Evidence for Cascaded Processing in L1 and L2 Written Production

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One of the major aims of written production studies has been to investigate the relationship between central linguistic processing (e.g., lexical and semantic access) and peripheral motor processes (e.g., writing action). *Staged accounts* of language production claim that linguistic processing is fully completed before the onset of motor processes [1,2], whereas *cascaded accounts* [3,4] suggest that linguistic processing is open to updates during motor processes. Inter-key Intervals (IKIs: time period between two successive key strokes) are well-tested measures to examine the predictions of these accounts. Accordingly, if IKIs do not vary across different letter intervals within a word, then it can be argued that linguistic processing is completed before writing. On the other hand, if longer IKIs are observed at intervals such as syllable and morpheme boundary than at non-boundary intervals, then this could be taken as evidence for the presence of ongoing linguistic processing even after the writing action is initiated. Compounds have been used as experimental stimuli in a considerable number of studies to test how linguistic processing unfolds in written production. L1 studies on compound word production have provided cross-linguistic evidence for cascaded processing in languages like Finnish, English, and German [5,6,7,8] by revealing the impact of various morphological factors on response latencies such as compound/constituent frequency and syllable/morpheme boundary [9]. In line with the predictions of the cascaded account, these studies arrived at longer IKIs at syllable and morpheme boundaries.

Furthermore, how compounds are retrieved from the lexicon has been another question addressed within the scope of written production studies. The effect of (whole) compound frequency and constituent frequency on Writing Onset Time (WOT: time period between the onset of stimuli presentation and first key stroke) has been investigated to find an answer to this question. It has been claimed that compounds are retrieved from the lexicon via the whole-word route if compound frequency is the only factor affecting WOTs (e.g., longer WOTs with low frequency compounds). However, it has been claimed that compounds are retrieved via decomposition if the only modulating factor is constituent frequency (e.g., longer WOTs with compounds having low second constituent frequency). Additionally, in cases where both compound and constituent frequency affect WOTs, a dual-route account is proposed, which involves whole-word and decomposition routes as retrieval paths operating in parallel and interacting with each other [5].

While studies focusing on native (L1) written word production comprise the majority of the relevant literature, studies investigating non-native (L2) speakers are relatively few in number. Importantly, as the possibility that the L1 can influence linguistic planning in the L2 is discussed in the spoken production literature, one could also entertain the possibility that the same influence holds for written word production as well. Accordingly, different processing patterns might be expected in L1 vs. L2 written word production, which may help to gain a better understanding of the bilingual language user. [10, 11]

Against this background, the present study investigated the relationship between linguistic processing and motor processes in L1 Turkish and L2 English by focusing on the effects of morphological factors on the written production of Turkish and English compounds. In two self-paced picture naming experiments, 30 adult L1 Turkish (Experiment 1) and 40 adult L2 English (Experiment 2) speakers typewrote the names of pictures they saw on a computer screen while their Writing Onset Time (WOT) and Inter-key Intervals (IKI) were recorded by the keylogging software *Inputlog* [12]. 64 compounds in the L1 and 32 compounds in the L2 experiment were placed into four experimental conditions by manipulating compound frequency and second constituent frequency (High-High: *gözyaşı* ‘teardrop’; fireplace, High-Low: *kafatası* ‘skull’; footprint, Low-High: *denizkızı* ‘mermaid’; seahorse, Low-Low: *balkabağı* ‘pumpkin’; barcode)*.

The WOT results of the L1 experiment showed a significant main effect of both compound frequency [F(1,29)=13.782, p<.001)] and second constituent frequency [F(1,29)=11.251, p=.002)] together with a significant interaction between these two [F(1,29)=10.261, p=.003]. There was a significant difference between high and low second constituent compounds in the low compound frequency condition but not in the high compound frequency condition, which supported the dual-route account for the lexical retrieval of the compounds. Contrary to the L1 results, the L2 WOT analysis (Figure 1) did not reveal a significant effect of compound or constituent frequency (p>.05). However, it is important to note that WOTs were found to be more variable in the L2 compared to the L1 participants. IKI results in the L1, on the other hand, displayed a significant main effect of interval location [F(1.95, 56.63)=223.148, p<.001] and compound frequency [F(1,29)=10.777, p=.003] in addition to a significant interaction between these two [F(3,87)=25.704, p<.001]. Moreover, IKIs were longer at syllable and morpheme boundary compared to non-boundary positions (p<.001). Also, longer IKIs were found at the morpheme boundary compared to the syllable boundary (p<.001), which is suggestive of the role of morphology independent of orthography. These results provided evidence for the cascaded account in L1 Turkish similar to earlier L1 studies conducted in various other languages. In parallel with the L1 results, the IKI findings of the L2 experiment (Figure 2) also showed significant effects of interval location [F(1.55, 60.60)=121.513, p<.001] and compound frequency [F(1, 39)=32.327, p<.001]. Most importantly, longer IKIs were obtained at syllable/morpheme boundary than non-boundary intervals (p<.001). The difference between non-boundary intervals did not reach statistical significance (p>.05). Overall, these findings lend support to the claim that linguistic processing is cascaded into motor execution not only in L1 but also in L2 written production.

* For each condition, the first examples are from the L1 experiment (English translations given within semi-quotes) whereas the second examples are from the L2 experiment.

References

[1] Damian & Stadthagen-Gonzalez (2009). [2] Baus, Strijkers, & Costa (2013). [3] Roux et al. (2013). [4] Álvarez et al. (2009). [5] Bertram et al. (2015). [6] Gagné & Spalding, (2014c). [7] Gagné & Spalding, (2016). [8] Sahel, Nottbusch, & Weingarten, (2008). [9] Kandel, Álvarez, & Vallée (2006). [10] Sadat et al. (2012). [11] Kroll & Gollan (2014). [12] Leijten & Van Waes (2013).

Figure 1. Mean Writing Onset Time (ms) by Second Constituent Frequency and Compound Frequency (left: L1 Experiment; right: L2 Experiment)

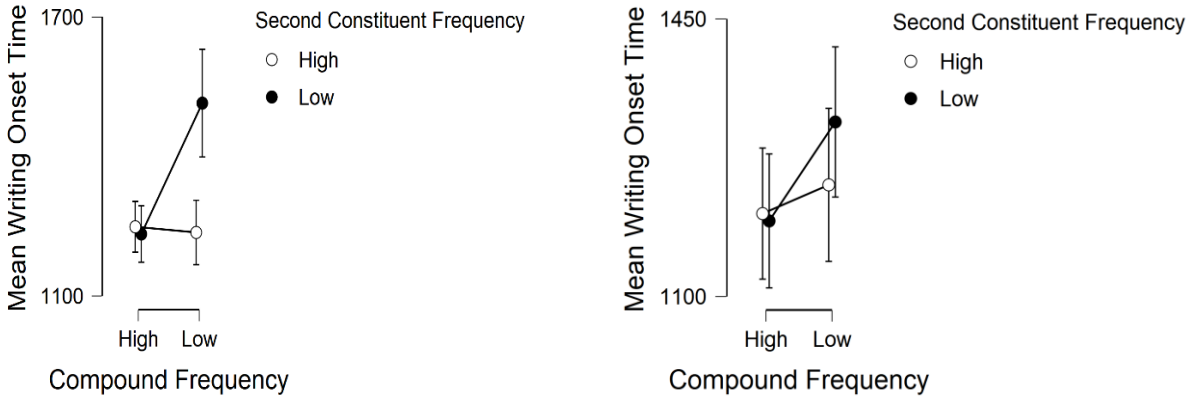

Figure 2. Mean Inter-key Intervals (ms) by Interval Location and Condition in the L1 Experiment (left: L1 Experiment; right: L2 Experiment)