COGNITIVE STYLES COULD BE IMPLICITLY ASSESSED IN THE INTERNET ENVIRONMENT: REFLECTION-IMPULSIVITY IS MANIFESTED IN INDIVIDUAL MANNER OF SEARCHING FOR INFORMATION

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Abstract. *The present research aimed to determine whether the cognitive style of reflection – impulsivity (R-I) diagnosed in a standard way also manifests itself in the Internet environment. A special task was designed that involved searching for particular information on the Internet. Science students took part in two studies (pilot study, n=11, and replication, n=37). Data analyses revealed that indicators of performance in the simple computer task allow the differentiation of respondents in terms of the R-I dimension. The time spent on reading the command and thinking of a strategy for obtaining the information revealed a high correlation with R-I. The amount of explained R-I variance reached 82%, indicating that the online searching task is a valid indicator of this cognitive style. The practical conclusion is that the Internet environment may be used in cognitive styles' assessment which, in turn, may lead to creating interactive, cognitive style-friendly hypermedia learning facilities.*

Key words: *cognitive styles, hypermedia, Internet, learning facilities, reflection-impulsivity.*

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Introduction

At the turn of the 20th century, information technology entered all areas of life, enlivening the discussion about the benefits that it gives and the threats and dangers that it poses (Kraut, Patterson, Landmark, Kiesler, Mukophadhyay & Scherlis, 1998). Nowadays, the discussion revolves around the thesis on the ambivalent, twofold effects of the technological expansion that was formulated many years ago in the form of the "laws of media" (McLuhan & McLuhan, 1992). The authors have called the beneficial effects "the law of enhancing and retrieving", and referred to the unfavourable ones as "the laws of obsolence and reverse". According to Brown, Brailsford, Fisher, Moore and Ashman (2006), this duality of the consequences of the presence of technology in education was noticed much earlier. In the 1950s and 60s, while introducing the idea of programmed learning and with it learning-assisting machines, the merits and drawbacks of the cooperation of the human with machines were remarked upon.

Psychologists had large hopes for the widespread use of IT, noticing its role also in the diagnostic process, which is imperative in research work as well as therapeutic work (Giannetti, Klinger, Johnson & Williams, 1976). The issue of the applications of technology remains pertinent and is accentuated today by the widespread use of computers and mobile devices connected to the Internet. It continues to be used by both students and teachers alike for different purposes and in different ways. Accepting the type of actions manifest as criteria, mention can be made of four dominant

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activities directed towards expression, protection, interruption and collection of information (Megens & Martin, 2003). The latter belongs to the most frequently initiated and this probably happens for two reasons. The first is the size of the information resources and the data offered. In 2006, the Internet contained 200, while in 2009 it already held 500, exabytes of information. In the years 2010–2011, 1 zetabyte (10^{21} bytes) was approached. The new measure of information will, in the near future, be the yottabyte – yt $=10^{24}$ bytes (Mongay Batalla & Ledzińska, 2011). The second reason is that the Internet, through its information resources, facilitates the satisfaction of important psychological needs, particularly the need for cognition (Petty & See, 2007) as well as the need to belong (Baumeister & Leary, 1995; Pelling & White, 2009). Thus, as it seems, is the basic justification for its psychological appeal.

When using the information resources of the Internet, problems are encountered that are connected with the vast diversity and anarchic structure of the medium. It is for this reason that the so-called paradox of accessibility and the difficulties in making choices among the incredibly diverse data offered is discussed (Woods, Patterson & Roth, 2002). The problem is somewhat lessened, but not solved by such technical solutions as Rich Site Summary (RSS) readers. The selection process requires application of choice criteria, the most important being knowledge and the value system, which are acquired gradually in the socialisation process. It is worth noting that the discomfort arising from experiencing information overload is approached not only in the category of putting too much strain on the mind, but also psychological stress (Ledzińska, 2009; Matthews & Campbell, 2009).

The search for information on the Internet gives rise to an individual's manner of reaching it, and this is connected with the method of searching for it so characteristic of humans, which can be more precisely referred to as searching fields (perception, own memory, external stores of data). This may be diverse, starting from the very method of defining the target, the type of data sought and its intended purpose (what am I looking for and why?), right up to random actions brought about by trial and error. The first can be referred to as more cognitively mature and advanced: the action is clearly guided by a clearly defined goal and the initiated cognitive activity is deliberate and unhurried and subjected to personal control in terms of achieving intentions. The gathering of necessary information ends the search, which is treated as a task to be solved. Another way of navigating through the Internet is characterised by randomness and a chaotic nature due to there being no clearly defined goal and strategy, haste, as well as being satisfied with content that is "close to that sought for". The mentioned ways represent extreme behaviours among which there also may be intermediate actions. These individual, preferred ways of searching and processing information are labelled "cognitive styles", constituting one of the manifestations of human differences. They have been studied for many decades, firstly in laboratories and later in natural conditions, and, with the dissemination of modern techniques, also in the Internet environment (Brown, Brailsford, Fisher, Moore & Ashman, 2006; Chen & Macredie, 2002).

Everyday observation supplies grounds to state that adults – particularly parents and teachers – are increasingly interested in the content that young people look for and in the way in which they do so. The latter, i.e., one's preference for formal characteristics of information seeking, is important and can also be studied and improved with the use of contemporary technology. This article presents a sample of theoretical reflections and empirical studies dedicated to this issue. It has been preceded by important information on the two main methods of psychological characterisation of the mind.

Two Ways of Characterising the Mind – Abilities and Preferences

The importance of studying the specificity of human mind functioning in research on the specificity of using the Internet seems obvious. The mind remains a cognitive instrument registering stimuli, deciphering them, initiating reactions or deciding on their absence. Representatives of the cognitive paradigm claim that the mind is a system that processes information, while processing programs determine the individual differences in the dynamics of transformation and the end results of data processing (e.g., Cowan, 1988). The increasing popularity of studies on the mind – treated as a system of collecting, transforming and using information – has not eliminated earlier approaches. Nowadays, we are dealing with a plurality of different research paradigms, but three of them – the developmental (Sternberg, 1998; Sternberg & Grigorenko, 1995; Zhang & Sternberg, 2002), individual difference (Matczak, 1990, 1994,

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2000; Nęcka, Orzechowski, & Szymura, 2007; Nosal, 1990; Sternberg, 1990; Strelau, 2002; Zhang, 2001) and cognitive (Chlewiński, 1999, 2007) – have proved to be particularly popular.

The popularity of psychometric approaches that are directed at measurement, hence their name, has not declined. Followers of this approach point out that the comprehensive profile of the mind should take two dimensions into account: a) capacities (abilities), and b) preferences, or in other words likings, predilections. They correspond – on the diagnostic level – to characterising intelligence and cognitive styles, sometimes referred to as thinking styles (Matczak, 1982, 2000; Sternberg, 1990, 1998;). Reference was made to this taxonomy in further analyses, paying attention to the specificity of information processing expressed in a terminology of styles. There are two arguments behind such a decision. The first is substantive in nature: interest in Internet users, which include laymen, students and active professionals. It can be assumed that they are in the broadest part of the distribution of results in intelligence tests, namely, that the results obtained are within normal range. The second reason is methodological. The advancement of differential psychology – a branch of psychology intensively developing on a global scale – allows for the diagnosis of different cognitive styles. Instruments with tested psychometric properties can be applied in group trials and the empirical data obtained in this manner can be expressed and explained in categories of the specificity of information processing software.

Cognitive Styles – Their Essence and Classification

A cognitive style is a preferred manner of cognitive functioning corresponding to the specific needs of an individual (Matczak 1982, 2000; Sternberg, 1990; Witkin & Goodenough, 1981). In other words, it is a method of cognitive involvement that an individual is likely to select among others available to them, therefore, the one that they spontaneously most frequently use. Attention is paid to its complex determinants, treating a cognitive style as a consequence of a person's individuality and of the demands of the environment. This relatively constant method of organising cognitive activities serves to balance the individuality – determined by the type of temperament and personal experience profile – with the objective demands of the environment, i.e., situation or task (Nosal, 1990). The distinguishing feature of style remains the principle of the composition of elements or organisation of a series of cognitive operations, creating an intellectual activity or action (Nosal, 2000). Therefore, styles remain one of the most important manifestations of a person's individuality and are relatively constant. They can and should be investigated and respected, while the least adaptive should be corrected.

The cognitive style is manifested particularly when the task situation in which a person finds themselves in does not contain detailed instructions concerning the manner of performing the task. An individual then selects a manner that is consistent with their own preferences. When testing cognitive styles, the answer to the following question is sought: how do people perceive, think, learn and solve problems? The content aspect, namely, what people perceive, what they think about, or what problems they solve, remains outside the field of interest.

Cognitive styles are dimensional in nature, with precisely specified peripheries. Their multitude and diversity of approaches – almost 30 have been recorded – has encouraged attempts to be made to order so many dimensions and to approach them comprehensively. These are the most commonly mentioned: 1) field dependence – independence; 2) fragmentariness versus comprehensiveness; 3) broad versus narrow inclusion; 4) conceptual diversity, namely, the scope of equivalence; 5) expression of concepts and conceptual structures; 6) tolerance for unrealistic experiences; 7) escalation versus smoothing; 8) scanning; 9) reflection – impulsivity; 10) constricted versus flexible control; 11) internal versus external locus of control; 12) temporality styles (for a detailed review of these and other cognitive styles' dimensions see: Kozhevnikov, 2007; Nosal, 1990; Sternberg & Grigorenko, 1997).

Attempts were made to order the styles, adopting, among others, the following classification criteria: relationships between given styles and various information processing levels. The taxonomy created in this way can be presented in the following manner (Nosal, 2000): Styles

<u>1 and 2</u> are usually connected with the mental registration of stimuli and picture representations (organisation of the field of perception);

<u>3, 4 and 5</u> concern operating with concept categories and expressing general conceptual structures

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(organisation of concept categories);

6 and 7 take into consideration connecting the information received with the structures of knowledge held (searching information structures);

8, 9, 10, 11 and 12 concern programming and control of purposeful acts (control and self-regulation, i.e., metacognition).

Kozhevnikov (2007) endorsed an alternative method of classification of cognitive styles, focusing on information processing levels. The taxonomy of the author is as follows:

1) The level of creating representations of the surroundings in the form of short-term perceptional images. The main informational processes of this level constitute capturing, sharing and searching information fields containing original, relatively unordered data;

2) The level of creating cognitive representations in the form of conceptual categories;

3) The level of informational structures making up an individual experience, i.e. knowledge and self-knowledge;

4) The level of informational structures determining purposefully directed activity encompassing programming and control of the course of behaviour, and decision-making concerning the change of goals or strategies used in fulfilling them.

The novelty of this approach is a result of an attempt to identify metadimensions, i.e., clusters of cognitive styles understood in a double frame of reference. Referring to Nosal's (1990) work, Kozhevnikov (2007, p. 474) proposed four such dimensions:

1) *field structuring*, which describes "the way individuals selectively encode field data and sift out relevant from irrelevant information";

2) *field scanning* describes "different methods of information scanning, such as systemic (…) versus random (…) information search, and could also reflect the choice of representation and organization of information";

3) *conceptual equivalence* reflects "the way an individual combines pieces into a whole (e.g., analysis versus synthesis)";

4) *control allocation* refers to the "methods of self-monitoring, and regulation of intellectual functioning (including such styles as reflectivity-impulsivity, rigidity-flexibility of control, and time orientation)".

The conceptual formulation of cognitive styles reveals certain weaknesses resulting from a missing link (essentially a theory) connecting the identified dimensions. There is also no clarity as to the relationships between the styles and many basic categories of cognitive psychology: the cognitive schema, representation, encoding.

Cognitive styles are rarely subjected to evaluation on a "better–worse" scale. Some researchers (e.g., Jamieson, 1992), however, go beyond this convention by accentuating the small functionality of certain behaviours. They include, among others, the anarchic style of thinking, extreme dependence on the field or intensified impulsivity. The latter makes an individual obtain results below their real capacity due to the errors they commit (incorrect reactions). And although reflection – treated as a cognitive inclination – is essentially intensified with age, this effect does not concern all pupils. Some of them – distracted additionally with various stimuli – function in an impulsive manner.

Diagnosis of Reflection–Impulsivity (R-I)

Reflection–impulsivity is one of the two most often investigated cognitive styles (besides field dependence) and, presumably, one of the most important for human functioning (Matczak, 2000; Sternberg & Grigorenko, 1997). The dimension is defined operationally by two simultaneously recognised indicators: speed, and correctness of solutions. Impulsivity is the tendency to give fast responses and to make many mistakes. Reflection is connected with a predilection to taking a long time to consider things and committing few mistakes.

Psychological methods for diagnosing cognitive style are numerous and varied, including tests, questionnaires and non-standardized experimental tasks (e.g., classification, sorting). A method of characterising styles that also remains available is observation of behaviour, for example in a school

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environment. A person conducting classes often has an opportunity to notice a pupil's level of concentration, observation of the commands and the manner of responding to questions. Some pupils, prior to responding, have to give the issue some thought and hesitate in giving an answer before making sure that it is an accurate reply. Their statements are correct and they rarely make mistakes, but this accuracy is "at the cost" of a time delay in response. This is a typical example of the behaviour of reflective individuals making themselves appear to be not very talented. In the meantime, this is their preferred method of cognitive functioning, a feature of their individuality and, therefore, their distinct style: they tend to operate and function slowly, but precisely. Impulsive individuals behave completely differently: they respond very quickly without first meticulously analysing the available data, thus, risking – through their hastiness – committing mistakes.

It seems that the interface remains a sufficient area for recording manifested cognitive styles (including reflection–impulsivity). This "borderline area" between a human and machine creates possibilities to characterise the way various applications are used, including the ever-popular searching for information. Since the cognitive style reveals traits of constancy and remains independent from the context, the precise description of the behaviour of individuals that are solving simple tasks on the Internet may provide valuable information on their cognitive style. Devising a task consisting of searching for information in the resources available on the Internet that takes into consideration indicators typical of a cognitive style which is the subject of the undertaken analyses remains a valid methodological challenge. Having data obtained in this manner about the specific nature of the exploration it is possible to make cautious deductions about the preferred style. This, for obvious reasons, will be rather a general assessment, not a diagnosis in the psychological sense. The result from the standard measurement supplies information about the type of cognitive control exercised, which is strong in reflective persons and weak in impulsive persons (Nosal, 2000). In cooperation with a psychologist, a teacher can design teaching activities (sets of exercises) correcting ineffective control (extreme impulsivity or reflection) and fulfil them in the ever-so-attractive-for-pupils Internet environment. Correction of an unadaptive method of cognitive functioning can enter the list of teachers' duties. Many researchers have suggested this, highlighting the relationships between cognitive predilections and achievements in various fields of human activity (Sternberg, 1998; Sternberg & Grigorenko, 1995; Zhang & Sternberg, 2002).

Methodology of Research

General Background of Research

The area of interest is the analysis of psychological characteristics of the interface in terms of the possibilities of characterising cognitive preferences, especially the R-I dimension. The investigated problem adopted the form of the following questions:

- How strong is the relationship between a standard measurement of reflection–impulsivity and the method of solving tasks consisting of searching for information on the Internet?

- Can the method of browsing the Internet environment constitute a complementary – in relation to the psychometric means – method of assessing the R-I cognitive style?

In order to solve them, a questionnaire which is used in standard diagnosis was applied, along with a task that is focused on the Internet environment and which was specially created for this study

Sample of Research

Study 1 – pilot research

Eleven students aged between 20 and 23 years took part in the pilot study. These are highly proficient users of the Internet and are familiar with web search engines. The sample was so small due to two selection criteria applied: 1) the participants were all students of the first year of science studies; and 2) only students with a frequency of Internet use close to average (from half an hour to 4 hours per day) were included.

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Study 2 – replication

The sample is a group of 37 students aged from 20 to 24 years. All of the students are highly proficient users of the Internet and are familiar with web search engines.

All the measurements were individual in nature. They were conducted among students of the University of Warsaw and the Warsaw University of Technology in the period from April until December 2012. Again, the sample size was rather small due to the same selection criteria as in the pilot study.

Instruments

Reflection–impulsivity: a standard measure. Self-report measures remain a popular instrument for diagnosing cognitive styles (Demars, 2010; Zawadzki, 2006). One of them is the R-I Questionnaire (Matczak, 1996), serving to diagnose the cognitive style treated as a dimension, the ends of which constitute reflection and impulsivity. Reflection – according to the already signalled approach – is defined as the tendency to postpone utterances in problem-solving situations in order to consider the accuracy of various potential solutions. Impulsivity, in contrast to reflection, is the tendency of providing quick but not very well thought-over responses. The instrument, which is self-report in nature, comprises 75 statements forming three scales: reflection, cautiousness, activeness. The first measures the intensity of reflection and the two remaining serve as diagnoses of its hypothetical variations (Matczak, 1996).

The reflection scale used in the research contains 25 items. The statements are formulated in the first-person singular, assessed by respondents as being true of false. Some sample statements included:

"I consider all the pros and cons before making an important decision"
"After completing some work I usually carefully check it to make sure I haven" made any mistakes"
"It's difficult for me to comment on something that I haven't thought over earlier"
"I prefer the working style that involves the meticulous and precise carrying out of tasks"

The questionnaire has good psychometric properties. The reliability, established by way of internal consistency measured by Cronbach's alpha amounted to 0.82. Sufficient accuracy is also supported by the following relationships:

- Negative relationship (-0.31 in women, -0.36 in men) with non-conformism measured by the KANH (Creative Behavior Questionnaire) of S. Popek (Krawczyk, 1999),
- Positive relationship (0.28) with a sense of internal locus of control measured by the KBPK (Locus of Control Inventory) (Krawczyk, 1999),
- Positive relationship (0.45) with the planning–improvisation scale, and negative (-0.29) with the preference for stimulating environment of the WKP (Multidimentsional Questionnaire of Preferences) questionnaire measuring preference for work environment and interests (Matczak, Jaworowska, Ciechanowicz, Zalewska & Stańczak, 2006),
- Negative relationship (-0.24) between reflection and the strength of experience of information stress (Ledzińska, 2009).

Assessing R-I in the Internet environment (authors' own proposal). In the present research a novel approach based on using search engines in the Internet, is proposed. Tests based on search engines can be performed in a simpler way as this does not require the tested persons to complete a questionnaire but to perform a common search on the Internet. Moreover, search engines are very usual nowadays and the provided tools to test and enhance impulsivity in these engines could introduce a smooth reflection learning process.

As pointed out above in the text, reflection is related to the manner in which a person searches for information. Web search engines are one of the most used tools in the world today. The three most important web search engines are bing® [bing], yahoo!® [yahoo] and, in particular, Google® [google]. The network where the web search engines search for the required information is composed of an uncountable number of servers containing interlinked hypertext documents (both text and multimedia).

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This network is known as the World Wide Web. It is not over presumptive to say that everyone who has a contact with the Internet frequently uses a search engine. Therefore, we believe that the possibility provided by these engines to qualify reflection could prove to be a valuable help for psychologists and educators in researching reflection in a way that is more convenient than R-I tests. Moreover, this knowledge could be used to correct the misguided way that some persons search for information.

It was assumed that understanding the search process on the Internet may give important information about the learning process of Internet users. There are three main stages during a search process on the Internet: (1) inputting the search key; (2) analysing information; (3) end of search process. In these three stages, five variables have been identified that can be measured during the search process. The objective was to verify whether these variables reflect the level of R-I of the users.

1) reading time (RdT) is the time that the user takes to read a text. Reading documents on the Internet is conditioned by the large amount of information available (different web pages) by from the search engine. Users have a tendency to read part of the text in passing with the unique objective of finding the desired information. It is predicted that reflective persons read the text more attentively than impulsive ones. Specifically, RdT is the time used for reading divided by the number of words in the read documents.

2) renewed comparisons (RCs) - this index is related to the manner in which a user analyses the received information, i.e., if they compare the information with previous information. Reflective readers would presumably come back to previous parts of the text to order and analyse the information. Specifically, RCs is the number of times that the user performs one of these actions: (1) they move the mouse towards the upper part of a document or (2) they come back to any document that they had read previously.

3) number of pages (NoP) is the number of web pages that the reader opens at the beginning of the search. It was assumed that a reflective person may open only a few web pages at the beginning of the search and continue to open more pages during the reading process, if needed; whereas impulsive people open more pages at the beginning. Briefly, NoP is the number of pages opened after inputting the first search key.

4) number of keys (NoK) is the number of different search keys that the user tries during the search process. It was expected that reflective persons tend to find the information required by trying different possibilities.

5) thinking time (ThT) is the time that the subject uses for thinking about the first search key for the search. It was assumed that reflective people think longer about how to search for the information, whereas impulsive people quickly input the first possible search key which comes to mind. ThT is the time from which the user is placed in front of the search web page to the time when they start writing the search key.

In providing web search engines for our test purposes, great effort was put into implementing a program that gathers information from the PC on which the user is searching information concerning the given question. Despite the simple functionalities of the program, the work input in implementing this program was not commonplace due to the great variety and complexity of hardware drivers involved in the tester program.

The user works in a normal way with a commercial web search page (in our case Google®) and the implemented program runs in the background in a manner that is undetectable to the user. The program collects and stores information about the mouse movements across the screen and the movements of the web page (up/down). The program also contacts the web search server in order to collect the statistics of the documents, e.g., the number of words. Moreover, a clock controls the different times taken for each aspect of the research, e.g., the reading time or the time from accessing the web page until starting to input the first search key.

As part of the implementation process, we built a program for collecting data from the different hardware of a personal computer (PC). This hardware included the mouse, the keyboard and the screen. In order to connect our program with the drivers of the hardware, we used different Windows Application Programming Interfaces (API) as, for example, *GetAsyncKeyState*. Moreover, we implemented an interface for contacting the Custom Search Engine [Goo_CS] created by Google Inc. in order to obtain

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statistics about the pages visited by the user. The program works similarly to the common keystroke logging engines in its software-based version.

The details concerning the implementation have been omitted and only the source of the statistical information for the five variables tackled in the present study have been shown. Table 1 shows the information necessary for each variable and the source of such information.

Table 1. The task: variables and measurement.

Variable	Measurements	External source	How information is provided
RdT	Reading time	Screen driver	Tester program receives information on when the user is screening a given document and measures the time in the application internal clock
	Number of words of the doc.	Google stats.	Program requests from the Custom Search engine the statistics of the number of words of each of the opened pages
RCs	Up movements of the page	Screen driver	Program computes the times that the up click is pressed
	Revisit just to read pages	Screen driver	Program computes the times that a page that is marked as "read" is visited
NoP	Opened pages	Mouse driver	Tester program receives information on the number of mouse clicks when the search results for the first search key are displayed on the screen
NoK	Different search keys introduced	Keyboard driver	Tester program receives information on the number of times that the user pressed the Enter key on the keyboard during the search process
ThT	Thinking time	Screen driver / Keyboard driver	The program computes the time between two moments: (1) the screen shows the search page; and (2) the keyboard sends the signal of the first letter written

Note. The task was designed by J. Mongay Batalla, PhD.

Procedure

The test runs as follows: at the beginning, everybody completed all the questions of the R-I questionnaire. After a break of two hours, they started the test on the web search engine. Each person was seated in front of one computer station where the search web page http://www.google.pl was active. Participants were asked to search for information on the Internet to answer the following question: *"What is the connection between King Alfonso XIII (Spain) and the Mount of Abarrán and why is this mount so important in the King's life?"* The topic was unknown to the persons completing the test (no one was very familiar with the history of Spain).

The measurements necessary for calculating the five variables were automatically taken by the tester program during the search process. Some pertinent details concerning the tests include that none of the tested persons underwent any form of speed-reading courses that could distort the results. At the beginning of the test, it was announced that the time for answering the question was insignificant. The students voluntarily cooperated in a friendly atmosphere during the whole test. The study meets ethical standards of the Declaration of Helsinki and University of Warsaw.

Data Analysis

Data were analysed using IBM SPSS Statistics version 21. The analyses applied include r-Pearson's correlations, and linear regression analysis.

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Results of Research

Study 1

The results obtained from the R-I questionnaire were correlated with the indicators of the manner of task solving on the Internet and the results obtained have been presented in Table 2.

Table 2. **Pearson's zero-level correlation coefficients between the R-I scores and computer task scores in the pilot study (*n*=11).**

	M	*SD*	RdT	RCs	NoP	NoK	ThT
R-I	18.09	2.30	0.75**	0.34	-0.09	-0.34	0.63*
Web-searching task scores							
RdT	91.36	7.78	-				
RCs	1.00	0.78	0.66*	-			
NoP	2.00	1.00	-0.13	-0.26	-		
NoK	0.19	0.40	-0.34	-0.25	0.00	-0.25	
ThT	3591.82	169.34	0.75**	0.56+	-0.15	0.04	-

+$p<0.10$, *$p<0.05$, ** $p<0.01$ (two-tailed)

The correlation analysis revealed two significant indicators of R-I: reading time (RdT), and thinking time (ThT). Therefore, it seemed probable that the temporal characteristics of the performed web search are the most marked predictors of the investigated cognitive style. People scoring high on reflection spend more time on reading (or, presumably, reflecting on the read text), and thinking about the most appropriate search term. However, the strength of these relationships proved unexpectedly high. Moreover, the sample size was relatively small. Therefore, the result obtained definitely required verification using a bigger sample.

Study 2

The second study was identical in its design; however, the number of participants was this time higher, allowing for some more in-depth analyses. First, similarly to Study 1, we calculated correlation coefficients. The results are provided in Table 3.

Table 3. **Pearson's correlation coefficients between the R-I scores and computer task scores in the pilot study (*n*=37).**

	M	SD	RdT	RCs	NoP	NoK	ThT
R-I	17.40	1.82	0.82***	0.31+	-0.27	-0.05	0.79***
Web-searching task scores							
RdT	65.73	6.18	-				
RCs	0.35	0.63	0.11	-			
NoP	1.41	0.80	-0.24	-0.26	-		
NoK	0.16	0.44	-0.14	0.19	-0.11	-0.25	
ThT	2091.89	101.73	0.66***	0.20	-0.37*	0.09	-

+$p<0.10$, *$p<0.05$, ** $p<0.01$, *** $p<0.001$ (two-tailed)

The results of Study 1 were perfectly confirmed in Study 2. The obtained relationships for the two strongest correlates were even stronger, reaching the level of 0.80, showing that both RdT and ThT coef-

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ficients could in fact be treated as direct indicators of reflection–impulsivity. Taking into account that the two variables are intercorrelated at 0.66 level (p <0. 001), we decided to perform a regression analysis, in order to determine whether one of them explains the incremental variance of R-I over and above the other. The additional reason for this analysis was to assess the amount of variance in R-I explained by the searching task coefficients. Conducting analogical analysis for Study 1 was unreasonable due to the insufficient sample size. The results of the regression analysis are presented in Table 4.

Table 4.   **Predicting R-I scores with the web-searching task indicators.**

Predictor	B	SE B	β	t	p	Regression statistics
Explained variable: Reflection-Impulsivity						
RdT	0.152	0.031	0.52	4.92	0.000	
RCs	0.521	0.229	0.18	2.27	0.030	R = 0.90
NoP	0.100	0.190	0.04	0.53	0.602	R2 = 0.82 adjusted R2= 0.79
NoK	-0.198	0.334	-0.05	-0.59	0.557	F(5, 31) = 27.80,
ThT	0.008	0.002	0.44	4.00	0.000	p < 0.001

The analyses revealed that the RdT and ThT indicators (reading and thinking time) are not redundant in predicting R-I. Moreover, additionally, the RCs' coefficient (i.e., revisits to just read pages) turned out to be a significant predictor in addition to the former two, despite the fact that it failed to prove its significance in the zero-level correlational analysis. Thus, it seems possible that we deal with some kind of suppression effect (MacKinnon, Krull & Lockwood, 2000); however, such analyses are beyond the remit of the present study. In all, the set of indicators from our web-search task allowed as much as 82% of R-I variance to be explained, which exceeded our expectations.

Discussion

The obtained results show that both the time for reading the documents and the time for thinking about the search key are linearly related with the R-I test. Regarding the reliability of the results, the Pearson's r indices for RdT and ThT are very high, showing almost perfect linear relationship between these two variables and the R-I test. One of the main reasons for such high values of the Pearson index is that the group is highly uniform in the sense that all the people completing the tests are of a similar age, have a similar level of education (i.e., students with scientific and technical profiles), have a similar knowledge of computers and Internet search engines, etc. Therefore, all the differences in the search engine test results are related to the differences in reflection of the respondents and not to the differences between the participants. This can also be observed by the low variance (as compared to mean values) of the results shown in Table 2. In statistical terms, we can say that the samples are highly homoscedastic, i.e., the variance of the results is almost entirely due to the reflection of the participants and not to any other factors (such as age, sex, etc.). Note that this point is very important because, generally, psychological tests are bases on a heterogeneous population where homoscedascity cannot be assumed and, as a result, the test values are much more approximate and the confidence level is not as high as in our tests. Because of this, we can suppose that for a more heterogeneous group of people, the results may not be equally impressive. This could be a line for future research. Nevertheless, nothing seems to question the relation of the two variables (RdT and ThT) and the reflection of the participants, which was, after all, the objective of our studies. The results of the present research suggest that data provided by search engines could be efficiently used to analyse reflection in any sample of Internet users, students or pupils.

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Cognitive styles, including R-I, are developed in ontogeny, mainly due to environmental influences, including familial and school settings. Nowadays, the crucial role of environment related to technological revolution simply cannot be ignored. H. M. McLuhan emphasised the role of modern technologies in everyday life, labelling them total, and saying that nothing remained unchanged (McLuhan & Zingrone, 1995). Psychologists emphasise two major changes: haste and intense stimulation, caused by physical stimuli and information. Also doctors (psychiatrists) notice that life conditions facilitate superficiality rather than reflection (e.g., Spitzer, 2012). Cognitive style, as has already been mentioned, has a continuous nature, thus both extreme impulsivity and reflection are maladaptive. The contemporary environment enhances impulsivity, thus it is possible and desirable to counterbalance these influences by reinforcing reflection. The human-computer interface seems to be a useful setting for both the diagnosis and correction of cognitive styles.

Conclusions

The results presented in the present article show that speed of decision-making remains the most important indicator of impulsive behaviour, whereas consideration preceding undertaking action (entering the search term), is its opposite, constituting a valid indicator of reflection. This reflective delay could be trained by practising the rule "think before you act". The postulate is in line with the more general recommendation of rational usage of the Web: to act purposively. Woods, Patterson and Roth (2002) claim that online activity should be preceded by the questions: 1) what am I looking for?; 2) how do I reach the necessary information?; 3) where do I start from?; and 4) which strategy should I choose?

The results obtained encourage further studies to be undertaken with a modified procedure. Three options seem possible: increasing the size of the group, increasing the diversity of the group (other fields of study), and developing the procedure admitting the possibility of free narration while solving a task. The practice of recording the utterances of the participants of a study that were made out loud – referred to as phenomenography – is recognised in contemporary psychology and used by representatives of its various fields. It is applied, among others, in studies on the diagnosis of methods of learning, supplying valuable information to methods of thinking and acting verbalised by respondents (Marton, 1990; Marton & Booth, 1997).

In the long term, the present findings may contribute to the development of "psychologically friendly", self-adaptive hypermedia learning systems (i.e., taking into account individual differences in cognitive preferences). Such attempts have been made with respect to cognitive styles (e.g., Mampadi, Chen, Ghinea, & Chen, 2011). This study adds new valuable information on the most reliable indicators of R-I that could be derived from simple online behaviours, e.g., conducting web searches.

The interface, i.e., the contact area between human and computer, may provide an environment for the diagnosis and correction of cognitive styles, including the R-I dimension. Psychologists usually diagnose reflection using standard psychometric tools. Educators and teachers may estimate the characteristic by assessing the way of solving tasks on the computer screen. This method broadens the spectrum of available methods for the diagnosis of cognitive functions in humans.

The endorsed method for diagnosing R-I is conducted in natural conditions, and the applied task is typical for those usually solved using the Web. Among psychologists, the postulate of measurement in natural conditions is increasingly endorsed (the so-called "ecological validity standpoint"), however, despite its incontestable value, it cannot completely replace standard diagnosis (Cooper, Camic, Long, Panter, Rindskopf & Sher, 2012).

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