Research highlights

- Typical and atypical young readers extract viewpoint-invariant vertices from written strings
- Beginning readers extract vertices from written strings less than adults
- Beginning readers extract vertices from written strings in proportion to their reading skills
- Dyslexic children extract vertices from written strings less than age-matched controls
- Dyslexic children extract vertices from written strings similarly as reading-level controls

Abstract

We aimed at investigating whether typical and atypical young readers extract vertices (viewpoint-invariant line junctions) in reading, as has been shown for fluent adult readers. In an identification task, we presented partly deleted printed letters, words and pseudowords, preserving either the vertices or the midsegments of the letters. This allowed assessing the occurrence of a *vertex effect*, i.e., more errors when vertices are partly removed, keeping the midsegments intact, than in the reverse situation. In Experiment 1, the vertex effect was observed on words and pseudowords in three groups of typical readers: 48 adults, 56 beginning readers (Grade 2 and 3) and 42 more advanced readers (Grade 4 and 5). Yet the effect was smaller in the beginning readers, in relation to their irregular word reading skills. In Experiment 2, we compared 40 children with dyslexia with children selected from Experiment 1 to match them on either chronological age (30 *CA controls*) or reading level (42 *RL controls*). Although all groups displayed a vertex effect on words and pseudowords, dyslexic children presented a smaller effect than CA controls, without differing from RL controls. The whole result pattern suggests that vertices play an important role in the recognition of written strings not only in skilled adult readers but also in young readers, in relation to their actual reading skills rather than to a specific reading deficit.

Key words: reading acquisition; dyslexia; visual feature extraction

Reading by extracting invariant line junctions in typical and atypical young readers

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It has been suggested that visual word recognition builds upon the adaptation of nonlinguistic object recognition to the specific constraints of reading, a process that Dehaene and Cohen (2007) call “recycling”. For instance, reducing visual crowding (namely, the interference generated by spatially close stimuli) constitutes a key adaptation that allows optimizing parallel letter processing, which is a characteristic of fluent reading (e.g., Risko, Lanthier, & Besner, 2011; Tydgat & Grainger, 2009). Similarly, distinguishing mirrored letters like <b> and <d> requires breaking mirror invariance, a crucial property of the visual ventral system where mirrored images are considered to correspond to the same object (e.g., Borst, Ahr, Roëll, & Houde, 2015; Dehaene, Nakamura et al., 2010; Perea, Moret-Tatay, & Panadero, 2011). Hence, much effort has been devoted in these last years to understanding the ways visual word recognition differs from the processing of other kinds of visual objects (e.g., Grainger, 2018; Grainger & Hannagan, 2014) and how literacy acquisition modifies visual processes (for a review, see e.g., Dehaene, Cohen, Morais, & Kolinsky, 2015). In children, many studies have examined how the identified processes (e.g., reduced crowding, breaking mirror invariance) develop in beginning readers (e.g., Grainger, Bertrand, Lété, Beyersmann, & Ziegler, 2016; Fernandes, Leite & Kolinsky, 2016). Several studies have also examined whether the development of these processes is affected in developmental dyslexia, a persistent reading disorder despite normal IQ and sensory abilities and adequate educational opportunities (e.g., Fernandes, Vale, Martins, Morais, & Kolinsky, 2014; Lachmann & van Leeuwen, 2008; Martelli, Di Filippo, Spinelli, & Zoccolotti, 2009; Ziegler, Pech-Georgel, Dufau, & Grainger, 2010; Zorzi et al., 2012).

Most of the adaptations to reading probably occur in brain regions that code for complex visual properties (Dehaene, 2009). Yet, visual word recognition involves several levels of the visual system, which are organized in a hierarchical manner, with, at each level, neurons reacting to a conjunction of responses from the immediately lower level, as proposed for instance in the Local Combination Detector model (*LCD,* Dehaene, Cohen Sigman &

Vinckier, 2005) and in the theoretical framework of Grainger and colleagues (e.g., Grainger, Dufau, & Ziegler, 2016; Grainger, Rey, & Dufau, 2008). Crucially, it has been shown that even the most primary levels of visual processing undergo changes in expert readers. For instance, a comparison between the functional magnetic resonance imaging (*fMRI*) responses of literate and illiterate adults showed that literacy acquisition enhances retinotopic responses to checkerboards in the bilateral calcarine cortex, at the location of primary visual area V1, which is the first point of entry of visual signals into the cortex (Dehaene, Pegado et al., 2010). This effect is selective for horizontal over vertical checkerboards, which indicates that the visual cortex of readers becomes specifically responsive to the location at which alphabetic strings appear on the retina (for other examples, see Dehaene et al., 2015).

Given that even the primary visual processes are impacted by literacy acquisition, it seems worth examining the development, in young readers, not only of the parallel processing of the identity and location of abstract letters, but also of lower-level visual processes, that, despite being common to the processing of all visual objects, are crucial for visual word recognition. It seems especially worth examining atypical young readers, namely dyslexic children. As a matter of fact, the notion that reading disorders can emerge from impairment at any level of the reading network is now widely accepted (e.g., Bishop, 2006; Pennington, 2006; see also van Bergen, van der Leij, & de Jong, 2014), and computational evidence supports the idea that visual impairments affect phonological decoding and learning to read (Ziegler, Perry, & Zorzi, 2014).

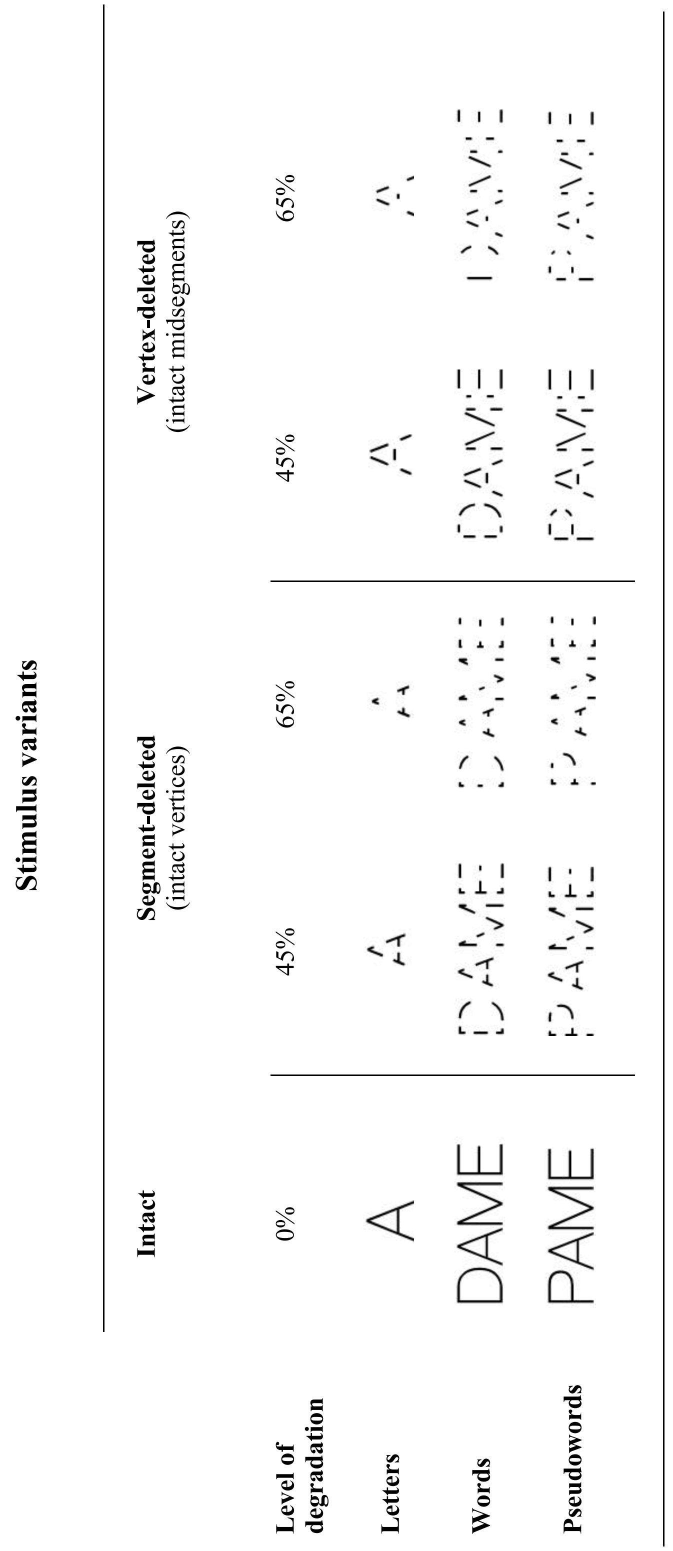
In the present study, we chose to investigate, in both typical and atypical young readers, the extraction of viewpoint-invariant visual features such as the manner in which lines meet at vertices, i.e., invariant line junctions (as in e.g., T, or L). Vertex invariants are largely used in object recognition, as originally demonstrated by Biederman (1987). Indeed, when vertices are deleted from the drawing of an object, object recognition is more impaired than when an equivalent proportion of contour is deleted from the midsegments, sparing the vertices. In

addition, line junction information is used to perceive depth and object shapes very early in development, by five months of age (e.g., Corrow, Granrud, Mathison, & Yonas, 2012). In adult readers, the extraction of line junctions also allows fast recognition of printed words. Indeed, the same *vertex effect* as the one observed for objects has been reported with words (Lanthier, Risko, Stolz & Besner, 2009; Szwed, Cohen, Qiao & Dehaene, 2009) and single letters (Lanthier et al., 2009). For both types of materials, the *segment-deleted* stimuli with degraded midsegments but intact vertices are better recognized than the *vertex-deleted* stimuli with degraded vertices but intact midsegments (see an illustration in Figure 1).

This vertex effect does not seem to be due to the fact that deletions at either midsegments or vertices affect reconstruction strategies in different ways. Indeed, strongly degraded printed words trigger several reconstruction strategies, namely serial, parietal-based reading mechanisms (Cohen, Dehaene, Vinckier, Jobert, & Montavont, 2008) and filling-in or amodal completion processes (Michotte, Thines, & Crabbe, 1991). However, reconstruction strategies need time to develop, and hence the vertex effect would either not be observed at all or be smaller with short than with longer exposure. This is not the case: the vertex effect has been observed with quite short word presentation times (50 ms exposure in Lanthier et al., 2009; 100 ms exposure plus a mask in Szwed et al., 2009), being as strong (Szwed et al., 2009) or even stronger (Lanthier et al., 2009) with shorter compared to longer exposure. Thus, the effect probably occurs at a relatively early level of visual processing, which is consistent with the proposal of the LCD model, according to which the extraction of vertices occurs before the recognition of abstract letter identities (Dehaene, 2009; Dehaene et al., 2005).

In addition, the brain area that responds more strongly to vertex-preserved words (compared to midsegment-preserved ones) partially overlaps with the Visual Word Form Area (*VWFA*, Cohen et al., 2000), an area considered to be at the heart of the reading network. More precisely, Szwed et al. (2011) found greater fMRI activation for vertex- than midsegment-preserved stimuli in the left mid-fusiform for words and objects, and in the

Figure 1. Stimulus design. Participants had to identify partially degraded letters, words and pseudowords. Stimuli were degraded by partial deletion of some of their component lines, either the vertices or the midsegments, with a 45% or 65% level of degradation.



symmetrical right-hemispheric fusiform for objects only. Thus, vertex invariants, which are largely used in object recognition, would have been co-opted for reading (Dehaene & Cohen, 2007). In agreement with this idea, it seems that all visual writing systems throughout the ages, whether alphabetical or not, make use of a similar set of line junctions, with a statistical distribution that matches the patterns of contour intersections that arise in natural scenes (Changizi, Zhang, Ye, & Shimojo, 2006). This suggests that the writing systems have evolved by adapting these visual features to be easily processed by the human visual system. Consistently, learning to read an atypical script that is devoid of line junctions (such as the Braille alphabet read visually) is much more difficult than learning to read a "normal" unknown script (Bola et al., 2017).

According to the view that vertex invariants are co-opted for reading, we would expect young beginning readers to use them in word and letter recognition, similarly to adult fluent readers. Yet we do not know whether the co-optation of vertex extraction by the reading network is an easy process and at what point it usually appears in the course of reading acquisition. To our knowledge, the use of vertex invariants in visual word recognition has not yet been studied in beginning readers, typical or atypical. In the present study, we thus first examined the occurrence of the vertex effect in typical beginning readers presented with linguistic stimuli and compared them to adults (Experiment 1). We then compared a subset of these young typical readers to dyslexic children (Experiment 2), matching them on either chronological age or reading level.

Experiment 1

Three groups of participants were examined: beginning readers from Grades 2 and 3, more advanced readers from Grades 4 and 5, and adults. All were reported as being typical readers, and the children's literacy abilities were assessed by independent tests. Reading proficiency was also assessed in both adults and children by asking them to identify the intact written stimuli used in the main task. Consistent with Szwed et al. (2009), we presented the

participants with two degraded variants of the written stimuli, one in which part of the vertices were deleted but the midsegments were preserved, and one in which part of the midsegments were deleted but the vertices were preserved. As in that study, the stimuli were either slightly degraded (with 45% of either the midsegments or the vertices deleted) or strongly degraded (with 65% of that information deleted). However, we chose to use a material adapted to children's reading capacities and hence used 4-letter words instead of 6- to 8-letter words as in Szwed et al. Four-letter words have already been used with adults by Lanthier et al. (2009), although their stimuli and procedure were slightly different. Furthermore, we wanted to check for the generality of the vertex effect, and hence presented participants with nonsense pronounceable strings (*pseudowords*) in addition to words and letters. Indeed, when words are practiced sufficiently, they can be read very rapidly, even when they are quite long (their letters would be processed simultaneously rather than serially, e.g., Zoccolotti et al., 2005). This might explain why Szwed et al. had to use more degraded stimuli (65%) with words than with objects (45%) in order to elicit a significant difference in adult fluent readers between the vertex-deleted and segment-deleted variants.

We predicted that, for all stimuli, all participants would make more errors when vertices rather than midsegments are deleted, and that this vertex effect would be stronger when stimuli are more degraded (at 65 vs. 45%), and when they are more complex (words and pseudowords vs. letters). More specifically, under the hypothesis that the extraction of vertex invariants in reading is a fundamental process that exploits a general object recognition procedure, we expected children to exhibit the same performance profile as adults, namely, significant vertex effects, with effect sizes varying according to stimulus degradation (being larger for more severe degradation). We thus expected to observe significant effects of the type of feature deleted and level of degradation as well as a significant interaction between those factors and, possibly, with stimulus type, but, critically, no interaction between the type of feature deleted and group. We therefore ran Bayesian analyses, as, contrary to significance

testing, the Bayes factor provides a continuous measure of evidence for the hypothesis at test (H_1) against the null hypothesis (H_0) and hence is directly interpretable as an odds ratio that can support either H_1 or H_0 (e.g., Dienes & Mclatchie, 2018). In addition, as the processing of written stimuli might be less automatized in beginners than in fluent readers, we examined whether the extraction of vertex invariants was related to the participants' literacy skills.

Method

Participants. The adult group included 48 French-speaking undergraduate students (40 females) from Université Libre de Bruxelles. They were aged from 17 to 34 years (average: 19.5) and reported no uncorrected sensory deficits and no general-learning problems. They received courses credit for their participation.

We examined a total of 98 children with no uncorrected sensory deficits and no general-learning problems. All were French speakers and typical readers, having learned to read in French. Among them, 56 children attended Grades 2 or 3 (*Grade 2&3* children; average age: 100 months; 27 girls), and 42 attended Grades 4 or 5 (*Grade 4&5* children; average age: 127 months; 24 girls). Ethics approval for the study was granted by Université Libre de Bruxelles. Written informed consent was obtained from the adult participants. For children, it was obtained from their parents, and oral agreement was obtained from each child.

All children performed seven ancillary tests of the *BALE* French battery (Jacquier-Roux, Lequette, Pouget, Valdois, & Zorman, 2010): reading of regular words, irregular words, and pseudowords (20 items each); initial and final phoneme deletion (10 items each) to estimate phoneme awareness, and digit span, a phonological working memory test in which participants repeat a sequence of digits (forward in the first block, backward in the second).

Materials. As illustrated in Figure 1, the stimuli consisted of printed letters and of 4-letter words and pseudowords. The same 20 different upper-case letters were used for single letters and to construct 20 different words and 20 different pseudowords; the latter were created by blending the first letter of one word with the remaining part of another word. As

did Szwed et al. (2009), we selected 20 predominantly non-curvy letters, all having monosyllabic names in French (ABDEFGHIJKLMNPRTUVXZ). For all stimuli, we used a sans serif font with thin lines (Helvetica Ultra Light 42 points); a serif was added to the letter ‘I’. Words were French nouns with frequency higher than one per million according to the *Lexique* database (New, Pallier, Brysbaert, & Ferrand, 2004).

These stimuli could be either intact or degraded by the removal of fragments. Two modes of degradation were used: compared to the intact stimulus (Figure 1, left), in the segment-deleted variant, the midsegments were deleted but the vertices were preserved (Figure 1, middle), whereas in the vertex-deleted variant the vertices were deleted and the midsegments preserved (Figure 1, right). In both cases, an equal proportion of contour was deleted, either 45% or 65% of the original, resulting in a total of five variants per stimulus.

Procedure. Each trial began with a 200 ms central fixation cross. This was then replaced by the target (a word, pseudoword or letter), which remained on the screen for 200 ms. Words and pseudowords subtended an elongated field of 1° height x 4.3° large, letters subtended a 1° height x 0.8 large field, except for M which was somewhat larger (1.1°). Participants were instructed to name the letter and read the word or pseudoword as rapidly as possible while minimizing errors. No feedback was provided. For adult participants, the next trial started 1500 ms after the offset of the target. For children, the experimenter triggered each trial manually, in order to individually adapt the pace of the experiment.

Stimulus variants were counter-balanced between participants, which allowed controlling for frequency: Each participant saw a given stimulus in only one out of its five possible variants. Stimuli were blocked according to stimulus type, with letters presented first, then words, and lastly pseudowords. Within each block, the level of stimulus degradation (45 vs. 65%) and feature deleted (segment vs. vertex) varied randomly from trial to trial. Stimuli presentation, timing and data collection were controlled by *Psyscope* (Cohen, MacWhinney, Flatt, & Provost, 1993). Reaction times (*RTs*) were acquired through a voice key.

Data analysis. For the experimental task, average error rates and RTs were computed for each participant and each condition. Error rates were very high, especially for the 65% vertex-deleted words and pseudowords (on average, 54 and 75% errors, respectively); consequently, for many children RT data were totally missing for at least one of the degraded word or pseudoword variants. We thus decided to consider RTs only in the analyses on intact stimuli and on letters. Yet, on both the remaining children and the adults, we checked that there was no speed/accuracy trade-off on the degraded words and pseudowords. In all the RT analyses we considered only RTs on correct responses and used the median absolute deviation to find outliers (Leys, Ley, Klein, Bernard, & Licata, 2013), which were then eliminated. This trimming procedure resulted in 3.67% of the RT data being discarded on the intact stimuli in adults and 6.92% in children, and in 4.35% and 5.7% discarded RTs on degraded letters in adults and children, respectively. RTs and error rates (the latter arcsine transformed[1]) were then entered in separate ANOVAs, with subjects as a random factor.

All data were analyzed through Bayesian analyses, including Bayesian analyses of variance (ANOVA), using the open-source graphical statistical package *JASP* (JASP Team, 2018, Version 0.9.1, https://jasp-stats.org/). Except when stated otherwise, all Bayesian analyses used the default priors proposed in JASP: a zero-centered Cauchy prior distribution with r scale parameter ≈ 0.707 for post-hoc *t*-tests and r scale fixed effects = 0.5 for ANOVAs.

In those analyses, the Bayes factor BF_{10} indicates how likely the data is under H_1 (e.g., that there is a group difference), compared to H_0 (no group difference) and is directly interpretable as an odds ratio: A value of 1 means that the data are equally likely to occur under H_0 and H_1, and a value of 3 indicates that the data are three times more likely under H_1 than under H_0, which is considered as substantial evidence for H_1 over H_0; odds greater than

[1] Yet, for the sake of clarity, error rates will be presented as percentages in Figures and tables.

10 are considered as strong evidence (Jeffreys, 1961). Conversely, a Bayes factor ≤ 0.33 indicates substantial support for H_0, namely, that the data are about three times more likely to occur under H_0 than under H_1 (1/0.33= 3.03), which is referred to as BF_{01}.

For the ANOVAs, in addition to model comparisons to the null model, we estimated the contribution of effects and interactions using the JASP matched-model comparison procedure suggested by Sebastiaan Mathôt (https://www.cogsci.nl/blog/interpreting-bayesian-repeated-measures-in-jasp). This procedure compares models that contain the effect to equivalent models stripped of the effect. Thus higher-order interactions are excluded from simple effects. Concerning interactions, this allows evidence for the interaction to be evaluated on its own by comparing the BF_{10} of a model with the interaction against the BF_{10} of a model with only the main effects (i.e., without the interaction). For instance, if there are two factors, the stimulus and the group, the stimulus X group $BF_{inclusion}$[2] corresponds to the BF_{10} value for the model [(stimulus + group) + (stimulus X group)] divided by the BF_{10} value for the model [stimulus + group].

Results and Discussion

Ancillary tests. Table 1 presents the average scores on ancillary tests in each group of children. Results of the ANOVAs performed on these scores are presented in Appendix A. Reading fluency was estimated by dividing the number of correctly read strings by reading time, measured for each series of 20 written strings[3]. The ANOVA on these scores took group (Grade 2&3 vs. Grade 4&5 children) as a between-subjects factor and written string type

[2] Those values were called *Baws Factor* by Sebastiaan Mathôt, but for sake of coherence we kept the JASP terminology, namely $BF_{inclusion}$.

[3] Raw scores were used in the analysis, but for sake of clarity in Table 1 and in the text these scores were multiplied by 60, providing an estimation of the number of correctly read strings per minute.

Table 1: Cognitive Profile of children of Experiment 1; average performance and standard deviations in brackets.

	Grade 2 & 3			Grade 4 & 5		
	Regular words	Irregular words	Pseudowords	Regular words	Irregular words	Pseudowords
Reading efficiency (% correct)	88.66	56.96	71.43	97.74	88.1	85
	[12.74]	[22.92]	[14.42]	[6.64]	[10.18]	[11.1]
Reading time (in s)	31.66	37.84	38.5	16.67	18.64	24.02
	[15.25]	[22.74]	[12.55]	[4.82]	[5.03]	[5.65]
Reading fluency (correct strings/min)	41	23.98	25.04	77.1	61.38	45.38
	[18.43]	[15.52]	[9.96]	[26.3]	[19.55]	[14.24]
	Inital phoneme	Final phoneme		Inital phoneme	Final phoneme	
Phoneme deletion (%)	68.57	78.93		86.67	87.38	
	[27.13]	[18.16]		[20.08]	[12.31]	
	forward	backward		forward	backward	
Digit span	6.36	2.89		7.24	4.31	
	[1.53]	[1.2]		[1.66]	[1.47]	

(regular words, irregular words, pseudowords) as a within-subjects factor.

There was strong evidence that both main effects contributed to explain performance. The Grade 4&5 children read more fluently than the younger children, and overall performance was better on regular words compared to both irregular words and pseudowords, BF_{10} = 2.130E+19 and = 7.91E+20, respectively, as well as better on irregular words than on pseudowords, BF_{10} = 96.86. The written string type by group interaction also contributed to explain performance. This reflected two main differences. First, the older children presented a stronger lexicality effect than the Grade 2&3 children (the average fluency gain for regular words compared to pseudowords was 31.72 and 15.96 strings per minute, respectively, BF_{10} = 1.36E+04). Second, most of the older children (81%) also read irregular words more fluently than pseudowords, with an average fluency gain of 16 strings per minute, BF_{10} = 2.2E+05, which was not the case for the younger children, BF_{10} = 0.18, among whom 57% read pseudowords more fluently than irregular words (group effect: BF_{10} = 5.01 E+05). Thus, the Grade 2&3 children were probably still reading predominantly through grapho-phonological decoding, whereas the older children were already relying on orthographic representations.

For phoneme deletion, the ANOVA included the position of the to-be-deleted phoneme (initial, final) as a factor in addition to group. There was strong evidence that the older children performed better than the younger ones, and although performance was better on the final compared to the initial phoneme there was no substantial evidence for a position effect, nor for an interaction between group and phoneme position. There was also strong evidence that groups differed on digit span and that all children performed better in the forward than backward condition.

Experimental task. We first examined separately performance on the intact stimuli, which evaluates reading proficiency in all groups. Average error rates and RTs are presented

Table 2: Performance on intact stimuli in Experiment 1. A: average performance; standard deviations in brackets. B: results of the ANOVAs on error rates and reaction times (RTs). Bayes factors (BF_{10}) and percentage of proportional errors (error%) for each model of interest compared to the null model, and effects estimated using a matched-model comparison procedure.

A. PERFORMANCE	**Error rates (%)**			**RTs (ms)**		
	Grade 2&3	Grade 4&5	Adults	Grade 2&3	Grade 4&5	Adults
Letters	2.23 [8.63]	2.98 [9.88]	0 [0]	789 [94]	718 [132]	598 [94]
Words	9.97 [22.33]	2.38 [7.43]	0.52 [3.61]	823 [164]	689 [107]	602 [100]
Pseudowords	9.38 [14.74]	11.9 [15.58]	1.39 [6.73]	938 [214]	795 [202]	645 [124]

B. ANOVA	**Error rates (%)**		**RTs (ms)**	
MODELS	BF_{10}	**error %**[a]	BF_{10}	**error %**[a]
Null model (incl. subject)	1		1	
Stimulus	1514.7	0.70	6.34E+11	0.62
Group	1.75E+5	0.78	1.87E+15	0.79
Stimulus + Group	3.15E+5	1306	1.17E+27	1111
Stimulus + Group + (stimulus ✻ Group)	3.26E+6	1323	1.09E+28	2150
EFFECTS	$BF_{Inclusion}$		$BF_{inclusion}$	
Stimulus	1797.98		6.266E+11	
Group	208.06		1.844E+15	
Stimulus ✻ Group	10.35		9346	

a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

in Table 2a, and results of the ANOVAs are shown in Table 2b.

In the ANOVA on error rates, the best model that accounted for performance on intact stimuli ([stimulus + group] + [stimulus X group]) provided strong evidence that the two main effects and their interaction contributed to explain performance. There was no evidence that groups differed on intact letters, BF_{10} = 0.409, but they differed on both intact words, BF_{10} = 11.02 (with only the younger children presenting more errors than adults, BF_{10} = 10.279), and intact pseudowords, BF_{10} = 139.534 (with both Grade 2&3 and Grade 4&5 children differing from adults, BF_{10} = 65.108 and = 759.573, respectively). Even stronger results were observed on RTs: groups differed from each other on all stimuli, BF_{10} = 1.197E+12, 5.9E+11 and = 4.32E+9 for intact letters, words, and pseudowords, respectively, with both groups of children differing from the adults, and the younger children differing from the older ones on each stimulus type, all BF_{10} > 12.5. In children, performance on intact stimuli strongly correlated with reading fluency assessed through the ancillary tests (see Appendix B).

We next examined the effect of stimulus degradation. Figure 2 presents the average error rates in each group, separately by stimulus type (henceforth, *stimulus*: letters, words, pseudowords), level of degradation (henceforth, *degradation* 45 vs. 65%) and type of feature deleted (henceforth, *feature*: vertex vs. segment). The main question of interest was whether deleting vertices was more detrimental than deleting midsegments to a similar extent in all groups. To examine this question, we ran a repeated measures ANOVA on error rates, with group (Grade 2&3 children, Grade 4&5 children, adults) as a between factor, and stimulus, degradation and feature as within factors.

Figure 2. Average error rates in each group of Experiment 1, separately by stimulus type (L: letters; W: words; PW: pseudowords), level of degradation (45 vs. 65%), and type of feature deleted (vertices: in light grey; midsegments: in dark gray). Errors bars: standard error of the mean.

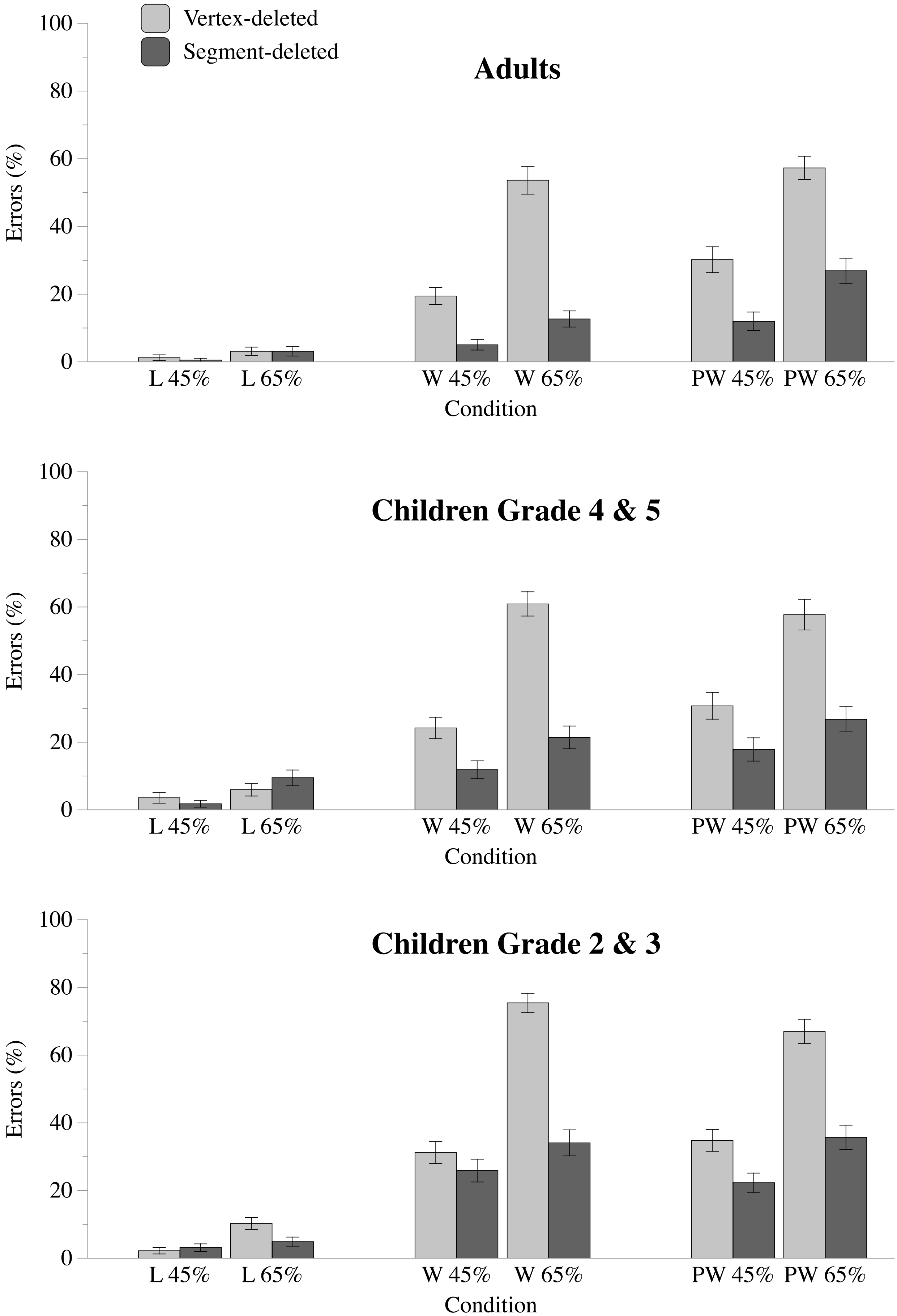

Vertex-deleted
Segment-deleted
Adults
Errors (%)
0
20
40
60
80
100
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition
Children Grade 4 & 5
Errors (%)
0
20
40
60
80
100
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition
Children Grade 2 & 3
Errors (%)
0
20
40
60
80
100
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition

Table 3: Experiment 1. Part A: $BF_{inclusion}$ values of the Bayesian ANOVA. Part B: BF_{10} values of the Bayesian paired samples *t*-tests. Ambiguous results (Bayes factors between 0.33 and 3, indicating data insensitivity) are shaded.

A. ANOVA

Effects	$BF_{Inclusion}$
Group	1.29E+5
Degradation	1.94E+52
Feature	1.91E+54
Stimulus	1.69E+150
Stimulus ✻ Feature	4.3E+26
Stimulus ✻ Degradation	7.34E+10
Degradation ✻ Feature	2.62E+10
Stimulus ✻ Degradation ✻ Feature	49926
Stimulus ✻ Group	2049
Degradation ✻ Feature ✻ Group	0.39
Feature ✻ Group	0.03
Degradation ✻ Group	0.03
Stimulus ✻ Degradation ✻ Feature ✻ Group	0.02
Stimulus ✻ Degradation ✻ Group	0.01
Stimulus ✻ Feature ✻ Group	0.01

B. Paired samples bilateral *t*-tests (N=146)

Stimulus type	**Degradation**	**Feature deleted**	Degraded vs. intact BF_{10}	Vertex effect: vertex vs. segment BF_{10}
Letters	45 %	vertex	0.19	0.10
		segment	0.14	
	65 %	vertex	8880	0.13
		segment	236.7	
Words	45 %	vertex	9.86E+22	5.74E+5
		segment	2.45E+6	
	65 %	vertex	3.16E+56	1.54E+27
		segment	4.72E+15	
Pseudowords	45 %	vertex	8.18E+19	4.85E+6
		segment	8.08E+5	
	65 %	vertex	1.04E+48	3.75E+17
		segment	4.6E+17	

Given that this ANOVA led to extensive model comparison results, these are presented in Supplementary Table 1, which shows that the best model accounting for the data was: stimulus + degradation + [stimulus X degradation] + feature + [stimulus X feature] + [degradation X feature] + [stimulus X degradation X feature] + group + [stimulus X group], BF_{10} = 1.17E+267. Table 3a presents the $BF_{\text{Inclusion}}$ values for all main effects and interactions. As predicted, performance was modulated by feature, with more errors for the vertex-deleted than segment-deleted variants (on average, 31.94 vs. 15.64%, respectively), by degradation, with more errors for the 65%- than 45%-degraded variants (on average 31.87 vs. 15.72%, respectively), and by stimulus, with more errors for words and pseudowords than for letters (on average, 31.96, 35.29 and 4.12%, respectively). As predicted, these factors interacted with each other: the difference in error rate between the vertex-deleted and segment-deleted variants, which reflects the vertex effect, was stronger for the 65%- than for the 45%-degraded variants (on average, 40.7 and 30.88%, respectively), and stronger for words and pseudowords than for letters (on average, 25.52, 22.69 and 0.72%, respectively).

We examined the stimulus X degradation X feature interaction in two ways. We first looked at the effect of stimulus degradation relative to intact stimuli, as did Lanthier et al. (2009). Across groups, there was a strong effect of degradation for all materials except for 45%-degraded letters (see the BF_{10} values of the paired samples bilateral *t*-tests in Table 3b). This held true for both the segment and vertex variants, and hence suggests a ceiling effect for 45%-degraded letters. The next set of analyses showed this was indeed the case. We estimated the vertex effect by comparing, across groups, but separately for each stimulus and level of degradation, the number of errors made on the vertex-deleted and segment-deleted variants. As illustrated by the BF_{10} values of the paired samples bilateral *t*-tests reported in Table 3b, this difference, which reflects the vertex effect, was supported by strong evidence for all word and pseudoword variants, but not for letters, which only elicited negligible effects, regardless

of the level of degradation (on average, 0.4 and 1.03% on 45%- and 65%-degraded letters).[4] The 65%-degraded words tended to elicit a stronger vertex effect than the 65%-degraded pseudowords (on average, 40.7 and 30.88%, respectively), but the evidence for this difference[5] was quite modest, $BF_{\text{inclusion}} = 2.98$; there was no evidence for a difference between the 45%-degraded words and pseudowords, which led to average effects of 10.33 and 14.5%, respectively, $BF_{\text{inclusion}} = 0.18$.

Performance also varied between groups. Unsurprisingly, the younger children exhibited more errors than both the adults and older children, $BF_{10} = 2.04\text{E+}7$ and = 30.38, respectively, whereas there was no evidence that the latter differed from the adults, $BF_{10} = 1.87$. However, crucially, there was no evidence for an interaction between group and feature. First, it is worth noting that the best model accounting for the data did not include that interaction. Second, the $BF_{\text{inclusion}}$ factors presented in Table 3b show substantial to strong evidence *against* the idea that groups differ according to the magnitude of the vertex effect (feature X group interaction: $BF_{01} = 1/0.03 = 33.33$).

Nevertheless, the data regarding the degradation X feature X group interaction were ambiguous : the Bayes factor was between 0.33 and 3, pointing to insensitive data that neither supported nor undermined the hypothesis that the vertex effect is modulated by group and

[4] For letters we checked whether there was evidence for an effect of the type of feature deleted on RTs. This was not the case in the ANOVA taking feature, degradation and group as factors, $BF_{\text{inclusion}} = 0.482$ (interaction with degradation: $BF_{\text{inclusion}} = 0.13$; all interactions involving group: $BF_{\text{inclusion}} < 0.11$). Nor was it the case overall, without the group factor ($BF_{\text{inclusion}} = 0.475$ for feature and = 0.14 for feature X degradation).

[5] More precisely, we looked at the stimulus X feature interaction when considering only the 65%-degraded words and pseudowords.

level of degradation[6]. Given that we had predicted that group would not interact at all with the type of feature deleted, regardless of the level of degradation, we examined this interaction in two ways. First, we compared groups on the vertex- vs. segment-deleted variants across materials, but separately for the 45%- and 65%-degraded variants. In both conditions, there was strong evidence for the main effects of group and feature, but not for their interaction, $B_{\text{inclusion}}$ = 0.765 and = 0.161, respectively. The result on the 65%-degraded variants suggests, on the contrary, that it is about six times more probable not to have such an interaction. Thus, at least in that condition, vertices are as important for the identification of written stimuli in children as in skilled adult readers. Nevertheless, the result on the 45%-degraded variants remains inconclusive, probably because on these only the Grade 2&3 children displayed a smaller vertex effect than adults (on average, 8.93 and 16.32%, respectively) when considering the average performance on words and pseudowords,[7] feature X group interaction: $BF_{\text{inclusion}} = 8.62$, whereas the comparison between adults and the Grade 4&5 children (who displayed an average vertex effect of 12.6% on words and pseudowords) led to an ambiguous result, $BF_{\text{inclusion}} = 0.87$.

To better understand the origin of the difference between adults and the younger children, we looked at the correlations between, one the one hand, age, digit span, and literacy-related scores, and, on the other hand, the average vertex effect on words and pseudowords, separately for the 45%- and 65%-degraded variants. Adopting a criterion of $BF_{10} > 10$, and considering all the adult and children participants, no strong correlation was observed with performance (including RTs) on intact stimuli. For the 98 children, there was

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[6] A non-Bayesian ANOVA ran on the same scores showed a marginally significant degradation X feature X group interaction, $F(2, 143) = 3.84$, $p = .024$, $\eta p^2 = 0.05$.

[7] We pooled these scores because words and pseudowords led to almost similar results in the ANOVA.

virtually no correlation with age (*r*(96)= -.04 for both vertex effects), and no strong correlation with digit span and literacy scores (either performance on intact stimuli, or in the ancillary tests). Yet the correlations with literacy scores varied between the two children's groups. In the Grade 2&3 children, the 65% vertex effect was correlated with reading fluency on irregular words, *r*(54) = .38, BF_{10} = 10.57, and there was a similar (although non-significant) trend for the 45% vertex effect, *r*(54) =.24. Those correlations were not observed in the Grade 4&5 children, *r*(40) = .02 and -.04, respectively. These different patterns of correlations are probably related to the fact that the development of orthographic representations was still not fully accomplished in Grade 2&3 children, as most of them were still decoding, whereas a large majority of the older children had already developed orthographic representations (see results on ancillary tests and Table 1).

Experiment 2

The same tasks and material as in Experiment 1 were presented to dyslexic children. The results of Experiment 1 suggest that it would be inappropriate to compare dyslexic children directly to adult skilled readers, as typical beginning readers (from Grade 2 and 3) displayed both a smaller vertex effect than adults on 45%-degraded words and pseudowords, and a correlation between the size of the vertex effect and reading fluency on irregular words. Thus, to compare dyslexic children with appropriate control participants, we selected two subsets of the typically-reading children of Experiment 1 in order to match them with the dyslexic group on either chronological age (*CA controls*) or reading level (*RL controls*). Whether a similar response pattern would be observed in the dyslexic children as in the typical readers was the question of interest.

Method

Participants. A total of 42 dyslexic children were recruited, either from two schools for children with learning disabilities (one in Brussels, one in Hainaut province), or via their language therapist (7 children). All had been diagnosed by a professional as presenting

developmental dyslexia, based on a 2-year lag on standardized reading tests. Among them, the data of two older ones had to be discarded because they could not be matched on either age or reading level with the typical readers. The final sample thus included 40 dyslexic children (average age: 135 months; SD = 15; 19 girls). They did not exhibit any comorbid disorders and had normal intelligence (4 indices of WISC-IV > 80, Wechsler, 2004). Among the 98 children examined in Experiment 1, we selected 30 CA controls (average age: 131 months; SD = 14; 15 girls; 90% attending Grade 4 or 5) on the one hand and 42 RL controls (average age: 97 months; SD = 6; 21 girls; 98% attending Grade 2 or 3) on the other hand. The three groups did not differ in the proportion of females/males, $\chi^2(2) = .064$. Ethics approval for the study was granted by Université Libre de Bruxelles. Written informed consent was obtained from the parents of each child, and oral agreement was obtained from each child. The dyslexic children performed the same seven ancillary tests as the typical readers (see Experiment 1).

Materials, procedure and data analysis. The materials and procedure were the same as the ones used with typically reading children in Experiment 1. Data analysis was also identical, with the trimming procedure on RTs resulting in 10.68% of the RT data being discarded on the intact stimuli and 6.97% on the degraded letters.

Results and discussion

Ancillary tests. Table 4 presents the average scores on the ancillary tests. Results of the ANOVAs performed on these scores are presented in Appendix C.

Table 4: Cognitive Profile of Children in Experiment 2 (dyslexic children, chronological age matched – CA – and reading level matched – RL– controls); average performance and standard deviations in brackets.

	Dyslexic children			CA controls			RL controls		
	Regular words	Irregular words	Pseudowords	Regular words	Irregular words	Pseudowords	Regular words	Irregular words	Pseudowords
Reading efficiency (% correct)	82.25	61.13	62.13	97	86.83	85	86.31	53.1	68.45
	[16.05]	[22.06]	[18.01]	[7.72]	[12.35]	[12.32]	[13.8]	[25.04]	[14.75]
Reading time (in s)	35	39.83	43.85	16.9	18.97	25.03	34.19	41.19	39.74
	[18.23]	[21.3]	[19.32]	[4.98]	[5.26]	[7.98]	[16.79]	[25.39]	[13.4]
Reading fluency (correct strings/min)	37.49	27.57	21.58	75.07	59.8	44.74	38.53	22.31	23.65
	[21.97]	[22.04]	[13.84]	[23.4]	[19.6]	[15.75]	[20.68]	[18.99]	[10.47]
	Inital phoneme	Final phoneme		Inital phoneme	Final phoneme		Inital phoneme	Final phoneme	
Phoneme deletion (%)	59	67		82.33	83		68.81	80.48	
	[27.44]	[25.34]		[24.31]	[19.32]		[27.16]	[15.77]	
	forward	backward		forward	backward		forward	backward	
Digit span	6.45	3.03		7.07	4.03		6.33	2.93	
	[1.55]	[1.53]		[1.46]	[1.33]		[1.68]	[1.28]	

The analysis of the reading fluency scores showed evidence that group, stimulus, and their interaction influenced performance. On the three stimulus types (regular words, irregular words and pseudowords), dyslexic children performed at the same level as the RL controls, BF_{10} = 0.24, 0.41 and 0.30, respectively, but much poorer than the CA controls, as was also the case for the RL controls, all BF_{10} > 4.66E+5. All groups read regular words more fluently than irregular words and pseudowords, all BF_{10} > 9687. The CA controls and the dyslexic children also read irregular words more fluently than pseudowords, BF_{10} = 4.61 and = 1112, respectively, which was not the case for the younger RL controls, BF_{10} = 0.2.

For phoneme deletion, there was substantial evidence that the position of the to-be-deleted phoneme modulated performance in addition to group, but no evidence for a group X position interaction. Performance was better for the final compared to the initial phoneme, and better in both CA and RL controls than in dyslexic children, BF_{10} = 2410.12 and = 10.49, respectively (CA vs. RL controls: BF_{10} = 1.39).

At the individual level, most of the dyslexic children (52.5%) exhibited mixed dyslexia, with low fluency scores on irregular word reading and on either pseudoword reading or phoneme deletion (or both).

Finally, for digit span, there was no evidence for an effect of group or for an interaction with group, but strong evidence that performance was better for forward than backward span.

Experimental task. We first examined separately performance on the intact stimuli through an ANOVA similar to the one used in Experiment 1, applied here to the data of dyslexic children, CA controls and RL controls. Results are presented in Table 5. In terms of error rates, groups differed from each other overall: both dyslexic children and RL controls showed more errors than CA controls, BF_{10} = 93.54 and = 7.32, respectively, but dyslexic children did not differ from RL controls, BF_{10} = 0.23. All children made fewer errors on letters compared to both words and pseudowords, BF_{10} = 106.88 and = 1.08E+6, respectively.

Table 5: Performance on intact stimuli in Experiment 2. A: average performance; standard deviations in brackets. B: results of the ANOVAs on error rates and reaction times (RTs). Bayes factors (BF_{10}) and percentage of proportional errors (error%) for each model of interest compared to the null model, and effects estimated using a matched-model comparison procedure.

PERFORMANCE	**Error rates (%)**			**RTs (ms)**		
	Dyslexic children	CA controls	RL controls	Dyslexic children	CA controls	RL controls
Letters	1.25 [5.52]	2.5 [10.06]	2.38 [9.26]	737 [94]	713 [133]	786 [105]
Words	13.75 [23.31]	0.83 [4.56]	13.29 [24.97]	914 [204]	694 [101]	816 [166]
Pseudowords	20.63 [23.94]	5.83 [10.75]	11.9 [15.85]	945 [196]	746 [124]	935 [216]

	Error rates (%)		**RTs (ms)**	
MODELS	BF_{10}	**error %**[a]	BF_{10}	**error %**[a]
Null model (incl. subject)	1		1	
Stimulus	4.32E+05	1.184	3.96E+10	0.967
Group	4.214	1.234	2571.53	1.39
Stimulus + Group	2.432E+6	1.495	1.09E+14	1.71
Stimulus + Group + (stimulus ✻ Group)	5.232E+6	1.348	1.04E+18	2.62
EFFECTS	$BF_{Inclusion}$		$BF_{inclusion}$	
Stimulus	5.49E+5		4.26E+10	
Group	5624		2763	
Stimulus ✻ Group	2.151		9517	

a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

In the analysis of RTs, there was in addition strong evidence for a group by stimulus interaction, with groups differing for words and pseudowords, but not for letters, BF_{10} = 7457.05, 715.62, and 2.63, respectively. For words and pseudowords, both dyslexic children and RL controls had longer RTs than CA controls, all $BF_{10} > 44$, whereas there was no strong evidence that dyslexic children differed from RL controls, BF_{10} = 2.63 and = 0.24 on words and pseudowords, respectively. As in Experiment 1, performance on intact stimuli strongly correlated with reading fluency assessed through the ancillary tests (see Appendix D).

We next examined the effect of stimulus degradation by running a repeated measures ANOVA on error rates similar to the one of Experiment 1, but applied to the data of dyslexic children, CA controls, and RL controls. Figure 3 presents the average error rates. The best model that accounted for the data was similar to the one obtained in Experiment 1: stimulus + degradation + [stimulus X degradation] + feature + [stimulus X feature] + [degradation X feature] + [stimulus X degradation X feature] + group + [stimulus X group], BF_{10} = 4.35E+21, with evidence that all those factors and interactions contributed to explain performance (see full results in Supplementary Table 2, and $BF_{inclusion}$ values in Table 6). As in Experiment 1, performance was modulated by feature, with more errors on the vertex-deleted than segment-deleted variants (on average, 35.73 vs. 21.52%, respectively), by degradation, with more errors on the 65%- than 45%-degraded variants (on average, 37 vs. 20.24%, respectively), and by stimulus, with more errors on words and pseudowords than on letters (39.04, 41.85 and 4.97, %, BF_{10} = 1.62E+74 and = 1.68E+90, respectively). These factors interacted with each other. The difference in error rate between the vertex-deleted and segment-deleted variants (the vertex effect) was, as predicted, stronger on the 65%- than 45%-degraded stimuli, and also varied as a function of stimulus type, being similar for words and pseudowords, BF_{10} = 0.08, but much stronger on both these types of strings than on letters, BF_{10} = 6.09E+8 and = 2.35E+10, respectively. As in Experiment 1, the interaction between stimulus, degradation and feature reflected the fact that the vertex effect was strong

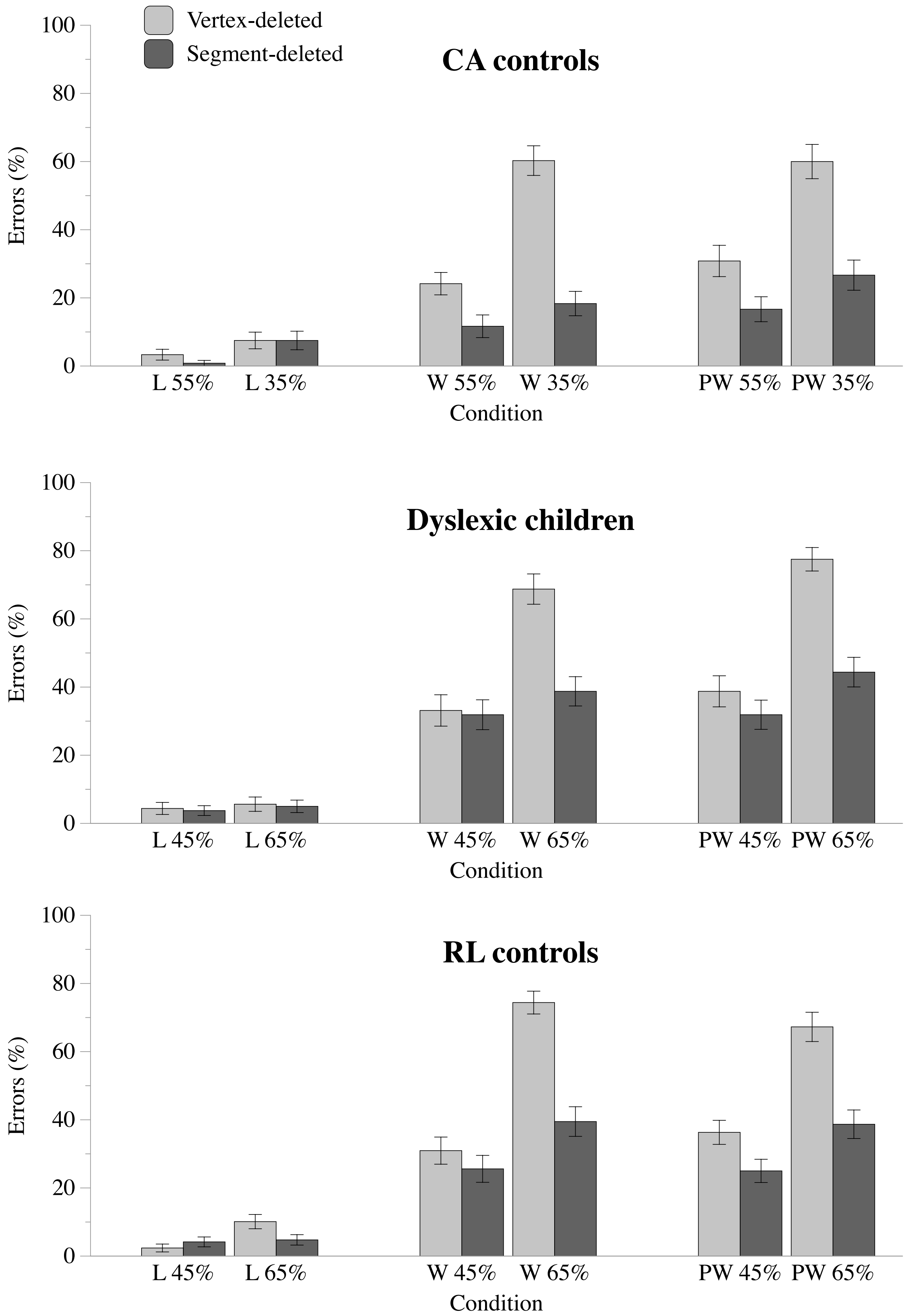
on the 65%-degraded words and pseudowords (on average, 35.04 and 31.47%, respectively), moderate on the 45%-degraded words and pseudowords (on average, 5.8 and 10.49%, respectively), but negligible on letters (on average, 0.22 and 2.23% on 45%- and 65%-degraded letters, respectively).

When examining the effect of degradation relative to intact stimuli across groups, as in Experiment 1, there was a strong effect of degradation for all stimuli except for 45%-degraded letters (see the BF_{10} values of the paired samples *t*-tests in Table 6b). When estimating the vertex effects by comparing the number of errors made on the segment and vertex variants across groups, but separately for each stimulus type and degradation level, results were also similar to those of Experiment 1, with substantial to strong evidence for a vertex effect on all word and pseudoword variants, but no evidence for letters (see the BF_{10} values of the paired samples *t*-tests in Table 6b).[8]

Performance also tended to vary between groups (see Table 6a), reflecting the fact that both dyslexic children and RL controls made more errors than CA controls, $BF_{10} = 669.27$ and 51.41, respectively, but no difference between dyslexic children and RL controls, $BF_{10} = 0.11$. Crucially, the vertex effects did not vary between groups; there was even substantial to strong evidence in favor of the idea that they did *not* differ between groups (see the $BF_{\text{inclusion}}$ associated with the interactions involving group and feature in Table 6a).

Figure 3. Average error rates in each group of Experiment 2, separately by stimulus type (L: letters; W: words; PW: pseudowords), level of degradation (45 vs. 65%), and type of feature deleted (vertices: in light grey; midsegments: in dark gray). Errors bars: standard error of the mean.

[8] For letters, as in Experiment 1, there was no evidence for a vertex effect on RTs, $BF_{10} = 0.3$ (interaction with degradation: $BF_{\text{inclusion}} = 0.15$; interactions involving group: all $BF_{\text{inclusion}} < 0.17$).


Vertex-deleted
Segment-deleted
CA controls
Errors (%)
100
80
60
40
20
0
L 55%
L 35%
W 55%
W 35%
PW 55%
PW 35%
Condition
Dyslexic children
Errors (%)
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition
RL controls
Errors (%)
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition

Note however that these results include the data on letters, which might make them somewhat insensitive. We thus restricted the analysis to words and pseudowords. The average vertex effect on these strings was numerically smaller in dyslexic children and RL controls than in CA controls, with 4.06, 8.33 and 13.33% on the 45%-degraded variants, and 31.56, 31.75 and 37.64% on the 65% degraded variants, respectively. Yet the evidence supporting a feature by group interaction in the analyses on the average error rates was ambiguous: on the 45%-degraded words and pseudowords, the evidence supporting the feature by group interaction was $BF_{\text{inclusion}}$ = 1.1 for the comparison between dyslexic children and CA controls, and = 0.36 for the comparison between RL and CA controls; on the 65%-degraded variants, $BF_{\text{inclusion}}$ = 0.64 and = 0.35, for these two comparisons, respectively. The comparison between dyslexic children and RL controls led to more interesting results: although the difference was ambiguous on the 45%-degraded variants ($BF_{\text{inclusion}}$ = 0.38), on the 65%-degraded words and pseudowords evidence suggests that it was about four times more probable that there was *no* interaction between feature and group, $BF_{\text{inclusion}}$ = 0.24.

Nonetheless, these tests may be considered as being too conservative, as they used the default priors, which favor large differences rather than the small ones usually found in the context of experimental work, and thus are strongly biased to H_0 (e.g., Dienes, 2014). We thus performed further comparisons using *informed Bayesian tests*. We contrasted the three groups on the vertex effect (difference in error rate between the vertex-deleted and segment-deleted word and pseudoword variants) using the so-called *Oosterwijk prior* (a *t*-distribution centered at 0.35, with a scale of 0.102 and 3 degrees of freedom), which is representative of the small-to-medium effects commonly observed in behavioral science (Gronau, Ly, & Wagenmakers, 2017). This showed that dyslexic children differed from CA controls on the 45%-degraded word and pseudowords, BF_{10} = 4.72, and also tended to differ from them (although not substantially) on the 65%-degraded variants, BF_{10} = 2.82, but did not differ at all from the RL controls, BF_{10} = 0.14 and = 0.20 on the 45%- and 65%-degraded variants, respectively. The

comparison between RL and CA controls led to ambiguous results, BF_{10} = 1.3 and = 1.07 on the 45%- and 65%-degraded variants, respectively.

Arguably, the reason why dyslexic children showed a somewhat lower score than CA controls might be that only 60% of them had already developed orthographic representations (i.e., read irregular words more fluently than pseudowords), whereas this was the case of the great majority of the Grade 4&5 children of Experiment 1 and hence here of the CA controls (80%). In addition, by definition dyslexic children had far poorer reading fluency scores on all stimuli compared to CA controls (see the results on ancillary tests). Yet there was no significant correlation between the vertex effects and reading fluency in the dyslexic group, not even with reading fluency on irregular words ($r(38)$ = .02 and .15 with the 45%-and 65%-degraded variants, respectively), as it was the case of the Grade 4-5 children in Experiment 1.

Table 6: Experiment 2. A: $BF_{inclusion}$ values of the Bayesian ANOVA. B: BF_{10} values of the Bayesian paired samples *t*-tests. Ambiguous results (Bayes factors between 0.33 and 3, indicating data insensitivity) are shaded.

A. ANOVA

Effects	$BF_{Inclusion}$
Stimulus	5.04E+145
Degradation	1.69E+38
Feature	1.84E+29
Group	12.3
Stimulus ✻ Feature	2.62E +11
Stimulus ✻ Degradation	6.16E+9
Degradation ✻ Feature	1.65E+9
Stimulus ✻ Group	303.32
Stimulus ✻ Degradation ✻ Feature	141.01
Feature ✻ group	0.22
Stimulus ✻ Degradation ✻ Group	0.06
Degradation ✻ Feature ✻ Group	0.05
Stimulus ✻ Degradation ✻ Feature ✻ Group	0.04
Degradation ✻ Group	0.03
Stimulus ✻ Feature ✻ Group	0.02

B. Paired samples bilateral *t*-tests (N=146)

Stimulus type	**Degradation**	**Feature deleted**	Degraded vs. intact BF_{10}	Vertex effect: vertex vs. segment BF_{10}
Letters	45 %	vertex	0.26	0.11
		segment	0.24	
	65 %	vertex	1507	0.26
		segment	6.51	
Words	45 %	vertex	1.92E+12	3.65
		segment	2.48E+4	
	65 %	vertex	2.76E+37	1.24E+17
		segment	1.13E+13	
Pseudowords	45 %	vertex	2.23E+13	190.29
		segment	9449	
	65 %	vertex	8.34E+35	2,62E+17
		segment	8.39E+14	

General Discussion

The present study aimed at examining the role of the extraction of vertices, namely of viewpoint-invariant line junctions, in letter, word and pseudoword identification by typical young readers compared to adults (Experiment 1) and in atypical young readers (Experiment 2). We drew on two previous studies (Lanthier et al., 2009; Szwed et al., 2009) and partially deleted either the vertices or the line midsegments of the stimuli, degrading either 45% or 65% of their original contour. With this manipulation, Lanthier et al. (2009) and Szwed et al. (2009) reported that adults made fewer errors and/or were faster to respond when vertices rather than midsegments were preserved, a difference that we term the *vertex effect*. This shows that the extraction of vertices is not only useful for non-linguistic object recognition (as originally demonstrated by Biederman, 1987) but also for reading, probably because vertices are relatively invariant properties that are common to most viewpoints.

Because we used the same stimulus degradation conditions and same exposure duration as Szwed et al. (2009) but shorter (4-letter) and more varied (words and pseudowords) strings as well as letters, in Experiment 1 we examined typical adult readers in addition to children. On those adult participants, with words we replicated the vertex effect observed by Szwed et al. and Lanthier et al. (2009). Our results were even stronger: Whereas Szwed et al. reported an effect only with strongly (65%) degraded words, we observed a similar, although smaller, effect with less degraded words (45%). In addition, we observed a similar error pattern with pseudowords. For letters, no effect was observed on either error rates or RTs, and this held true in the two groups of children.

Our data thus show that the vertex effect observed in previous studies generalizes to nonsense legal strings but fail to replicate the vertex effect observed on individual letters by Lanthier et al. (2009). Understanding the origin of this inconsistency requires more work, as it is difficult to directly compare the two sets of data. Indeed, Lanthier et al. did not report the exact level of degradation of their stimuli (although they look quite similar to the 65%-

degraded variants used here). It is worth noting that these researchers observed a significant effect on letters not only with very short presentation times (50 ms), but also with longer exposure than in the present experiment, namely when the letter was presented until the participant made a vocal response (which took on average 475 ms in their study). Nonetheless, the effects reported by Lanthier et al. were numerically small (in their first experiment, only on RTs: 7 ms; in the second, on both RTs – 10 ms– and errors –1.2%), although medium sized in terms of Cohen's *d* effect size.

The main result of Experiment 1 was that children from Grades 2 to 5 already showed a vertex effect on words and pseudowords. Nevertheless, compared to adults, the younger children (from Grades 2 and 3) obtained a somewhat smaller vertex effect on the 45%-degraded words and pseudowords. The pattern of correlations suggests that this difference is not linked to age but rather to literacy level, more precisely to the constitution of orthographic representations. As a matter of fact, in these children, whose majority was still decoding, the vertex effect was correlated with reading fluency on irregular words. This was not the case of the older children (from Grades 4 and 5), the majority of which were already using orthographic representations in reading.

In Experiment 2, we presented exactly the same materials to dyslexic children and selected, among the children tested in Experiment 1, those who matched them on either chronological age (CA controls) or reading level (RL controls). Conservative tests revealed no difference between these three groups of children, although the occurrence of vertex effects on words and pseudowords in all groups demonstrates the sufficient power of the study. Our Bayesian analyses even suggest that there is substantial to strong evidence supporting the idea that dyslexic children do *not* differ from control children, and hence use the same features as typical readers do in written string identification. Yet more specific informed tests suggest that dyslexic children display a somewhat smaller vertex effect on words and pseudowords compared to CA controls, but not compared to RL controls.

Interpreting a combination of, on the one hand, evidence for a difference between dyslexic children and CA controls and, on the other hand, no evidence for a difference with RL controls is very difficult (e.g., Goswami, 2003). Indeed, as both outcomes are ambiguous, this pattern does not necessarily reflect a mere developmental lag, with dyslexic children lagging developmentally rather than suffering from a specific deficit that would explain their reading failure (see examples in Goswami & Bryant, 1983). Nevertheless, we argue that we may understand the pattern of results we observed in the dyslexic children in the light of the clear difference observed in Experiment 1 between the youngest typical readers (from Grades 2 and 3) and adults, taking into account the fact that such a difference was related to the children's reading skills. Doing this, the overall pattern of results of the present study suggests that vertices play an important role in the fluent recognition of written strings not only in skilled readers (as had already been demonstrated by Lanthier et al, 2009 and Szwed et al., 2009) but also in young readers, in relation to their actual reading skills rather than to a specific reading deficit.

However, as our study is the first to have examined the extraction of vertex invariants in typical and atypical young readers presented with linguistic materials, more work is needed to ascertain the link between dyslexia and vertex extraction and, more generally, to better understand the relationship between reading level and vertex extraction. As a matter of fact, it might be the case that (either typical or atypical) beginning readers who have already developed orthographic representations rely somewhat more on vertices in reading than those who still decode grapho-phonological correspondences. An interesting alternative interpretation is that, reversing the direction of causality, a strong reliance on vertices may favor the rapid development of orthographic representations.

To study these issues, longitudinal studies examining the vertex effect on both linguistic materials and nonlinguistic objects should be conducted, starting before literacy acquisition (using for instance letters, in kindergartners). Indeed, as we studied children only

from Grade 2 on, we still ignore whether the use of line junctions in the identification of written signs emerges already in the very first steps of reading acquisition. Notably, some adaptations of the visual system to the specific constraints of reading are very rapid, requiring knowledge of only a few letters. This is the case, for instance, of the differential congruence effects between letters and non-letters: letters are processed in relation to surrounding information in a qualitative different way compared to other stimuli, even by adults who know the letters of the alphabet without being able to decode written strings (Fernandes et al., 2014).

Nonetheless, compared to Fernandes et al. (2014) and other studies (e.g., Grainger, Bertrand et al., 2016; Zorzi et al., 2012), in the present study we examined an earlier mechanism of the hierarchy of visual processing of written material (e.g., Dehaene et al., 2005; Grainger et al., 2008; Grainger, Dufau et al., 2016), which is shared with object recognition and probably intervenes before the recognition of abstract letter identities (Dehaene, 2009; Dehaene et al., 2005). Some have proposed that it is not the human visual system that has to be adapted for reading at the level of feature extraction, but rather that writing systems themselves have evolved under the constraint of having to remain easily learnable by our visual system, which thereby requires using features like vertices (Changizi et al., 2006; Dehaene & Cohen, 2007). Based on this idea, we would expect even the very beginning readers to display the vertex effect, and pre-readers to display it on letters and objects.

More generally, because we examined an early mechanism of feature extraction that is shared with object recognition, our results are not necessarily inconsistent with other data showing that dyslexic children differ from RL controls on several effects. In particular, the fact that we did not observe a difference between dyslexic children and RL controls does not contradict results pertaining to *letter-specific* processes, showing for instance, that dyslexic children are abnormally affected by crowding (e.g., Zorzi et al., 2012; but see Hakvoort, van

den Boer, Leenaars, Bos, & Tijms, 2017, for challenging results), specifically for letters (Fernandes et al., 2014).

Yet, interestingly, it has been reported that a subset of dyslexic children exhibits a *general* visual attention span disorder (Valdois et al., 2003), namely a reduced number of individual visual elements that can be processed simultaneously in a single fixation. This impairment has indeed been reported even with nonlinguistic stimuli (Lobier, Zoubrinetzky, & Valdois, 2012). Although this general visual impairment is restricted to multi-element parallel processing (single letter identification is preserved, as shown by Bosse et al., 2007, and Saksida et al., 2016), it might be worth examining in future studies whether it reflects visual anomalies at a lower processing level, for instance, in extracting letter features.

Up to now, only a few studies have examined the link between visual feature analysis and letter string-specific processing. Comparing words with equally long symbol strings while manipulating stimulus visibility, a magnetoencephalographic (MEG) study on dyslexic adults showed a clear dissociation between preserved early feature analysis and deficient later processing of letter strings (Helenius, Tarkiainen, Cornelissen, Hansen, & Salmelin, 1999). Yet this result was based on temporal and spatial MEG contrasts (proposed by Tarkiainen, Helenius, Hansen, Cornelissen, & Salmelin, 1999) between, on the one hand, early image processing (up to 130 ms after stimulus onset) in the postero-medial occipital cortex (bordering on the V1 area and extending laterally up to V4v), and, on the other hand, later (about 150 ms after stimulus onset) letter string-specific activation of the left inferior occipito-temporal area. Thus, the result of Helenius et al. (1999) reflects the fact that the dyslexic subjects extracted elementary lines, curves and surfaces from the input image in the same way as typical readers, but the implication of these results regarding the extraction of vertices remains unclear. Indeed, although the V4 visual area is tuned for some object features of intermediate complexity (Kobatake & Tanaka, 1994; see Roe et al., 2012, for a review), only the fusiform area, but not the lateral occipital area, is activated more for objects and

words with preserved vertices than for objects and words where vertices had been deleted (Szwed et al., 2011); in addition, this difference in activation was observed at a relatively high level of integration, as it was not found with scrambled stimuli (Szwed et al., 2011).

Notwithstanding, there are probably other visual features that are as important for reading as vertices. It would be worth examining in a systematic way the multiple features that typical and atypical readers may extract in processing letters and letters strings. In the present study, we only compared vertices and midsegments, and only used upper-case letters. Other potentially important features are line terminations (Fiset et al., 2008), or even segments for some lower-case letters (Rosa, Perea & Enneson, 2016). Still other candidates may include so-called *emergent features* like closure (e.g., in O) and line parallelism (e.g., in H, E and Z), which, at least in object recognition, seem to be extracted as early as simple features (e.g., Treisman & Paterson, 1984, with data replicated by Kolinsky & Morais, 1986).

In any case, the present results are in agreement with the general idea that basic visual processes and reading skills are related (Dehaene et al., 2015; Dehaene, Pegado et al., 2010; Dehaene et al., 2015). As the present study suggests that there is a link between the extraction of vertices in reading and the development of orthographic representations, establishing the direction of causality, or a likely reciprocal influence, might be relevant for learning methods.

References

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review, 94*(2), 115-147.

Bishop, D. V. M. (2006). What causes specific language impairment in children? *Current Directions in Psychological Science, 15*(5), 217-221.

Bola, L., Radziun, D., Siuda-Krzywicka, K. Sowa, J. E., Paplińska, M., Sumera, E., & Szwed, M. (2017). Universal visual features might be necessary for fluent reading. A longitudinal study of visual reading in Braille and Cyrillic alphabets. *Frontiers in Psychology, 8*: 514.

Borst, G., Ahr, E., Roëll, M., & Houde, O. (2015). The cost of blocking the mirror generalization process in reading: evidence for the role of inhibitory control in discriminating letters with lateral mirror-image counterparts. *Psychonomic Bulletin & Review, 22*(1), 228-234.

Bosse, M. L., Tainturier, M. J., & Valdois, S. (2007). Developmental dyslexia: the visual attention span deficit hypothesis. *Cognition, 104*(2), 198-230.

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments, and Computers, 25(2)*, 257-271.

Cohen, L., Dehaene, S., Naccache L., Lehericy, S., Dehaene-Lambertz, G., Henaff, M.-A., & Michel, F. (2000). The visual word form area. *Brain, 123*(2), 291-307.

Cohen, L., Dehaene, S., Vinckier, F., Jobert, A., & Montavont, A. (2008). Reading normal and degraded words: Contribution of the dorsal and ventral visual pathways. *Neuroimage, 40*(1), 353-366.

Changizi, M. A., Zhang, Q., Ye, H., & Shimojo, S. (2006). The structures of letters and symbols throughout human history are selected to match those found in objects in natural scenes. *American Naturalist 167*(5), E117-139.

Corrow, S., Granrud, C. E. Mathison, J., & Yonas (2012). Infants and adults use line junction information to perceive 3D shape. *Journal of Vision,12*(1): 8.

Dehaene, S. (2009). *Reading in the brain*. Penguin Viking.

Dehaene, S., & Cohen, L. (2007). Cultural recycling of cortical maps. *Neuron 56*(2), 384-398.

Dehaene, S., Cohen, L., Morais, J., & Kolinsky, R. (2015). Illiterate to literate: Behavioural and cerebral changes induced by reading acquisition. *Nature Reviews Neuroscience, 16*(4), 234-244.

Dehaene, S., Cohen, L., Sigman, M., & Vinckier, F. (2005). The neural code for written words: a proposal.*Trends in Cognitive Sciences, 9*(7), 335-341.

Dehaene, S., Nakamura, K., Jobert A., Kuroki C., Ogawa S., & Cohen, L. (2010). Why do children make mirror errors in reading? Neural correlates of mirror invariance in the visual word form area. *NeuroImage, 49*(2), 1837-1848.

Dehaene, S., Pegado, F., Braga, L. W., Ventura, P., Nunes, G. Jobert, A., Dehaene-Lambertz, G., Kolinsky, R., Morais, J., & Cohen, L. (2010). How learning to read changes the cortical networks for vision and language. *Science, 330*(6009), 1359-1364.

Dienes (2014). Using Bayes to get the most out of non-significant results. *Frontiers in Psycholology, 5: 781*.

Dienes Z., & Mclatchie, N. (2018). Four reasons to prefer Bayesian analyses over significance testing. *Psychonomic Bulletin & Review, 25*(1), 207-218.

Fernandes, T., Leite, I., & Kolinsky, R. (2016). Into the looking glass: Literacy acquisition and mirror invariance in preschool and first-grade children. *Child Development, 87*(6), 2008-2025.

Fernandes, T., Vale, A. P., Martins, B., Morais, J., & Kolinsky, R. (2014). The deficit of letter processing in developmental dyslexia: combining evidence from dyslexics, typical readers, and illiterate adults. *Developmental Science, 17*(1), 125-141

Fiset, D., Blais, C., Éthier-Majcher, C., Arguin, M., Bub, D., & Gosselin, F. (2008). Features for uppercase and lowercase letter identification. *Psychological Science*, *19*(11), 1161-1168.

Goswami, U. (2003). Why theories about developmental dyslexia require developmental designs. *Trends in Cognitive Sciences, 7(*12), 534-540.

Goswami, U., & Bryant, P. (1989). The interpretation of studies using the reading level design. *Journal of Reading Behavior, XXI*(4), 413-424.

Grainger, J. (2018). Orthographic processing: A 'mid-level' vision of reading: The 44th Sir Frederic Bartlett Lecture. *Quarterly Journal of Experimental Psychology, 71*(2) 335-359.

Grainger, J., Bertrand, D., Lété, B., Beyersmann, E., & Ziegler, J. (2016). A developmental investigation of the first-letter advantage. *Journal of Experimental Child Psychology, 152*, 161-172.

Grainger, J., Dufau, S., & Ziegler, J. C. (2016). A vision of reading. *Trends in Cognitive Sciences, 20*(3), 171-179.

Grainger, J., & Hannagan, T. (2014). What is special about orthographic processing? *Written Language & Literacy, 17*, 225-252.

Grainger, J., Rey, A., & Dufau, S. (2008). Letter perception: From pixels to pandemonium. *Trends in Cognitive Sciences, 12*(10), 381-387.

Gronau, Q. F., Ly, A., & Wagenmakers, E.-J. (2017). *Informed Bayesian t-tests*. arXiv preprintarXiv:1704.02479 .

Hakvoort, B. E., van den Boer, M., Leenaars, T., Bos, P. A., & Tijms, J. (2017). Improvements in reading accuracy as a result of increased interletter spacing are not specific to children with dyslexia. *Journal of Experimental Child Psychology, 164*, 101-116.

Helenius, P., Tarkiainen, A., Cornelissen, P., Hansen, P. C., & Salmelin, R. (1999). Dissociation of normal feature analysis and deficient processing of letter-strings in dyslexic adults. *Cerebral Cortex 9*(5):476-483.

Jacquier-Roux, M., Lequette, C., Pouget, G., Valdois, S. & Zorman, M. (2010). *BALE: Batterie analytique du langage écrit*. Grenoble : UPMF.

Jeffreys, H. (1961). *Theory of probability* (3rd ed.). Oxford, UK: Oxford University Press.

Kobatake, E., & Tanaka, K. (1994). Neuronal selectivities to complex object features in the ventral visual pathway of the macaque cerebral cortex. *Journal of Neurophysiology, 71*(3), 856-867.

Kolinsky, R., & Morais, J. (1986). Evidence for early extraction of emergent properties in visual perception: a replication. *Perceptual and Motor Skills, 63*, 171-174.

Lachmann, T., & van Leeuwen, C. (2008). Different letter-processing strategies in diagnostic subgroups of developmental dyslexia. *Cognitive Neuropsychology, 25*(5), 730-744.

Lanthier, S. N., Risko, E. F., Stolz, J. A., & Besner, D. (2009). Not all visual features are created equal: early processing in letter and word recognition. *Psychonomic Bulletin & Review, 16*(1), 67-73.

Leys, C., Ley, C., Klein, O., Bernard, P., & Licata, L. (2013). Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median. *Journal of Experimental Social Psychology, 49*(4), 764-766.

Lobier, M., Zoubrinetzky, R., & Valdois, S. (2012). The visual attention span deficit in dyslexia is visual and not verbal. *Cortex, 48*(6), 768-73.

Martelli, M., Di Filippo, G., Spinelli, D., & Zoccolotti, P. (2009). Crowding, reading, and developmental dyslexia. *Journal of Vision, 9*(4), 1-18.

Michotte, A., Thines, G., & Crabbe, G. (1991). *Les compléments amodaux des structures perceptives. Michotte's experimental phenomenology of perception*. Hillsdale, NJ:Erlbaum.

New, B., Pallier, C., Brysbaert, M., & Ferrand, L. (2004). Lexique 2: A new French lexical database. *Behavior Research Methods, 36*(3), 516–524.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101*(2), 385–413.

Perea, M., Moret-Tatay, C., & Panadero, V. (2011). Suppression of mirror generalization for reversible letters: Evidence from masked priming. *Journal of Memory and Language, 65*(3), 237-246.

Risko, E.F., Lanthier, S.N., & Besner, D. (2011). Basic processes in reading: The effect of interletter spacing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37(*6), 1449-1457

Roe, A. W., Chelazzi, L., Connor, C.E., Conway, B.R., Fujita, I., Gallant, J. L., Lu, H., & Vanduffel, W. (2012). Toward a unified theory of visual area V4. *Neuron, 74*(1), 12-29.

Rosa, E., Perea, M., & Enneson, P. (2016). The role of letter features in visual-word recognition: Evidence from a delayed segment technique. *Acta Psychologica, 169*, 133-142.

Saksida. A., Iannuzzi, S., Bogliotti, C., Chaix, Y., Démonet, J.F., Bricout, L., … Ramus F. (2016). Phonological skills, visual attention span, and visual stress in developmental dyslexia. *Developmental Psychology, 52*(10), 1503-1516.

Szwed, M., Dehaene, S., Eger, E., Kleinschmidt, A., Valabregue, R., Amadon, A., & Cohen, L. (2011). Specialization for written words over objects in the visual cortex. *NeuroImage, 56*(1), 330–344.

Szwed, M., Cohen, L., Qiao, E., & Dehaene, S. (2009). The role of invariant line junctions in object and visual word recognition. *Vision Research, 49*(7), 718-725.

Tarkiainen, A., Helenius, P., Hansen, P. C., Cornelissen, P. L., & Salmelin, R. (1999). Dynamics of letter string perception in the human occipitotemporal cortex. *Brain, 122*(11), 2119-2132.

Treisman A, Paterson R. (1984). Emergent features, attention, and object perception. *Journal of Experimental Psychology: Human Perception and Performance, 10(1)*, 12-31.

Tydgat, I., & Grainger, J. (2009). Serial position effects in the identification of letters, digits, and symbols. *Journal of Experimental Psychology: Human Perception and Performance, 35*(2), 480-498.

Valdois, S., Bosse, M.-L., Ans, B., Zorman, M., Carbonnel, S., David, D., & Pellat, J. (2003). Phonological and visual processing deficits are dissociated in developmental dyslexia : Evidence from two case studies. *Reading and Writing, 16*(6), 543-572.

van Bergen, E., van der Leij, A., & de Jong, P. F. (2014). The intergenerational multiple deficit model and the case of dyslexia. *Frontiers in Human Neuroscience, 8*, 346

Wechsler, D. (2004). *The Wechsler intelligence scale for children-fourth edition*. London: Pearson.

Ziegler, J. C., Pech-Georgel, C., Dufau, S., & Grainger, J. (2010). Rapid processing of letters, digits and symbols: what purely visual-attentional deficit in developmental dyslexia? *Developmental Science, 13*(4), F8-F14.

Ziegler, J. C., Perry, C., & Zorzi, M. (2014). Modelling reading development through phonological decoding and self-teaching: Implications for dyslexia. *Philosophical Transactions of the Royal Society B, 369*, 20120397.

Zoccolotti, P., De Luca, M., Di Pace, E., Gasperini, F., Judica, A., & Spinelli, D. (2005). Word length effect in early reading and in developmental dyslexia. *Brain and Language 93*(3), 369-373.

Zorzi, M., Barbiero, C., Facoetti, A., Lonciari, I., Carrozzi, M., Montico, M., … Ziegler, J. C. (2012). Extra-large letter spacing improves reading in dyslexia. *Proceedings of the National Academy of Science of the United States of America, 109*(28), 11455-11459.

Appendix A: Results of the ANOVAs on the ancillary tests in Experiment 1 (children's data). Bayes factors (BF_{10}) and percentage of proportional errors (error %) for each model of interest, and effects estimated using a matched-model comparison procedure

READING FLUENCY

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Stimulus	2.55E+30	0.6
Group	9.07E+12	1.34
Stimulus + Group	2.21E+43	12.32
Stimulus + Group + (Stimulus ✻ Group)	1.06E+50	4.71

Analysis of effects

Effects

	$BF_{inclusion}$
Stimulus	2.43E+30
Group	8.64E+12
Stimulus ✻ Group	4.78E+6

PHONEME DELETION

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Phoneme position	2.34	1.1
Group	138.58	0.898
Phoneme position + Group	409.16	11.91
Phoneme position + Group + (Phoneme position ✻ Group)	381.63	2.53

Analysis of Effects

Effects

	$BF_{inclusion}$
Phoneme position	2.95
Group	164.03
Phoneme position ✻ Group	0.93

DIGIT SPAN

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Span condition	8.99E+37	1.4
Group	28.98	1.19
Span condition + Group	9.87E+40	5.34
Span condition + Group + (Span condition ✻ Group)	7.31E+40	3.03

Analysis of effects

Effects

	$BF_{inclusion}$
Span condition	3.3E+39
Group	1096.78
Span condition ✻ Group	0.741

a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

Appendix B: correlations between the reading fluency scores obtained by the 98 typically reading children in the ancillary tests and performance (correct responses - CRs - and reaction times - RTs) on intact stimuli in Experiment 1.

	CRs ON INTACT STIMULI			**RTs ON INTACT STIMULI**		
	Letters	**Words**	**Pseudowords**	**Letters**	**Words**	**Pseudowords**
READING FLUENCY						
Regular words	0.04	0.43***	0.11	-0.32*	-0.48***	-0.51***
Irregular words	-0.04	0.37***	0.14	-0.34**	-0.45***	-0.46***
Pseudowords	0.02	0.43***	0.18	-0.34***	-0.46***	-0.54***

* $BF_{10} > 10$, ** $BF_{10} > 30$, *** $BF_{10} > 100$

Appendix C: Results of the ANOVAs on the ancillary tests in Experiment 2. Bayes factors (BF_{10}) and percentage of proportional errors (error %) for each model of interest, and effects estimated using a matched-model comparison procedure.

READING FLUENCY

Model comparison

Models

	BF_{10}	error %
Null model (incl. subject)	1	
Stimulus	1.88E+30	4.86
Group	8.32E+9	0.88
Stimulus + Group	1.65E+40	25.81
Stimulus + Group + (Stimulus ✻ Group)	6.05E+44	1.7

Analysis of effects

Effects

	$BF_{inclusion}$
Stimulus	1.98E+30
Group	8.76E +9
Stimulus ✻ Group	36743

PHONEME DELETION

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Phoneme position	5.67	0.882
Group	123.25	3.96
Phoneme position + Group	719.12	1.9
Phoneme position + Group + (Phoneme position ✻ Group)	201.54	3.76

Analysis of Effects

Effects

	$BF_{inclusion}$
Phoneme position	5.83
Group	126.21
Phoneme position ✻ Group	0.28

DIGIT SPAN

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Span condition	1.64E+46	0.895
Group	0.687	1.13
Span condition + Group	9.33E+46	1.55
Span condition + Group + (Span condition ✻ Group)	1.55E+46	12.76

Analysis of effects

Effects

	$BF_{inclusion}$
Span condition	6.5E+46
Group	5.68
Span condition ✻ Group	0.167

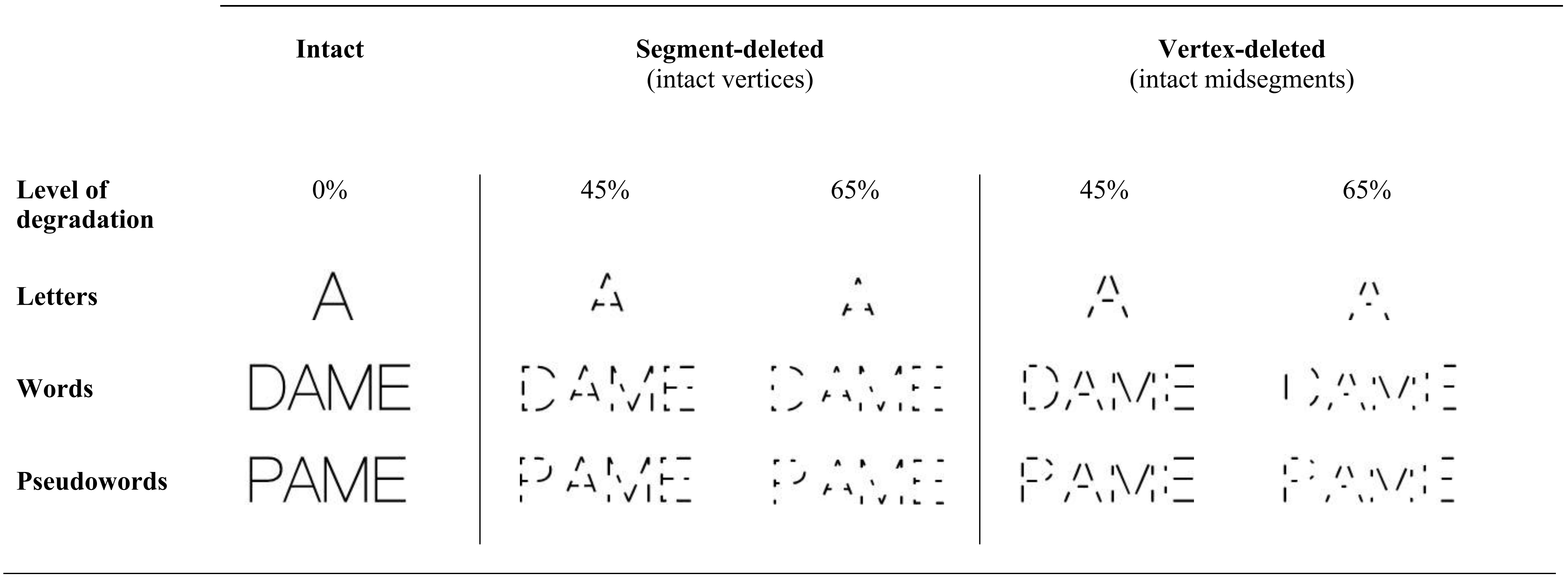
a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

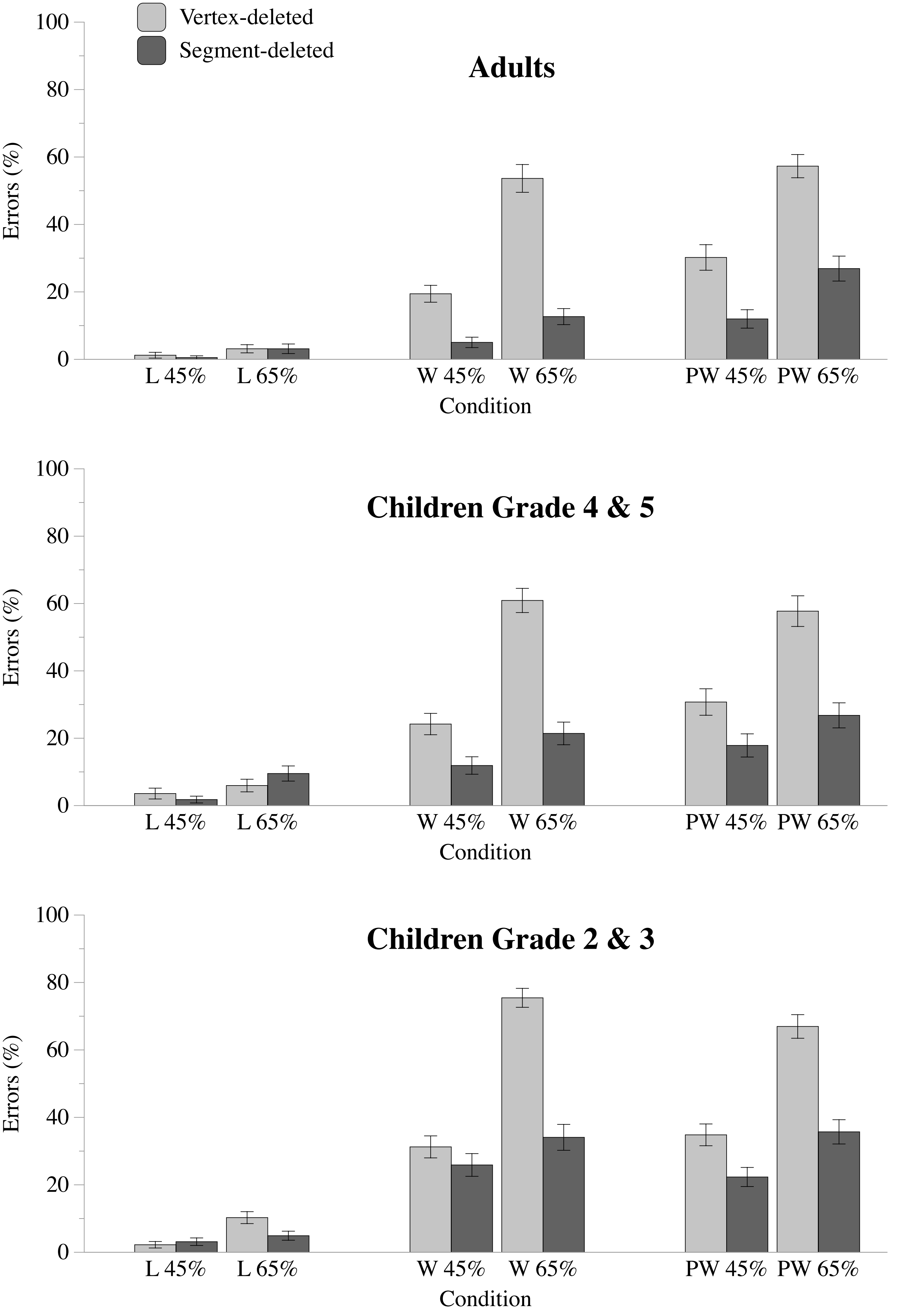
Appendix D: correlations between the reading fluency scores obtained by the 40 dyslexic children in the ancillary tests and performance (correct responses - CRs - and reaction times - RTs) on intact stimuli in Experiment 2.

	CRs ON INTACT STIMULI			RTs ON INTACT STIMULI		
	Letters	Words	Pseudowords	Letters	Words	Pseudowords
READING FLUENCY						
Regular words	0.11	0.49*	0.22	-0.22	-0.48*	-0.47*
Irregular words	0.06	0.42	0.22	-0.27	-0.47*	-0.45*
Pseudowords	0.06	0.32	0.27	-0.21	-0.50**	-0.44*

* $BF_{10} > 10$, ** $BF_{10} > 30$, *** $BF_{10} > 100$

Stimulus variants





Vertex-deleted
Segment-deleted
Adults
Children Grade 4 & 5
Children Grade 2 & 3
Errors (%)
0
20
40
60
80
100
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition

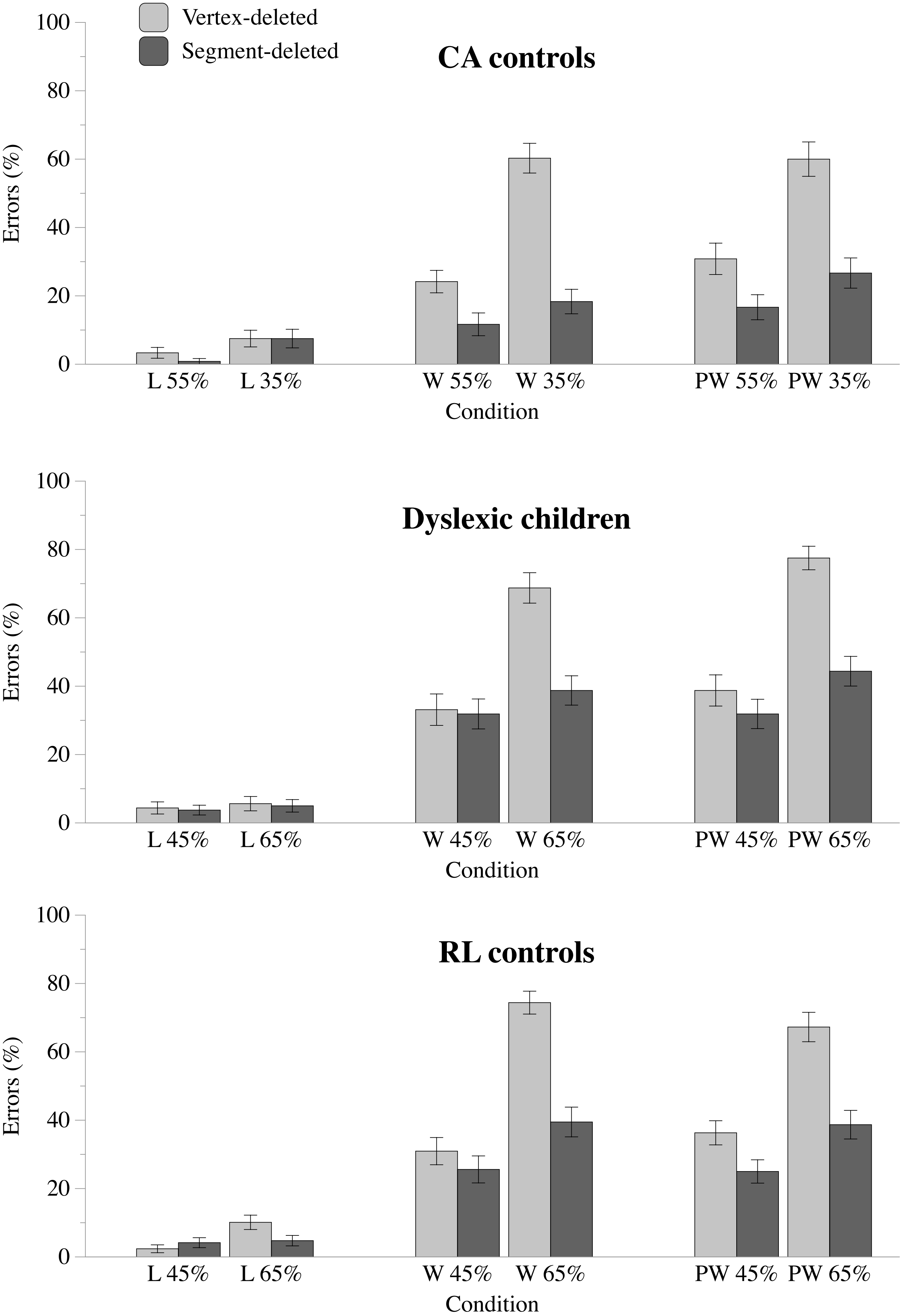

Vertex-deleted
Segment-deleted
CA controls
Errors (%)
100
80
60
40
20
0
L 55%
L 35%
W 55%
W 35%
PW 55%
PW 35%
Condition
Dyslexic children
Errors (%)
100
80
60
40
20
0
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition
RL controls
Errors (%)
100
80
60
40
20
0
L 45%
L 65%
W 45%
W 65%
PW 45%
PW 65%
Condition

Table 1: Cognitive Profile of children of Experiment 1; average performance and standard deviations in brackets.

	Grade 2 & 3			Grade 4 & 5		
	Regular words	Irregular words	Pseudowords	Regular words	Irregular words	Pseudowords
Reading efficiency (% correct)	88.66	56.96	71.43	97.74	88.1	85
	[12.74]	[22.92]	[14.42]	[6.64]	[10.18]	[11.1]
Reading time (in s)	31.66	37.84	38.5	16.67	18.64	24.02
	[15.25]	[22.74]	[12.55]	[4.82]	[5.03]	[5.65]
Reading fluency (correct strings/min)	41	23.98	25.04	77.1	61.38	45.38
	[18.43]	[15.52]	[9.96]	[26.3]	[19.55]	[14.24]
	Inital phoneme	Final phoneme		Inital phoneme	Final phoneme	
Phoneme deletion (%)	68.57	78.93		86.67	87.38	
	[27.13]	[18.16]		[20.08]	[12.31]	
	forward	backward		forward	backward	
Digit span	6.36	2.89		7.24	4.31	
	[1.53]	[1.2]		[1.66]	[1.47]	

Table 2: Performance on intact stimuli in Experiment 1. A: average performance; standard deviations in brackets. B: results of the ANOVAs on error rates and reaction times (RTs). Bayes factors (BF_{10}) and percentage of proportional errors (error%) for each model of interest compared to the null model, and effects estimated using a matched-model comparison procedure.

A. PERFORMANCE

	Error rates (%)			RTs (ms)		
	Grade 2&3	Grade 4&5	Adults	Grade 2&3	Grade 4&5	Adults
Letters	2.23 [8.63]	2.98 [9.88]	0 [0]	789 [94]	718 [132]	598 [94]
Words	9.97 [22.33]	2.38 [7.43]	0.52 [3.61]	823 [164]	689 [107]	602 [100]
Pseudowords	9.38 [14.74]	11.9 [15.58]	1.39 [6.73]	938 [214]	795 [202]	645 [124]

B. ANOVA

	Error rates (%)		RTs (ms)	
MODELS	BF_{10}	**error %**[a]	BF_{10}	**error %**[a]
Null model (incl. subject)	1		1	
Stimulus	1514.7	0.70	6.34E+11	0.62
Group	1.75E+5	0.78	1.87E+15	0.79
Stimulus + Group	3.15E+5	1306	1.17E+27	1111
Stimulus + Group + (stimulus ✻ Group)	3.26E+6	1323	1.09E+28	2150
EFFECTS	$BF_{Inclusion}$		$BF_{inclusion}$	
Stimulus	1797.98		6.266E+11	
Group	208.06		1.844E+15	
Stimulus ✻ Group	10.35		9346	

a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

Table 3: Experiment 1. A: $BF_{inclusion}$ values of the Bayesian ANOVA. B: BF_{10} values of the Bayesian paired samples *t*-tests. Ambiguous results (Bayes factors between 0.33 and 3, indicating data insensitivity) are shaded.

A. ANOVA

Effects	$BF_{Inclusion}$
Group	1.29E+5
Degradation	1.94E+52
Feature	1.91E+54
Stimulus	1.69E+150
Stimulus ✻ Feature	4.3E+26
Stimulus ✻ Degradation	7.34E+10
Degradation ✻ Feature	2.62E+10
Stimulus ✻ Degradation ✻ Feature	49926
Stimulus ✻ Group	2049
Degradation ✻ Feature ✻ Group	0.39
Feature ✻ Group	0.03
Degradation ✻ Group	0.03
Stimulus ✻ Degradation ✻ Feature ✻ Group	0.02
Stimulus ✻ Degradation ✻ Group	0.01
Stimulus ✻ Feature ✻ Group	0.01

B. Paired samples bilateral *t*-tests (N=146)

Stimulus type	**Degradation**	**Feature deleted**	Degraded vs. intact BF_{10}	Vertex effect: vertex vs. segment BF_{10}
Letters	45 %	vertex	0.19	0.10
		segment	0.14	
	65 %	vertex	8880	0.13
		segment	236.7	
Words	45 %	vertex	9.86E+22	5.74E+5
		segment	2.45E+6	
	65 %	vertex	3.16E+56	1.54E+27
		segment	4.72E+15	
Pseudowords	45 %	vertex	8.18E+19	4.85E+6
		segment	8.08E+5	
	65 %	vertex	1.04E+48	3.75E+17
		segment	4.6E+17	

Table 4: Cognitive Profile of Children in Experiment 2 (dyslexic children, chronological age matched – CA – and reading level matched – RL– controls); average performance and standard deviations in brackets.

	Dyslexic children			CA controls			RL controls		
	Regular words	Irregular words	Pseudowords	Regular words	Irregular words	Pseudowords	Regular words	Irregular words	Pseudowords
Reading efficiency (% correct)	82.25 [16.05]	61.13 [22.06]	62.13 [18.01]	97 [7.72]	86.83 [12.35]	85 [12.32]	86.31 [13.8]	53.1 [25.04]	68.45 [14.75]
Reading time (in s)	35 [18.23]	39.83 [21.3]	43.85 [19.32]	16.9 [4.98]	18.97 [5.26]	25.03 [7.98]	34.19 [16.79]	41.19 [25.39]	39.74 [13.4]
Reading fluency (correct strings/min)	37.49 [21.97]	27.57 [22.04]	21.58 [13.84]	75.07 [23.4]	59.8 [19.6]	44.74 [15.75]	38.53 [20.68]	22.31 [18.99]	23.65 [10.47]
	Inital phoneme	Final phoneme		Inital phoneme	Final phoneme		Inital phoneme	Final phoneme	
Phoneme deletion (%)	59 [27.44]	67 [25.34]		82.33 [24.31]	83 [19.32]		68.81 [27.16]	80.48 [15.77]	
	forward	backward		forward	backward		forward	backward	
Digit span	6.45 [1.55]	3.03 [1.53]		7.07 [1.46]	4.03 [1.33]		6.33 [1.68]	2.93 [1.28]	

Table 5: Performance on intact stimuli in Experiment 2. A: average performance; standard deviations in brackets. B: results of the ANOVAs on error rates and reaction times (RTs). Bayes factors (BF_{10}) and percentage of proportional errors (error%) for each model of interest compared to the null model, and effects estimated using a matched-model comparison procedure.

PERFORMANCE	**Error rates (%)**			**RTs (ms)**		
	Dyslexic children	CA controls	RL controls	Dyslexic children	CA controls	RL controls
Letters	1.25 [5.52]	2.5 [10.06]	2.38 [9.26]	737 [94]	713 [133]	786 [105]
Words	13.75 [23.31]	0.83 [4.56]	13.29 [24.97]	914 [204]	694 [101]	816 [166]
Pseudowords	20.63 [23.94]	5.83 [10.75]	11.9 [15.85]	945 [196]	746 [124]	935 [216]

	Error rates (%)		**RTs (ms)**	
MODELS	BF_{10}	**error %**[a]	BF_{10}	**error %**[a]
Null model (incl. subject)	1		1	
Stimulus	4.32E+05	1.184	3.96E+10	0.967
Group	4.214	1.234	2571.53	1.39
Stimulus + Group	2.432E+6	1.495	1.09E+14	1.71
Stimulus + Group + (stimulus ✻ Group)	5.232E+6	1.348	1.04E+18	2.62
EFFECTS	$BF_{Inclusion}$		$BF_{inclusion}$	
Stimulus	5.49E+5		4.26E+10	
Group	5624		2763	
Stimulus ✻ Group	2.151		9517	

a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

Table 6: Experiment 2. A: $BF_{inclusion}$ values of the Bayesian ANOVA. B: BF_{10} values of the Bayesian paired samples *t*-tests. Ambiguous results (Bayes factors between 0.33 and 3, indicating data insensitivity) are shaded.

A. ANOVA

Effects	$BF_{Inclusion}$
Stimulus	5.04E+145
Degradation	1.69E+38
Feature	1.84E+29
Group	12.3
Stimulus ✻ Feature	2.62E +11
Stimulus ✻ Degradation	6.16E+9
Degradation ✻ Feature	1.65E+9
Stimulus ✻ Group	303.32
Stimulus ✻ Degradation ✻ Feature	141.01
Feature ✻ group	0.22
Stimulus ✻ Degradation ✻ Group	0.06
Degradation ✻ Feature ✻ Group	0.05
Stimulus ✻ Degradation ✻ Feature ✻ Group	0.04
Degradation ✻ Group	0.03
Stimulus ✻ Feature ✻ Group	0.02

B. Paired samples bilateral *t*-tests (N=146)

Stimulus type	**Degradation**	**Feature deleted**	Degraded vs. intact BF_{10}	Vertex effect: vertex vs. segment BF_{10}
Letters	45 %	vertex	0.26	0.11
		segment	0.24	
	65 %	vertex	1507	0.26
		segment	6.51	
Words	45 %	vertex	1.92E+12	3.65
		segment	2.48E+4	
	65 %	vertex	2.76E+37	1.24E+17
		segment	1.13E+13	
Pseudowords	45 %	vertex	2.23E+13	190.29
		segment	9449	
	65 %	vertex	8.34E+35	2,62E+17
		segment	8.39E+14	

Appendix A: Results of the ANOVAs on the ancillary tests in Experiment 1 (children's data). Bayes factors (BF_{10}) and percentage of proportional errors (error %) for each model of interest, and effects estimated using a matched-model comparison procedure

READING FLUENCY

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Stimulus	2.55E+30	0.6
Group	9.07E+12	1.34
Stimulus + Group	2.21E+43	12.32
Stimulus + Group + (Stimulus ✻ Group)	1.06E+50	4.71

Analysis of effects

Effects

	$BF_{inclusion}$
Stimulus	2.43E+30
Group	8.64E+12
Stimulus ✻ Group	4.78E+6

PHONEME DELETION

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Phoneme position	2.34	1.1
Group	138.58	0.898
Phoneme position + Group	409.16	11.91
Phoneme position + Group + (Phoneme position ✻ Group)	381.63	2.53

Analysis of Effects

Effects

	$BF_{inclusion}$
Phoneme position	2.95
Group	164.03
Phoneme position ✻ Group	0.93

DIGIT SPAN

Model comparison

Models

	BF_{10}	error %[a]
Null model (incl. subject)	1	
Span condition	8.99E+37	1.4
Group	28.98	1.19
Span condition + Group	9.87E+40	5.34
Span condition + Group + (Span condition ✻ Group)	7.31E+40	3.03

Analysis of effects

Effects

	$BF_{inclusion}$
Span condition	3.3E+39
Group	1096.78
Span condition ✻ Group	0.741

a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

Appendix B: correlations between the reading fluency scores obtained by the 98 typically reading children in the ancillary tests and performance (correct responses - CRs - and reaction times - RTs) on intact stimuli in Experiment 1.

	CRs ON INTACT STIMULI			**RTs ON INTACT STIMULI**		
	Letters	**Words**	**Pseudowords**	**Letters**	**Words**	**Pseudowords**
READING FLUENCY						
Regular words	0.04	0.43***	0.11	-0.32*	-0.48***	-0.51***
Irregular words	-0.04	0.37***	0.14	-0.34**	-0.45***	-0.46***
Pseudowords	0.02	0.43***	0.18	-0.34***	-0.46***	-0.54***

* $BF_{10} > 10$, ** $BF_{10} > 30$, *** $BF_{10} > 100$

Appendix C: Results of the ANOVAs on the ancillary tests in Experiment 2. Bayes factors (BF_{10}) and percentage of proportional errors (error %) for each model of interest, and effects estimated using a matched-model comparison procedure.

READING FLUENCY

Model comparison

Models	BF_{10}	**error %**
Null model (incl. subject)	1	
Stimulus	1.88E+30	4.86
Group	8.32E+9	0.88
Stimulus + Group	1.65E+40	25.81
Stimulus + Group + (Stimulus ✻ Group)	6.05E+44	1.7

Analysis of effects

Effects	$BF_{inclusion}$
Stimulus	1.98E+30
Group	8.76E +9
Stimulus ✻ Group	36743

PHONEME DELETION

Model comparison

Models	BF_{10}	**error %**[a]
Null model (incl. subject)	1	
Phoneme position	5.67	0.882
Group	123.25	3.96
Phoneme position + Group	719.12	1.9
Phoneme position + Group + (Phoneme position ✻ Group)	201.54	3.76

Analysis of Effects

Effects	$BF_{inclusion}$
Phoneme position	5.83
Group	126.21
Phoneme position ✻ Group	0.28

DIGIT SPAN

Model comparison

Models	BF_{10}	**error %**[a]
Null model (incl. subject)	1	
Span condition	1.64E+46	0.895
Group	0.687	1.13
Span condition + Group	9.33E+46	1.55
Span condition + Group + (Span condition ✻ Group)	1.55E+46	12.76

Analysis of effects

Effects	$BF_{inclusion}$
Span condition	6.5E+46
Group	5.68
Span condition ✻ Group	0.167

a: error % is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor

Appendix D: correlations between the reading fluency scores obtained by the 40 dyslexic children in the ancillary tests and performance (correct responses - CRs - and reaction times - RTs) on intact stimuli in Experiment 2.

	CRs ON INTACT STIMULI			RTs ON INTACT STIMULI		
	Letters	Words	Pseudowords	Letters	Words	Pseudowords
READING FLUENCY						
Regular words	0.11	0.49*	0.22	-0.22	-0.48*	-0.47*
Irregular words	0.06	0.42	0.22	-0.27	-0.47*	-0.45*
Pseudowords	0.06	0.32	0.27	-0.21	-0.50**	-0.44*

* $BF_{10} > 10$, ** $BF_{10} > 30$, *** $BF_{10} > 100$

Supplementary Table 1: Results of the Bayesian Repeated Measures ANOVA. The first column of the output table, *Models*, lists the models under consideration; *P(M)* indicates prior model probabilities (which in JASP is equal across all models at hand); *P(M|data)* indicates the posterior probability of the models, namely the updated probabilities after the data was collected; BF_M indicates the degree to which the data have changed the prior model odds. The BF_{10} column shows the Bayes factor for each row-model against the null model. The first BF_{10} is 1 because the null model is compared against itself. The second is 2.066E+116, which means that the data are about 2E+116 times more likely under the model that includes Stimulus than under the null model, and so forth for other lines. The rightmost column, *error %*, is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor.

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. subject)	0.006	8.043E-268	1.335E-265	1.000	
Stimulus	0.006	1.662E-151	2.759E-149	2.066E+116	0.973
Degradation	0.006	6.478E-239	1.075E-236	8.054E+28	1.617
Stimulus + Degradation	0.006	3.881E-110	6.443E-108	4.826E+157	2.903
Stimulus + Degradation + Stimulus ✻ Degradation	0.006	1.966E-102	3.263E-100	2.444E+165	1.823
Feature	0.006	3.478E-236	5.774E-234	4.324E+31	1.171
Stimulus + Feature	0.006	3.125E-106	5.188E-104	3.885E+161	1.176
Degradation + Feature	0.006	2.656E-204	4.409E-202	3.302E+63	3.097
Stimulus + Degradation + Feature	0.006	1.783E-58	2.960E-56	2.217E+209	3.093
Stimulus + Degradation + Stimulus ✻ Degradation + Feature	0.006	3.931E-49	6.525E-47	4.887E+218	4.836
Stimulus + Feature + Stimulus ✻ Feature	0.006	1.986E-85	3.296E-83	2.469E+182	1.777
Stimulus + Degradation + Feature + Stimulus ✻ Feature	0.006	3.787E-34	6.286E-32	4.708E+233	4.282
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature	0.006	5.685E-24	9.438E-22	7.068E+243	2.441
Degradation + Feature + Degradation ✻ Feature	0.006	8.495E-199	1.410E-196	1.056E+69	1.992
Stimulus + Degradation + Feature + Degradation ✻ Feature	0.006	1.754E-49	2.912E-47	2.181E+218	2.496
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature	0.006	8.540E-40	1.418E-37	1.062E+228	11.749
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature	0.006	2.202E-24	3.655E-22	2.738E+243	3.185
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature	0.006	9.677E-14	1.606E-11	1.203E+254	6.986
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature	0.006	3.580E-9	5.944E-7	4.451E+258	5.531
Group	0.006	2.119E-264	3.517E-262	2633.904	1.294
Stimulus + Group	0.006	3.997E-147	6.635E-145	4.969E+120	1.780
Degradation + Group	0.006	3.051E-235	5.064E-233	3.793E+32	1.407
Stimulus + Degradation + Group	0.006	1.623E-105	2.694E-103	2.018E+162	2.483

Stimulus + Degradation + Stimulus ✻ Degradation + Group	0.006	9.868E-98	1.638E-95	1.227E+170	2.376
Feature + Group	0.006	1.787E-232	2.966E-230	2.221E+35	3.582
Stimulus + Feature + Group	0.006	1.574E-101	2.612E-99	1.957E+166	2.461
Degradation + Feature + Group	0.006	2.464E-200	4.091E-198	3.064E+67	2.154
Stimulus + Degradation + Feature + Group	0.006	1.324E-53	2.197E-51	1.646E+214	1.961
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group	0.006	3.195E-44	5.304E-42	3.973E+223	3.910
Stimulus + Feature + Stimulus ✻ Feature + Group	0.006	1.224E-80	2.033E-78	1.522E+187	2.504
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group	0.006	4.032E-29	6.694E-27	5.013E+238	5.372
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group	0.006	9.805E-19	1.628E-16	1.219E+249	31.438
Degradation + Feature + Degradation ✻ Feature + Group	0.006	9.513E-195	1.579E-192	1.183E+73	2.860
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group	0.006	1.596E-44	2.649E-42	1.984E+223	3.699
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group	0.006	8.897E-35	1.477E-32	1.106E+233	7.519
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group	0.006	2.666E-19	4.426E-17	3.315E+248	5.178
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group	0.006	1.102E-8	1.829E-6	1.370E+259	4.033
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group	0.006	4.615E-4	0.077	5.738E+263	8.210
Stimulus + Group + Stimulus ✻ Group	0.006	5.313E-146	8.819E-144	6.605E+121	1.210
Stimulus + Degradation + Group + Stimulus ✻ Group	0.006	7.232E-104	1.201E-101	8.992E+163	1.698
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Stimulus ✻ Group	0.006	6.411E-96	1.064E-93	7.971E+171	4.646
Stimulus + Feature + Group + Stimulus ✻ Group	0.006	7.695E-100	1.277E-97	9.567E+167	2.363
Stimulus + Degradation + Feature + Group + Stimulus ✻ Group	0.006	3.503E-51	5.816E-49	4.356E+216	2.633
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group	0.006	1.239E-41	2.057E-39	1.541E+226	3.361
Stimulus + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group	0.006	1.275E-78	2.117E-76	1.586E+189	2.162
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group	0.006	2.469E-26	4.098E-24	3.070E+241	5.323
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group	0.006	7.219E-16	1.198E-13	8.975E+251	5.090
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	5.615E-42	9.321E-40	6.981E+225	3.595
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	4.364E-32	7.245E-30	5.426E+235	8.106

Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	2.586E-16	4.293E-14	3.215E+251	2.776
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	1.873E-5	0.003	2.329E+262	3.642
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	0.944	2803.541	1.174E+267	6.366
Degradation + Group + Degradation ✻ Group	0.006	5.718E-237	9.492E-235	7.109E+30	1.865
Stimulus + Degradation + Group + Degradation ✻ Group	0.006	3.408E-107	5.658E-105	4.238E+160	1.820
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Degradation ✻ Group	0.006	2.332E-99	3.872E-97	2.900E+168	4.433
Degradation + Feature + Group + Degradation ✻ Group	0.006	4.885E-202	8.109E-200	6.074E+65	2.003
Stimulus + Degradation + Feature + Group + Degradation ✻ Group	0.006	3.877E-55	6.436E-53	4.820E+212	10.879
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Degradation ✻ Group	0.006	7.701E-46	1.278E-43	9.575E+221	5.973
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Degradation ✻ Group	0.006	5.946E-31	9.871E-29	7.393E+236	29.379
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Degradation ✻ Group	0.006	1.653E-20	2.744E-18	2.055E+247	3.138
Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	1.961E-196	3.255E-194	2.438E+71	4.460
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	3.590E-46	5.960E-44	4.464E+221	3.741
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	2.004E-36	3.326E-34	2.491E+231	4.929
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	6.544E-21	1.086E-18	8.136E+246	5.945
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	2.965E-10	4.921E-8	3.686E+257	3.582
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	1.131E-5	0.002	1.406E+262	4.594
Stimulus + Degradation + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	1.607E-105	2.667E-103	1.998E+162	2.284
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	1.443E-97	2.396E-95	1.794E+170	3.486
Stimulus + Degradation + Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	8.676E-53	1.440E-50	1.079E+215	2.980

Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	3.058E-43	5.076E-41	3.801E+224	4.524
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	6.481E-28	1.076E-25	8.058E+239	3.497
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	1.942E-17	3.224E-15	2.414E+250	7.075
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	1.373E-43	2.280E-41	1.707E+224	3.245
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	1.076E-33	1.787E-31	1.338E+234	4.721
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	6.402E-18	1.063E-15	7.959E+249	3.155
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	6.124E-7	1.017E-4	7.614E+260	10.777
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	0.026	4.356	3.179E+265	6.724
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	7.452E-100	1.237E-97	9.266E+167	3.351
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	4.720E-46	7.835E-44	5.868E+221	51.156
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	1.052E-19	1.746E-17	1.308E+248	2.815
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	7.531E-36	1.250E-33	9.363E+231	12.405
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	4.000E-9	6.639E-7	4.973E+258	12.456
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	1.588E-4	0.026	1.975E+263	4.270
Feature + Group + Feature ✻ Group	0.006	4.041E-234	6.709E-232	5.025E+33	11.612
Stimulus + Feature + Group + Feature ✻ Group	0.006	3.963E-103	6.579E-101	4.927E+164	5.522

Degradation + Feature + Group + Feature ✻ Group	0.006	5.395E-202	8.955E-200	6.707E+65	3.668
Stimulus + Degradation + Feature + Group + Feature ✻ Group	0.006	3.608E-55	5.990E-53	4.486E+212	2.397
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Feature ✻ Group	0.006	8.832E-46	1.466E-43	1.098E+222	4.868
Stimulus + Feature + Stimulus ✻ Feature + Group + Feature ✻ Group	0.006	3.006E-82	4.991E-80	3.738E+185	2.129
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Feature ✻ Group	0.006	1.037E-30	1.722E-28	1.290E+237	3.340
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Feature ✻ Group	0.006	1.759E-20	2.919E-18	2.186E+247	2.944
Degradation + Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	2.105E-196	3.495E-194	2.617E+71	6.913
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	4.311E-46	7.156E-44	5.360E+221	6.595
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	2.294E-36	3.808E-34	2.852E+231	13.137
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	6.977E-21	1.158E-18	8.674E+246	2.632
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	3.187E-10	5.290E-8	3.962E+257	3.670
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Feature ✻ Group	0.006	1.430E-5	0.002	1.777E+262	16.779
Stimulus + Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	1.980E-101	3.286E-99	2.461E+166	9.633
Stimulus + Degradation + Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	1.030E-52	1.710E-50	1.281E+215	5.361
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	3.395E-43	5.636E-41	4.221E+224	3.336
Stimulus + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	3.176E-80	5.273E-78	3.949E+187	2.224
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	8.645E-28	1.435E-25	1.075E+240	9.795
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	2.025E-17	3.361E-15	2.517E+250	3.481
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	1.494E-43	2.480E-41	1.858E+224	3.207
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	1.727E-33	2.866E-31	2.147E+234	29.152

Stimulus + Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Feature * Group	0.006	7.142E-18	1.186E-15	8.880E+249	3.152
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Feature * Group	0.006	6.371E-7	1.058E-4	7.922E+260	10.120
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Feature * Group	0.006	0.028	4.798	3.493E+265	5.685
Degradation + Feature + Group + Degradation * Group + Feature * Group	0.006	9.966E-204	1.654E-201	1.239E+64	2.132
Stimulus + Degradation + Feature + Group + Degradation * Group + Feature * Group	0.006	8.917E-57	1.480E-54	1.109E+211	3.274
Stimulus + Degradation + Stimulus * Degradation + Feature + Group + Degradation * Group + Feature * Group	0.006	2.041E-47	3.388E-45	2.537E+220	2.679
Stimulus + Degradation + Feature + Stimulus * Feature + Group + Degradation * Group + Feature * Group	0.006	2.922E-32	4.851E-30	3.633E+235	13.668
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Group + Degradation * Group + Feature * Group	0.006	4.995E-22	8.291E-20	6.210E+245	4.485
Degradation + Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	3.778E-198	6.271E-196	4.697E+69	3.573
Stimulus + Degradation + Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	1.017E-47	1.688E-45	1.264E+220	6.117
Stimulus + Degradation + Stimulus * Degradation + Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	4.850E-38	8.052E-36	6.030E+229	3.348
Stimulus + Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	1.956E-22	3.247E-20	2.432E+245	5.449
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	8.912E-12	1.479E-9	1.108E+256	5.164
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	3.144E-7	5.219E-5	3.909E+260	3.891
Stimulus + Degradation + Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	2.418E-54	4.014E-52	3.006E+213	4.840
Stimulus + Degradation + Stimulus * Degradation + Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	8.672E-45	1.440E-42	1.078E+223	7.016
Stimulus + Degradation + Feature + Stimulus * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	2.012E-29	3.340E-27	2.501E+238	12.907

Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	5.244E-19	8.704E-17	6.519E+248	3.644
Stimulus + Degradation + Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	4.105E-45	6.814E-43	5.103E+222	6.815
Stimulus + Degradation + Stimulus * Degradation + Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	3.037E-35	5.041E-33	3.775E+232	8.406
Stimulus + Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	1.937E-19	3.216E-17	2.409E+248	3.757
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	1.441E-8	2.393E-6	1.792E+259	3.449
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	8.601E-4	0.143	1.069E+264	10.577
Stimulus + Degradation + Stimulus * Degradation + Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group	0.006	4.997E-47	8.296E-45	6.213E+220	6.136
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group	0.006	3.515E-21	5.834E-19	4.370E+246	5.952
Stimulus + Degradation + Stimulus * Degradation + Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group	0.006	1.757E-37	2.917E-35	2.185E+230	4.016
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group	0.006	8.768E-11	1.455E-8	1.090E+257	3.355
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group	0.006	4.889E-6	8.116E-4	6.079E+261	6.842
Stimulus + Feature + Stimulus * Feature + Group + Stimulus * Group + Feature * Group + Stimulus * Feature * Group	0.006	3.356E-82	5.571E-80	4.172E+185	4.398
Stimulus + Degradation + Feature + Stimulus * Feature + Group + Stimulus * Group + Feature * Group + Stimulus * Feature * Group	0.006	8.225E-30	1.365E-27	1.023E+238	6.276
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Group + Stimulus * Group + Feature * Group + Stimulus * Feature * Group	0.006	2.406E-19	3.994E-17	2.991E+248	4.652

Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	1.411E-19	2.342E-17	1.754E+248	38.130
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	8.512E-9	1.413E-6	1.058E+259	9.858
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	3.591E-4	0.060	4.465E+263	7.662
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	2.971E-31	4.933E-29	3.694E+236	23.749
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	6.281E-21	1.043E-18	7.809E+246	4.343
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	2.261E-21	3.752E-19	2.810E+246	4.149
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	1.953E-10	3.241E-8	2.428E+257	8.023
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	1.024E-5	0.002	1.274E+262	6.433
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	4.286E-23	7.114E-21	5.328E+244	7.321
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	1.269E-12	2.106E-10	1.577E+255	7.182
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	5.789E-8	9.610E-6	7.197E+259	6.515
Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	6.691E-199	1.111E-196	8.318E+68	13.854

Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	3.107E-48	5.158E-46	3.863E+219	9.106
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.742E-38	2.891E-36	2.165E+229	4.014
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	7.574E-23	1.257E-20	9.416E+244	14.935
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	4.533E-12	7.524E-10	5.635E+255	25.183
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.379E-7	2.290E-5	1.715E+260	5.690
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.156E-45	1.918E-43	1.437E+222	4.552
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.072E-35	1.779E-33	1.333E+232	4.997
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	7.601E-20	1.262E-17	9.450E+247	4.513
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	6.314E-9	1.048E-6	7.850E+258	4.837
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	3.300E-4	0.055	4.103E+263	5.055
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	6.495E-38	1.078E-35	8.075E+229	6.853
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group +	0.006	4.387E-11	7.283E-9	5.454E+256	6.545

Stimulus * Degradation * Group + Feature * Group + Degradation * Feature * Group					
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group + Degradation * Feature * Group	0.006	2.295E-6	3.810E-4	2.854E+261	8.789
Stimulus + Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group + Stimulus * Feature * Group + Degradation * Feature * Group	0.006	8.428E-22	1.399E-19	1.048E+246	4.881
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group + Stimulus * Feature * Group + Degradation * Feature * Group	0.006	7.840E-11	1.302E-8	9.748E+256	5.519
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group + Stimulus * Feature * Group + Degradation * Feature * Group	0.006	4.421E-6	7.339E-4	5.496E+261	6.356
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group + Stimulus * Feature * Group + Degradation * Feature * Group	0.006	5.227E-13	8.678E-11	6.499E+254	9.017
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group + Stimulus * Feature * Group + Degradation * Feature * Group	0.006	2.857E-8	4.743E-6	3.552E+259	5.431
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Degradation * Group + Stimulus * Degradation * Group + Feature * Group + Stimulus * Feature * Group + Degradation * Feature * Group + Stimulus * Degradation * Feature * Group	0.006	6.763E-10	1.123E-7	8.408E+257	6.776

Supplementary Table 2: Results of the Bayesian Repeated Measures ANOVA. The first column of the output table, *Models*, lists the models under consideration; *P(M)* indicates prior model probabilities (which in JASP is equal across all models at hand); *P(M|data)* indicates the updated probabilities after having observed the data; BF_M indicates the degree to which the data have changed the prior model odds. The BF_{10} column shows the Bayes factor for each row-model against the null model. The first BF_{10} is 1 because the null model is compared against itself. The second is 3.671E+117, which means that the data are about 3.7E+117 times more likely under the model that includes Stimulus than under the null model, and so forth for other lines. The rightmost column, *error %*, is similar to a coefficient of variation, as it indicates the size of the error relative to the Bayes factor.

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. subject)	0.006	1.806E-212	2.998E-210	1.000	
Stimulus	0.006	6.631E-95	1.101E-92	3.671E+117	1.467
Degradation	0.006	1.959E-192	3.252E-190	1.085E+20	4.870
Stimulus + Degradation	0.006	1.645E-62	2.730E-60	9.106E+149	1.499
Stimulus + Degradation + Stimulus ✻ Degradation	0.006	6.227E-55	1.034E-52	3.448E+157	4.134
Feature	0.006	1.333E-197	2.213E-195	7.380E+14	1.303
Stimulus + Feature	0.006	8.488E-71	1.409E-68	4.699E+141	2.020
Degradation + Feature	0.006	2.850E-176	4.731E-174	1.578E+36	2.596
Stimulus + Degradation + Feature	0.006	7.261E-35	1.205E-32	4.020E+177	2.416
Stimulus + Degradation + Stimulus ✻ Degradation + Feature	0.006	3.387E-26	5.623E-24	1.875E+186	2.518
Stimulus + Feature + Stimulus ✻ Feature	0.006	3.317E-62	5.506E-60	1.837E+150	1.727
Stimulus + Degradation + Feature + Stimulus ✻ Feature	0.006	1.198E-24	1.989E-22	6.633E+187	6.463
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature	0.006	1.577E-15	2.618E-13	8.731E+196	2.419
Degradation + Feature + Degradation ✻ Feature	0.006	8.097E-172	1.344E-169	4.483E+40	5.850
Stimulus + Degradation + Feature + Degradation ✻ Feature	0.006	1.420E-26	2.357E-24	7.863E+185	3.693
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature	0.006	1.540E-17	2.556E-15	8.526E+194	2.991
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature	0.006	5.669E-16	9.411E-14	3.139E+196	2.206
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature	0.006	2.339E-6	3.882E-4	1.295E+206	4.385
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature	0.006	2.161E-4	0.036	1.196E+208	4.087
Group	0.006	4.959E-212	8.232E-210	2.746	0.709
Stimulus + Group	0.006	4.601E-94	7.637E-92	2.547E+118	1.274
Degradation + Group	0.006	6.570E-192	1.091E-189	3.638E+20	3.269

Stimulus + Degradation + Group	0.006	1.472E-61	2.443E-59	8.149E+150	2.474
Stimulus + Degradation + Stimulus ✻ Degradation + Group	0.006	5.648E-54	9.375E-52	3.127E+158	2.718
Feature + Group	0.006	4.289E-197	7.119E-195	2.374E+15	2.172
Stimulus + Feature + Group	0.006	6.684E-70	1.110E-67	3.701E+142	1.529
Degradation + Feature + Group	0.006	1.121E-175	1.861E-173	6.206E+36	1.451
Stimulus + Degradation + Feature + Group	0.006	7.485E-34	1.242E-31	4.144E+178	2.294
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group	0.006	3.346E-25	5.555E-23	1.853E+187	2.397
Stimulus + Feature + Stimulus ✻ Feature + Group	0.006	2.835E-61	4.706E-59	1.569E+151	1.776
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group	0.006	1.238E-23	2.056E-21	6.857E+188	3.496
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group	0.006	3.008E-14	4.994E-12	1.666E+198	40.395
Degradation + Feature + Degradation ✻ Feature + Group	0.006	2.978E-171	4.944E-169	1.649E+41	2.313
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group	0.006	1.627E-25	2.701E-23	9.009E+186	6.466
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group	0.006	1.580E-16	2.622E-14	8.746E+195	2.482
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group	0.006	7.274E-15	1.207E-12	4.027E+197	7.613
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group	0.006	2.468E-5	0.004	1.366E+207	3.364
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group	0.006	0.003	0.443	1.474E+209	6.788
Stimulus + Group + Stimulus ✻ Group	0.006	3.162E-93	5.248E-91	1.750E+119	1.641
Stimulus + Degradation + Group + Stimulus ✻ Group	0.006	2.936E-60	4.873E-58	1.625E+152	2.071
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Stimulus ✻ Group	0.006	1.654E-52	2.746E-50	9.157E+159	8.440
Stimulus + Feature + Group + Stimulus ✻ Group	0.006	1.048E-68	1.740E-66	5.803E+143	2.452
Stimulus + Degradation + Feature + Group + Stimulus ✻ Group	0.006	4.190E-32	6.955E-30	2.320E+180	2.129
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group	0.006	3.110E-23	5.163E-21	1.722E+189	3.762
Stimulus + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group	0.006	6.430E-60	1.067E-57	3.560E+152	2.538
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group	0.006	1.076E-21	1.785E-19	5.955E+190	2.913
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group	0.006	2.946E-12	4.891E-10	1.631E+200	11.518
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	1.242E-23	2.062E-21	6.879E+188	2.496

Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	2.174E-14	3.609E-12	1.204E+198	3.321
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	9.345E-13	1.551E-10	5.174E+199	4.763
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	0.006	0.960	3.182E+209	3.746
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group	0.006	0.786	609.128	4.351E+211	6.150
Degradation + Group + Degradation ✻ Group	0.006	1.437E-193	2.385E-191	7.956E+18	3.995
Stimulus + Degradation + Group + Degradation ✻ Group	0.006	3.933E-63	6.530E-61	2.178E+149	2.031
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Degradation ✻ Group	0.006	1.539E-55	2.555E-53	8.520E+156	3.006
Degradation + Feature + Group + Degradation ✻ Group	0.006	2.912E-177	4.835E-175	1.613E+35	8.303
Stimulus + Degradation + Feature + Group + Degradation ✻ Group	0.006	2.391E-35	3.969E-33	1.324E+177	12.397
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Degradation ✻ Group	0.006	1.038E-26	1.723E-24	5.748E+185	5.017
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Degradation ✻ Group	0.006	2.894E-25	4.805E-23	1.603E+187	22.095
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Degradation ✻ Group	0.006	5.379E-16	8.928E-14	2.978E+196	5.003
Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	6.778E-173	1.125E-170	3.753E+39	2.333
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	4.068E-27	6.753E-25	2.252E+185	2.704
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	4.666E-18	7.746E-16	2.583E+194	2.541
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	3.127E-16	5.190E-14	1.731E+196	33.598
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	7.849E-7	1.303E-4	4.346E+205	3.828
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Degradation ✻ Group	0.006	8.581E-5	0.014	4.751E+207	6.159
Stimulus + Degradation + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	8.197E-62	1.361E-59	4.538E+150	3.980
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	4.519E-54	7.501E-52	2.502E+158	3.814

Stimulus + Degradation + Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	1.254E-33	2.081E-31	6.940E+178	4.143
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	8.761E-25	1.454E-22	4.850E+187	2.714
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	3.466E-23	5.754E-21	1.919E+189	4.393
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	7.622E-13	1.265E-10	4.220E+199	89.396
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	3.762E-25	6.246E-23	2.083E+187	4.473
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	6.773E-16	1.124E-13	3.750E+196	3.161
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	2.938E-14	4.877E-12	1.627E+198	6.750
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	1.730E-4	0.029	9.580E+207	3.190
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group	0.006	0.023	3.837	1.251E+210	4.575
Stimulus + Degradation + Stimulus ✻ Degradation + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	1.660E-55	2.756E-53	9.193E+156	3.014
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	4.135E-26	6.864E-24	2.289E+186	2.998
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	4.556E-15	7.563E-13	2.523E+197	6.802
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	3.614E-17	6.000E-15	2.001E+195	4.814
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	1.038E-5	0.002	5.745E+206	3.809
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group	0.006	0.001	0.241	8.021E+208	7.094
Feature + Group + Feature ✻ Group	0.006	2.209E-198	3.666E-196	1.223E+14	1.866

Stimulus + Feature + Group + Feature ✻ Group	0.006	7.210E-71	1.197E-68	3.992E+141	4.438
Degradation + Feature + Group + Feature ✻ Group	0.006	6.487E-177	1.077E-174	3.591E+35	2.042
Stimulus + Degradation + Feature + Group + Feature ✻ Group	0.006	9.793E-35	1.626E-32	5.422E+177	2.886
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Feature ✻ Group	0.006	4.866E-26	8.077E-24	2.694E+186	2.947
Stimulus + Feature + Stimulus ✻ Feature + Group + Feature ✻ Group	0.006	3.419E-62	5.676E-60	1.893E+150	3.218
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Feature ✻ Group	0.006	1.749E-24	2.903E-22	9.683E+187	3.174
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Feature ✻ Group	0.006	2.960E-15	4.914E-13	1.639E+197	7.884
Degradation + Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	2.018E-172	3.349E-170	1.117E+40	9.589
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	2.303E-26	3.822E-24	1.275E+186	4.669
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	2.692E-17	4.469E-15	1.491E+195	4.455
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	1.081E-15	1.795E-13	5.987E+196	3.482
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Feature ✻ Group	0.006	4.507E-6	7.482E-4	2.495E+206	6.047
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Feature ✻ Group	0.006	4.750E-4	0.079	2.630E+208	4.605
Stimulus + Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	1.116E-69	1.852E-67	6.178E+142	2.614
Stimulus + Degradation + Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	5.989E-33	9.942E-31	3.316E+179	3.286
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	6.040E-24	1.003E-21	3.344E+188	16.904
Stimulus + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	7.147E-61	1.186E-58	3.957E+151	2.354
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	1.713E-22	2.844E-20	9.485E+189	2.664
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	4.874E-13	8.091E-11	2.699E+199	5.576
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	1.935E-24	3.213E-22	1.071E+188	3.916
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group	0.006	3.962E-15	6.577E-13	2.193E+197	6.401

Stimulus + Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Feature * Group	0.006	1.613E-13	2.678E-11	8.933E+198	3.514
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Stimulus * Group + Feature * Group	0.006	0.001	0.169	5.625E+208	2.754
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Stimulus * Group + Feature * Group	0.006	0.172	34.520	9.531E+210	12.297
Degradation + Feature + Group + Degradation * Group + Feature * Group	0.006	1.554E-178	2.580E-176	8.605E+33	3.948
Stimulus + Degradation + Feature + Group + Degradation * Group + Feature * Group	0.006	2.897E-36	4.809E-34	1.604E+176	4.001
Stimulus + Degradation + Stimulus * Degradation + Feature + Group + Degradation * Group + Feature * Group	0.006	1.427E-27	2.368E-25	7.898E+184	2.589
Stimulus + Degradation + Feature + Stimulus * Feature + Group + Degradation * Group + Feature * Group	0.006	5.567E-26	9.241E-24	3.082E+186	4.241
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Group + Degradation * Group + Feature * Group	0.006	1.169E-16	1.941E-14	6.474E+195	23.693
Degradation + Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	4.107E-174	6.818E-172	2.274E+38	3.667
Stimulus + Degradation + Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	6.094E-28	1.012E-25	3.374E+184	3.500
Stimulus + Degradation + Stimulus * Degradation + Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	8.068E-19	1.339E-16	4.467E+193	4.598
Stimulus + Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	3.136E-17	5.206E-15	1.736E+195	5.910
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	1.491E-7	2.474E-5	8.253E+204	8.411
Stimulus + Degradation + Stimulus * Degradation + Feature + Stimulus * Feature + Degradation * Feature + Stimulus * Degradation * Feature + Group + Degradation * Group + Feature * Group	0.006	1.585E-5	0.003	8.774E+206	6.233
Stimulus + Degradation + Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	1.703E-34	2.828E-32	9.431E+177	2.720
Stimulus + Degradation + Stimulus * Degradation + Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	1.400E-25	2.324E-23	7.750E+186	3.871
Stimulus + Degradation + Feature + Stimulus * Feature + Group + Stimulus * Group + Degradation * Group + Feature * Group	0.006	5.702E-24	9.466E-22	3.157E+188	6.525

Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group	0.006	1.387E-14	2.303E-12	7.680E+197	4.039
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group	0.006	8.690E-26	1.443E-23	4.811E+186	34.299
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group	0.006	1.169E-16	1.940E-14	6.472E+195	5.477
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group	0.006	3.228E-15	5.358E-13	1.787E+197	30.199
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group	0.006	3.455E-5	0.006	1.913E+207	3.775
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group	0.006	0.004	0.706	2.344E+209	3.456
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group	0.006	6.804E-27	1.129E-24	3.767E+185	3.796
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group	0.006	7.541E-16	1.252E-13	4.175E+196	4.787
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group	0.006	5.646E-18	9.372E-16	3.126E+194	3.213
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group	0.006	2.390E-6	3.967E-4	1.323E+206	8.318
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group	0.006	2.578E-4	0.043	1.427E+208	3.908
Stimulus + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	1.079E-62	1.790E-60	5.972E+149	3.017
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	3.039E-24	5.044E-22	1.682E+188	3.618
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	8.685E-15	1.442E-12	4.809E+197	6.371

Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	2.850E-15	4.731E-13	1.578E+197	3.172
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	2.211E-5	0.004	1.224E+207	8.048
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	0.003	0.442	1.470E+209	5.920
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	9.051E-26	1.502E-23	5.011E+186	2.776
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	2.730E-16	4.531E-14	1.511E+196	8.777
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	8.585E-17	1.425E-14	4.753E+195	5.063
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	6.502E-7	1.079E-4	3.600E+205	4.083
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	7.897E-5	0.013	4.372E+207	3.635
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	1.343E-17	2.230E-15	7.437E+194	5.239
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	3.994E-8	6.631E-6	2.211E+204	6.226
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group	0.006	7.459E-6	0.001	4.130E+206	22.721
Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.652E-175	2.742E-173	9.146E+36	6.910

Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	2.696E-29	4.476E-27	1.493E+183	5.121
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.678E-20	2.785E-18	9.288E+191	27.800
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.389E-18	2.305E-16	7.688E+193	5.973
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	5.735E-9	9.521E-7	3.175E+203	3.564
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	7.387E-7	1.226E-4	4.090E+205	6.601
Stimulus + Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	2.682E-27	4.453E-25	1.485E+185	10.973
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	4.637E-18	7.698E-16	2.567E+194	3.287
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	2.060E-16	3.419E-14	1.140E+196	4.838
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.848E-6	3.068E-4	1.023E+206	9.011
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	2.212E-4	0.037	1.225E+208	7.997
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	2.482E-19	4.120E-17	1.374E+193	3.362
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group +	0.006	8.798E-8	1.461E-5	4.871E+204	5.581

Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group					
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.137E-5	0.002	6.296E+206	4.788
Stimulus + Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	4.035E-18	6.699E-16	2.234E+194	10.424
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	3.019E-8	5.011E-6	1.671E+204	8.341
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	3.862E-6	6.411E-4	2.138E+206	5.280
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	1.683E-9	2.794E-7	9.317E+202	5.280
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group + Degradation ✻ Feature ✻ Group	0.006	2.186E-7	3.629E-5	1.210E+205	4.360
Stimulus + Degradation + Stimulus ✻ Degradation + Feature + Stimulus ✻ Feature + Degradation ✻ Feature + Stimulus ✻ Degradation ✻ Feature + Group + Stimulus ✻ Group + Degradation ✻ Group + Stimulus ✻ Degradation ✻ Group + Feature ✻ Group + Stimulus ✻ Feature ✻ Group + Degradation ✻ Feature ✻ Group + Stimulus ✻ Degradation ✻ Feature ✻ Group	0.006	9.706E-9	1.611E-6	5.374E+203	10.587