Review of A.Newell & H.A.Simon, 'Human Problem Solving (1972)', Chapter 1: 'Introduction', Version 1.4

A Review from a Philosophical Point of View

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Abstract

This is Part 1 of a philosophically minded review of the 1972-Book of Allen Newell and Herbert A.Simon [NH72]. The book is a kind of a synthesis of both authors (although both authors have published more books afterwards). Taking the ideas of the book the reviewer discusses these ideas in the light of his own research. This can be criticized because then the ideas of the authors could be 'diminished' in some sense, but otherwise it is at the same time important to evaluate the great work of Newell and Simon in the light of more actual problems. The reviewer really admires the work of both authors and views these as really outstanding researchers, and because of this, he believes that a re-reading of these ideas – as in the case of Gallistel and Gärdenfors too – can be of some help for the actual discussions.

Contents

1 Knowledge as a Process

Right from the beginning (p.1) Newell and Simon outline a picture from human thinking related to *problem solving*, which has to *start at a fixed point*, which shall exclude to take into consideration the whole of knowledge, and has then to *proceed in single steps*, hopefully approximating some new and more integrated view of the world. Although taking the 'big picture' not into account is difficult or even indeed impossible in the beginning, to focus in the beginning onto a too narrow aspect of the problem and then digging deeper and deeper is also dangerous. One can be lead astray and loosing the context.[1]

The general outline of the theory building process from Newell and Simon reveals a little bit the implicit conflict between this limiting-scope picture and the more general, integrating picture characterizing a theory. A *theory* should be the final stage of scientific research based on a *set of data* gained from *experiments* dealing with certain *phenomena* who are understood as defining the *subject* of the research. If there exists explicitly such a theory then one can *derive* some *consequences* (theorems, forecasts) which should be represented in a language, which allows a *verification* or a *falsification* or a *delay* of the decision on account of a missing situation'.

2 Comments: Theory-Loaden Research

Thus however one starts a scientific exploration the outcome should be a *minimal generalization* which establishes minimal relations which are not yet given in the data as such. Newell and Simon require such minimal generalization and Newell in his speech (1973) even made it to a quality measure of science that the different experiments are leading to some more general frameworks which allow the *integration of different experiments* into *one theory*.

Furthermore it is well known in the history of modern general philosophy as well as in philosophy of science that even in the beginning of a scientific research

[1] It is interesting to remember a speech of Newell where he had to comment on the papers of a conference on 'visual information processing'. The main thesis of Newell there was to criticize the main stream of work in cognitive psychology on account of there very limited scopes of research each and a missing of any integrated view! (see Newell (1973) [New73])

there is *never a 'tabula rasa' mind* but a *'pre-formatted mind'* which has at least one *guiding question* why some researcher is investigating some phenomena, and in 'normal science' a researcher has a whole bundle of *pre-knowledge* about existing hypothesis, existing theories, existing methods of measurements and more. Thus even if a concrete experiment, a concrete search has to start at a concrete, single location, at a single point of view, this concrete point of departure is usually embedded in this pre-knowledge defining a certain subset in the actual world-view which is causing some question which has to be answered. Without such a pre-knowledge every kind of scientific research is impossible.

The pre-knowledge must not be a complete theory, a situation which has to be assumed in the beginning of science. But as soon as a scientific knowledge process starts the outcome will inevitably be a theory, otherwise we do not talk about science. This means that besides the very beginning of science we have always some kind of a theory given before experimental work starts and before we try to confirm or to expand or to criticize our theory.

If we accept this assumption of a *theory-loaden research process* then every knowledge process is associated with a theory and the question of the relations between the different theories is inevitable.

Before I discuss this point a little bit more I want to complete the description of the scope of the Newell-Simon book.

3 Performance of Intelligent Adults

After the very general scope from page 1 about developing theories the authors describe their scope of the book on the pages 2-4 a bit more.

As one can see the real scope of the book is finally only a very small fragment of the overall picture. While more than 45 years later the scope of science in general is facing more the view of development and learning, Newell and Simon had focused in their book at that time on the *performance* of people, not all people, but only *intelligent adults*. And within this performance they are looking to a limited fraction consisting of three prominent tasks within symbolic behavior: playing *chess*, doing *symbolic logic*, and solving *algebraic puzzles*. According to there requirement of a final theoretical perspective allowing some general conclusions there is one more general point of view called *problem solving*. In the light of the discussion in the section before one can classify this point of 'problem solving' as the presupposed theoretical point of view which is the driver to pose questions, to make experiments, and to try to find some general insights.

4 Comments: Smart Citizens for Smart Democracies

As mentioned in the preceding section our actual point of view in 2019 is clearly different than in the year 1972 when Allen and Newell have compiled their ingenious

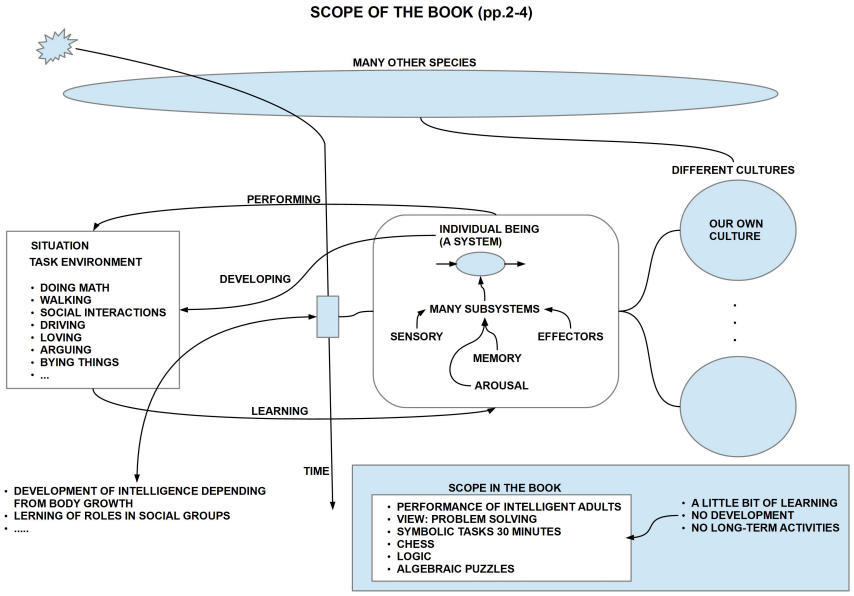

Figure 1: The scope of human problem solving

book.

Besides reading and discussing the book as it is it can make sense to pose the question, whether there exist some relationships between the scope of the book and our actual situation. And, yes, it can make sense that I focus this question even more by relying on my own actual research agenda: I am working on a general theory of actor-actor analysis as part of engineering at one hand, and as part of the empowerment of citizens for democratic societies at the other. And compared to the scope of Newell and Simon I am not only interested in already adult intelligent people but in all ages of people being citizens. I am also not only interested in the *actual intelligence* of these people but also in those processes which can *enable* all *different kinds of people* to gain that *kind of intelligence* which is necessary to *understand each other and the municipal or urban environment* they are living in. And from this follows too that I am not only interested in those kinds of symbolic tasks Newell and Simon are mentioning but in all kinds of task which are needed for this empowerment. *Symbolic communication* will surely be one of the major factors.
I am assuming from the beginning that every citizen, every individual, is not a neutral system but has always some *picture of the world* (knowledge, including the environment), has a *motivation* with many sub-fields, and has certain *formats for his communication* with the others. The *world picture can change* by communication, by learning, by changes in the individual itself.

It is interesting that Herbert A.Simon had his first research agenda in a topic called *Administrative Behavior* (see [H.A97]), where he analyzed the conditions of how an institution can act optimally. In the preface to the 1st edition 1947 he stated

that a theory about administrations is yet far away but that the *heart of administration is the decision-making*. In the preface to the 4th edition 1997 he points out that the main processes of humans in administration belonging to decision-making and management of people are in their general outlay the same since about 4000 years. And then, there is an interesting shift in his scope: he not only addresses the people working *inside* administrations but also *all citizens* which are confronted with large institutions and administration of the state and of the economy. Every citizen is a *watcher* of administrations and somehow as a citizen also a possible *designer*.

Thus there seems to be an interesting link between the the approach of Herbert A.Simon with his organizational point of view and my view of 'smart citizens for smart democracies'.[2]

5 Comments: Coherence of Theories

The '*procedural view*' of human knowledge generation as it is mentioned in the first phrases of the book 'Human Problem Solving' is hiding the problem of *integration* and *generalization*: however someone will proceed – for instance first in depth, then integrating all, or first giving an overview, then going in depth as necessary, coming back – the requirement of a 'general view' in the end trying to integrate different data in one view is always present, even – as I remarked above – before some experiment will be started.

This raises the question, how different knowledge processes associated with their characteristic special theories can be *transformed* into a more integrated, more general framework. Can there be some 'cultural' or 'societal' mechanism which works as an 'overall context' which supports the integration of all the individual knowledge processes into one coherent view?

What we know is that this overall '*mechanism of knowledge integration*' has as 'input' the individual processes which produce their specific 'outcome' as some special *theory*. And it is the interesting question how such a knowledge integration mechanism can work?

Is it conceivable that – analogously to the way how the brain enables in every human person many pre-installed processes which do the job of perception, memory organization, abstractions, associations, and much more – there are societal processes taking the individual outputs and process them in a way which makes them elements of something bigger?

Some possible questions here could be:

1. What is the '*format*' of the individual knowledge output?

[2] In his Nobel Prize lecture from 1978 [Sim78] Simon gives an overview of the economic theories and locates the book Human Problem Solving in this big picture in a certain context which deals with the question of the nature of decision processes. He identifies this as the core of the problem every citizen is faced in his world.

2. What *kinds of relations* are possible between different knowledge outputs?

3. How can a combined knowledge output still *be 'understandable' for a human person*?

5.1 FORMAT OF KNOWLEDGE OUTPUT

Here we assume as *main case symbolic communication*, spoken or written, with or without gestural or pictorial elements.

5.2 KINDS OF RELATIONS BETWEEN KNOWLEDGE

Within language the main relations of integration is the *'timely (or 'spatial') coherence'* of parts of speech, their '*syntactical* coherence', and their '*meaning*' ('semantical coherence').

To base such a 'coherence' on a concept of '*representational similarity*' – like nearly all big data algorithm work today – does not suffice for these kinds of data, because the different parts of a speech or a text can be representational completely 'different', but do nevertheless form a 'coherent piece of talk or text'. Thus the *non-representational aspects* of a speech or talk or text are *important*.

From this follows the possibility that analogously two representational different speeches or texts can have a 'coherence' on account of some *other criteria than 'representational similarity'*!

Meaning is a structure which is located in the individual brain and is a product of a series of interactions of the individual person with possible *empirical* meaning objects and their co-occurrence with certain language expressions under certain conditions. Later also *non-empirical* objects can to some extend be used in a meaning relation. This *meaning-encoding function (fm))* connects the individual brain with its individual inner states with the outer world of empirical objects.[3] Thus, the encoding function fm serves as an interface.

Whether there exists a meaning function fm in the different human persons and whether these different functions fm_i are 'sufficient similar' to each other is a question which will primarily be decided by every individual person for itself, but it can in a rather *approximate* way also be decided on account of empirical data. In everyday situations one calls such a sufficient similarity in the meaning functions from the perspective of the persons '*understanding*'. From an empirical point of view one can only measure some 'representational similarity' of the inputs (seen as '*stimuli*', S) associated with the outputs (seen as '*responses*', R). The empirical data as such are in general not sufficient for a final classification. But they can give some hints with some probability. *A 'pure' empirical representational similarity would not be*

[3]Attention: the 'empirical objects' are for the processing brain not directly accessible but only as encoded by the sensor organs and the perceptual processing in interaction with the past experience in the memory. Thus the 'empirical objects' are not different from the internal objects on the level of subjective experience, but there 'context of experience' is such, that the brain can distinguish these subjective states from other subjective states!

able to distinguish between an affirmative statement or it's counterpart.

DIFFERENT LANGUAGES: If we have two different languages L1 and L2 in the sense that we have different expressions talking about the 'same subject', then the expressions as such do not give us a key for understanding. Representational similarity is somewhere nearby zero. But if a person P1 speaking language L1 with meaning function fm_{L1} has 'learned' the meaning function fm_{L2}, then the person can '*translate*' expressions from language L2 into the intended meaning fm_{L2}(L2) = M2 and if this 'interpretation' is part of the individual 'knowledge K1' of the person P1 as a true subset (M2 subset K1), then the person P1 can re-translate the meaning of M2 as part of her knowledge K1 with the meaning function fm_{L1} back to expressions of L1, $fm_{L1}(M2\ subset\ M1) \in L1$.

Therefore the 'key' of relating two different texts t1 (from language L1) and t2 (from language L2) to each other is the intended meaning and it's encoding or decoding.

5.3 UNDERSTANDABILITY OF INTEGRATED KNOWLEDGE

While the meaning functions fm_i from different natural languages L_1 in general and between individual person P_i with the same language can differ, it is a question how different persons can somehow *'bootstrap' a meaning function* in a way that this suffices to enable a communication with other persons.

As we know today the structure and functions of the human brain are in a way 'similar' that children usually are able to learn every language without explicit teachers by only being an active part of the everyday world of living. That means that the brain provides mechanisms, processes, which automatically process the flow of stimuli data in a structured and organized way which allows a mapping between the elements of 'cognition' and expressions of some 'language'. It is completely sufficient for a child to be in some environment to enable stimuli, which then will be processed mostly 'automatically'! In this automatic context a meaning function fm '*emerges*' from this 'machinery'.

In this context several researches have raised the question whether there is some 'general structure' of all the different languages. Usually this question was limited in it's scope to the representational dimension of language. But this is the 'dark side of the language' because the 'sun' of the meaning structure is thrown away. That some researches introduced nevertheless some aspects of meaning in this limited scope is misleading because they did not describe the meaning as a subject on it's own but as an 'appendix' to the syntax they investigated.

An interesting circumstance here is that besides the so-called *everyday languages* there exist the *mathematical language* – the set theoretical language Lset – which is used by all engineers and scientists world wide as the common language of engineering and science. This language has only two basic concepts: 'set' and 'relations between sets'.

Instead of using the richness of everyday language it is an interesting point of view to ask for the *cognitive presuppositions* which are necessary to *allow* a sufficient *meaning function* fm_{Lset} to encode the knowledge of a whole population of engineers and scientists (and then of everybody).

To answer the question one has to propose a *theoretical model* Th_{cog} of those minimal processes in a human person P_i which encode the experience of the world Pw.i in a meaning structure M.i which serves as the domain of the meaning function $fm_{i,Lset}$ as $fm_{i,Lset} : M_i \leftrightarrow Lset$. Given such a theoretical model Th_{cog} one can asses it by experimental setting generating data which at least can '*confirm*' or '*dis-confirm*' the conclusions of the model.

Because the theoretical model Th_{cog} together with the meaning function fm_{Lset} will be common for all human persons the possible meanings M.i will all have a same basic format[4]. This points to a situation where the different knowledge outputs can be seen as partial structures $fm.i_{Lset}$(M.i) = Out.i, $fm.j_{Lset}$(M.j) = Out.j, which in principal can be integrated in 'bigger chunks of knowledge'. This outputted knowledge Out.i is represented in the mathematical language, which is 'situation-bounded' and can be 'verified' for every mentioned aspect (actually verified or postponed for later or falsified). This outputted knowledge Out.i can also directly be fed into a computer and being simulated.

6 Information Processing Systems (IPS)

After the outline of the main subject of the book Newell & Simon describe the way how they look to the empirical object *human person*. They point out that they locate themselves in the *new turn of psychology* from a discipline which was oriented to learning mechanisms in lower animals with simple learning tasks to a discipline which after 1956 used many new methods developed during the World War II and which now spread into many disciplines, especially in the realm of psychology and the new computer.

This new turn used heavily the new digital computers, but Newell & Simon underline that they did not use the computer directly as a metaphor for human persons but the more abstract theoretical concept of an *Information Processing System (IPS)*. Generally is an IPS an abstraction, a generalization which as such allows only an approximation, but on the other side allows the formalized concept of an IPS the introduction of precise theoretical terms and a complexity of modeling which otherwise would not be possible. And it allows a comparison of the model with empirical data.

It is interesting to recognize that Newell & Simon explicitly *exclude the physiological perspective* because these data do not directly fit into the description of behavior.

[4]Possible differences can result from different *learning histories* which include many different factors which effect learning and the learning result.

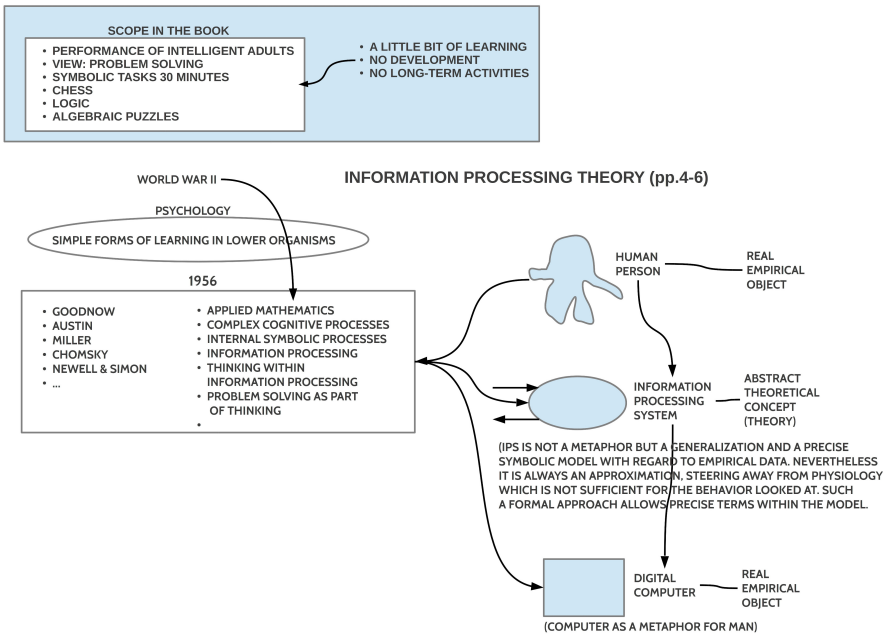

Figure 2: Graphical Reconstruction of IPT

7 Comments on IPS: Philosophy of Science

From the point of a history of ideas it is interesting that Newell & Simon trace their research back to the development of psychology, applied mathematics and information processing theory but they do not mention a timely parallel process under the label of *Philosophy of Science* dealing with the *Structure of Theories*.[5] At the same time did philosophy of science not absorb these new empirical and technological developments. And it seems to me that this twofold separation continued until today with very bad consequences.

If one knows the tradition of philosophy of science and one reads the text of Newell & Simon then one experiences immediately the lack of certain concepts which could be applied to the question of how to deal with the empirical reality of a human person – and even with large groups of them – from a scientific point of view.

As Newell & Simon point out: a strong point for the usage of the IPS concept together with the digital computer was (and is) the possibility to built more advanced formal models to describe complex behavioral processes understood as rooted in an internal information processing machinery. Without such formal (mathematical) models it wouldn't be possible.

From the point of research – and from the point of engineering to use this new knowledge – this is the strongest argument which is possible.

[5]See the wonderful book of Frederick Suppe (1979) [Sup79] about the status of that field in that time.

But even if the intensive discussion in the field of philosophy of science can reveal the details of such formal models as tools for the description of a dynamic empirical reality the formal explication is by far not trivial and full of possible pitfalls.

It is here not the place to discuss all this in detail but one should keep in mind that already in this part of history we observe the beginning of a separation of two very important strains of thought which should be live in an active symbiosis but they do not.

The way how Newell & Simon talk about their IPS indicates a little bit the absence of philosophy of science terms and the difficulties which this implies. They discuss whether the computer can be a *metaphor* of man, but decide then to talk about an *abstract concept* as what they understand an IPS, but comment themselves that it is *not the most abstract possible way to describe* an IPS. Why not a *metaphor*? What is an *abstract concept*? What would be a *more abstract way of description*?

They talk then about their approach as a *precise symbolic model* on the basis of which *specific aspects* of man's problem solving *behavior* can be *calculated*. This raises the question how the *overall format* of such a symbolic model has to be understood, that this format allows *calculation of behavior*. What does it mean that *behavior* will be *calculated*? Usually calculation deals with numbers, which isn't what behavior usually is understood to be.

Then they characterize again their symbolic model of an IPS as an *approximation* – as apparently synonymous with the word *abstraction* – which lets open how I can classify a model as an approximation compared to what and with which criteria.

More important is that Newell & Simon state explicitly that such an approximation/ abstraction does *hypothesize discrete symbols* and a *set of elementary processes*. These are understood as *replacements* of the otherwise used physiological elements and mechanisms and therefore they seem to function here as a kind of a *model of those (hypothesized) internal elements and processes* which are assumed to enable the observable behavior. The way how Newell & Simon introduce such hypothesized models reads at a first glance as an approach which does not need any more physiology, which appears to them – as they state it – to be *not at all adequate* for the tasks dealt in their book.

From the point of philosophy of science this opposing attitude seems to be superfluous and somehow contrary. If one takes the empirical data of observable behavior as point of empirical reference then it is completely acceptable to define some formal theory which uses some formal model describing internal processes presupposed as those non-observable internal structures which are assumed to *enable* the observable data.[6] As long as the *predictions* based on the formal theory with their assumed model are in agreement with the observations everybody feels good. If the agreement works bad or not at all one should change the theory with their model.

[6]Modern physics does this all the time.

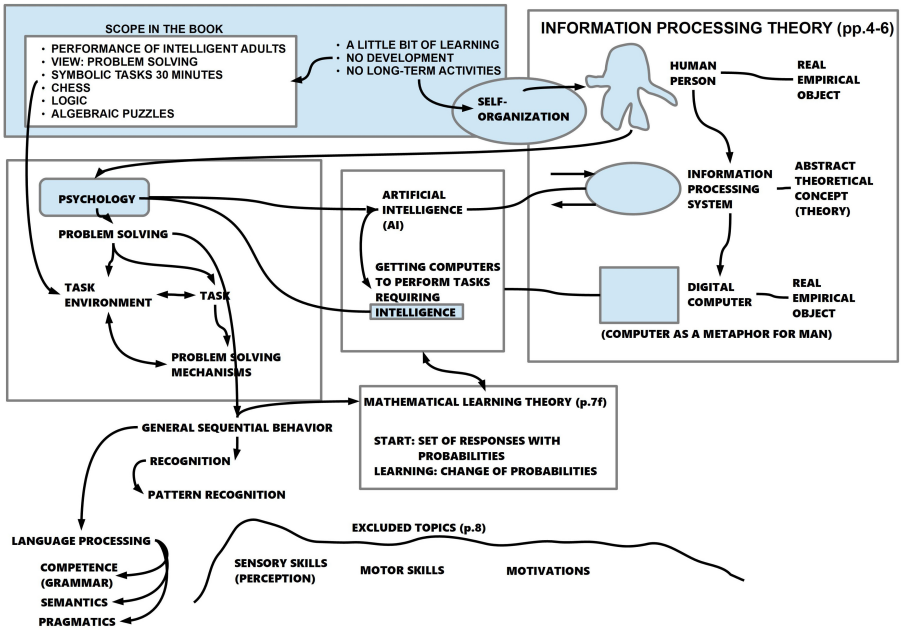

Figure 3: After IPS remarks to AI, Performance and some Omissions

But because in the case of a human person the *body* with the *brain* is understood as that machinery which enables the observable behavior it makes sense to try to *correlate* aspects of the physiology with the behavioral data. This implies an advanced complex theory ideally called *Neuropsychology*, which could eventually be of help to interpret the abstract model of Psychology about internal processes. But Newell & Simon state explicitly that the explanation (including forecasting) of complex behavior is not possible with the available physiological data. This is in some accordance with new insights that physiological data on the level of measured signals alone can never give a clue to the implicit functions of the brain and the body. To be of help for a better understanding of tat machinery which enables observable behavior one needs an additional theory which has to use behavioral data as well. Neuropsychology would be the right label, but it is open to which extend there exists really neuropsychological theories in the intended sense. It remains the other question how one can compare or even integrate a psychological theory with a neuropsychological theory. As far as I see this question is not solved.[7]

8 AI, Performance, Omissions

After the description of the *scope of the book* and the concept of *information processing systems (IPS)* described above Newell & Simon explaining now topics like

[7] These severe lacks in the clarifications of methodological questions is probably due to the fact that the individual disciplines today have no sufficient philosophical resources and outside of the individual disciplines there are no philosophical resources available which directly deal with the individual disciplines in a satisfying way.

artificial intelligence (AI) related to general psychology, general problem solving, language processing and some subjects which are missing.

AI: While today (2019) there is a strong tendency in computer science to separate artificial intelligence from the field of psychology and one has coined a dedicated label for this separated intelligence called *machine learning (ML)*. Newell & Simon instead are still advocating the position, that artificial intelligence associated with computers is borrowoing a lot from psychology, especially some rudimentary conecpts related to the term *intelligence*. And indeed in a historical as well as methodological perspective the term *intelligence* is only used in the realm of psychology by desribing certain aspects of the behavior of biological systems, especially man.

GPS: Newell & Simon subsume the topic AI under the general topic of general problem solving which presupposes a system fulfilling some *task* within a *task environment*. The processing system needs a *set of mechanisms* which can generate the needed *responses* in the task environment.

Learning: Larning is being understood as a special topic inside of GPS. In early mathematical learning theories in psychologie a learning system has been analyzed as a *set of responses* associated with a *set of propabilities*. Learning happens when these probabilties are changing in a certain way during the process. But according to Newell & Simon this learning concept presupposes a general sequential process as in GPS.

Language Processing: Newell & Simon understand language processing with its subfields *grammar* (as competence), semantics and pragmatics as a subfield of GPS too.

Other Omissions: There are more topics left out like *sensory* skills and *motor* skills as well as the topic of *motivations*. They also are understood as follow ups from the more general ideas of GPS.

9 Comments on GPS, AI, Learning, Language ...

One can get the impression that Newell & Simon try to organize these different topics along the idea of a most general point of view called *general problem solving (GPS)* understood as sequential process which gives the framework for all the other topics.

From a formal point of view including philosophy of science is this argumentation a bit sloppy. Otherwise one has to conceed that the whole field at this time is

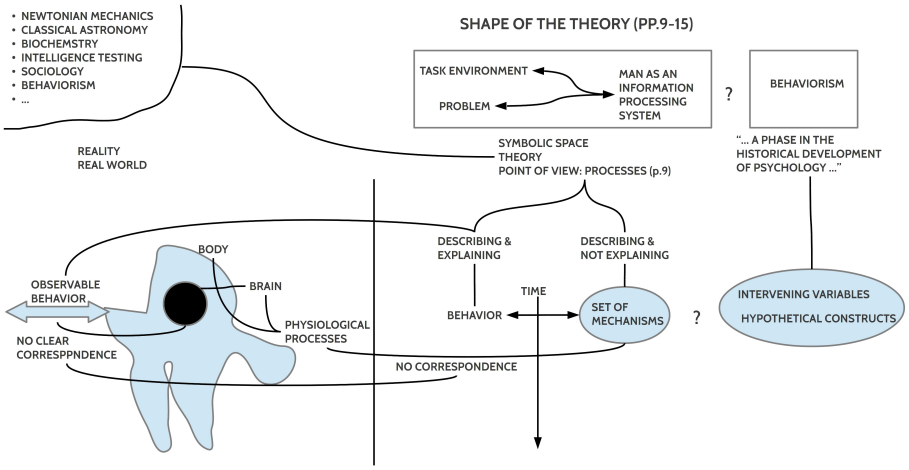

Figure 4: Graphical outline of chapter 1, section 'The Shape of the Theory', first paragraphs

characterized by many research fields which are not completely analyzed with regard to their methodological and formal relationships. This is due in some sense to the lack of an overall and commonly accepted formal framework at that time as well as to the newness of all these topics; there are no known prototypes from the past onto which one can built the new ideas. Therefore it is in interesting question what the next section entitled 'The Shape of the Theory' will tell us.

10 The shape of the Theory

The final section of chapter 1 starts with a paragraph naming some prominent theories of the past, characterizing them with some prominent properties, and states that in the following paragraphs the *shape* of the *present theory* should be described in analogy to these examples (see figure 4).

Remark: The way how Newell & Simon mentioning these past examples is *different* from a point of *philosophy of science*! It mentions individual properties without looking to the common structures, and in no way to structures which are possibly *common to all examples*!

10.1 A Process Theory

As pointed out in figure 4 Newell & Simon assume for their theory that *man* can be considered as an *information processing system (IPS)* at least as long as it deals with problem solving (in a task environment). And because *problem solving* happens during a *process* they characterize their theory as a *process theory* to locate this theory in the space of historical examples of theories.

That part of their theory which is dealing with the *processing system* which represents the theoretical description of man during problem solving contains a *set of mechanisms* which are *not* understood as an *explanation* but only as a *description*, and this description has *no correspondence* to the physiological processes of the brain of real man. This lack of correspondence is motivated by Newell & Simon with the argument that the brain theories so far have not enough evidences about the relations between physiological processes and observable behavior. The theories of behavior would not change by taking into account of the insights in physiology!

With regard to the *behavior* which is described in their theory they claim to give not only a *description* but an *explanation* too.

Behaviorism as the shape of psychology during many decades is only shortly mentioned by the authors. They cite the terms *intervening variables* and *hypothetical constructs* without comments and classify behaviorism as "... a phase in the historical development of psychology ..."(p.10)

10.2 Comments to: A Process Theory

The lack of philosophy of science shortly mentioned in the beginning continues in this section very concretely. The mentioning of *behaviorism* only as a 'phase in the history of psychology' plays down that the formal shape of behaviorism from the point of view of philosophy of science is nearly identical with their own theory. The cited terms *intervening variables* and *hypothetical constructs* are from a formal point of view nothing else then theoretical terms in a theory representing some aspects of the internal mechanisms of the system; nothing else do the *mechanisms* of Newell & Simon! And to say that these mechanisms represent only a *description* and not an *explanation* is formally not adequate: the *whole* theory contains the environment, the behavior, as well as some internal structures, and independent of some special meaning these internal structures as a whole serve the theory to *explain* the whole behavior in the assumed environment. The special shape of these internal structures doesn't matter. To stress the point that these mechanisms have to be understood as *information processing* structures does not change their general function as explaining variables. In this formal sense this *information processing approach* appears not to be really different to the general behaviorism. The information processing approach is still a theory to explain behavior with the aid of some *assumptions about internal structures* independent of the special kind of structures. The 'set of mechanisms' is a *hypothetical construct* too and clearly does this hypothetical construct function as an *intervening variable* in the explanation of observable behavior.

Because Newell & Simon disclaim to use some correspondence to the physiology of the brain and the body their formal construct of the internal mechanisms is *free of direct empirical relevance*, only *implicitly* they claim some empirical relevance with regard to the behavior. Nothing else does behaviorism.

The wording *information processing* was at the time of writing the book part of the *mainstream thinking*. But this does not free of the necessity to explain what *information* in this context means. Interestingly the authors do not really explain this term. As we know today the definition of information as introduced by Shannon

(1948)[Sha48] does in no way describe that kind of information which is functional inside human communication. While Shannon dealt with statistical properties of signals in communication channels does human communication deal with the implicit meanings of symbolic processes; this is fundamentally different. Therefore to use the term *information processing* without further explanations is really dangerous.

From later books with Newell (see for instance Card, Moran and Newell (1983) [CMN83]) we know that their the internal structures to explain the observable behavior in certain task environments is fairly well structured to encompass so-called *perception*, *memory*, *planning* etc. The terms mentioned there are very well known in psychology but not in any other discipline (in brain science today too, but there they are clearly borrowed from psychology) . These terms are receiving their 'meaning' from the observed behavior, the task environment, and from the different kinds of theoretical constructs used in psychology so far. To call this *information processing* does not explain anything; if you cancel the term information in this context you will not loose anything from the theory, and in the context of the later theories the term 'information' is not really explained (and it would be impossible to explain the term 'information' in this context!)

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