A CONTRIBUTION TO THE ANALYSIS OF HUMAN SPEED OF INFORMATION PROCESSING: DEVELOPMENTAL AND DIFFERENTIAL ARGUMENTS

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Speed of human information processing (SIP) is a research construct which has been examined under different names and with different intensity for more than sixty years. Its importance is briefly described in four research fields: differential, experimental, aging and cognitive development. Since SIP presents an important component of contemporary intelligence models and life-span cognitive development research, an attempt for the construction of an integrated SIP picture was necessary. Review and systematic analysis of 42 research papers and additional related literature showed that there are problems with the validity of the SIP construct, but it also revealed other theoretical and empirical inconsistencies. A new proposal for SIP phenomena has been made, which abandons the SIP construct with related measures, and introduces the RCP property as one of the general attributes of every cognitive process.

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PROCESSING SPEED AS AN IMPORTANT CONSTRUCT OF HUMAN COGNITIVE FUNCTIONING

Speed of information processing (SIP) is probably one of the most intriguing constructs in the research of human intellectual functioning. In different times, under different names, it was an object of intensive research in, at least, four psychological research fields: (1) intelligence, (2) experimental cognitive psychology, (3) aging and (4) development.

Intelligence researchers have rather thoroughly analysed the speed of human information processing in their attempts to explain human intellectual abilities. First, at the very beginning of scientific psychology (19th century) when Francis Galton tried to prove his eugenic theory of intelligence by using reaction time in addition to other psychological and anthropometrical measures (Gardner et al., 1999). Later, during the period when psychometric approach dominated the research of intelligence, processing speed was considered as an independent factor of non-hierarchical intelligence models (e.g. perceptive speed in Thurstone's Primary Mental Abilities Model) (Gardner et al., 1999), but mostly as a factor of hierarchical models (e.g. processing speed – second order factor in Horn & Cattell Gf-Gc Theory and in Carroll's Three-Stratum Theory of Cognitive Abilities) (Woodcock, 1994; Bickley et al., 1995). The latest attempt started – and is still under way – with the cognitive correlates approach to intelligence, where processing speed is one of the key constructs of intelligence models, often labelled as mental speed (Kyllonen, 1994; Neubauer & Knorr, 1998; Roberts et al., 1996; Roberts & Pallier, 2001).

On the whole, processing speed has been a clearly recognised cognitive ability in intelligence research.

Experimental cognitive researchers had the task to propose the most complete theoretical model of human cognitive functioning by analysing the flow of individual information processes during solving some cognitive tasks (starting from initial perception, through a series of other cognitive processes and resulting in either an observable response or merely in a change of contents of the individual's memory). In that sense, a wide variety of experimental designs and cognitive tasks were designed to isolate the informational flow through different cognitive subsystems (Vernon, 1994; Shepard & Metzler, 1971; Sternberg, 1966; Posner & Mitchell, 1967). The time spent in solving cognitive tasks specific to the defined cognitive subsystems actually reflects the speed of information processing in those subsystems. Later on, experimental cognitive research comprising processing speed (or, more precisely, processing time – the inverse operationalisation of processing speed) started considering the problem of continuity vs. discontinuity of information processing (Levy and Pashler, 1995; Mulder and van Galen, 1995). Experimental cognitive research also analysed the relationship of processing speed with other aspects of cognitive functioning, (e.g. errors during cognitive task solving) (Nettelbeck, 1994; Coles et al., 1995), and with other constructs important for the description of the human cognitive system – mostly working memory (Hitch et al., 1989;

Brandimonte et al., 1992). To summarise, experimental cognitive research treated processing speed as a basic property of human information processing which served as a key-means for examining the components of informational flow through the human cognitive system and its characteristics (continuity, error probability, etc.).

Researchers of aging included processing speed quite comprehensively in their attempt at describing the age of related changes in human intellectual functioning. The main reason for that was the role of speed of information processing in almost all contemporary models of intelligence and great sensitivity of the processing speed to age related changes. The first research of the influence of age on processing speed described the relationship between the rate of processing in young adults and the elderly (Cerella, 1985). Further aging research investigated whether the age related changes of a wide variety of processing speed measures are independent of each other, or whether they share a significant amount of the variance (Salthouse, 2000). Timothy Salthouse systematically investigated the shared variance of age related changes of processing speed and of other cognitive variables, e.g. memory, reasoning, spatial abilities, etc. (Salthouse, 1994a, 1994b, 1998) and tried to define the mediation effect of age related changes of processing speed on age changes of other cognitive variables when they are not assessed in a limited time (Salthouse, 1991, 1994b). Research often focused on the relationship between processing speed and working memory capacity in their mediation of age changes of higher cognitive variables (Salthouse, 1991; Verhaeghen and Salthouse, 1997; Stankov, 1999), and on the examination of the age-complexity relation in adulthood (Salthouse, 1988). Finally, some comprehensive theoretical models of cognitive slowing in adulthood were proposed on the basis of processing speed (Myerson et al., 1990; Salthouse, 1996).

Developmental research of processing speed showed that it was the most important, or at least second most important construct (after working memory capacity) of the information processing approach to cognitive development. Developmental changes of processing speed were recorded very early in developmental psychology through Smith's (1934) research of age changes of simple reaction time on visual stimuli, and Goodenough's (1935) research of auditory reaction time developmental changes (Wickens, 1974). Systematic research of developmental changes in the speed of processing started in the 1970s with the main objective of finding the mechanism of processing speed development (Wickens, 1974; Chi, 1977; Kail, 1986). The same objective has inspired researchers for the last twenty years and is still on the agenda. The most important question of the research (whose solution implied the answer to the mechanism of processing speed development) was whether the developmental change of processing speed is global, or process specific. Precisely, whether the processing speed changes during the life-span in the same way for all domains of human cognitive processing or if it changes differently in different domains? If it is global, then the developmental mechanism is mostly (but not completely) determined by neurobiological factors – maturation. If it is process specific, then it is mostly determined by experience – the practice and age changes of different strategies in cognitive task solving. Although process specific explanation has some remarkable evidence (Stiegler et al., 1988; Molenaar & van der Molen, 1994; Ridderinkhof & van der Molen, 1997) there is even more evidence for the global explanation of processing speed development (Hale, 1990; Kail, 1991a, 1991b; Hale et al., 1993; Hale & Jansen, 1994; Kail & Salthouse, 1994; Miller & Vernon, 1997). However, for the purpose of this paper it is relevant to point out that the neurobiological mechanism (maturation) of processing speed development – as a part of global hypotheses – has been verified by some more direct research (Eaton & Ritchot, 1995; Travis, 1998; Rose et al., 2002.). In the last decade, the diversity of developmental studies on processing speed has been enriched with quite a number of research projects on the developmental relationship between processing speed, working memory and some higher intellectual abilities (Kail & Hall, 1994; Kail & Park, 1994; Kail, 1997; Fry & Hale, 2000).

Finally, all this specific research of processing speed development and its relationship to other cognitive functions have given arguments to Andreas Demetriou to build one of the most comprehensive theories of cognitive development, which clearly incorporates the speed of processing as one of three dimensions of the processing system – the core of the human mind (Demetriou & Raftopoulos, 1999; Demetriou et al., 2002).

A broad presence of processing speed in psychological research certainly might be indicative for the fundamental role of that construct in human intellectual functioning.

DEFINITIONS AND MEASURES OF SPEED OF INFORMATION PROCESSING (SIP) – UNFINISHED STATE

In the previous section it has been demonstrated that speed of information processing is a widely accepted and used construct in several fields of psychological research, and therefore the need for its critical review and analysis might surprise. Moreover, the idea becomes intriguing when one considers the fact that the speed of information processing (SIP) has been treated like an important and inevitable component of the human intellect by leading authors in the field of intelligence research: Horn (Horn, 1968), Cattell (Cattell, 1971), H. J. Eysenck (Eysenck, 1987), Nettelbeck (Nettelbeck, 1994), Carroll (1993), Vernon (1994), Stankov (1999), Roberts & Pallier (2001), Deary (2000), Neubauer & Knorr (1998). It has also a very important role in newer theories of cognitive development (Platsidou et al., 1997; Demetriou & Raftopoulos, 1999; Demetriou et al., 2002) and in research on age changes of cognitive functioning during life span (Kail & Salthouse, 1994; Cerella & Hale, 1994).

One of the methodological reasons for this construct analysis is a confusion produced by the fact that the construct of SIP appears in the literature at least under seven different names (mental speed, speediness, speed of mental processing, cognitive speed, processing speed, speed of information processing, information processing rate), it is operationalised with at least 98 different measures (which we reported in the *Appendix*, according to research fields)[1] and has at least two complementary definitions connecting all these names and measures (which we will mention at the end of this section). This unfinished state of the SIP treatment in psychological research can seriously influence the research orientation and consequent errors in research projects including SIP as research variable. Another, more important reason for this construct review and analysis is the fact that the uncritical overtaking, or uncritical generating of new measures for SIP from the definition of that construct, leads to different and sometimes even opposite results in research. For example, a number of developmental researchers took some SIP measures from differential research on SIP-intelligence relationship without taking into account related dilemmas on the structure of that construct. Consequently, they got different results about the global/domain specific nature of SIP development (Kail, 1991b; Ridderinkhof, van der Molen, 1997). The very fact obviously obstructs construction of a complete picture of the SIP and its relationship with other cognitive constructs as well as its role in human cognitive functioning. Therefore, a systematic presentation of possible problems with the SIP definition and measures is needed.

Developmental Evidence of Inconsistency

The majority of problems most probably appear in those research fields from which SIP does not originate, but the researchers in those fields take it over from experimental and differential psychology where it was originally introduced and systematically examined. An example of such a research field would be newer theories of cognitive development. Reviewing the content of 24 articles from that field (listed in the literature of this paper) it was found that in merely four of them,[2] there is an explicit definition of SIP. That reflects either the intentional avoiding of an explicit definition because of the vague state of the construct, or neglecting it because SIP is perceived as such a well-known and clear construct (some kind of construct primitive in models of cognitive functioning) that it appears not to be necessary to be explicit. However, the complexity of the SIP definition is clearly visible in the Fry and Hale (2000) review written on the relationship among SIP, working memory and fluid intelligence during childhood:

> ... For many years, researchers interested in examining the relationship between the speed of information processing and intelligence used very simple tasks (e.g. simple reaction time or choice reaction time) to measure the processing speed. The reason for using simple tasks was to minimize the contribution of higher cognitive functions that would be included in one's assessment of intelligence. Instead, the speed of information processing was meant to capture the speed at which an individual completed basic cognitive functions such as identification or simple discriminations. Within this framework, some researchers even attempted to distil the cognitive speed from any motor speed involved in the actual execution of the response ... More recent findings from multitask experiments suggest that speed of information processing should be viewed as a general or task-independent construct. The speed of information processing of young adults has been found to be highly correlated across different tasks that span a wide range of complexity and the speed performance on many different tasks improve in concert during childhood, reflecting a global developmental trend in processing speed... (pp 2-3).

These quotes indicate the unresolved status of the SIP definition, and will be used later as argument for the proposal of a possible definition of a new construct.

A further problem concerning the SIP construct, especially its age changes, is the well-known and still unresolved discussion on the global, or domain specific change of SIP (mentioned in the previous section). Besides the difference in approach to data analysis, the unresolved status of this dilemma reflects also the differences in the used measures of SIP. Namely, authors who argue global hypotheses use almost exclusively behavioural measures of SIP (reaction time, and time per task – in paper and pencil tests). On the other hand, proponents of domain specific hypotheses, besides mathematical simulations, mostly use psycho physiological measures of SIP (different forms of event-related brain potential, such as P3 latency and lateralized readiness potential onset) and reaction time (RT) in Eriksson flanker task for which most of cognitive psychologists state that it reflects interference resistance – a measure of selective attention.

A further inconsistency, connected with the previous one, which points at the unfinished definitional status of SIP in developmental literature can be seen in the explanation of developmental changes of SIP by Robert Kail – one of the leading authors in the research of SIP development. Until 1994 he continuously argued (Kail, 1986, 1991a, 1991b) that one of the possible mechanisms of age changes of SIP is the development of processing resources, and in 1994 (Kail & Salthouse, 1994) he concluded that SIP itself is a processing resource, crucial for human cognitive functioning. However, the resource definition of SIP is clearly questioned in the work of Ridderinkhof & van der Molen (1997). In that work the authors argued that the regression approach – used by global hypotheses proponents – conceals process-specific age-related changes in processing speed, and therefore, they offered the ANOVA approach for the analysis of developmental changes in processing speed. Furthermore, they gave empirical evidence in the form of chronopsychophysiological data, which clearly show a difference between the development of perceptual processes and the development of response-selection processes activated during cognitive task solving.

The next developmental evidence of inconsistency, which points to a more methodological aspect of SIP determination, is the fact that there have been found 58 different measures of SIP (mentioned *Appendix 1*) in a review of developmental literature, with some of them widely recognized for measuring other constructs in other fields of cognitive research. For example, Stroop task, and Eriksen flanker task are used as SIP measures in the research of SIP development during childhood and adolescence (Kail, 1991b; Ridderinkhof & van der Molen, 1997). At the same time they are widely accepted measures of selective attention in cognitive psychology (MacLeod, 1991; Sternberg, 1996), and in newer theories of cognitive development (Demetriou et al., 2002).

Another example is the difference in understanding SIP measures between R. Kail (1991b) and A. Demetriou (et al. 2002), which has already been mentioned in the comment on Stroop task, but it is also obvious in the research of Kail and Hall (1994). In that research, the result in the Reading Recognition subtest of Peabody Individualized Achievement Test (PIAT) is treated by Kail as a measure of higher cognitive ability (reading skill), while only a slightly different form of the same test is treated by Demetriou as a representative measure of SIP (Demetriou et al., 2002). In the same research Kail and Hall use three paper and pencil tests of perceptive speed (Coding Test, Visual Matching Test, and Cross-Out Test) for measuring SIP, which – in the perspective of componential analysis of task demands – are more complex than the Reading Recognition Test,[3] thus disagreeing with the basic criteria for the selection of SIP tasks (at least in earlier conceptualisations of SIP).

Comparative Evidence of Inconsistency

There are some more examples from SIP studies that show the lack of unanimity of the leading authors in the field concerning the real measure of SIP, which are not restricted to cognitive development research.

It was already mentioned that Demetriou (et al. 2002), in his theory of cognitive development, suggests the speed of single-word reading in one's native language as an appropriate SIP measure. On the other hand, Salthouse (1996), in presenting his theory of cognitive aging, as example of an inappropriate measure of SIP mentions exactly the tasks of reading speed. In the same article, Salthouse suggests that paper and pencil tasks of perceptive speed are appropriate measures of SIP, which Stankov (1999) criticises as inappropriate, since these tasks include attention mechanisms of visual search which are clearly treated differently from SIP in cognitive correlate approach to intelligence research.

The next example of inconsistent treatment of SIP measures comes from differential psychology, more specifically, from the cognitive correlate approach to intelligence research. In their analysis of the basic information processing (BIP) unit, Roberts, Pallier and Stankov (1996) used reaction time (RT) in 10 computerised elementary cognitive tasks (ECT), clearly differentiating them from the tests of clerical-perceptive speed, which constitute the Gs factor of wide cognitive ability in the Horn-Cattell theory of intelligence. On the other hand, Neubauer and Knorr (1998) used the well-known chronometric ECTs of short-term memory scanning (Memory Scanning Test) and long-term memory retrieval (Letter Matching Test) to construct appropriate paper and pencil tests. These paper and pencil tests, according to my assessment of their cognitive and motor content, belong to the group of standard clerical-perceptive speed tests, but – unlike Roberts, Pallier and Stankov – Neubauer and Knorr (together with Coding Test) did use them as measures of SIP.

Furthermore, Roberts, Pallier and Stankov used Colour Stroop Test in the same research (1996) as a measure of clerical-perceptive speed, which has already been mentioned as a widely accepted measure of selective attention in cognitive psychology. Additionally, they also used Multitask Card-Sorting and Multitask Word Classification as measures of SIP, and these tests clearly demand cognitive processes of divided attention which should not be present in SIP tasks – at least according to some earlier definitions of that construct.

The next example of inconsistency comes from the Neubauer and Bucik (1996) analysis of mental speed-IQ relationship, where they clearly distinguished paper and pencil tests of SIP (Lindley's Coding Test, Posner's Letter Matching Test and Sternberg's Memory Scanning Test) from processing speed subtests in the Berlin Intelligence Scale (BIS) which they treated as intelligence measures. On the other hand, Wilhelm and Schulze (2002) used exactly these processing speed subtests of BIS as SIP measures in their research of the relation of speeded and unspeeded reasoning with mental speed.

Finally, concerning the SIP construct a comparative observation should be proposed pointing to at least a partial inconsistency in the material aspect of the SIP definition. Namely, in various models of cognitive functioning the SIP and working memory (WM), together with attention (in some of the models) are treated as equivalent key-factors/constructs of intellectual functioning. On the other hand, WM and attention have relatively precisely defined and localised the biological substrate (Kinchla, 1992; LaBerge, 1995; Awh and Jonides, 2001; Smith and Jonides, 1998) while SIP does not have it. This fact becomes problematic in terms of internal consistency of the models of human intellect, which treat these three constructs as dimensions spanning all cognitive processes (while two dimensions have relatively precisely determined the biological substrate, the third one does not have it). One example of such a model is the processing system in the Three-level theory of developing mind (Demetriou & Raftopoulos, 1999; Demetriou et al., 2002), where SIP, WM and attention are treated as three dimensions of the system. The second example comes from differential psychology where Carroll's Three-stratum theory of cognitive abilities (Bickley et al., 1995) and Horn-Cattell's Gf-Gc theory of intelligence (Woodcock, 1994) are found. In these models of human cognitive abilities SIP and WM have a crucial position as second order factors in the hierarchy and should be treated as equivalent (although there are frequent debates which of the two constructs is more important for the definition of *g*). The third example of such a model of cognitive functioning that stresses the equivalent role of SIP, WM and attention, is Kail and Salthouse's explanation of life-span changes of SIP, which consider SIP as a mental resource (Kail & Salthouse, 1994). In this explanation the authors introduce a concept of mental resource, which has clearly defined characteristics and a relatively strong analogy to three physical resources: time, space and energy. All of them are respectively – on an analogical level – connected with three key-characteristics of the processing system of human cognition: SIP, WM and attention.

Definitions and Measures Résumé

Previous discussion clearly shows that the comprehension and treatment of SIP within the same, but also in different research fields, are not integrated. It is, therefore, rational to wonder why.

One important reason is certainly the lack of a unique and existence of rather complementary definitions of SIP (which stress different aspects of the phenomena), from which numerous related measures of the construct are derived. That might be a consequence of the multifaceted nature of SIP (Stankov, 1999). However, the problem stems from a great number of different operationalisations of SIP thus suggesting that every cognitive subsystem should present one facet – and there are plenty of them.

Although it was stressed at the beginning of this section (by using the words of Astrid Fry and Sandra Hale) that there are some problems with the SIP definition, for the purpose of this paper it is important to summarise the definitions of SIP in reviewed literature on intelligence, aging and development. That summary is complicated by two facts. First, in reviewed literature only A. Demetriou explicitly defined SIP (as maximum speed at which a given mental act may be efficiently executed – Demetriou et al., 2002, 6), while all other articles contain sentences that only herald the definition of SIP. To some extent, some of those sentences might be seen as too general or circular definitions of SIP, while others are merely a set of operationalisations without necessary abstraction. The second factor complicating this conclusion is the fact that the SIP construct has independently emerged in two research fields under different names, but later on, it was used and developed through the interrelationship of those fields – differential and experimental psychology. An additional problem arose because in neither of these research fields has a unique approach to the treatment of that construct been adopted to date. For example, Stankov (Stankov, 1999) stresses that in differential psychology biological oriented researches – Jensen, H.J. Eysenck, Vernon and Deary –

emphasise a broad presence of SIP in the structure of intellectual abilities, and its biggest influence on *g*, while on the other hand, authors like Horn, Carroll, Sternberg, Roberts and Stankov do not accept the leading role of SIP in the human intellect, holding it only for one of several wide cognitive factors. In the information processing approach (i.e. experimental psychology) a unique definition of SIP also does not exist, primarily because that research approach is only a theoretical framework, and not a consistent theory with a strong organisation of assumptions and propositions, and well-specified relations among constructs (McShane, 1991; Salthouse, 1992).

Nevertheless, from all previously reviewed literature two different definitions of SIP, belonging to two different traditions, could be abstracted.

In differential tradition (e.g. Carroll, 1993; Kyllonen, 1994; Nettelbeck, 1994; Deary, 2000; Neubauer & Bucik, 1996; Neubauer & Knorr, 1998; Stankov & Roberts, 1997) SIP is defined as an important factor in the structure of human cognitive abilities, which reflects the speed of execution of elementary cognitive processes present in all cognitive tasks (such as perception, encoding, short-term memory scanning, long-term memory retrieval, comparison, etc.). The most frequent measures of SIP are reaction times (in chronometric design) and time per task (in paper and pencil design) in elementary cognitive tasks (ECT). An ECT is defined as "any one of possibly a very large number of tasks in which a person undertakes, or is assigned, a performance for which there is a specifiable class of "successful" or "correct" outcomes or end states which are to be attained through a relatively small number of mental processes or operations, and whose successful outcomes depend on the instructions given to, or the sets or plans adopted by, the person." (Carroll, 1993, 10).

In experimental tradition (e.g. Sternberg, 1966; Posner & Mitchel, 1967; Shepard & Metzler, 1971; Wickens, 1974; Cerella, 1985; Myerson et al., 1990; Levy & Pashler, 1995) SIP is a common characteristic of every cognitive process, which reflects the duration of information transformation in that process during execution of any information-processing task. Information-processing task is defined as any cognitive demanding task in which a person has to register some aspects of the presented task situation, transform them in his/her cognitive system into a set of information which will be interconnected, or connected with existing information in the memory, compare them and finally, produce some observable response.

From these two complementary definitions numerous measures of SIP emerged, which are probably best classified in Salthouse's analysis of aging and measures of processing speed (Salthouse, 2000):

1. Decision speed (time to respond in cognitive tests with moderately complex content)

2. Perceptual speed (speed of responding in paper and pencil tests with simple content in which everyone would be perfect if there were no time limits)

3. Psychomotor speed (typically assessed with relatively simple tasks requiring repetitive finger tapping, or marking or drawing lines in specified locations on a peace of paper)

4. Chronometric speed (reaction time tasks such as choice reaction time with visual stimuli and manual key-press responses)

5. Psychophysical speed (tasks of decision accuracy with briefly presented visual or auditory stimuli)

6. Psycho physiological measures of speed (time course of internal responses on any ECT, e.g. latency of particular components of the event-related potential).

As a final remark in this section, one common property of all measures of SIP, which is taken for granted, should be stressed. Namely, if a closer look at all the mentioned measures of SIP (either in Salthouse's classification, or in the *Appendix* of this paper) is taken, it is obvious that they are basically presented by one quantity – the minimal duration of solving some cognitive task, or of its neurological processes. That means, that in the largest number of cases the SIP measure is time quantity, except in those that use a measurement paradigm similar to Jensen's paradigm with the Hick apparatus (Vernon, 1990), where SIP is measured as an amount of information (measured in bits) processed in a unit of time. None other than that measure of SIP coincides with the physical definition of the rate of any process, which states that the rate of a process is the time change of the quantity transformed in the process, i.e. dQ/dt (where Q = quantity, t = time) (Feynman et al., 1977). It should be stressed here that in physics an appropriate term for time change of any process is not "speed" but "rate" (since speed denotes only time change of displacement), and some cognitive psychologists did recognize that (Cerella, 1985; Cerella & Hale, 1994).

In that context, the important question is why SIP (which is a concept overtaken from natural and technical sciences) is measured by the time of duration of the cognitive process during solving some cognitive task, and not by the amount of information processed in the time of solving that task? There is only one acceptable answer to this question that greatly depends on how the amount of information processed during solving some cognitive task is comprehended.

In order to differentiate the subjects according to SIP in some cognitive task, it is not necessary to know the amount of information processed in the task because it is the same for every subject solving the same task. Therefore, only the time of answering is sufficient for their differentiation. Using the above physical definition of speed of some process, *dQ* is constant and only *dt* varies, thus becoming sufficient for subject differentiation.

The assumption that *dQ* is equal for every subject solving the task implies that the amount of information processed in the task reflects: (1) the totality of physical information contained in the task situation without selection of any specific information, or (2) a defined amount of information selected from the task situation in exactly the same way by every subject solving the task.

The first explanation of amount of information might be appropriate because the totality of physical information is the same for any subject solving the same task in the same physical conditions, but the question is: do we have this identical task situation for every subject, in every trial? Additionally, this explanation of the amount of information is not consistent with the common measure of amount of information used in psychology research, defined through the number of response alternatives (Vernon, 1990).

The second explanation is also questionable, because we cannot exactly prove that the perceptual organization responsible for information selection from the task situation is identical for every subject from trial to trial.

Therefore it is suggested that, if there is a tendency of explaining human cognitive functioning in terms of cognitive neuroscience a more appropriate term for all this time measuring used in research of the SIP phenomena would be "time of information processing", instead of "speed of information processing". After all, that was the term used by some authors in several papers (Wickens, 1974; Myerson et al., 1990; Kail, 1991a; Kail & Park, 1994; Kail, 1997). On the other hand, if modelling of human cognitive functioning is not firmly integrated in the theoretical frame of cognitive neuroscience (and does not lean on the physical definition of the rate of a process), then SIP might be expressed by time measures of solving cognitive tasks.

PROPOSAL FOR A BETTER SOLUTION: ABANDONING THE SIP CONSTRUCT AND INTRODUCING THE RCP PROPERTY

When summarising the previous discussion, several problems concerning the SIP construct are relevant:

1. There is no consensual and unique definition of SIP and related set of measures, necessary for the unambiguous

use of that construct in any model, or aspect of human intellectual functioning.

2. Although the SIP construct is predominantly defined by the meaning in the information processing approach to cognitive functioning and related analogy to computer information processing, the purely time definition of its measures is not consistent with computer processing analogy. In other words, measures of the construct are not consistently derived from the theoretical framework which the construct originates from.

3. Measures of SIP used in several research fields severely question construct validity of the SIP. There are too many different measures, some of them represent other constructs in other research fields (or even in the same field), and there is no validity agreement concerning particular SIP measures among different authors.

4. The mechanism, or the nature of age changes of SIP is not consistently explained with existing definitions and operationalisations of the construct (in spite of the fact that numerous researches were conducted in the last 20 years).

5. Those theoretical models that aim to explain human cognitive functioning by introducing the equivalent role of SIP, WM, and attention in different forms of the human processing system (and which are, at present, the dominant models), generate at least partial inconsistency concerning the material basis of that processing system. Namely, WM and attention are recognised as cognitive neurosystems and SIP is not.

How serious are these problems with the SIP construct?

The problem concerning the lack of unique definition is not a rare phenomenon in psychology. Therefore SIP is not in a worse position than many other psychological constructs.

Consequences of inconsistency of SIP measures with computer processing analogy depend on how strong we stick to this analogy in modelling the human mind. Since this analogy has confined scientific value, we should not be too much concerned with this inconsistency.

However, the last three problems of the SIP construct mentioned above call for the proposal of quite a different explanation of SIP phenomena, which might resolve the existing problems elaborated above. That explanation is based on the experimental tradition of the SIP definition and some common assumptions of cognitive neuroscience, but also on some biological properties of the phenomena.

Before the elaboration of explicit fundamental assumptions of the new proposal, it is important to stress that the speed of information processing construct (with related numerous and quite different operationalisations) is abandoned in the proposal while the rate of cognitive process property is introduced instead.

The assumptions of the new proposal are:

A. The rate of cognitive process (RCP) is one of the general properties of every cognitive process that takes place during execution of any cognitive task;

B. Every cognitive process (activated during execution of any cognitive task) has its physical basis, which means that it takes place in a defined space, in real time, and through defined energy transformation;

C. RCP is a general property that emerges from the time determination of any cognitive process.[4] From time determination of cognitive processes emerge at least three additional general properties (which will be explained in short later): stability, endurance and adaptability of cognitive process;

D. Every cognitive process takes place in a defined cognitive subsystem (of the whole cognitive system called mind), which has its material, i.e. biological basis in the form of defined neural circuits activated during the task execution in defined parts of the brain;

E. The biological basis of the cognitive subsystem activated during cognitive task execution (i.e. cognitive process) is – unlike a computer system – functionally unreliable and is not permanently defined (i.e. different neural circuits can execute the same cognitive processes, but with different success). All functional properties of the biological basis are a consequence of physical characteristics of neural cells and interaction of their activity.

Before deriving the RCP definition from previous assumptions, I would like to stress the time nature of that definition. It is primarily a consequence of the fact that psychological research uses mostly behavioural measures of examined phenomena and therefore, space and energy determination of cognitive processes (realised through very sensitive electric activity in a very confined space of the brain size) are mostly out of reach of regular psychological measurements.[5]

Therefore, the rate of cognitive process (RCP) is defined as the minimal time needed for successful execution of the cognitive task that generates the related cognitive process (or, during which that cognitive process takes place).

There are a few related issues to this definition, which are inevitable for its operationalisation:

(i) Cognitive process is defined by related cognitive task;

(ii) To get a reliable measure of someone's RCP in a related cognitive task, the person has to successfully execute at least a certain number of parallel forms of a particular cognitive task (which might be also a certain number of trials in the very same cognitive task);

(iii) Minimal time assessment in some cognitive task might be expressed by various functions of at least one of the shortest response times in a successfully executed parallel task (e.g. minimal time might be assessed by an average of three response times that have minimal values – 1st, 2nd, and 3rd the shortest response time).

The first important question for this new proposal is: have we solved the problems of the SIP construct by introducing the RCP property with related definition and propositions for its measures?

Firstly, this proposal offers quite a precise definition of RCP that can be unambiguously used in any model of cognitive functioning. Moreover, that definition comprehends all previous definitions of SIP in different research traditions without contradictions, but to the level of measures.

Secondly, by leaving out the concept of "information" from the RCP definition, we departed from computer processing analogy, and avoided problems with the amount of processed information during the execution of some cognitive task.

Thirdly, instead of continuous debate on what is the most appropriate measure of SIP and related number of inconsistencies concerning the particular cognitive tasks, the proposal clearly states that the response time of any cognitive task can be used as a measure of RCP, since RCP is common property of every cognitive task execution.

With regard to the fourth problem the answer could be elaborated to the extent to which SIP measures are correlated to RCP measures. Namely, SIP is mostly assessed by the average response time in a set of tasks/trials contained in some cognitive test related to SIP, while RCP is measured by previously described related minimal time assessment. Nevertheless, these two measures should be relatively highly correlated, and the answer to global versus domain specific hypotheses follows. RCP is predominantly biologically determined, which follows from the assumptions of the new proposal and from the fact that it comprises SIP – which is known to be predominantly biologically determined (Myerson et al., 1990; Salthouse, 1996, 2000; Hale et al., 1993; Hale & Jansen, 1994; Cerella & Hale, 1994; Eaton & Ritchot, 1995; Travis, 1998; Rose et al., 2002). Because of the predominant biological determination of RCP, the age changes of RCP are domain specific to that extent to which the age related changes of biological base are domain specific. A certain number of nervous system components change independently of other components during the life span, and therefore, with specific methodology and data analysis we get results that point to the more domain specific nature of the age changes of RCP. On the other hand, a great part of the biological basis of related cognitive subsystems activated during cognitive task execution is shared across different cognitive tasks, and therefore age changes of response times in those tasks are also shared, pointing at the global nature of age changes of RCP. Additionally, a great deal of shared experience and positive transfer across different task execution also contributes to the global hypotheses explanation.

The fifth problem related with the SIP construct, in the proposed model of cognitive processes appears to be only a consequence of mixing two important aspects of the human processing system, which statistical procedures cannot differentiate. One aspect represents a set of important cognitive neurosystems, which are subsystems of the whole cognitive system of the human mind, in this case – working memory and attention. Another aspect represents a general property of any cognitive subsystem that reflects its efficiency, specifically – the rate of cognitive process (RCP). Since, on one hand, behavioural measures of these two aspects of the human processing system do not reflect the nature of related constructs and, on the other hand, both of them are very important for processing system functioning, statistical procedures give them equivalent position in the structure of human intellect.

An obvious consequence of the RCP property is the fact that WM and attention (and any other cognitive neurosystem) have their own RCP when they are in function during some cognitive task execution, and that fact is already present in some SIP measures. For example, Memory scanning test for working memory RCP, Stroop colour test for selective attention RCP, Multitask word classification task for divided attention RCP (see *Appendix*).

The second important question for RCP proposal is whether it contradicts in any way the empirical data related to the SIP construct. So far, the answer is no.

Since RCP is a general property of any cognitive process that greatly determines the efficiency of related cognitive task execution, RCP must have a high position in any intelligence model – which has been proved in all the data in contemporary SIP-intelligence relationship research (Nettelbeck, 1994; Neubauer & Knorr, 1998; Stankov & Roberts, 1997; Vernon, 1990). The fact that SIP correlates with a wide range of cognitive variables is comprised in the fact that RCP is an integral part of any cognitive variable by its definition – even if so-called nonspeeded variables are concerned (Hale & Jansen, 1994; Kail & Hall, 1994; Kail, 1997).

Research data on the age related changes of SIP, provide an even better theoretical framework for modelling cognitive development with introduction of the RCP property. First of all, RCP offers a solution for the global vs. domain specific life-span SIP development dilemma (as it was previously explained). Secondly, research data that show the necessity of previous SIP development for successive WM capacity development (Fry & Hale, 2000; Kail & Park, 1994; Salthouse, 1991; Verhaeghen & Salthouse, 1997) are theoretically more understandable with introduction of the RCP property instead of using the SIP construct. Reason: RCP is more integrated with the WM capacity than SIP, since it represents one property of that cognitive neurosystem, and capacity represents another property of the same neurosystem. Thirdly, most of the research data and theoretical models suggest biological mechanisms as the predominant ones for age changes of SIP, although they do not neglect experience and positive transfer between cognitive tasks (Eaton & Ritchot, 1995; Hale, 1990; Hale et al., 1993; Kail, 1986; Myerson et al., 1990; Rose et al., 2002; Salthouse, 1996, 2000; Travis, 1998). That fits the RCP concept even more, since – primarily from the D and E assumptions of the RCP definition – the predominantly biological nature of RCP is obvious (as it has already been mentioned).

When discussing the predominantly biological nature of the RCP property, one must point out its concordance with one aspect of the SIP construct that makes the construction of a multidisciplinary integrated picture of human cognitive functioning possible. Namely, in life-span development and differential research of human cognitive functioning, there are authors that point to processing speed as a bridging construct between behavioural and neurophysiological research (Salthouse, 1996; Roberts & Pallier, 2001). This is primarily because of the time measure of SIP, which is an objective and absolute dimension, rather then a norm reference scale (as it is the case with most behavioural measures) – and as such, it is inherently meaningful in all disciplines. Additionally, the biological nature of RCP keeps strengthening this behavioural-neurophysiological bridging, because it binds biological characteristics of cognitive subsystems during processes (observable by contemporary neuroimaging techniques) with behavioural data in the form of response time.

As previously announced, besides RCP, cognitive processes have at least three additional general properties,[6] which are predominantly related to the mentioned biological characteristics of cognitive subsystems activated during some cognitive process, but also to the previous experience.

Stability of cognitive process (SCP) is defined as an average response time variation of successful execution of cognitive task that generates related cognitive process. Average response time variation in some cognitive task might be some function of the differences between minimal time assessment (RCP) and every other response time in a given set of parallel tasks.

Adaptability of cognitive process (ACP) is defined as a growth of response time efficiency in successful execution of cognitive task (that generates related cognitive process) with increasing number of a task. A possible ACP measure might be the ratio of some function of response times in the first, and in the last half of a given set of tasks.

Endurance of cognitive process (ECP) is negatively defined as an increment of response times in successfully executed cognitive task (that generates related cognitive process) with increasing number of a task. A possible ECP measure might be the slope of the curve that presents response time as a function of task number in a given set of tasks. ECP can be assessed only when the given cognitive subsystem is finally adapted to cognitive task, i.e. when related response time does not decrease with further solving of the cognitive task.

Finally, we might ask how new is the proposal of RCP and other general properties of cognitive processes?

The fact that processing speed may reflect overall efficiency of the nervous system is already explained in the literature (Hale and Jansen, 1994), which partially corroborates the newly proposed definition of RCP. Recent multitask experiments go in the same direction, when suggesting SIP should be viewed as a general or task-independent construct (Fry and Hale, 2000).

Dynamic properties such as speed, stability and endurance of neural system measured with chronometric tests are systematically explained in the psychodiagnostic work of Mirko Drenovac, which theoretically leans on Russian neurophysiology (Drenovac, 2001). Moreover, Drenovac's psychodiagnostic concept has already been tested in research of cognitive development (Živičnjak et al., 2001).

The concept of stability of processing can be found under different names (e.g. within-subject performance variability, response consistency, stability) in developmental (Hale et al., 1993), differential (Roberts & Pallier, 2001) and cognitive neuroscience (Clearfield & Thelen, 2001) literature on cognitive functioning. Adaptability is a less known property of cognitive processes, but it has appropriate analogy in the flexibility concept analysed in the dynamic system theory applied in developmental cognitive neuroscience (Clearfield & Thelen, 2001).

Bearing in mind all previously mentioned facts, it should be concluded that the RCP proposal for solving problematic aspects of SIP phenomena synthesises the existing data and theories with new ideas and insights. However, empirical validation needs still to be undertaken.

NOTES

[1] The author has collected the data by reviewing chapters of several books concerned with human intellectual functioning and the contents of 42 research papers dealing with different aspects of SIP (24 of them were empirical research papers, 11 were reviews and 7 were purely theoretical papers) mentioned in the literature of this paper.

[2] Three of them were from the same author, A. Demetriou.

[3] Reading aloud a single word should be less demanding then searching for several identical objects in a bigger set of objects, and crossing them out when found.

[4] In this paper we won't analyse space and energy determination of cognitive processes since they are not related to proposed measures of speed of cognitive process, and because that analysis demands systematic introduction of contemporary neuroimaging techniques.

[5] But not completely – ERP techniques, and techniques of neuroimaging are more and more in psychological use.

[6] We say at least because the capacity of some cognitive neurosystems (e.g. WM) emerges from energy determination of cognitive processes, which we won't discuss in this paper.

APPENDIX

1. Measures of SIP used in reviewed cognitive development researches

1. Abstract matching (e.g. Hale, 1990; Hale & Jansen 1994)
2. Analogies (e.g. Kail, 1991b)
3. Arrows test (e.g. Miller & Vernon, 1997)
4. Category retrieval (e.g. Kail, 1986)
5. Choice reaction time (RT)* (e.g. Hale, 1990; Kail, 1991b)
6. Classification (e.g. Kail, 1991b; Eaton & Ritchot, 1995)
7. Coding test (e.g.Kail, 1991a; Kail & Hall, 1994)
8. Colour string test (e.g. Miller & Vernon, 1997)
9. Colour test (e.g. Miller & Vernon, 1997)
10. Continuous tracking tasks (e.g. Wickens, 1974)
11. Cross-out test (WJ-R) (e.g. Kail & Hall, 1994)
12. Eriksen-Flanker selective attention RT (e.g. Ridderinkhof & van der Molen, 1997)
13. Identical pictures test (e.g. Kail & Park, 1994)
14. Imaginal speed (e.g. Demetriou et al., 2002)
15. Inspection time (e.g. Fry & Hale, 2000)
16. Judgements of acoustic & semantic features (e.g. Kail, 1991b)
17. Judging sentence truth (e.g. Kail, 1991b)
18. Judgments of category membership (e.g. Kail, 1991b)
19. Judgments of inequality (e.g. Kail, 1991b)
20. Letter matching task (e.g. Hale, 1990)
21. Line-length discrimination (e.g. Hale & Jansen, 1994)
22. LRP onset (e.g. Ridderinkhof & van der Molen, 1997)
23. Mapping analogies* (e.g. Kail, 1986)
24. Matching test (e.g. Miller & Vernon, 1997)
25. Matching to sample task (e.g. Kail, 1991b)
26. Matrix solutions RT (e.g. Fry & Hale, 2000)
27. Memory scanning for digits* (Kail, 1986)
28. Mental arithmetic tasks* (e.g. Chi, 1977; Kail, 1991a)
29. Mental paper folding (e.g. Hale & Jansen, 1994)
30. Mental rotation* (e.g. Chi, 1977; Kail, 1986; Hale, 1990)
31. Name retrieval task (e.g. Kail, 1986)
32. Number comparison test (e.g. Kail & Park, 1994)
33. Number of trials to criterion (habituation) (e.g. Rose et al., 2002)
34. Number test (e.g. Miller & Vernon, 1997)
35. Numerical speed (e.g. Demetriou et al., 2002)
36. P3 latency (e.g. Ridderinkhof & van der Molen, 1997)
37. P300 latency (e.g. Travis, 1998)
38. Pegboard (e.g. Kail, 1991a)
39. Picture identification (e.g. Fry & Hale, 2000)
40. Picture-sentence matching (e.g. Kail, 1991b)
41. Quantification (e.g. Kail, 1991b)
42. Reading (e.g. Chi, 1977; Kail, 1991b)
43. Recognition memory (e.g. Kail, 1991b)
44. Same-different judgements* (e.g. Kail, 1991b)
45. Search tasks (visual) (e.g. Chi, 1977; Kail, 1991b)
46. Sentence completions RT (e.g. Fry & Hale, 2000)
47. Shape string test (e.g. Miller & Vernon, 1997)
48. Shape test (e.g. Miller & Vernon, 1997)
49. Simple RT (e.g. Hale, 1990; Kail, 1991a)
50. Size test (e.g. Miller & Vernon, 1997)
51. Stroop task (e.g. Kail, 1991b)
52. Tachistoscopic recognition tasks (e.g. Wickens, 1974)
53. Tapping (e.g. Kail, 1991a)
54. Temporal judgments (e.g. Kail, 199b)
55. Total looking to the familiar (habituation) (e.g. Rose et al., 2002)
56. Verbal analogies* (e.g. Hale, 1990)
57. Verbal speed (e.g. Demetriou et al., 2002)
58. Visual matching test (WJ-R)* (e.g. Kail & Hall, 1994)

(these cognitive development SIP measures are derived by reviewing 15 empirical research papers, 6 reviews, and 3 theoretical papers – mentioned in Literature)

2. Measures of SIP used in reviewed cognitive aging researches

1. Alerted RT (e.g. Cerella, 1985)
2. Alerted stimulus discrimination (e.g. Cerella, 1985)
3. Arithmetic time (e.g. Salthouse, 1994b)
4. Boxes (e.g. Salthouse, 1994a)
17. Memory scanning* (e.g. Cerella, 1985)
18. Mental rotation* (e.g. Myerson et al., 1990)
19. Multiple response choice reaction time (e.g. Myerson et al., 1990)
20. Number comparison* (e.g. Salthouse, 1994b)

5. Choice RT* (e.g. Myerson et al., 1990)
6. Cued RT* (e.g. Myerson et al., 1990)
7. Digit copy (e.g. Salthouse, 1994a)
8. Digit-symbol substitution (e.g. Myerson et al., 1990)
9. ERP-latency (e.g. Salthouse, 2000)
10. Finger tapping* (e.g. Salthouse, 2000)
11. Geometric analogies decision time (e.g. Salthouse, 1994b)
12. Horizontal line marking (e.g. Salthouse, 1994b)
13. Inspection time* (e.g. Salthouse, 2000)
14. Letter copy (e.g. Salthouse, 1994b)
15. Letter matching/comparison* (e.g. Myerson et al., 1990)
16. Line length discrimination* (e.g. Cerella, 1985)
21. Paired associate (e.g. Cerella, 1985)
22. Pattern comparison (e.g. Salthouse, 1994a)
23. Playing card classification (e.g. Cerella, 1985)
24. Rotated figures (e.g. Myerson et al., 1990)
25. Series completion decision time (e.g. Salthouse, 1994b)
26. Simple RT* (e.g. Myerson et al., 1990)
27. Speed of test taking (e.g. Stankov, 1999)
28. Stimulus decoding (e.g. Cerella, 1985)
29. Stimulus discrimination (RT & card sorting time)* (e.g. Cerella, 1985)
30. Vertical line marking (e.g. Salthouse, 1994b)
31. Word matching* (e.g. Myerson et al., 1990)
32. Word switch (e.g. Salthouse, 1994b)

(these cognitive aging SIP measures are derived by reviewing 2 empirical research papers, 4 reviews, and 4 theoretical papers – mentioned in Literature)

3. Measures of SIP used in reviewed intelligence researches

1. Arithmetic operator* (e.g. Wilhelm & Schulze, 2002)
2. Binary Reaction Task (e.g. Roberts & Pallier, 2001)
3. Choice reaction and mental arithmetic task (e.g. Neubauer et al. 2000)
4. Classification of words* (e.g. Wilhelm & Schulze, 2002)
5. Coding Substitution Task (e.g. Nettelbeck, 1994)
6. Coding test* (e.g. Neubauer & Knorr, 1998)
7. Colorado Perceptual Speed Test (e.g. Neubauer et al. 2000)
8. Complex Choice Reaction Task* (e.g. Roberts & Pallier, 2001)
9. Crossing out letters* (e.g. Wilhelm & Schulze, 2002)
10. Digit-symbol substitution* (e.g. Wilhelm & Schulze, 2002)
11. Fitt's Movement Task (e.g. Roberts & Pallier, 2001)
12. Incomplete words (e.g. Wilhelm & Schulze, 2002)
13. Inspection time* (e.g. Neubauer & Knorr, 1998)
14. Joystick Reaction Task (e.g. Roberts & Pallier, 2001)
15. Letter matching test* (e.g. Neubauer & Knorr, 1998)
16. Letter Reading Test from Kurztest für Allgemeine Intelligenz (e.g. Roberts et al., 1996)
17. Memory scanning test (e.g. Neubauer & Knorr, 1998)
18. Memory Span Test from Kurztest für Allgemeine Intelligenz (e.g. Roberts et al., 1996)
19. Mental rotations task (e.g. Roberts & Pallier, 2001)
20. Modified Blink Reflex Latency (e.g. Smyth, Anderson & Hammond, 1999)
21. Multitask Card-Sorting (e.g. Roberts & Pallier, 2001)
22. Multitask Word-Classification (e.g. Roberts & Pallier, 2001)
23. Number Comparison Test* (e.g. Roberts et al., 1996)
24. Odd-man-out task (e.g. Vernon, 1994)
25. Old English (e.g. Wilhelm & Schulze, 2002)
26. Part-whole (e.g. Wilhelm & Schulze, 2002)
27. Rapid Automatic Naming Test (e.g. Neubauer et al. 2000)
28. Sentence Verification Task (e.g. Roberts & Pallier, 2001)
29. Seven divisible (e.g. Wilhelm & Schulze, 2002)
30. Single Card-Sorting Task (e.g. Roberts & Pallier, 2001)
31. Single Response Choice Reaction Task (e.g. Roberts & Pallier, 2001)
32. Single Word-Classification Task (e.g. Roberts & Pallier, 2001)
33. Stimulus discrimination test (e.g. Neubauer & Knorr, 1998)
34. String Search Test (e.g. Roberts et al., 1996)
35. Stroop Colour Test* (e.g. Roberts et al., 1996)
36. Tachistoscopic Choice Reaction Task (e.g. Roberts & Pallier, 2001)
37. x Greater (e.g. Wilhelm & Schulze, 2002)
38. Zahlen-Verbindungs Test (e.g. Neubauer & Knorr, 1998)

(these intelligence SIP measures are derived by reviewing 7 empirical research papers and 1 review– mentioned in Literature)

* Measures of SIP marked by asterix denote the ones that replicate among these three reviewed research fields, or belong to the variations of one task (they have the same logic and processing complexity, but different stimulus and response modality). They are not counted as different SIP measures (otherwise, the number of SIP measures in this review would be greater than 98).

** Since 11 of 42 papers were reviews without detailed description of SIP measures, we took quite a conservative strategy in denoting some measures as different. Nevertheless, it may happen that a few more of the mentioned measures are only design variations of the same task.

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Doprinos analizi ljudske brzine obradbe podataka: razvojni i diferencijalni argumenti

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Ljudska brzina obradbe podataka (BOP) istraživački je konstrukt koji je u psihologiji pod različitim imenima i s različitim intenzitetom istraživan više od 60 godina. Njegova važnost sažeto je opisana u četiri istraživačka područja: diferencijalna i eksperimentalna psihologija, starenje te kognitivni razvoj. S obzirom na to da je to važna sastavnica suvremenih modela inteligencije te istraživanja cjeloživotnoga kognitivnog razvoja, nužno je pokušati izgraditi integriranu sliku toga konstrukta. Pregled i sustavna analiza 42 znanstvena članka i dodatne literature s toga područja pokazali su da postoje problemi s konstruktnom valjanošću BOP-a, ali i određene teorijske i empirijske nekonzistentnosti. Iznesen je nov prijedlog za objašnjenje brzine obradbe podataka koji napušta BOP s pripadnim mjerama, a uvodi se svojstvo BKP (brzina kognitivnoga procesa) kao jedno od nekoliko općih svojstava svakoga kognitivnog procesa.

Beitrag zur Analyse der Geschwindigkeit der Datenauswertung durch den Menschen: Entwicklungsbezogene und differentiale Argumente

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Die Geschwindigkeit der Datenauswertung durch den Menschen ist ein von Forschern geschaffenes Konstrukt, das in der Psychologie unter verschiedenen Bezeichnungen und mit schwankender Intensität seit mehr als 60 Jahren untersucht wird. Die Bedeutung dieses Phänomens wird anhand von vier Forschungsbereichen knapp umrissen. Das sind: Differentielle und Experimentelle Psychologie, Altern und kognitive Entwicklung. Da die Geschwindigkeit der Datenauswertung durch den Menschen einen wichtigen Bestandteil zeitgenössischer Intelligenzmodelle sowie wissenschaftlicher Forschungen zur lebenslangen Fortentwicklung des Menschen darstellt, muss versucht werden, ein integratives Bild dieses Konstruktes zu entwerfen. Die Durchsicht und systematische Analyse von 42 wissenschaftlichen Arbeiten sowie weiterer fachliterarischer Texte zu diesem Thema ergab, dass das Konstrukt der Geschwindigkeit der Datenauswertung durch den Menschen in mancherlei Hinsicht problematisch ist und dass es gewisse theoretische und empirische Inkonsistenzen aufweist. Der Verfasser nimmt Abstand von diesem Konstrukt und seinen bezüglichen Werten und schlägt einen neuen Versuch zur Erklärung der Geschwindigkeit der Datenauswertung durch den Menschen vor. Er führt den Begriff der Eigenschaft der Geschwindigkeit des kognitiven Prozesses ein – als eine von mehreren allgemeinen Eigenschaften eines jeden Erkenntnisvorgangs.