International
Journal of Psychology

IUPsyS

International Journal of Psychology, 2016
Vol. 51, No. 5, 383–391, DOI: 10.1002/ijop.12171

The role of simultaneous and successive processing in EFL reading

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This study examines the relationship between simultaneous and successive processing (the Planning, Attention, Simultaneous and Successive processing [PASS] theory processes) and reading skills in English as a foreign language (EFL). A group of 81 children were administered two batteries of tests. One was used to measure EFL reading skills, while the other one assessed simultaneous and successive processing. We hypothesised (a) cognitive processes to predict reading ability, as well as (b) the presence of a significant relationship between (c) simultaneous processing and reading comprehension and (d) successive processing and letter and word decoding. The findings confirmed that the anticipated relationships between these domains exist and are of moderate effect size. The research has helped to contribute to the understanding of how simultaneous and successive processing can affect EFL reading skills both on the level of basic word and letter decoding and reading comprehension.

Keywords: Simultaneous processing; Successive processing; The PASS theory; English as a foreign language (EFL); Reading skills.

According to the Planning, Attention, Simultaneous and Successive processing (PASS) theory of intelligence, human cognition is organised in three systems: (a) planning, which is responsible for programming and behaviour control, (b) attention, which regulates alertness and an activated state of mind, (c) simultaneous and successive processing, which covers encoding, transforming and retaining information. These three systems are subsequently divided into four processes, based on Luria (1973) in the field of neuropsychology: (a) planning, (b) attention, (c) simultaneous processing, (d) successive processing. All these processes are separate but interdependent. This means that effective functioning in any cognitive task is conditioned by the proper functioning of these processes. Nevertheless, the processes are rarely equally involved in a task. Each of them contributes differently, depending on the nature of a task. For instance, planning is responsible for spontaneous speech, attention for reading a book in a noisy environment, simultaneous processing for copying a design such as a cube and successive processing for understanding statements such as “the girl hit the boy” and answering the question “who got hurt?”, taking into account the order of the words within the sentence (Naglieri & Reardon, 1993).

Simultaneous and successive processing are the key PASS theory processes in this study. According to Naglieri (1999), they help to understand the way information is coded, transformed and stored. Simultaneous processing is defined as a mental process involving integration of individual stimuli into one unit after recognising that certain stimuli share a common characteristic. Simultaneous processing is possibly involved, for instance, when an individual examines logical grammatical relations (e.g. the father’s brother and the brother’s father) or solves figural matrices (Naglieri & Reardon, 1993). Successive processing represents a mental process in which stimuli are integrated into specific serial order where the elements form a chain-like progression (Luria, 1973). Successive processing is present in the repetition of words or numbers in proper order, such as, for instance, in digit span tasks.

The PASS theory represents a comprehensive theoretical framework that serves as a basis for research in information processing. Studies are grounded either in a neuropsychological background or in the field of cognitive psychology. Based on the former viewpoint, the PASS processes are related to identifiable neurological areas and are influenced by physical changes in the brain.

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According to Luria's, (1973) research on brain lesions, the unit of simultaneous and successive processing is regulated by the occipital, parietal and temporal lobes.

The research in the latter field, cognitive psychology, comprises studies of diverse character. Some studies focus on outlining the relation between information processing and IQ (e.g. Das, Kirby, & Jarman, 1979), where simultaneous and successive processes represent a modern approach to intelligence in comparison to traditional understanding of intelligence as measured by IQ tests. Naglieri and Reardon (1993) examined the hypothesis that tests based on the PASS theory of intelligence may be more sensitive to learning disabilities (especially reading disabilities) than the traditional IQ tests. Das et al. (1979) imply that the traditional IQ tests (Wechsler scales, K-ABC and Standford-Binet) overlap with simultaneous and to limited extent to successive portions of the PASS theory.

Within this study, two domains are addressed: English as a foreign language (EFL) reading skills and cognitive processes. There are a variety of models (see Seidenberg, 2007; Share, 1995 for example) describing the character of information processing while reading. They differ, besides other, in attributing the prevalence of individual processes in various levels in reading. More specifically, the models vary in how they present the activation and use of simultaneous and successive processes, two crucial processes responsible for qualitatively different ways of work with a stimulus (letter and text).

This study is grounded in the PASS theory, explanation of information processing. The PASS model generally ascribes word/letter decoding to successive processing and comprehension to simultaneous processing, As Naglieri and Das (1997) emphasise a cycle of simultaneous and successive processing is required to help the reader master the component skills of reading. An example of this cyclic operation is provided by Das et al. (1979), who attribute coding of letters in a sequence to form words and words to form sentences to successive processing, while at the same time, simultaneous processing facilitates both recognition of whole words and forming of text units for better comprehension.

The studies examining the relationship between individual reading subskills and PASS processes are dated back to the 1980s (e.g. Kirby & Robinson, 1987). Contemporary studies provide further evidence supporting previous findings (e.g. Georgiou & Das, 2014; Mahapatra, 2015a). Research conducted by Keat and Ismail (2011) reveals the relationship between simultaneous processing and reading comprehension, because the correlation ($r = .70$, $p < .01$) was found strong. Similar results were obtained by Mahapatra, Das, Stack-Cutler, and Parrila (2010) with correlation $r = .75$, $p < .001$ and Mahapatra (2015b) with correlation $r = .70$, $p < .01$. Georgiou and Das (2014) consider successive processing a significant predictor of phonemic decoding with correlation $r = .44$, $p < .01$. Moreover, the available body of literature brings information about experiments in the field of cognitive remediation of problems with spelling and word decoding (see Papadopoulos, 2013) using the PASS remedial program (PREP), a theoretically based programme inspired by the PASS theory. Papadopoulos (2013) found the improvement in word identification and word attack skills as a result of PREP intervention.

Within the PASS theory, however, it is important to differentiate between cognitive processing of beginner readers and more advanced readers. Successive processing seems to be present in initial reading as well as in decoding of unfamiliar words in advanced reading (Naglieri & Das, 1997). In both cases, the reader is learning the association of the sounds (in correct order) with the letters of the words. The study of Georgiou and Das (2014) confirms that successive processing is more important for basic reading decoding skills and simultaneous processing is more important for advanced reading comprehension.

There are, though, studies (e.g. Dash & Dash, 2011) that emphasise the importance of both simultaneous and successive processing in reading comprehension, when comprehension is understood as the ultimate goal of reading. From this viewpoint, difficulties in successive processing may cause difficulties in acquiring phonological coding. This, consecutively, may lead to an inability to decode words efficiently, which finally leads to reading failure and the absence of comprehension (Naglieri, 1999). In their study, Keat and Ismail (2011) found that successive processing scores correlate with reading comprehension $r = .39$, $p < .01$.

Despite numerous studies, dealing with the relation between information processing and mother tongue (L1) reading ability (Kirby, 1992; Mahapatra, 2015b), it can be said that there is an absence of similar research examining foreign language reading ability. Available literature does not offer information about studies connecting the concept of simultaneous and successive processing with foreign language (FL) reading ability. In other words, although the research in the field is vast, it involves almost exclusively L1 (Dash & Dash, 2011), occasionally second language L2 (Khaidzir bin & Ooi, 2008), but almost never foreign language.

Based on these findings, a research question about the relationship between the PASS processes (simultaneous and successive processing) and EFL reading skills was formulated. Three hypotheses were posed. Firstly, we hypothesised that simultaneous and successive processing account for a significant amount of variance in EFL reading skills. The second hypothesis concerned the relationship between the level of simultaneous processing and reading comprehension. We expected these domains to correlate positively. The same was anticipated in the third hypothesis, where a positive correlation between the level of successive processing and EFL word and letter decoding was expected.

METHOD

Participants

A total of 41 girls and 40 boys ($N = 81$) took part in the study. The children had finished their first year of EFL study, third grade, and were gathered from four classes at primary school. Their mean age at the beginning of the research was 9 years and 6 months. All the children were native Slovak speakers with standard exposure to English language through mass media and English lessons at school.

The sample came from a population of standard (without diagnosed severe psychological disorders) pupils at elementary school.

Measures

The variables were measured using the test array consisting of two parts:

1. Test measuring EFL reading skills.
2. Test battery measuring simultaneous and successive processing.

Both parts of the test array were adjusted for the purposes of this study.

EFL reading skills

EFL reading skills were measured by a test battery adapted from Kahn-Horwitz, Shimron, and Sparks (2005). The test measures EFL reading acquisition of children at primary school. It is divided into five tasks, as described below.

The first task measured knowledge of English letter sounds and names. A child was presented with 26 lower case letters of the English alphabets ordered randomly. The child was expected to pronounce the sounds represented by the letters and name the letters. The maximum score was 26 points for correctly pronounced sounds and 26 points for correctly named letters, that is 1 point per each sound and name. The total score served as the dependent measure. This task actually measured the ability to decode at the letter level.

The second task, focusing on the speed and accuracy of reading, consisted of 20 basic English words of various word classes (cat, green, stop, you …) that were familiar to the participants from their EFL study. The list of words comprised most of the English alphabet letters (with the exception of the letters d, q, v, x and z), common digraphs (ee, oo, th and ch) and two irregular verbs. The child was supposed to read the list of words aloud as accurately and quickly as possible. The score for accuracy (maximum 20 points) and reading speed (measured in seconds) was calculated. The time taken to complete the task and the number of correctly read words were used as dependent measures.

Another task, pseudoword decoding, was originally taken from WRMT-R Woodcock Reading Mastery Test—Revised (Woodcock, 1987). Word attack required reading English non-words with increasing difficulty. The number of correctly pronounced words was used as the dependent measure. The test was discontinued when a child made six consecutive errors.

The fourth task, word identification, also originates from WRMT-R. In word identification, a child was supposed to read English words with increasing difficulty. The test was discontinued when a child made six consecutive errors in pronunciation. Similarly as in word attack, the number of correctly pronounced words was defined as the dependent measure. This task, together with the two previous ones, focuses on the assessment of the ability to decode at the word level.

The purpose of the last task was to measure reading comprehension. The child silently read two simple short texts that covered topics that he/she had already been exposed to during EFL study. Five multiple choice questions written in the mother tongue followed each text and were scored 1 point per correct answer. The number of correctly answered questions was used as an indicator of reading comprehension.

EFL reading ability was divided into three constructs. Each construct reflected the child's performance in the following indicators:

1. Word decoding comprised WRMT-R subtests (word attack and word identification) as well as speed and accuracy of reading.
2. Letter decoding included the first task, the knowledge of English letter sounds and letter names.
3. Reading comprehension covered two texts from the fifth task.

Performance in the word and letter decoding tasks provided us with the operational definition of the word and letter decoding subskill. Performance in the reading comprehension task served to operationally define the subskill of reading comprehension.

Simultaneous and successive processing

Tests measuring selected cognitive processes originated from three testing batteries:

1. WISC-IV (Wechsler, 2003), with block design, matrix reasoning and digit span.
2. D-KEFS (Delis, Kaplan, & Kramer, 2001), with trial making test and verbal fluency.
3. Cognitive assessment system (CAS) (Naglieri & Das, 1997) with word series.

The following tests were used as measures of the latent variable simultaneous processing:

Matrix reasoning. This test is a constituent of many intelligence tests. The aim was to complete 35 figural (pictorial) analogies by choosing from the available options. The score represented the number of correctly solved items, which was used as the dependent measure. The test was discontinued when the examinee made four consecutive mistakes or four mistakes in five successive items.

Trail making test, its 3rd condition (TMT 3)—number–letter switching (Delis et al., 2001). The essence of the task was the alternating connection of letters and numbers. The child was required to simultaneously align letters in alphabetical order and numbers in ascending order, that is he/she had to continuously switch categories in his/her mind and not to lose track of the concept that followed at the same time. The task was discontinued when a child managed it all, or when the 240-second time limit was reached. The time taken to complete TMT 3 was used as an indicator of simultaneous processing.

Block design. It measures the ability to analyse and synthesise abstract visual stimuli, spatial skills, as well as simultaneous processing (Wechsler, 2003). This WISC-IV subtest requires the examinee to recreate the desired pattern according to model pictures within a time limit. The blocks have two white sides, two red sides and two red–white sides. The test encompassed graded items with increased levels of difficulty. The test was discontinued when a child made three consecutive mistakes, that is he/she did not meet the time limit or he/she created a wrong pattern. The total score served as the dependent measure.

Verbal fluency test—category switching. The D-KEFS verbal fluency test comprises three conditions – letter fluency, category fluency and category switching. The condition of category fluency with simultaneous switching intends to assess the ability to alternate between verbalising words of two semantic categories within the time limit. The examinee had 60 seconds to alternately name as many fruits and furniture pieces as possible. The number of correct switches was used as the dependent measure.

The following tests were used as the measures of the latent variable successive processing:

Digit span (*forward*). The administrator read a sequence of digits with increasing length and the child was asked to repeat the sequence of digits in the same order. The dependent measure was the score which represented the number of sequences the child repeated correctly. The test was discontinued after a child made two mistakes in a group of trials with the same span length.

Trail making test. Successive processing is measured by two conditions of the test—number sequencing (TMT 1) and letter sequencing (TMT 2); see Smith et al. (2008). This test loads on the successive scale of the CAS battery (Strauss, Sherman, & Spreen, 2006). The child was required to connect letters in alphabetical order or numbers in an ascending sequence. The time taken to complete both tasks (TMT 1 and TMT 2) was used as dependent measures.

Word series. From the CAS battery is a test that involves serial memory recall and includes the demand for successive processing paradigm linearity (Naglieri, 1999). The administrator read out a set of one-syllable words (one word per second) in the examinee's mother tongue L1 (in this study, these were Slovak words, e.g. dom, strom and pes, …). The child's task was to repeat the words in the same order as he/she heard them. The test was discontinued after three consecutive scores of zero. The number of sequences the child repeated correctly was in this case the dependent measure used as an indicator of successive processing.

Procedure

Each child was tested both in EFL reading skills and in simultaneous and successive processing. The testing batteries were administered consecutively within two sessions, that is the children were first tested in EFL reading skills and then the cognitive battery was administered to them, where children's mother tongue was used. Children were tested individually with a mean time duration of 35–45 minutes per battery.

EFL reading skills were tested in the order set by the original test as listed above. The fixed sequence of tests in the cognitive battery was as follows: Digit span, verbal fluency, word series, block design, trail making test and matrix reasoning. The reason for such an arrangement was the need for the alternated spread of simultaneous and successive processing domains. Probable sequencing and fatigue effects were not controlled for, which rules out the possibility to interpret normative performances in single tests.

Data analysis

As our variables present latent, not directly measurable constructs, it was necessary to define observable, manifested variables for their measurement. Manifested variables were represented by individual tests described above. The partial least squares regression method (PLS), carried out using SmartPLS 2.0 software, enabled us to define latent variables ("latent variables" are in PLS "weighted composites," as a matter of fact). In PLS, each latent variable explains the performance in several indicators (scores of tests).

Taking into account the characteristics of PLS, such as: (a) PLS avoids small sample size problems and can therefore be applied in some situations when other methods cannot, (b) PLS has less rigorous assumptions about the distribution of variables and error terms (Henseler,

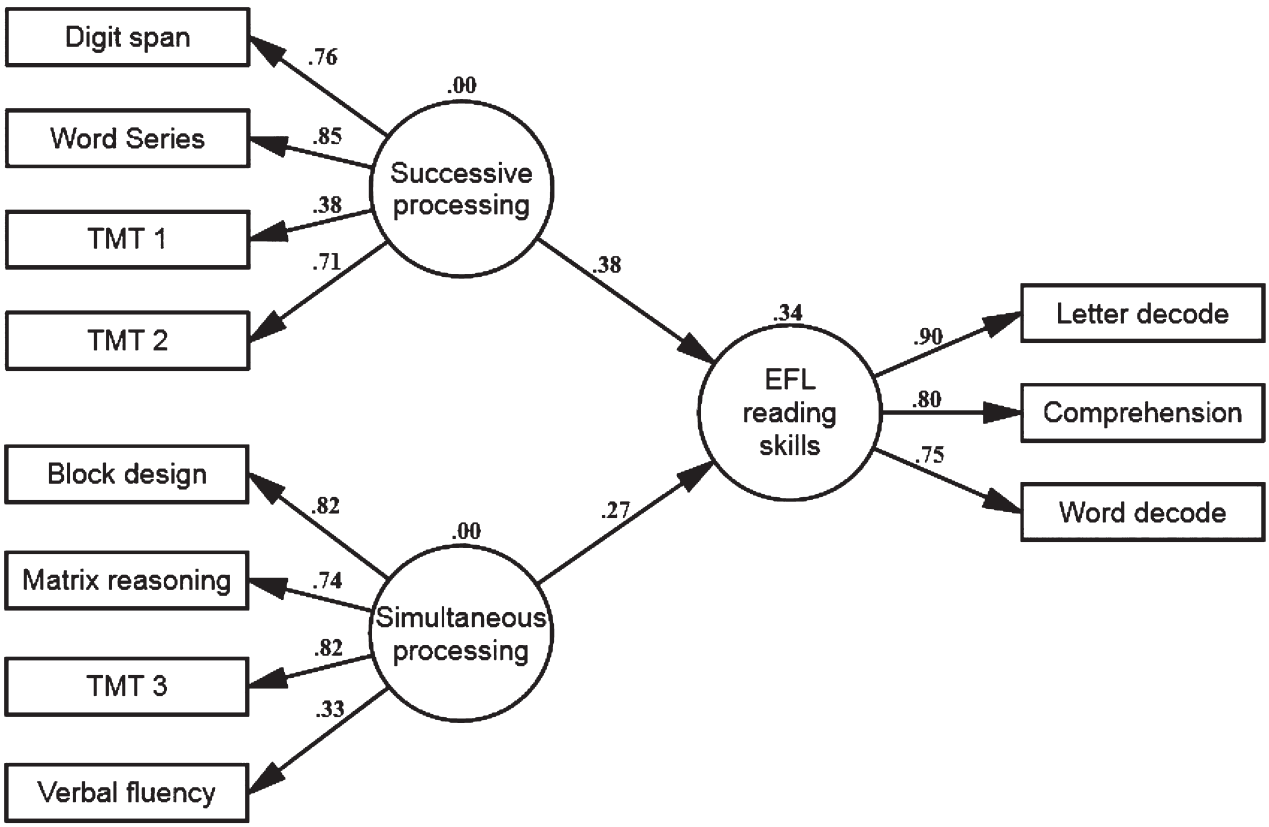

Figure 1. Loadings and regression paths in the present model. *Note*: All factor loadings are significant at the .05 level ($p < .05$).

Ringle, & Sinkovics, 2009), this technique met our needs for modelling relationships between sets of observed variables by means of latent variables. As PLS is a limited-information technique, the minimum sample size requirements follow the regression heuristic of 10 times the number of predictors of the dependent variable with the highest number of indicators, what is met by the present sample. Within a PLS analysis, a model characterising the relationship between the latent and manifested variables was created and subsequently tested. Loadings and regression paths in the present model are visible in Figure 1.

RESULTS AND INTERPRETATION

Before data analysis was made, variables were screened in order to find out their distributional qualities (Table 1). The screening procedure followed the system of steps suggested by Tabachnick and Fidell (2007). For the 1% of missing data, a regression estimate was imputed. The visualisation of distributions followed, which signalised outliers in most of the variables. To identify the outliers, a matrix of z-scores was created (mean $\bar{x} = 0$, SD $s = 1$). Identified excessive values were replaced by the value from the borderline of two standard deviations from the mean ($\bar{x} \pm 2s$). The distributions of most of the variables were positively skewed. These indications were confirmed by the significant value of Kolmogorov-Smirnov measure and consequently the non-normal variables were subjected to non-linear transformations ($\log(x + 1)$, $\sqrt{(x)}$). The matrix of correlations for indicator variables can be seen in Table 2.

Analysis of the model, that is the relationships between outcome variable and individual predictor variables was then carried out.

As the PLS regression does not rely on parametric distributions, it is not possible to determine statistical significance in a standard way. Thus, statistical significance was determined by using the resampling technique of bootstrapping. This technique generates pseudosamples by repeated random sampling from an original sample. Values of $t > 2$ are statistically significant at the level of $p < .05$.

Within the analysis, the need for establishing the validity of latent variable measurement emerged. Convergent validity determines the extent to which individual items represent the latent construct. According to Johnson and Stevens (2001), this type of validity is achieved after the following has been fulfilled: (a) the latent variables should demonstrate the value of the average variance extracted (AVE) higher than 50% (AVE > .50), (b) communalities should be higher than 0.50 (within PLS analysis, all

TABLE 1
Descriptive statistics

	Minimum	*Maximum*	*Mean*	SD	*Skewness*	*Kurtosis*
TMT 1	1.34	2.02	1.66	0.16	0.08	−0.43
TMT 2	21	109	54.04	19.49	0.75	0.28
DS	6	12	8.01	1.55	0.58	−0.44
WS	6	15	9.38	2.08	0.29	−0.48
TMT 3	1.66	2.36	2.01	0.15	0.19	−0.44
VF-CS	0	15	6.94	2.77	−0.14	0.82
BD	3.16	7.81	5.52	1.17	−0.05	−0.89
M	0	25	12.88	5.06	−0.19	−0.37
ABC 1	0	26	13.53	6.41	0.08	−0.93
ABC 2	19	26	24.27	1.69	−1.26	1.19
R-A	7	20	16.02	3.52	−0.79	−0.19
R-S	1.11	1.86	1.44	0.19	0.42	−0.79
WI	1.41	5.20	3.64	0.70	0.07	0.44
WA	0	18	8.38	3.49	0.22	0.48
RC A	1	5	3.74	1.22	−0.62	−0.68
RC B	1	5	3.51	1.05	−0.22	−0.38

Notes: $N = 81$; standard error of skewness: 0.27; standard error of kurtosis: 0.53. ABC 1 = letter sound; ABC 2 = letter name; BD = block design; DS = digit span; M = matrix reasoning; R-A = reading accuracy; R-S = reading speed; RC A = reading comprehension part A; RC B = reading comprehension part B; TMT 1 = trail making test—number sequencing; TMT 2 = trail making test—letter sequencing; TMT 3 = trail making test—number–letter switching; VF-CS = verbal fluency-category switching; WA = word attack; WI = word identification; WS = word series.

variables are Z-standardised, thus, AVE is also the value of average communalities extracted) and at the same time, (c) the loadings should be higher than 0.70. For the latent variable simultaneous processing, AVE was at .65; the loadings of indicators block design, matrix reasoning, TMT 3 and verbal fluency were 0.82, 0.74, 0.82 and 0.33, respectively. Lower loading of verbal fluency indicator demonstrated that, apart from the target construct, the indicator reflects the effects of other constructs as well. Regarding the latent variable successive processing, AVE was .78, while the loadings of indicators digit span, word series, TMT 1 and TMT 2 were 0.76, 0.85, 0.38 and 0.71, respectively. TMT 1 indicator, similarly as verbal fluency indicator, reflects the effects of other constructs along with the target construct. AVE for the latent variable EFL reading skills was .68, while the loadings of the indicators word decoding, letter decoding and reading comprehension were 0.75, 0.90 and 0.80, respectively. It can be stated that the majority of indicators (more than three-fourths) reflect the given constructs in sufficient quality. Based on these values, the model complies with the requirements of convergent validity.

Divergent validity requires that the latent construct shares a greater amount of variance with its own indicators than with other constructs in the model. Divergent validity is assessed by comparing the square root of AVE and constructs' intercorrelations in the model, with the square root of AVE higher than the intercorrelations. The square roots of AVE for EFL reading skills, simultaneous processing and successive processing were .82, .81 and .88, respectively. As the values of intercorrelations (Table 3) are not higher than the square root of AVE, it can be noted that the model fulfils the condition of divergent validity.

Construct reliability is demonstrated by the value of composite reliability (CR). If this value is greater than .70 (CR > .70), it can be assumed that the items of individual constructs measure the latent concept in a reliable way. The CR for EFL reading skills, simultaneous processing and successive processing are .86, .85 and .88, respectively. These values indicate that the variables correlate well with their "parental" factors, that is the manifested variables are well explained by their latent variables.

The analysis of the model led to confirmation of the stated hypotheses:

1. When analysing the model, focus was also put on variation in the latent variables. R^2 (the coefficient of determination) represents the proportion of variance that the model explains in the outcome variable. We hypothesised that simultaneous and successive processes account for a significant amount of EFL reading skills variance. The results show that simultaneous and successive processing accounted for 34% of the variance in the outcome latent variable. It can thus be stated that the hypothesis is accepted. This amount of variance indicates that besides cognitive aspects of reading skills, which comprise more than one third of the domain, there probably also exist other factors or constituents of EFL reading skills (e.g. visual-motoric skills, prosody, affective and behavioural aspects).
2. The next hypothesis was that simultaneous processing positively correlates with EFL reading comprehension. This premise was based on studies referring to the relationship between the successful mastering of reading skills (on the level of reading comprehension) and simultaneous processing (e.g. Kirby, 1992). Many studies (e.g. Keat & Ismail, 2011; Mahapatra et al., 2010) proved simultaneous processing to be an eminent predictor of L1 reading skills. For instance, the correlation between the latent variables simultaneous processing and reading comprehension is found at the level of .56 ($p < .05$, $N = 74$) (Kirby, 1992). The correlation between simultaneous processing and reading comprehension in our study at .30 ($p < .01$) can be considered moderate. Based on these results, the hypothesis assuming the positive relationship was accepted. (The correlations stated in hypothesis 2 and hypothesis 3 are actually cross-loadings, i.e. they describe the relationship between a latent variable and an indicator of another latent variable.)
3. Lastly, based on the knowledge that successive processing plays a crucial role in developing L1 reading skills, we hypothesised a positive correlation between

TABLE 2
Correlation matrix for the indicator variables

	TMT 1	*TMT 2*	*DS*	*WS*	*TMT 3*	*VF-CS*	*BD*	*M*	*ABC 1*	*ABC 2*	*R-A*	*R-S*	*WI*	*WA*	*RC A*	*RC B*
TMT 1	1															
TMT 2	$.50^{**}$	1														
DS	−.17	$-.28^{*}$	1													
WS	−.12	$-.37^{**}$	$.57^{**}$	1												
TMT 3	$.56^{**}$	$.69^{**}$	$-.33^{**}$	$-.33^{**}$	1											
VF-CS	−.08	−.13	.11	$.23^{*}$	−.16	1										
BD	$-.39^{**}$	$-.41^{**}$	$.23^{*}$	$.33^{**}$	$-.60^{**}$	$.23^{*}$	1									
M	−.14	$-.36^{**}$	$.29^{**}$	$.36^{**}$	$-.39^{**}$	−.02	$.45^{**}$	1								
ABC 1	−.15	$-.40^{**}$	$.34^{**}$	$.42^{**}$	$-.49^{**}$	.19	$.43^{**}$	$.44^{**}$	1							
ABC 2	−.07	$-.25^{*}$	.22	$.38^{**}$	−.19	.06	.07	$.27^{*}$	$.36^{**}$	1						
R- A	−.01	$-.28^{*}$	$.38^{**}$	$.47^{**}$	$-.38^{**}$	$.24^{*}$	$.28^{*}$	$.33^{**}$	$.60^{**}$	$.52^{**}$	1					
R- S	.12	$.23^{*}$	−.17	−.11	$.30^{**}$	−.18	−.18	.00	$-.33^{**}$	$-.35^{**}$	$-.53^{**}$	1				
WI	−.10	$-.36^{**}$	$.37^{**}$	$.45^{**}$	$-.36^{**}$	$.25^{*}$	$.25^{*}$	$.29^{**}$	$.57^{**}$	$.48^{**}$	$.77^{**}$	$-.47^{**}$	1			
WA	−.07	−.19	.16	$.35^{**}$	−.19	.11	.19	.20	$.40^{**}$	$.46^{**}$	$.61^{**}$	$-.46^{**}$	$.60^{**}$	1		
RC A	−.02	$-.28^{*}$	$.25^{*}$	$.31^{**}$	$-.26^{*}$	.21	.08	$.24^{*}$	$.46^{**}$	$.34^{**}$	$.55^{**}$	$-.29^{**}$	$.40^{**}$	$.29^{**}$	1	
RC B	−.02	$-.24^{*}$	$.33^{**}$	$.31^{**}$	−.21	.03	.04	$.29^{**}$	$.46^{**}$	$.31^{**}$	$.44^{**}$	−.18	$.47^{**}$	$.35^{**}$	$.43^{**}$	1

Notes: Pearson correlation r was used to estimate standardised covariance. $N = 81$. ABC 1 = letter sound; ABC 2 = letter name; BD = block design; DS = digit span; M = matrix reasoning; R-A = reading accuracy; R-S = reading speed; RC A = reading comprehension part A; RC B = reading comprehension part B; TMT 1 = trail making test—number sequencing; TMT 2 = trail making test—letter sequencing; TMT 3 = trail making test—number–letter switching; VF-CS = verbal fluency-category switching; WA = word attack; WI = word identification; WS = word series.
* indicates that correlation is significant at the .05 level (two-tailed). ** indicates that correlation is significant at the .01 level (two-tailed).

TABLE 3
Correlations of latent variables (correlation of factor scores in the latent variables)

	Reading	*Simultaneous*	*Successive*
Reading	1		
Simultaneous	$.49^{**}$	1	
Successive	$.50^{**}$	$.45^{**}$	1

** indicates that correlation is significant at the .01 level (one-tailed).

successive processing and EFL word and letter decoding skill. Research in the field of L1 refers to reading improvement as a result of successive processing training. One selected study (Kirby, 1992) put the positive correlation between latent variables successive processing and phonological skills (word decoding) at .37 ($p < .05$, $N = 74$). The PLS analysis in our study revealed an existing positive relationship between the domains of successive processing and EFL reading skill. The correlation between the successive processing and word decoding at .35 ($p < .01$) proved to be moderate. Similarly, strong correlation .53 ($p < .01$) between successive processing and reading at the level of letter decoding helped us to accept the hypothesis.

DISCUSSION

In this study, we investigated the relationship between the PASS cognitive processes and reading skills in EFL. The results of the study provide evidence of the relationships between simultaneous and successive information processing skills and selected subskills of EFL reading skills. While simultaneous processing demonstrates significant correlation with reading comprehension, successive processing significantly correlates with word and letter decoding. The results support our assumption that not only do cognitive processes influence successful development of L1 reading skills, but they also represent a crucial factor in EFL reading.

As it was mentioned above, the relationship between information processing and foreign language acquisition is relatively unexplored. The current research tried to shed light on the issue; nevertheless, it presents only one viewpoint, limited in some aspects. To prove that our conclusions are consistent with reality, it would be interesting to replicate the findings using different tests to see how the results would differ. One test worth using would be the CAS battery (Naglieri, 1999). This test battery is designed to assess cognitive processes and is the only test battery that is based completely on the PASS theory of cognitive processing. Although there are some authors (see Kranzler & Keith, 1999) who question construct validity of the CAS, others (e.g. Thompson, 2004) acknowledge construct validity of the CAS stating that data presented by the authors in the CAS interpretive handbook (Naglieri & Das, 1997) provide generally strong support. Additionally, the recent study of Das, Sarnath, and Nakayama (2013) successfully tested construct validity of the CAS.

Another aspect we did not take into consideration in this study was planning process as the PASS theory component. The results could be interpreted differently if planning process had been measured taking into account the findings of Kirby and Robinson's (1987) study. According to this study, reading disabled children deficient in simultaneous and successive processes may be suffering more from deficient planning process needed for applying the appropriate information integration mode to the reading task. That is, these children may be using simultaneous mode of processing where successive mode would have been more appropriate. Similarly, the study of Naglieri and Prewett (1990) revealed that the combination of planning, simultaneous and successive processes accounted for more than 70% of the variance in total reading achievement scores. Moreover, simultaneous, successive as well as planning processes correlated significantly with reading decoding and reading comprehension (Dash & Dash, 2011; Mahapatra, 2015a).

To conclude, the results of this study have provided us with new information about the character of the reading process. The article has revealed some important relationships between simultaneous and successive processing and EFL reading skills. Although the relationships were not very strong in this study, these findings emphasise the importance of particular cognitive processes for the child's functioning in certain EFL reading subskills. Simultaneous processing seems to be of importance for reading comprehension and successive processing appears to play a role in mastering word and letter decoding. Further systematic research in this area would help to either support or contradict our findings; moreover, it may shed more light on the PASS theory as well as bring more information to help us understand the nature of cognitive processes affecting reading in a foreign language.

The findings of such research should lead to practical utilisation, such as intervention programmes aiding pupil's deficient cognitive processes, or they should have other exploitable impact. This study has brought pedagogical implications. Teachers and educational psychologists should consider using the PASS theory measures in order to detect possible information processing deficits in children, especially simultaneous and successive processes, the prerequisites of decoding and comprehension. The results of the study suggest that the PASS theory can provide directions for identification of possible specific deficits in EFL reading. As decoding unique English sounds and reading comprehension belong to the most common difficulties in EFL reading, detection of such difficulties on the level of cognitive processing would help to determine intervention, apply the right remediation and finally improve reading performance and help with EFL reading difficulties of a child at primary level.

ACKNOWLEDGEMENTS

This work was supported by the Slovak Research and Development Agency under grant number APVV-0281-11. Marta Filickova contributed towards conception and design, collection and interpretation of data, drafting the article and revising it critically for important intellectual content. Iveta Kovalcikova contributed towards conception and revising the article critically for important intellectual content. Ivan Ropovik contributed towards analysis of data and drafting the article or revising it critically for important intellectual content

Manuscript received May 2014
Revised manuscript accepted April 2015
First published online April 2015

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