

## Styles of Reasoning in a Sensorimotor Operation in Humans

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**Abstract:** The author presents an attempt at joining the concepts of intelligence by R.B. Cattell and attention by R.M. Nideffer, and including them into a system of a motor operation production, from stimulus reception through movements' execution. Such a system may be presented as the movements' management matrix. Joining the two-dimensional concept of attention by Nideffer and one-dimensional concept of intelligence by Cattell results with creation of a three-dimensional model of intellect. The latter makes the central component of the "main production unit" of a motor operation, consisting of three "working" mechanisms (attention, intellect, and foresight) and two auxiliary ones (motivation and decision). Author presents the model of a three-dimensional intellect in the context of the movements' management matrix and the modalities' ladder, based on theory by N.A. Bernstein.

**Key Words:** Attention, Intelligence, Intellect, Modalities' Ladder, Movements' Management Matrix.



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International Association of Sport Kinetics. He claims

that in researches into processes underlying human motor behavior mathematics is hardly useful. In this respect, promising seems to be a system-theoretical perspective. Petryński traced the roots of such a perspective in the works of N.A. Bernstein and P.D. MacLean, and the essence of a system as such –in the works of J.M. Morawski. Recently he presented his views in detail in the book, "Motor Control in Humans. A System-Theoretical Approach" (Nova Science Publishers, Hauppauge, NY, 2016). His hobby is sailing; he is ocean yacht skipper and former vice-president of the Polish Yachting Association

### 1. Introduction

The inspiration for this paper were the achievements of two outstanding psychologists: Raymond Cattell (intelligence) and Robert Nideffer (attention).

At first, however, let us remember that the only manifestation of any unobservable mental activeness, including attention and intelligence, is an observable motor phenomenon. Philosopher Andrzej Wohl remarked, "Whole human history is the history of human activities; all that we dispose of, all what constitutes the resource of our culture, all the pieces

of art, science and technology – all that results from motor activities" [1].

Let us term "**motor operation**" a set of intentionally prepared movements aimed at solving of a specific task in environment. If such an operation is being initiated by reception of a certain stimulus (or stimuli), it is the "**motor response**".

Cattell has invented a model of intelligence consisting of two components: fluid intelligence and crystallized intelligence [2]. The former bases on just being formed knowledge, whereas the latter is being founded on the already possessed experience. It

seems worth noting that according to Oscar Wilde, "Experience is the name every one gives to their mistakes." This witty, apparently frivolous statement is in fact worth deep, scientific reflection. Actually, it reflects the feedback mode of information processing (which includes "their mistakes" correction) in the process of learning, or motor operation perfecting.

By the way: This is why a scientist, apart from knowledge and inventiveness, needs the sense of humor as well.

Symptomatically, in his famous book on intelligence, Cattell did not present a... definition of this notion. Even in the glossary included to his book there is no such entry. Moreover, he attempted to describe it based on empirical data and factor analysis. In this context, it seems instructive to quote the following words by physicist, philosopher and theologian Michał Heller

"In the course of centuries, we have worked out the empirical-mathematical method of world research. It is extremely efficacious, but for some price. It does not discern everything. Some things are transparent to it" [3].

It seems quite evident that just the psychological issues are "transparent" to mathematical-empirical methods. Therefore, the knowledge in this field has to be ordered in other way. Here the system approach seems to be very promising. Let us remember that only the properly ordered knowledge deserves the noble name "science".

Accordingly, intelligence – while seen from the system-theoretical motor control perspective [4] – is not an independent mechanism of information processing. One may perceive what Cattell termed "intelligence" as a system, consisting of three information-processing tools: instinct, intuition and intelligence. Such a system may be labelled "**intellect**".

The system works always as a whole, so in the final product of intellect it is not possible to single out, what has been produced by intelligence, what by intuition, and what by instinct. In short, it seems hardly possible to create a definition of highly

abstract intelligence while observing the real events, even with factor analysis. All information processing mechanisms are too distant (on the abstraction scale) to the observable reality to enable their one-to-one association with reality while basing on empirical data [5]. Such an association is specific to a good definition, and additionally should be simply explainable verbally. Accordingly, in the system-theoretical perspective the listed mechanisms might be defined arbitrarily as follows:

**Intelligence** – in motor control: a potentiality of a living being for building a reliable motor response while having whole necessary current information of proper modality, or modalities, and using the logic suitable for that information.

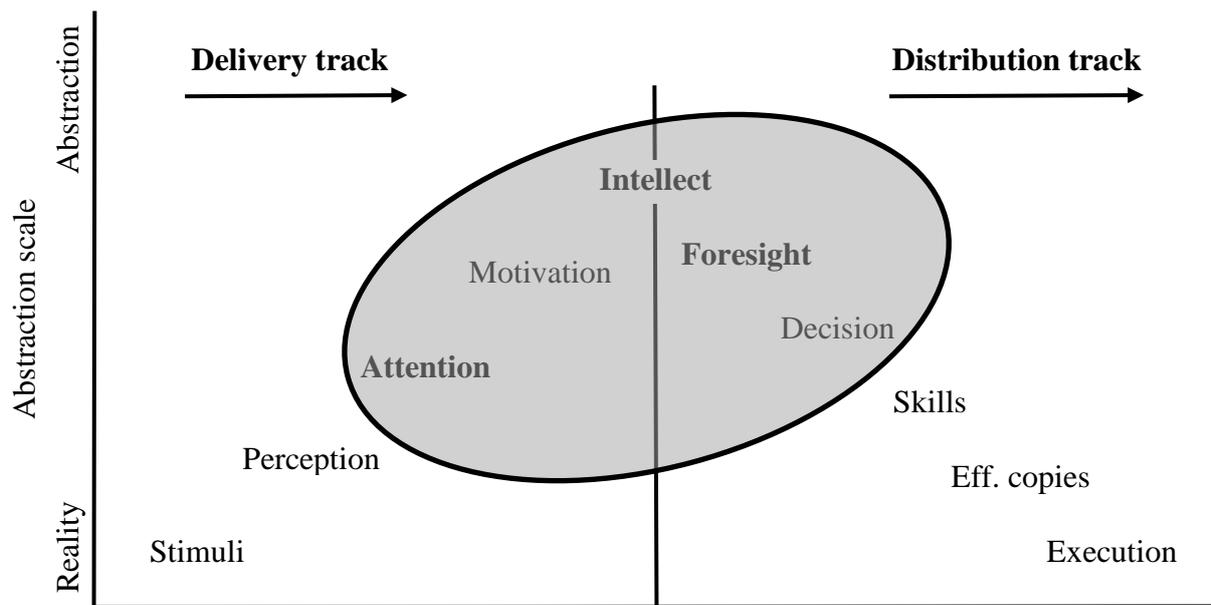
**Intuition** – in motor control: a potentiality of a living being for guessing the lacking information, necessary for employment of intelligence.

**Instinct** – in motor control: inborn (closed), or acquired (open), well established tendency to look for lacking information, necessary for solving a given task, in specific directions, where probability of its finding is greatest, or propensity for choosing by intelligence the definite methods of developing of response likely to produce desired results.

**Intellect** – an internal system of a living being that enables processing of current information, shaped by attention, usually in order to work out the behavior pattern aimed at bringing about the desirable changes in environment in the future [4].

As already stated, in the system-theoretical model, the intelligence, intuition and instinct together make the intellect. Along with memory, it makes the mind. Both they are systems, and not sums. The difference between sum and system is dramatic. In a sum  $2+2$  equal 4. Point. Full stop. On the other hand, in a system 2 and 2 makes 4 plus a qualitatively new, unpredictable, emergent system effect, resulting from cooperation of the first and second "2s" [6].

Let us illustrate this with a following example. Imagine that we take a car (by far simpler than any biological system) and dismount it to the most elementary components.



**Figure 1.** The model of sensorimotor response. The gray oval represents the “main production unit” of a sensorimotor response. “Eff. copies” means “efferent copies”.

Then let us invite three specialists: professor of “theoretical carology”, engineer-car designer and mechanic, who repairs cars. Ask them; what will be power, acceleration, maximum speed or fuel consumption of this dismantled vehicle. Neither each of them nor all together are able to answer such a question. Because it concerns the unpredictable – by definition – system effects, which appear only when all the components are assembled together and make not a sheer sum, but a sophisticated system.

In our further, system-theoretical analyzes, let us substitute the “**creative style of reasoning**” and “**reproductive style of reasoning**” for Cattell’s “fluid intelligence” and “crystallized intelligence”, respectively.

Nideffer has invented two-dimensional model of attention. The first dimension is the direction of attention (in or out), the other – its width (broad or narrow). Therefore, he discerned four concentration styles: broad-external (aware), narrow-external (focused), broad-internal (strategic), and narrow-internal (systematic) [7].

However, in the movements’ management matrix [5], attention and what Cattell has termed “intelligence” (in our model we will dub it “intellect”) are not independent information processing mechanisms, but make components of a series of

phenomena and processes from stimuli reception through motor response execution. It may be presented as in Fig. 1.

The information processing chain shown in Fig. 1 consists of ten elements:

1. Stimuli reception; sensory inputs production (“sensors”),
2. Sensory inputs perception, i.e., joining them with a specific information retrieved from memory (“detectors”),
3. Attention, hierarchical ordering the information according to its importance (“input filter”),
4. Motivation (“input on-off switch with amplifier”),
5. Intellect (“information processor”),
6. Foresight, quality of response pattern assessment (“output filter”),
7. Decision (“output on-off switch with amplifier”),
8. Skills, already earlier prepared motor sub-operation patterns (“controllers”),
9. Efferent copies, recording the just being performed motor operation (“records”),
10. Execution, physical realization of the motor response in environment (“actuators”) [4].

Let us term the elements to the left of

intellect “delivery track”, and to the right of intellect – “distribution track” (Fig. 1). The former “deals” with supplying information necessary for processing in intellect and creation of a motor response pattern, the latter – with reducing the highly abstract sensorimotor operation pattern to the level of practical execution. As one can see in Fig 1, the delivery track ascends from the level of reality to higher and higher regions of abstraction, whereas the distribution track – on the contrary, from high abstraction to the “tangible” reality.

The components in gray oval field in the Fig. 1 might be termed the “main production unit”. It consists of three “working components” – attention, intellect and foresight – and two “auxiliary links” – motivation and decision. Both the latter ones make only a kind of fuses and on-off switches with amplifiers, but for realizable motor operation pattern production responsible are mainly attention, intellect and foresight.

In such a model, the delivery track supplies the main production unit with necessary “stuff” for motor operation pattern production, whereas the distribution path transfers the product of the unit to the level of realizability.

## 2. Attention and intellect as the components of the same system

While seen from the system-theoretical perspective, the attention (as presented by Nideffer) and intellect (equivalent of Cattell’s “intelligence”) make the parts of the same system of information processing during a sensorimotor operation. Accordingly, they have to “mesh” somehow with each other, to “speak” a “language” understandable for both of them. Following such an assumption, let us try to join both these concepts (or, in other words, to invite Nideffer and Cattell for a beer, with Petryński as waiter).

Let us check whether the two-dimensional Nideffer’s attention might have an equivalent in the intellect. May be joined action of intuition, instinct and intelligence directed towards psychological interior or exterior? Absolutely. Accordingly, this dimension of attention may be applied to the intellect

as well. May it be wide or narrow? In this case, the answer sounds “yes”, either. Consequently, the two-dimensional model of Nideffer’s attention may be adjusted also to the intellect.

Is it possible to apply Cattell’s idea of creative and reproductive reasoning to the attention? It seems hardly conceivable. At first, let us define attention (again from the system-theoretical perspective) as follows:

**Attention** – a link of thinking chain that identifies information, gives specific importance to it, and thus creates a hierarchy of information; the least important chunks of information are rejected and are not transferred to intellect; it determines the direction of further thinking [4].

In the movements’ management matrix identification means joining a sensory input (delivered by sensory organs) with an information (retrieved from memory) specific to it. Such an information cannot be created “on line”; it has to be shaped previously and to reside in memory – usually with an assessment assigned to it – ready to be regained if necessary. Specific importance is being attributed to the information based on previous experiences. The psychological tool, which collects such experiences, distills from them what is good and what is bad, and makes a “toolbox” enabling quick – yet not always precise – assessment, is termed “**emotions**”. Accordingly, attention bases on the already shaped set of assessments and does not create new ones “online”. Such a process is possible, indeed – James J. Gibson has termed it “education of attention” [8] – but it happens in a quite long period and not during the course of events in reality.

While taking such assumptions one might create a two-dimensional model of attention, as by Nideffer. Attention resides on “delivery track”, and its “twin sister” on “distribution track” is the foresight. Hence, all the analyses concerning the “input” attention may be applied also to the “output” foresight.

At that point of analyzes one comes across the conclusion that, unlike attention and foresight, the intellect may be perceived as a mental structure with three-dimensions:

- Active (intrinsic)-reactive (extrinsic),
- General (wide)-focused (narrow),
- Creative (fluid)-reproductive (crystallized).

However, it is necessary to introduce a specific modification. Attention “receives” information from outside and assesses them. Accordingly, it is either external, or internal. On the other hand, the intellect “produces” new information and transfers it to further links of cause-effect chain. Therefore, such a product may be either intrinsic (because of independent mental work), or extrinsic (if it results from reception of external stimulus).

Accordingly, one may distinguish the following styles of reasoning:

- Intrinsic-creative-general – free philosophy;
- Intrinsic-creative-focused – ordered science;
- Intrinsic-reproductive-general-acquired competencies;
- Intrinsic-reproductive-focused –realizable skills;
- Extrinsic-creative-general –overall invention;
- Extrinsic -creative-focused – particular cleverness;
- Extrinsic-reproductive-general – general qualifications;
- Extrinsic -reproductive-focused – specific dexterities.

Such a classification is coherent with the assumption that in humans an information processing may be perceived as one continuous – yet not homogenous – system, from knee jerk through general theory of relativity creation (or from practical, specific dexterities through general, abstract philosophy).

### 3. Attention and foresight “planes” and intellect “cube” at various rungs of the modalities’ ladder

It is worth remembering that each of the rungs of the modalities’ ladder has its own “identity”, which differs from identities of other rungs [4, 5]. The main component of such an identity is the modality of information processing.

The “mother” of the modalities’ ladder is the “brain skyscraper” invented by Nikolai A. Bernstein [9]. It is based on evolutionary and neurophysiological data, hence it is quite complex. On the other hand, Bernstein himself has invented the “reduction of freedom degrees principle” [10] to convert of non-controllable systems into controllable ones. In short, the Bernstein’s rule may be identified with the “007 Principle” by Andy Clark: “...to know only as much as you need to know to get the job done” [11]. Accordingly, let us remain the very core of Bernstein’s model, but distill only information processing aspects, and leave aside the evolutionary and neurophysiological ones, not so important in practical execution of any motor operation. As a result, we obtain a mental structure parallel to Bernstein’s “brain skyscraper”, but by far simpler: the modalities’ ladder (Tab. 1). Moreover, one may join particular rungs of the modalities’ ladder (which are equivalents of the movements’ construction levels in the Bernstein’s brain skyscraper) with the specific information processing modality, internal motor operation pattern, class of a motor operation and the movements’ control mode.

Table 1 needs at least two comments. Fantastic, symbolic rung E cannot manage any real motor operation. I can imagine, e.g., that with a single step I am walking from Katowice, Poland, to Oslo, Norway. However, to perform it, the time and space would have to “shrink”, what is not possible in our Euclidean world. Nevertheless, just the E-rung (and E-level in Bernstein’s theory) makes the most powerful tool for invention, e.g., the general theory of relativity or Higgs’ boson concept. In this respect, some explanation needs the term “politics.” It means adjusting the external conditions to the planned (usually not realizable here and now) performance rather, and not embedding any realizable performance in a physically existing environment.

The other comment concerns the C-level. It includes ability to perform movements in the space of “three and fraction” dimensionality. At first, however, let us remind the following quotation from Bernstein:

**Table 1.** The modalities' ladder.

Bernstein's level	Information processing modality	Internal motor operation pattern	Class of a motor operation	Movements' control mode
E	Symbolic	No real motor operation pattern	No real motor operation	Politics
D	Verbal	Program	Performance	Strategy
C	Teleceptive, mainly visual	Scenario	Habit	Tactics, "measure-in-eye"
B	Contactceptive, mainly haptic	Template	Automatism	Technique, movements' harmony
A	Proprioceptive	Coupling	Reflex	Strength control, "feeling-in-hand"

"It is interesting to note that the reflex loop in primitive animals ... works quite differently from how it functions in us. Consider a worm that crawls to an obstacle or a snail that reaches the tip of a grass blade. When there are complications of this kind, these animals start rather animated, aimless searching movements in all directions. In the more highly developed neokinetic animals, movements follow sensations; that is, movements are directed and controlled by sensations. In the lower animals, the opposite is true; sensations are served and provided by movements" [9].

The translation from Russian has been excellently done by Mark L. Latash. There is only one word, which – to my opinion – needs correction. Mark wrote: "start rather animated, aimless (my emphasis – WP) searching movements." In original, Bernstein stated "начинаются беспорядочное ... ощупывания" [12]. It should be understood not as "aimless searching movements", but rather as "disordered groping." From the perspective of psychokinesiology, the difference is quite essential. Each and every motor operation is somehow directed towards future [13], i.e., it cannot be "aimless". In the case of the snail, the "disordered groping" are aimed at finding of a haptic stimulus, necessary for crawling further.

For the snail, a B-rung animal (its primitive "eye" cannot be regarded as a full featured visual sense organ), the external world is limited to the small two-dimensional surface, where its body (foot) touches

the ground. The higher C-rung appeared because of formation and development of teleceptors, mainly vision. It unveiled three-dimensional nature of the environment and forced the necessity of its apprehension. A very important "by-product" of the three-dimensional perception of the world was discovering of the movement. As it Isaac Barrow, mentor of Isaac Newton, remarked, "Time implies motion to be measurable; without motion we do not perceive the passage of time" [14; 15]. As a result, the notion of time has been included to the general "armory" of intellectual tools enabling understanding of the world surrounding humans, though the term "time" is hardly liable to any definition. As it Albert Einstein stated, "The only reason for time is so that everything doesn't happen at once". However, this witty and apparently frivolous aphorism has a deep meaning. Arturo Hotz wrote:

"Time is a human invention. It has been developed because of need for orientation in events. Nature itself produces the various rhythms only: sun and moon periodical rises and settings, heart beating – all these phenomena enable us to recognize and experience flow of time" [16].

Accordingly, time is an abstract, mental tool for ordering the succession of events. At C-rung, it encompasses only small part of time axis – this is why I termed it a "three-and-fraction dimensional". Full fourth, time dimension appears only at D-rung. It is possible because of creation of language, i.e., the information carrier resistive to the passage of time.

In the course of evolution, it was another great revolution: at C-rung, the time has been discovered, and at D-level, it was “harnessed.” Such a “tamed” time enables ordering the series of events far in the past and far in the future. The latter makes a basis for the most effective ability of a human in the evolutionary struggle for life: the far-reaching anticipation. At the “geometrical” D-level, the “independent” variable is the environment, and the “dependent” variable – a planned event, which has to be adjusted to the environmental real constraints. At the higher E-level, the situation is opposite: the “independent” variable is the event, and the “dependent” variable – the environmental spatial-temporal constraints. At that rung, the time is not only discovered or “harnessed”, but also freely shapeable. Therefore, both the time and space become “rubber”. Such an imaginable, rubber time-space meta-reality may be regarded as being insane, indeed, but on the other hand just at the “topological” E-rung resides the most powerful inventiveness. For example, just such a “rubber” time enabled Einstein to conceive the general theory of relativity. Nevertheless, the independence of what is commonly termed “common sense” makes probably human genius and madness dangerously close to each other.

In short, one might state that the D-rung is then responsible for “working” culture and science, whereas the E-rung – for “musing” inventiveness.

Such characteristics of information processing at particular rungs of the modalities’ ladder determine the scope of the two-dimensional attention and foresight and the three-dimensional intellect. For example, all the mental processes directed towards interior, without any contact with environment, needs anticipation. The latter means ordering the succession of future, anticipated events, and here the notion of time is necessary. Accordingly, it is possible only at C (in embryonic form), D, and E rungs. Other analyzes I leave for the Reader. It is worth mentioning that creation or correction of a motor operation pattern at a certain rung needs “cooperation” of a higher rung [5].

## 4. Conclusion

Psychokinesiology is the young discipline, which only searches for its scientific identity. Accordingly, it is not known, what course will it sail across the Ocean of Unknown. In such a situation, we are forced to apply the “Foraminifera politics.” It is small, one cellular organism, which builds a test of sand around its one-cellular body. This shell, while seen under microscope, looks as if it were polished. Therefore, Foraminifera take suitable grains of sand no matter, where they are to be found.

While following the Foraminifera example, let us quote the thought of the novelist Jo Nesbø, who stated: “You can discover new things by changing your perspective and your location. You can compensate for any blind spots”. It well corresponds with the statement of Albert Einstein: “Insanity: doing the same thing over and over again and expecting different results.” Just this makes the core of old, already many times falsified belief that quantity will miraculously transform into quality, i.e., the incessantly raising piles of “new, original experimental data” will automatically produce the fruitful progress in science, not infertile development.

At the end let me allow, please, for a more general reflection. The world around us is made of real things, phenomena and processes, whereas the science is woven of abstract words, statements and theories. They are two different worlds, ruled by different laws. Physicist Andrzej Staruszkiewicz remarked: “mathematical theorems are valid on the strength of a proof and not by observations”. This concerns all the theoretical statements. Accordingly, it is impossible to prove or to disprove any scientific statement based on experiments. The latter may merely produce a cue, whether this or that theory is applicable in a given region of reality, or not. More generally, philosopher Paul Feyerabend invented a model consisting of sober, reliable Truth and full of fantasy, coltish Freedom. The former is responsible for order, the latter – for inventiveness. In the system-theoretical perspective, one might join them with D-rung and E-rung, respectively. When they paths meet, the science is being born. However, it is possible only on a short distance. The paths of “stiff”

Truth and “elastic” Freedom have inevitably to split up, rather sooner than later. This is why each scientific theory has only a limited range of applicability; this is why K. Popper has stated:

“A theory which is not refutable by any conceivable event is nonscientific. Irrefutability is not a virtue of a theory (as people often think) but a vice”.

Also physicist Werner Heisenberg, Nobel Prize laureate, remarked that “Every word or concept, clear as it may seem to be, has only a limited range of applicability.” However paradoxically may it sound, just such a disjunction of Truth and Freedom paths makes the main engine of science development. Moreover, the statements by Popper and Heisenberg justify the assumption that theory and experiment belong to two different – yet not independent of each other – worlds. The main task of Science (with great “S”) is to find a common language for both of these worlds.

Unfortunately, contemporary science is clearly fascinated with its measuring tools – with a clear bias towards observations and calculations, and not reflection and interpretation. In this respect, a deep reflection deserve the following words by outstanding mathematician René Thom:

“We know ... what we gained thanks to Galileo: the mathematical formalism that underlies the whole contemporary technology. But we are not sensitive enough to what we lost because of it: the ability to understand the qualitative transformations. To push our thinking forward anew, we should move Galileo closer to Aristotle, quantitative closer to qualitative, comprehensible closer to graspable, knowledge closer to understanding”.

Thus, nowadays it is more and more clear that conferring at least equal status on elusive, “moonshine” mental work and on measurable, “handmade” experiments is absolutely necessary. This is especially important in psychokinesiology, the very matter of which is by far more abstract than “empirical needlework”, i.e., closer to Aristotle than to Galileo.

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