each of which is subject to continuous but different transformations. This should be verified by menas of VRFs.

The invariants of continuous transformations is what one could call the topology of perceived structures. Indeed, a point inside a circle cannot be transformed into a point outside this circle by means of continuous functions. This means that the characteristics of visual perceptions are first of all topological characteristics rather than geometrical ones. This is confirmed by caricature drawings. They can be horribly deformed and will nevertheless be recognized as long as the topology in not affected, i.e., as long as the nose is between the eyes and the eyes between the ears.

These are theoretical considerations on how our cognitive apparatus may function. Even if some confirmations suggest their acceptance a more detailed analysis is needed by means of VRFs.

Virtual reality and arts

Let us remember: if we speak of adaptation, accommodation or topological characteristics, we do this with a view to moving and acting in physical spaces, i.e. with a view to mastering our geometrical environment, which is the classical field of virtual reality. This does not reply the question how much we can transform a painting without destroying its esthetical qualities, or how much a man will be ready to change his individual preferences if he runs about with spectacles transforming all the well shaped women into twiggy like girls.

There is more than just a joke behind it. Both the theoretical menagement of our physical experiences and esthetical cathegories are based on symmetry considerations:

(1) A space-like symmetry is a pattern which is invariant under certain rotations or translations. A circle is invariant under all rotations, a square under the transformation of 90°. A christal is invariant under certain linear translations etc. The importance of symmetry in physics is due to the fact that the conservation laws (which are the framework of all physics) result from the symmetry of space and time. The law of energy conservation results from the fact that time itself is invariant under time translation, (i.e. that time has always the same homogeneous structure), and the law of momentum conservation results from fact that space iteself is invariant under space translation (i.e. that space has everywhere the same homogeneous structure) etc.

This can be understood as a very sophisticated consequence of a rather simple principle. Having identified a regular pattern or a symmetry means that we can extrapolate it in space or time respectively. And this means that we can do forecasting, which is vital for any life management. Having identified the regularity of space and time means that we have found the consrvation laws of physics which means that we can extrapolate the behaviour of any mechanical system into any time or space.

(2) Symmetry and regularities are one of the basic elements in any art. It starts from the patterns of the band ceramic people to medieval ornaments, and to the constituting regularities of music and to the patterns of wall paper.

I think it’s no accident that symmetry is important in both physical life management and arts. In order to stimulate man to look for new symmetries or regularities evolution enfowed the successful result with positive feelings. Indeed, we are pleased if we identify a regularity or recognise something we have already seen before. From this it is near to believe that we will produce these regularities artificially for no other reason than to be pleased. (Evolution missed here to be more precise in order to exclude the misuse of these stimulation mechanisms). This is the birth of arts, and it is exactly what we expect from virtual reality processes: to bring about something artificially which usually requires the reference to nature. Of coarse, it will comprise also painting and other products of art which are not characterised by any symmetry as long as they depict a situation, a place or a person we like. And it will also comprise physical theories in so far they present statements which I have not to verify explicitly in nature. So we see: virtual reality in the widest sense is a synonym for representation.

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