LANGUAGE, COGNITION AND NEUROSCIENCE
2021, VOL. 36, NO. 5, 668–673
https://doi.org/10.1080/23273798.2021.1880608

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The transposed-word effect revisited: the role of syntax in word position coding

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ABSTRACT

Skilled readers may misinterpret "*you that read wrong*" for "*you read that wrong*": a transposed-word effect. This relatively novel finding, which supports parallel word processing during sentence reading, is attributed to a combination of noisy bottom-up word position coding and top-down syntactic constraints. The present study focussed on the contribution of syntactic constraints in driving transposed-word effects. In a speeded grammatical decision experiment, two types of ungrammatical transposed-word sequences were compared, namely a transposition either across a syntactic phrase ("*the have girls gone home*") or within a syntactic phrase ("*the girls gone have home*"). We found longer response times and lower accuracy rates for within-phrase transpositions than across-phrase transpositions, demonstrating a direct influence of syntactic structures on the transposed-word effect. We conclude that the assignment of words to positions in a sentence is guided by top-down syntactic constraints.

ARTICLE HISTORY
Received 20 April 2020
Accepted 19 January 2021

KEYWORDS
Transposed words; word position coding; grammatical decision task; parallel processing; reading

Introduction

Skilled adult readers can read more than 200 words per minute (Brysbaert, 2019; Rayner et al., 2016). Such fast reading comprehension not only consists of correct identification of individual words, but also requires successful encoding of word order within a sentence. However, word position coding in reading is not always error-free. As demonstrated in a recent speeded grammatical decision study (Mirault et al., 2018), participants were slower and more error-prone in judging a transposed-word sequence (e.g. "*you that read wrong*") as ungrammatical compared with a control sequence (e.g. "*you that read worry*"). This novel effect has been consistently found in follow-up investigations (Pegado & Grainger, 2019, 2020; Snell & Grainger, 2019b; Wen et al., 2021). As explained in previous studies, the transposed-word effect is assumed to be driven by a combination of noisy bottom-up encoding of word order and the operation of top-down sentence-level syntactic constraints. This combination of bottom-up and top-down processes drives the language processor to interpret a transposed-word sequence like "*you that read wrong*" as "*you read that wrong*". The transposed-word effect is consistent with the assumption that the language processor builds imprecise representations of the input (for a review on shallow language processing, see Christianson, 2016), and importantly it contributes to the theoretical debate over the serial versus parallel processing in reading.

One of the most prominent accounts of reading behaviour, the EZ-Reader model (Reichle et al., 1998) endorses a strictly one-word-at-a-time serial processing assumption. According to the serial processing view, sequential word order must be encoded incrementally to achieve successful reading comprehension, whereas failure of word position coding is inevitable if the language processor operates in a parallel fashion (Reichle et al., 2009). Obviously, the transposed-word effect provides clear evidence for incorrect encoding of word position, which fits better with the parallel processing account (see Pegado & Grainger, 2020; Snell & Grainger, 2019a, for more discussion). In particular, the transposed-word effect can be perfectly accounted for by Snell et al. (2017, 2018) model of parallel orthographic processing and reading. As proposed in their model, when multiple words are processed in parallel, the association between word identities and their locations remains uncertain. This uncertainty will not end up with confusions because an elementary sentence-level representation is quickly generated which then guides the assignment of word identities onto

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Supplemental data for this article can be accessed at https://doi.org/10.1080/23273798.2021.1880608

spatiotopic locations along a line of text. For example, having identified word *n* as an article, the syntactic processor will expect that word *n +1* is more likely to be a noun than a verb. Therefore, if both a noun and a verb are processed in parallel, the noun will be assigned to position *n +1*. Due to such top-down syntactic constraints on allocating word identities to plausible positions, a transposed-word sequence can be perceived as being grammatically correct.

Further evidence in line with Snell and colleagues' proposal of interactive processing between word identities and sentence-level structures is the sentence superiority effect observed with the Rapid Parallel Visual Presentation (RPVP) procedure (Declerck et al., 2020; Snell & Grainger, 2017; Wen et al., 2019, 2021). The first demonstration of a sentence superiority effect using RPVP came from Snell and Grainger (2017). In this behavioural study, a sequence of four words was simultaneously presented for a brief duration (200 ms) and participants were asked to identify one post-cued word from the sequence. The post-cued target words (e.g. "*can*") were easier to identify when embedded in a grammatical sequence (e.g. "*the man can run*") than embedded in a corresponding ungrammatical scrambled sequence (e.g. "*run the can man*"). The sentence superiority effect is interpreted as a reflection of parallel word processing which generates an elementary sentence-level representation in grammatical sequences, and this syntactic representation then influences on-going word processing via feedback connections. This interpretation has been further supported by two electrophysiological studies using either the same word-in-sequence identification task (Wen et al., 2019) or a grammatical decision task (Wen et al., 2021) combined with the RPVP procedure, both of which revealed an N400 reduction in grammatical sequences relative to scrambled sequences. This N400 reduction is assumed to reflect facilitatory feedback to word identities from sentence-level representations which are present in grammatical sequences due to parallel processing. Taken together, the interactive mechanisms in a parallel processing system outlined by Snell and colleagues provide a valid explanation for recent experimental findings in the field.

The present study seeks further evidence in favour of Snell and colleagues' account of the transposed-word effect. If syntactic constraints are a major contributor to the transposed-word effect, we reasoned that the syntactic distance between the transposed words should modulate the effect. More specifically, syntactic constraints would be stronger for two adjacent words within a syntactic phrase ("*have gone*") than across a syntactic phrase ("*girls have*") in a sentence ("*the girls have gone home*" composed of a noun phrase "*the girls*" and a verb phrase "*have gone home*"). Therefore, a within-phrase transposition ("*the girls gone have home*") should be harder to classify as being ungrammatical relative to an across-phrase transposition ("*the have girls gone home*"). Following this logic, the present study set out to test the transposed-word effect within or across a syntactic phrase.

Methods

Participants

Forty native French speakers (31 females; mean age = 24.15 years, SD = 3.66) received monetary compensation or course credit for their participation. All participants reported having normal or corrected-to-normal vision, and no history of language impairment. Their average LexTALE_Fr vocabulary score (Brysbaert, 2013) was 90.05 (SD = 4.64, range: 80.4–98.2). Data from four additional participants were excluded from the analyses because of low LexTALE_Fr vocabulary scores (< 80). Based on a priori power analysis using the data of Mirault et al. (2018), we achieved 100% power with 40 participants (Brysbaert & Stevens, 2018; Green & MacLeod, 2016).

Materials and design

We first constructed 80 grammatically correct sentences in French in order to create the critical ungrammatical stimuli. Each of these sentences consisted of five words with an average word length of 5.15 letters (SD = 2.34). The average word frequency in Zipf values was 5.79, SD = 1.09 (Ferrand et al., 2010; van Heuven et al., 2014). We used the Stanford Parser (Green et al., 2011) to validate the syntactic structure of each sentence in order to define whether two adjacent words constitute a phrase. In half of the 80 sentences (e.g. *The girls have gone home*), a transposition of the words at positions 2 and 3 generated across-phrase transposed sequences (e.g. *The have girls gone home*), whereas a transposition of the words at positions 3 and 4 generated within-phrase transposed sequences (e.g. *The girls gone have home*). And this was reversed for the other half of the sentences to counterbalance (e.g. *Sometimes the man runs fast*). Therefore, for each sentence, two ungrammatical versions were generated by either transposing words at positions 2 and 3 or positions 3 and 4. The average word frequency of the transposed words was 6.0 for within-phrase transpositions and 5.69 for across-phrase transpositions in Zipf values (Ferrand et al., 2010; van Heuven et al., 2014). Two counterbalanced lists were created, and participants were randomly assigned to one of the lists. In order to have an equal number of grammatical and ungrammatical sequences, another 80 grammatically correct five-word sequences were included as fillers (e.g. *These two guys are tall*). The words in the filler sequences matched the words used in the critical stimuli in word length (average word length: 5.00 letters, SD = 1.96) and frequency (average word frequency in Zipf values: 5.76, SD = 1.12).

Procedure

The study was approved by the "Comité de Protection des Personnes SUD-EST IV" (No. 17/051). All participants provided their written informed consent before the experiment started. Participants were tested individually in a sound-attenuated experimental room. The stimuli were presented on a monitor using OpenSesame (Mathôt et al., 2012). Each participant received a unique random trial order. Each trial began with a central fixation across, presented for 400 ms followed by a 200 ms blank screen. Next, a sequence of five words was simultaneously presented. Participants were asked to decide whether the presented sequence was grammatically correct nor not by pressing buttons on a gamepad connected to the computer. They were instructed to perform the task as quickly and as accurately as possible. The word sequence remained on the screen up to a maximum of 3000 ms or until the participants responded (Snell & Grainger, 2019b). Feedback was then provided with a green (correct) or red (incorrect) dot presented for 700 ms. The inter-trial interval was set at 1000 ms. Prior to the experiment, 16 practice trials were used to familiarise the participants with the procedure.

Data analysis

Reaction times of incorrect responses were removed (13.75%), and values beyond 3.5 standard deviations from the mean of each condition for each participant were discarded as outliers (0.29%). To reduce the skewness in the distribution, reaction times were log transformed. Using the lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) packages in R (Version 3.6.2; R Core Team, 2019), the response times were analysed with a linear mixed-effects model, and the accuracy data were analysed with a logistic mixed-effects model (Jaeger, 2008). Participants and items were included as random effects (Baayen et al., 2008), and by-participant and by-item random slopes were also included (Barr et al., 2013).

Table 1. Results of mixed-effects modelling on RT data.

Random effects		Variance	SD	
Item	Intercept	0.003661	0.06051	
	Across vs. Within	0.005519	0.07429	
Subject	Intercept	0.005412	0.07356	
	Across vs. Within	0.000277	0.01664	
Fixed effects	Estimate	SE	*t* value	*p*
Across vs. Within	0.032579	0.009456	3.445	< .001

Results

Participants were slower in judging the within-phrase transposed sequences as ungrammatical relative to across-phrase transposed sequences, mean RTs: 1400 ms vs. 1324 ms respectively, $t = 3.445$, $p < .001$ (see Table 1). Similarly, participants were more likely to mistake the within-phrase transposed sequences as being grammatical than the between-phrase transposed sequences, mean accuracy rates: 80.7% vs. 91.8% respectively, $z = -4.10$, $p < .001$ (see Table 2).

A post-hoc analysis on the RT data was conducted to address the potential concern that an ungrammaticality may be detected earlier in across- than in within-transposed sequences if words are processed sequentially in a left-to-right fashion. For across-phrase transposed sequences, the critical point of ungrammaticality occurred at position 2 and position 3 for transpositions at positions 2–3 and positions 3–4 respectively. For the within-phrase condition, the critical point of ungrammaticality occurred at position 3 and position 4 for transpositions at positions 2–3 and 3–4 respectively. The critical point of ungrammaticality was then entered as a fixed factor in the mixed-effect modelling analysis. The difference between two types of transpositions remained significant, $b = 0.11239$, SE = 0.04583, $t = 2.452$, $p = 0.01640$, suggesting that the observed difference between across-phrase and within-phrase transposed conditions is not driven by the critical point of ungrammaticality.

Discussion

The present study examined the impact of syntactic structure on word position coding by comparing two

Table 2. Results of logistic mixed-effects modelling on accuracy data.

Random effects		Variance	SD	
Item	Intercept	0.654151	0.80880	
	Across vs. Within	2.168510	1.47259	
Subject	Intercept	0.405979	0.63716	
	Across vs. Within	0.006904	0.08309	
Fixed effects	Estimate	SE	*z* value	*p*
Across vs. Within	−0.9298	0.2268	−4.10	<.001

types of transposed-word sequences in a grammatical decision task. As predicted, we found that deciding a word sequence as ungrammatical was harder when the transposition occurred within a syntactic phrase compared with transpositions that occurred across a syntactic phrase. This, we suggest, is due to greater top-down syntactic influences on re-ordering transposed words within a syntactic phrase where two adjacent words are more closely bound.

As noted in the introduction, serial and parallel processing views make contrasting predictions concerning word order errors during reading. Proponents of serial processing reason that encoding words sequentially is a necessary prerequisite for encoding word order within a sentence (Reichle et al., 2009). Although words within a sentence can be fixated out of order under the assumption of serial processing, it is generally agreed that parallel processing is more susceptible to incorrect word ordering. It is apparent that the transposed-word effect is a clear manifestation of incorrect word ordering, thus providing support for the parallel processing view (Mirault et al., 2018; Pegado & Grainger, 2019, 2020; Snell & Grainger, 2019b; Wen et al., 2021). According to Snell et al.'s (2017, 2018) model of parallel orthographic processing and reading, there are two mechanisms that contribute to transposed-word effects. One is the noisy association of word identities to spatiotopic locations along a line of text, and the other concerns the top-down constraints imposed by sentence-level syntactic structures on word order encoding. The top-down contribution posited in this parallel reading framework is unequivocally supported by the current study which reveals top-down syntactic processes influencing word position coding.

Although the results of the present study clearly respond to our specific research question, one potential issue is that we did not include a baseline control condition. Following the same logic as Snell and Grainger (2019b), we considered that it was not necessary to replicate the transposed-word vs. control manipulation as in Mirault et al. (2018) because such a replication would not provide additional leverage with respect to interpreting the current findings. Moreover, the choice of control condition is not straightforward. Following the logic of transposed-letter effects (e.g. Perea & Lupker, 2004), the two transposed words should be replaced by two different words that cannot be re-arranged to form a correct sentence (e.g. "*the girls like were home*" as a control for "*the girls gone have home*"). This procedure was adopted by Pegado and Grainger (2019; 2020) with the same-different matching task. Pegado and Grainger (2020) also found robust transposed-word effects when a single word was substituted in the control condition. This was also the case in the Mirault et al. (2018) study, where the control condition that was created by changing the final word in the transposed-word sequences with a different word (e.g. "*the white was cat big*" / "*the white was cat slowly*") and using pairs of sentences in order to match words in the two conditions (e.g. "*the black dog ran slowly*" paired with "*the white cat was big*" to generate the transposed-word and control sequences matched to the previous example: "*the black ran dog slowly*" / "*the black ran dog big*"). With this particular control procedure, purely lexical-level influences between the transposed-word and control conditions were minimised. To conclude on this complex issue, we surmise that there are two easy options for future research on transposed-word effects obtained with the grammatical decision task (other options are of course open for investigations using other tasks, such a priming version of the grammatical decision task). One is to investigate how the degree of ungrammaticality of the control condition impacts on the size of transposed-word effects. The other is to investigate how different types of transposition impact on the effects. It is the second option that was adopted in the present work.

Notwithstanding the existing research on word transpositions in favour of the parallel processing view, there are some caveats to be pointed out. First, the sentences used in the present study as well as previous studies on transposed-word effects were relatively short and simple. We note that using longer and more complex sentences (e.g. garden path sentences) would be an interesting avenue for future research. It should be also acknowledged that the existing studies on transposed-word effects have not manipulated sentential constraint, which would also be an interesting topic for future investigations. Furthermore, the present study used an artificial experimental task, and reading to make grammatical decisions might be different from reading for comprehension. However, we would point to the potential of the grammatical decision task as a means to investigate sentence reading in analogy with the widely-used lexical decision task applied in investigations of single word reading. Moreover, the transposed-word effect is not specific to the dependent measures obtained in the grammatical decision task. Mirault et al. (2020) reported transposed-word effects in a measure of total reading time obtained with eye-movement recordings, and Chang et al. (2020) found a transposed-character effect in Chinese in a natural sentence reading experiment with eye-movement recordings. Finally, as already noted above, Pegado and Grainger (2020) found transposed-word effects in a same-different matching task in which participants were presented with two sequences of words and simply had to judge whether the two sequences were the same or not. Different judgments were found to be harder to make when the difference involved a word transposition compared with a word substitution.

In sum, the current results demonstrate the impact of syntactic constraints on word position coding and thus provide clear evidence for the parallel and interactive mechanisms underlying reading as postulated by Snell et al. (2017, 2018). We conclude that top-down syntactic constraints guide the parallel processing of words and the encoding of word information during sentence reading. Future research is necessary to test whether current findings are generalisable to various types of syntactic structures and different experimental paradigms.

Acknowledgments

This research was supported by ERC grant ADG 742141. We thank Charlotte Leflaëc and Agnès Guerre-Genton for their help with stimuli creation and data collection.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by European Research Council [grant number ADG 742141].

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References

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412. https://doi.org/10.1016/j.jml.2007.12.005

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Brysbaert, M. (2013). LEXTALE_FR: A fast, free, and efficient test to measure language proficiency in French. *Psychologica Belgica*, *53*(1), 23–37. https://doi.org/10.5334/pb-53-1-23

Brysbaert, M. (2019). How many words do we read per minute? A review and meta-analysis of reading rate. *Journal of Memory and Language*, *109*, 104047. https://doi.org/10.1016/j.jml.2019.104047

Brysbaert, M., & Stevens, M. (2018). Power analysis and effect size in mixed effects models: A tutorial. *Journal of Cognition*, *1*(1), 9. https://doi.org/10.5334/joc.10

Chang, M., Hao, L., Zhao, S., Li, L., Paterson, K. B., & Wang, J. (2020). Flexible parafoveal encoding of character order supports word predictability effects in Chinese reading: Evidence from eye movements. *Attention, Perception, & Psychophysics*, *82*(6), 2793–2801. https://doi.org/10.3758/s13414-020-02050-x

Christianson, K. (2016). When language comprehension goes wrong for the right reasons: Good-enough, underspecified, or shallow language processing. *Quarterly Journal of Experimental Psychology*, *69*(5), 817–828. https://doi.org/10.1080/17470218.2015.1134603

Declerck, M., Wen, Y., Snell, J., Meade, G., & Grainger, J. (2020). Unified syntax in the bilingual mind. *Psychonomic Bulletin & Review*, *27*(1), 149–154. https://doi.org/10.3758/s13423-019-01666-x

Ferrand, L., New, B., Brysbaert, M., Keuleers, E., Bonin, P., Méot, A., Augustinova, M., & Pallier, C. (2010). The French Lexicon Project: Lexical decision data for 38,840 French words and 38,840 pseudowords. *Behavior Research Methods*, *42*(2), 488–496. https://doi.org/10.3758/BRM.42.2.488

Green, S., De Marneffe, M.-C., Bauer, J., & Manning, C. D. (2011). Multiword expression identification with tree substitution grammars: A parsing tour de force with French. Proceedings of the 2011 Conference on Empirical Methods in Natural Language Processing, pp. 725–735.

Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, *7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language*, *59*(4), 434–446. https://doi.org/10.1016/j.jml.2007.11.007

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). Lmertest package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13), https://doi.org/10.18637/jss.v082.i13

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). Opensesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, *44*(2), 314–324. https://doi.org/10.3758/s13428-011-0168-7

Mirault, J., Guerre-Genton, A., Dufau, S., & Grainger, J. (2020). Using virtual reality to study reading: An eye-tracking investigation of transposed-word effects. *Methods in Psychology*, *3*, 100029. https://doi.org/10.1016/j.metip.2020.100029

Mirault, J., Snell, J., & Grainger, J. (2018). You that read wrong again! A transposed-word effect in grammaticality judgments. *Psychological Science*, *29*(12), 1922–1929. https://doi.org/10.1177/0956797618806296

Pegado, F., & Grainger, J. (2019). Dissociating lexical and sublexical contributions to transposed-word effects. *Acta Psychologica*, *201*, 102943. https://doi.org/10.1016/j.actpsy.2019.102943

Pegado, F., & Grainger, J. (2020). A transposed-word effect in same-different judgments to sequences of words. *Journal* *of Experimental Psychology: Learning, Memory, and Cognition*, *46*(7), 1364–1371. https://doi.org/10.1037/xlm0000776

Perea, M., & Lupker, S. J. (2004). Can CANISO activate CASINO? Transposed-letter similarity effects with nonadjacent letter positions. *Journal of Memory and Language*, *51*(2), 231–246. https://doi.org/10.1016/j.jml.2004.05.005

Rayner, K., Schotter, E. R., Masson, M. E. J., Potter, M. C., & Treiman, R. (2016). So much to read, so little time. *Psychological Science in the Public Interest*, *17*(1), 4–34. https://doi.org/10.1177/1529100615623267

R Core Team. (2019). *R: A language and environment for statistical computing*.

Reichle, E. D., Liversedge, S. P., Pollatsek, A., & Rayner, K. (2009). Encoding multiple words simultaneously in reading is implausible. *Trends in Cognitive Sciences*, *13*(3), 115–119. https://doi.org/10.1016/j.tics.2008.12.002

Reichle, E. D., Pollatsek, A., Fisher, D. L., & Rayner, K. (1998). Toward a model of eye movement control in reading. *Psychological Review*, *105*(1), 125–157. https://doi.org/10.1037/0033-295X.105.1.125

Snell, J., & Grainger, J. (2017). The sentence superiority effect revisited. *Cognition*, *168*, 217–221. https://doi.org/10.1016/j.cognition.2017.07.003

Snell, J., & Grainger, J. (2019a). Readers are parallel processors. *Trends in Cognitive Sciences*, *23*(7), 537–546. https://doi.org/10.1016/j.tics.2019.04.006

Snell, J., & Grainger, J. (2019b). Word position coding in reading is noisy. *Psychonomic Bulletin & Review*, *26*(2), 609–615. https://doi.org/10.3758/s13423-019-01574-0

Snell, J., Meeter, M., & Grainger, J. (2017). Evidence for simultaneous syntactic processing of multiple words during reading. *PLOS ONE*, *12*(3), e0173720. https://doi.org/10.1371/journal.pone.0173720

Snell, J., van Leipsig, S., Grainger, J., & Meeter, M. (2018). OB1-reader: A model of word recognition and eye movements in text reading. *Psychological Review*, *125*(6), 969–984. https://doi.org/10.1037/rev0000119

van Heuven, W. J. B., Mandera, P., Keuleers, E., & Brysbaert, M. (2014). SUBTLEX-UK: A new and improved word frequency database for British English. *The Quarterly Journal of Experimental Psychology*, *67*(6), 1176–1190. https://doi.org/10.1080/17470218.2013.850521

Wen, Y., Mirault, J., & Grainger, J. (2021). Fast syntax in the brain: Electrophysiological evidence from the rapid parallel visual presentation paradigm (RPVP). *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *47*(1), 99–112. https://doi.org/10.1037/xlm0000811

Wen, Y., Snell, J., & Grainger, J. (2019). Parallel, cascaded, interactive processing of words during sentence reading. *Cognition*, *189*, 221–226. https://doi.org/10.1016/j.cognition.2019.04.013