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RAN related to Visual Orienting of Attention and Phonology: Different contributions in Two Reader Subgroups

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Objectives

Numerous studies in the past four decades have indicated RAN as an important predictor of reading. However, questions as to the neurocognitive nature of RAN and its reading-predictive mechanisms still remain. This study has two objectives. First, it aims to offer empirical evidence for the hypothesis that visual orienting of attention processes substantially and uniquely contribute, i.e., beyond phonological processing, to RAN task performance in reading disabled (RD) and non-reading disabled (NRD) subgroups. Second, it aims to explore and clarify the possibly different 'weights' of visual attention and phonological contributions to RAN performance in reader subgroups.

Methods

Study sample
Participants were 76 eight-to-twelve-year-old Dutch primary school children, who were divided into reader subgroups of poor (RD) versus average-to-good (NRD) readers on the basis of word reading performance. In order to assess the possible interactive effects between reading (dis)abilities and frequently occurring clinical conditions, a number of children with ADHD and SLI were included. Six subgroups were investigated: RD, ADHD, SLI, two comorbid groups: RD+ADHD and RD+SLI, and typically developing controls (see Table 1 for details).

Word Reading (WR) was assessed by two standardized Dutch tests of word recognition (Brus & Voeten, 1999; Van den Bos & Lutje Spelberg, 2010), and a standardized Dutch pseudoword reading test (Van den Bos, De Groot, & De Vries, 2019) measuring phoneme decoding skill. Total items correct in 1 or 2 minutes, respectively, were transformed to age-corrected and averaged z-scores.

Phonemic Awareness (PA) In order to control for phonological contributions to RAN, PA was assessed by a standardized Dutch test of phonemic analysis ability (FAT-R; De Groot, Van den Bos & Van der Meulen, 2014), comprising phoneme elision and phoneme substitution sub tests. Response times and task accuracy were transformed to an age- corrected index score (z-score)

Rapid Automatized Naming (RAN) Alphanumeric RAN performance was assessed by the letter and digit naming subtests of a standardized Dutch testing battery (Van den Bos & Lutje Spelberg, 2010). Total reading times of 50 items each were transformed to age-corrected and averaged z-scores.

Table 1. Subgroup frequencies, mean and sd for AGE (in months)

Subgroup	n	Age (months)	sd
RD	19	128.4	16.9
SLI	6	129.7	12.9
ADHD	12	120.6	18.0
RD+SLI	12	120.3	15.8
RD+ADHD	8	132.4	20.9
CONTROL	19	125.8	18.9

WR group	n	Age (months)	sd
RD	39	126.7	17.6
NRD	37	124.7	17.6
Total	76	125.8	17.5

Analysis
Data were analysed using analysis of variance and hierarchical multiple linear regression. Having calculated and inspected the basic descriptive statistics, first, a series of ANOVA's were carried out to test individual group differences for all included variables. Next, as the main analyses, separate step-wise hiërarchical multiple regression analyses were carried out for the RD and Non-RD groups, with alphanumeric RAN performance as the dependent variable, in order to assess and compare the predictive values of the VCT measures (i.e., N2-amplitudes and latencies (ERPs), and response times) for each group, while including/controlling for AGE and phonological measures (PA).

Experimental task
Orienting of attention was assessed with an experimental **visuospatial cueing task (VCT)** (cf. Dhar et al., 2008; De Groot, 2015). The VCT paradigm comprises 300 trials , which are divided equally over 6 conditions: right-/left-peripherally, (in)validly cued, and two left/right uncued Target conditions (see also *Figure 1*). Participants were required to respond to Target stimuli as quickly as possible by pressing the corresponding key [X or O] on a standard computer keyboard.

Overt VCT-measurements were comprised of **response times (RT)** in milliseconds and **error rates**.

Neurophysiological VCT-measurements comprised of event related potentials of the **N2 component** to capture the automatic orienting responses located in the superior parietal lobe, and temporal-parietal junction. Focusing on posteriorly mediated visual attentional processing, N2 analyses were restricted to latencies and amplitudes for left-parietal (P3), central-parietal (Pz), and right-parietal (P4) electrode sites.

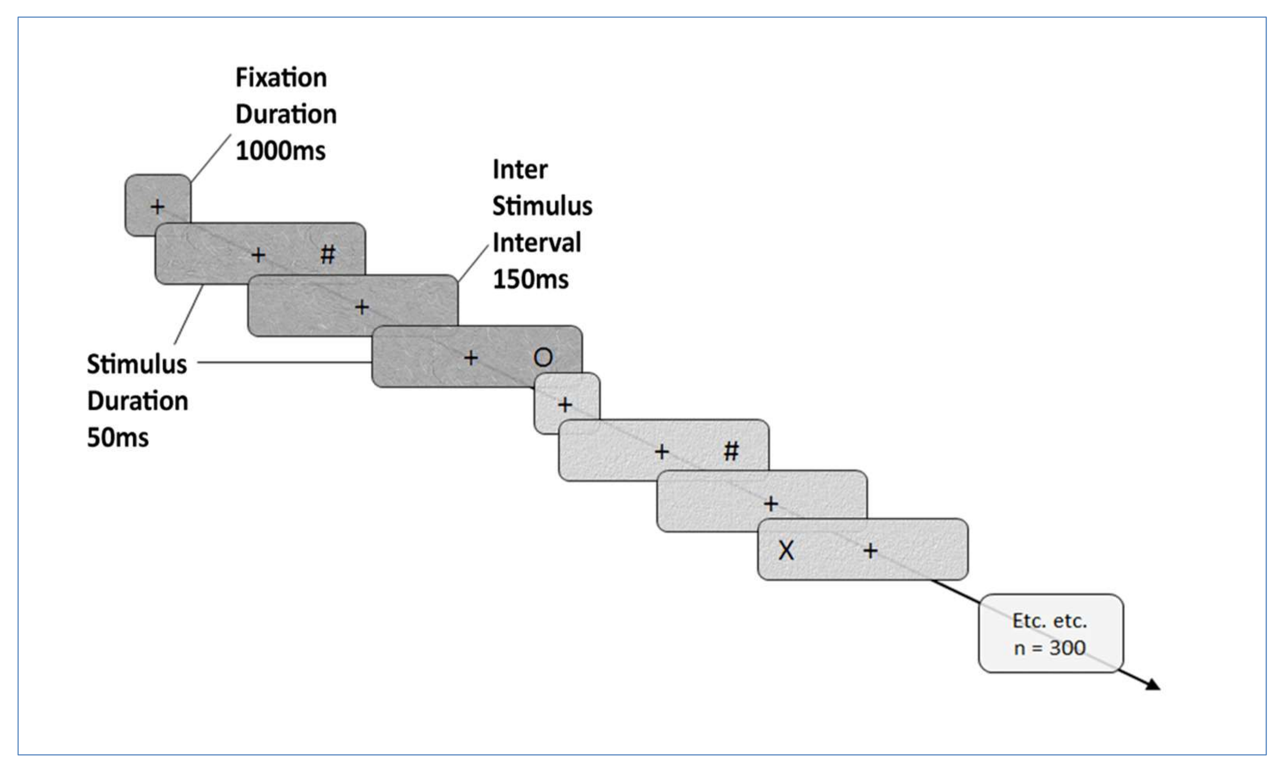

Figure 1 Spatial cueing paradigm (congruent trial in dark gray, and incongruent in light gray)

Results

Table 2 Means (z-scores) and standard deviations for Word Reading (WR), RAN (alphanumeric), and Phonemic Awareness (PA).

WR group	Sub group	WR mean (z)	WR sd	RAN mean (z)	RAN sd	PA mean (z)	PA sd
NRD	SLI-only	-.81	.55	-1.28	.77	-1.85	1.18
	ADHD-only	-.52	.82	-.92	1.10	-1.48	1.46
	CONTROL	-.16	.97	-.42	1.02	-.78	1.58
	Total	**-.38**	**.89**	**-.72**	**1.04**	**-1.18**	**1.51**
RD	RD-only	-2.27	.49	-1.58	.92	-2.18	1.01
	RD+SLI	-2.25	.57	-1.83	.77	-2.78	.71
	RD+ADHD	-2.11	.42	-1.63	.98	-1.96	.97
	Total	**-2.23**	**.50**	**-1.67**	**.87**	**-2.32**	**.95**

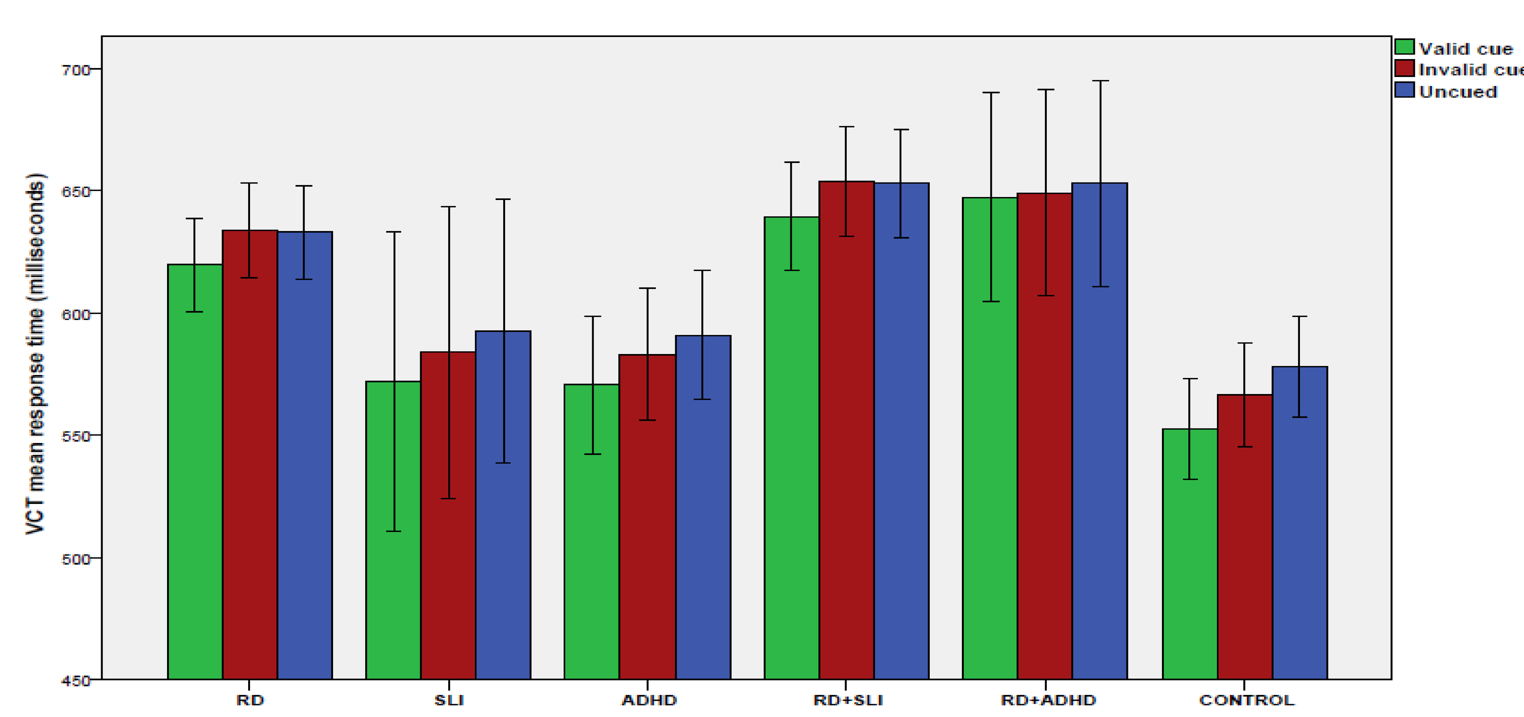

Figure 2 VCT mean response times (RT) (in milliseconds) by condition and clustered for subgroup

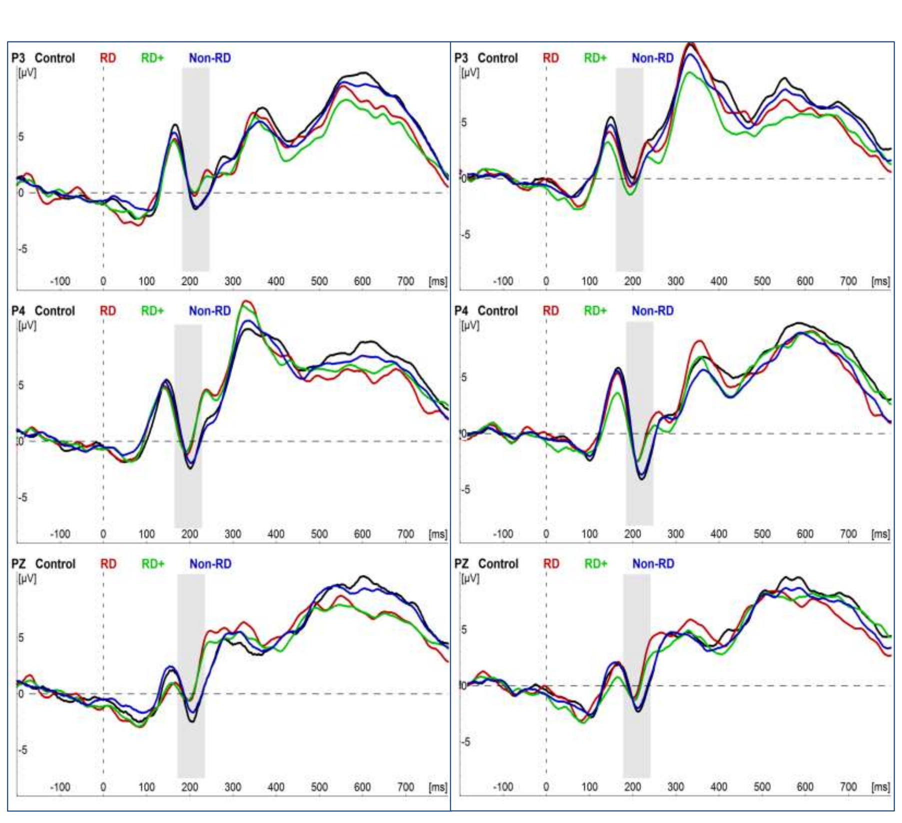

Figure 3 Cue-locked parietal N2 potentials for left-cue (left column) and right-cue (right column) trials

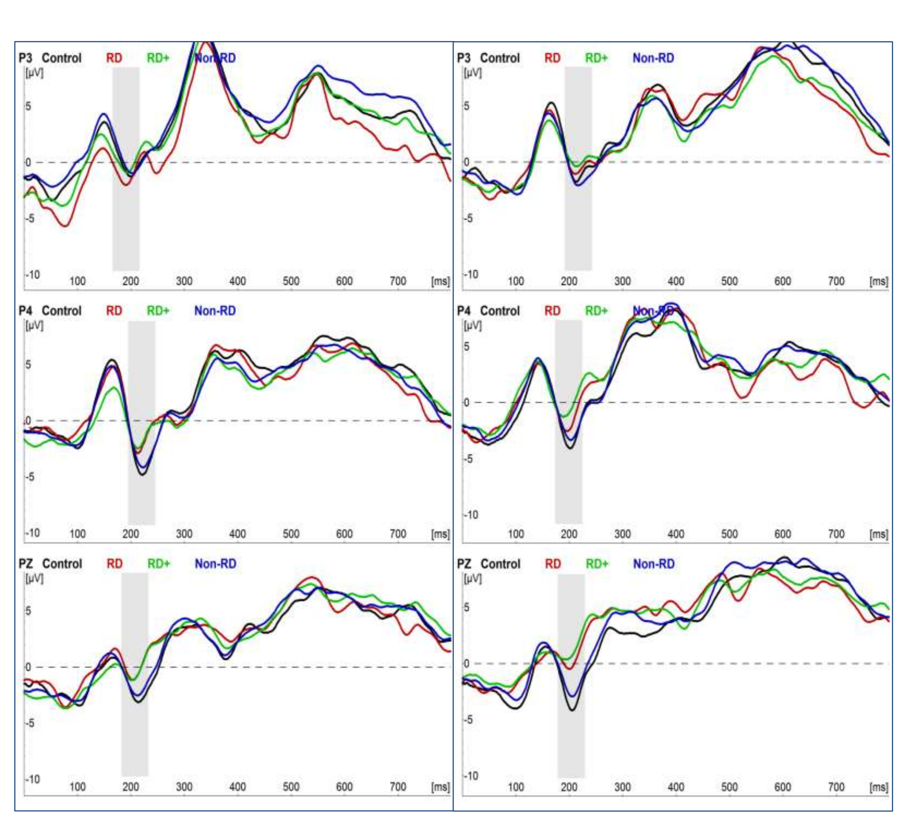

Figure 4 Target-locked parietal N2 potentials for valid-cue right targets (left column) and invalid-cue target (right column) trials

Table 3 Separated results of two stepwise multiple regression analyses (for RD and NRD) on RAN performance with VCT measurements (N2 amplitudes/latencies and response times) as predictors, while also including/controlling for AGE and PA.

Model Summary

WR group	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
Non-RD	1	,599[a]	,358	,340	5,835	,358	18,996	1	34	,000
	2	,770[b]	,593	,568	4,720	,234	18,975	1	33	,000
	3	,801[c]	,642	,609	4,493	**,049**	4,418	1	32	,044
RD	1	,549[d]	,302	,282	7,855	,302	15,564	1	36	,000
	2	,666[e]	,444	,412	7,108	,142	8,963	1	35	,005
	3	,722[f]	,521	,478	6,697	**,076**	5,426	1	34	,026
	4	,765[g]	,586	,536	6,319	**,065**	5,192	1	33	,029
	5	,827[h]	,683	,634	5,612	**,097**	9,829	1	32	,004
	6	,856[i]	,732	,680	5,243	**,049**	5,672	1	31	,024

a. Predictors: (Constant), AGE
b. Predictors: (Constant), AGE, PA
c. Predictors: (Constant), AGE, PA, LR_N2_P4_latency
d. Predictors: (Constant), PA
e. Predictors: (Constant), PA, AGE
f. Predictors: (Constant), PA, AGE, RL_N2_P3_amplitude
g. Predictors: (Constant), PA, AGE, RL_N2_P3_amplitude, LR_N2_P3_amplitude
h. Predictors: (Constant), PA, AGE, RL_N2_P3_amplitude, LR_N2_P3_amplitude, RT_FalseCue_LR
i. Predictors: (Constant), PA, AGE, RL_N2_P3_amplitude, LR_N2_P3_amplitude, RT_FalseCue_LR, RT_FalseCue

Discussion

Results indicate that a significant proportion of RAN variance is explained by VCT performances in both reader groups. However, VCT contribution was found to be substantially larger in the RD group, and that these results were not affected by ADHD or SLI status. Moreover, there were qualitative differences in terms of event related potentials (N2). That is, whereas the VCT contribution for the normal readers was restricted to N2 latency, the RD readers exhibited smaller N2 amplitudes in response to peripheral cues, and slower response times in incongruent cue conditions. These results indicate that the RD readers are particularly less prone to fleeting peripheral information to guide visual attention. As this outcome was found to be independent of ADHD or SLI status, the orienting of attention effect appears to be reading specific. This typically non-phonological mechanism seems intrinsic to reading fluency in particular, with, in case of RD, detrimental cascading effects for subsequent phonological processing and identification of alphanumeric stimuli in series of items – as in RAN tasks – and, with regard to reading, in series of letters, letter chunks or words. With these results a new and important explanatory element is added to the RAN-reading link.

References

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