



Qualitative differences in L3 learners' neurophysiological response to L1 versus L2 transfer

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Abstract

Third language (L3) acquisition differs from first language (L1) and second language (L2) acquisition. There are different views on whether L1 or L2 is of primary influence on L3 acquisition in terms of transfer. This study examines differences in the event-related brain potentials (ERP) response to agreement incongruencies between L1 Spanish speakers and L3 Spanish learners, comparing response differences to incongruencies that are transferrable from the learners' L1 (Swedish), or their L2 (English). Whereas verb incongruencies, available in L3 learners' L2 but not their L1, engendered a similar response for L1 speakers and L3 learners, adjective incongruencies, available in L3 learners' L1 but not their L2, elicited responses that differed between groups: Adjective incongruencies engendered a negativity in the 450-550 ms time window for L1 speakers only. Both congruent and incongruent adjectives also engendered an enhanced P3 wave in L3 learners compared to L1 speakers. Since the P300 correlates with task-related, strategic processing, this indicates that L3 learners process grammatical features that are transferrable from their L1 in a less automatic mode than features that are transferrable from their L2. L3 learners therefore seem to benefit more from their knowledge of their L2 than their knowledge of their L1.

Index Terms: third language learning, event-related brain potentials, language comprehension, LAN, P300, P600

1. Introduction

Third language acquisition has been of increased interest during the last decade. Current research [1, 2] suggests that first language acquisition differs from the acquisition of subsequent languages. Whereas L1 acquisition occurs without awareness of the acquisition process, L2 learning implies awareness of the learning process [3]. According to Ullman [4], L1 acquisition takes place during an early, critical period in the child's life and is automatically learned and implicitly 'stored' in procedural memory. Subsequent languages are acquired at later ages under awareness of the learning process and are to a greater extent consciously stored in declarative memory. Information in declarative memory is more accessible, simpler to understand and reflect upon.

The process of applying knowledge from one language to another, such as features and/or structures, is referred to as *language transfer* [5]. Differences in transfer from L1 to L3, in comparison to transfer from L2 to L3, provide insights into similarities and differences in the influence of L1 versus L2 on L3 learning. The present study investigates whether transfer into L3 is equally strong from L1 and L2, or whether transfer into L3 primarily occurs from L2. The results of some studies indicate that L3 learning is equally influenced by the learners' knowledge of their L1 and their L2 [6]. Bardel and Falk [2], on the other hand, claim that L2 has a stronger influence than L1

as a transfer source in L3 learning. They hypothesize that this is due to the L2 Status Factor. Accordingly, there is a higher degree of cognitive similarity between L2 and L3 than between L1 and L3 which is due to the difference in acquiring the first versus learning subsequent languages. Whereas L1 is acquired and implicitly stored in procedural memory, both L2 and L3 are consciously learned and stored in declarative memory [4].

In the present study, L1 and L2 language transfer is investigated on the basis of L3-learners' ERP response to grammatical anomalies in their L3, which also exist either in their L1 or their L2. It investigates if L3 (Spanish) learners react stronger to verb incongruencies that exist in their L2 (English) but not in their L1 (Swedish), if they are more sensitive to adjective incongruencies that are found in their L1 but not in their L2, or if they are equally sensitive to both of these incongruencies. If the influence on L3 is similar for L1 and L2, similar responses should be observed. On the other hand, if the L2 influence is stronger than the L1 influence, the response to L2 incongruencies should be more "native-like" than the response to L1 incongruencies.

Several studies investigating agreement processing of adjectives or verbs in Spanish [7, 8, among others] have found adjective and verb incongruencies to engender a biphasic ERP response. This pattern consists of a negativity in the 300-500 ms time window with a left anterior scalp distribution, often referred to as the *LAN* effect, which is followed by a positive deflection in the 500-800 ms time window with a centro-parietal scalp distribution, commonly called the *P600* effect. The LAN is engendered by agreement incongruencies in particular, and is assumed to reflect early detections of morphosyntactic violations [7]. The P600, on the other hand, is engendered by morphosyntactic anomalies more generally as well as by syntactic ambiguities and syntactically complex sentences, and is assumed to reflect late reanalysis, reinterpretation and integration costs [7, 9, 10].

2. Method

2.1. Participants

A total of 33 participants divided into two groups performed the study. The first group consisted of 18 (8 female, 10 male) L3 learners of Spanish that were native Swedish speakers, and had English as their L2. Their age ranged from 21 to 44 years with a mean of 31.6 years. The second group consisted of 15 (7 female and 8 male) Spanish native speakers that had English as their L2 and Swedish as their L3. Their age ranged from 22 to 42 years with a mean of 27.5 years. Their L3 proficiency was tested with a written and oral test according to the Common European Framework of Reference for Languages, showing both initial and advanced proficiency. All participants had normal or corrected vision, were right-handed, and provided informed consent in writing.

Table 1: *Example sentences from each condition. Because of space limitations only the relevant agreement features are glossed.*

Condition	Example sentence					
AdjCon/ PredCon	La the.FEM	tierra earth.FEM	es is	redonda round.FEM	y and	la luna también the moon also
	'The earth is round and the moon as well'					
AdjInc/ PredCon	La the.FEM	tierra earth.FEM	es is	*redondo round.MASC	y and	la luna también the moon also
	'The earth is round and the moon as well'					
PredInc	La the	tierra earth	*eres is.2SG	redonda round	y and	la luna también the moon also
	'The world is round and the moon as well'					
VerbCon	Tú You	anotas annotate.2SG	la the	cifra cipher		
	'You write down the cipher'					
VerbInc	Tú You	*anoto annotate.3SG	la the	cifra cipher		
	'You write down the cipher'					

2.2. Stimulus material

The stimuli consisted of written Spanish sentences with either subject-adjective agreement, available in L1 (Swedish) but not in L2 (English), or subject-verb agreement, existing in L2 (English) but not in L1 (Swedish). These sentences consisted of the 5 conditions exemplified in Table 1 with either congruent (AdjCon, VerbCon) or incongruent (AdjInc, PredInc, and VerbInc) agreement. The AdjCon, AdjInc and PredInc sentences were predicative constructions with a definite lexical subject, a copula verb, and an adjective. Whereas AdjCon were grammatical, AdjInc and PredInc contained adjective and copula verb incongruencies, respectively. ERP responses to copula incongruencies in the PredInc condition was therefore controlled against the ERP response to congruent copula verbs of the AdjCon and AdjInc conditions, henceforth referred to as *PredCon*. The VerbCon and VerbInc sentences were prototypical transitive sentences with an initial pronominal subject NP, a lexical verb, and a definite lexical object NP. The former were grammatical and the latter contained verb incongruencies. The experiment contained 45 sets of sentence conditions, such as the set exemplified in Table 1. The grammatical features of gender and number of the sentence subjects were evenly distributed across condition sets. In order to make sure that participants attended the sentences and understood them correctly, each sentence was followed with a comprehension question to be answered with 'yes' or 'no'. The sentences were divided into 5 blocks in a manner that ensured that each block only contained one sentence from each condition set. Sentences were evenly distributed across blocks with respect to conditions and grammatical features (gender and number).

2.3. Procedure

Participants were informed about the procedure of the experiment and the possibility to end it at any time, and then signed a consent form and took the Spanish language proficiency test. They were seated one meter in front of a monitor and asked not to blink while the sentences were presented. The presentation order of the blocks was counterbalanced across participants using a latin-square design. The sentence order within each block was uniquely random for each subject. The experiment started with a practice session consisting of twelve practice trials, during which participants received feedback on their answers of

the comprehension questions. Sentences were presented visually, beginning with the 800 ms presentation of a fixation cross centered on the screen, followed by a 100 ms blank screen, and the word-by-word presentation of the sentence at hand. Each word was presented for 400 ms with an interstimulus interval of 100 ms. The screen was then blank for 800 ms before the comprehension question was presented until participants made their answer, using a two button response box marked with "yes" or "no". There was no time limit for answering. Experimental sessions varied from 60 to 90 minutes.

2.4. Data processing and statistical analysis

EEG was recorded with 128 electrode Hydrocel Sensor Nets. Net Station 4.2. (Electrical Geodesics, Inc.) was used for recording and analyzing. The electrooculogram (EOG) was monitored with eight electrodes around the eyes. Recordings were done with a sampling rate of 250 Hz and band-pass filtered off-line with a 0.5- to 20-Hz filter. Channels were referenced to the average of the left and right mastoids. Bad channels, in which the signal exceeded $\pm 100 \mu\text{V}$ in more than 20% of the initial 4000 ms of experimental sentence presentations, were interpolated from surrounding channels. Single-trial epochs ranged from -200 ms to +1000 ms relative to the onsets of the critical words (200 ms being used for baseline correction). Epochs with more than 15 channels with more than a $\pm 100 \mu\text{V}$ range, with more than a $\pm 100 \mu\text{V}$ range in a 600 ms time window in any of the anterior or posterior EOG channels, with more than a $\pm 55 \mu\text{V}$ in a 500 ms time window, or in which participants answered incorrectly were excluded. Single-subject ERPs time locked to the critical words of each condition were calculated for subjects with at least 15 remaining epochs in all conditions. This entailed that data from two of the L1 Swedish participants were excluded.

Statistical analyses were conducted on averages in time windows and electrode groups, regions of interest (ROIs), that were selected on the basis of findings in previous studies and visual inspection of scalp plots [11]¹. ROIs consisted of the centro-frontal ('CF') region (electrodes FPz, 18, AFz, 10, F1, Fz, F2, 20, 12, 5, 118, FCz), the centro-parietal ('CP') region (electrodes 7, 106, 31, CPz, 80, 54, 79, 61, Pz, 78, PO3 and PO4), the left-parietal ('LP') region (electrodes C3 CP1, CP3, 53, P3, P1, 59 and 56) and the right-parietal ('RP') region (electrodes CP2, C4, 86, CP4, P2, P4, 84 and 91) (see Figure 1). Separate analyses were conducted for each incongruence type (i.e., adjective, verb and copula). These consisted of 2 (Incongruence) \times 4 (ROI) \times 2 (Language) mixed ANOVAs conducted in selected time windows with Incongruence and ROI as within-subjects factors and Language as a between-subjects factor. Follow-up analyses consisted of 2 (Incongruence) \times 2 (Language) mixed ANOVAs within each ROI as well as paired t-tests comparing differences between the congruent and incongruent conditions, and unpaired t-tests comparing L3 speakers to L1 speakers. We only report significant effects.

3. Results

In the following, we report analyses for each incongruence type, first for adjective incongruencies, then verb incongruencies and finally for copula incongruencies. Figure 2 shows grand average ERP responses to each of these types in selected electrodes (see Figure 1) from ROIs where the effects were significant.

¹We were unable to include these in the paper due to the page restrictions but they are available upon request.

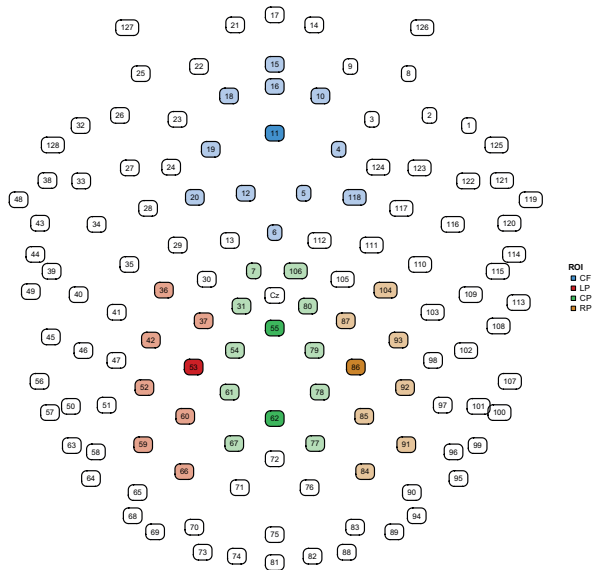


Figure 1: Approximate electrode positions and regions of interest (ROIs). Electrodes with a darker shades show the selected electrodes for which grand average ERPs are illustrated in Figure 2.

3.1. Adjective incongruities

Visual inspection of scalp plots indicate that adjective incongruities engender a small negative deflection peaking in the 350-450 ms time window with a left-parietal scalp distribution. An across-ROI analysis in the 350-450 ms time window confirmed this by showing a significant main effect of Congruence ($F(1, 28) = 4.54, p < .01$). Follow-up within-ROI analyses showed a significant effect of Congruence in the LP ($F(1, 28) = 8.55, p < 0.01$), and the RP ($F(1, 28) = 5.18, p < .05$) ROIs. Subsequent t-tests found, however, that the effect only is significant in the LP ROI of the L1 speakers ($t(14) = 2.82, p < .05$).

L3 speakers also show a more pronounced positivity in the 200-300 ms time window in both conditions in comparison to L1 speakers. This was confirmed by an across-ROI analysis in the 200-300 ms time window, which found a significant Language \times ROI interaction ($F(3, 84) = 3.39, p < .05$). Follow-up within-ROI analyses found a significant speaker difference in the LP ($F(1, 28) = 4.68, p < .05$) and the CP ($F(1, 28) = 7.71, p < .001$) ROIs. Follow-up t-tests found the speaker difference in the AdjCon condition to be significant in the LP ($t(28) = -2.13, p < .05$) and the CP ($t(28) = 2.89, p < .01$) ROIs. For the AdjInc condition, the difference was significant in the CP ROI only ($t(28) = 2.10, p < .05$).

3.2. Verb incongruities

Visual inspection of scalp maps indicate that verb incongruities engender a negative deflection with a centro-parietal scalp distribution, peaking in the 350-550 ms time window, both for L1 and L3 speakers. An across-ROI analysis in the 350-550 ms time window found a significant main effect of Congruence ($F(1, 28) = 13.38, p < .001$). Follow-up within-ROI analyses found a significant Congruence effect in the LP ($F(1, 28) = 13.51, p < .001$), the CP ($F(1, 28) = 14.61, p < .001$), and the RP ($F(1, 28) = 12.47, p < .01$) ROIs. For L1 speakers, follow-

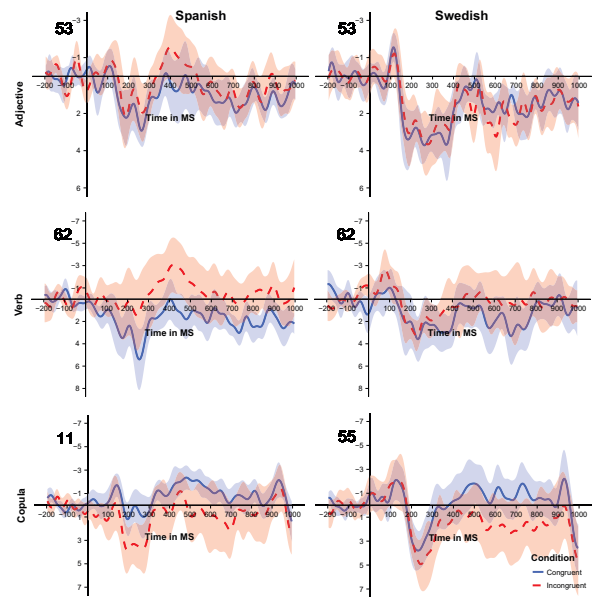


Figure 2: Grand average ERP responses to Adjective, Verb and Copula congruencies and incongruencies from selected electrodes in ROIs where effects are significant. Shaded areas illustrate 95% confidence intervals.

up t-tests found the effect to be significant in the LP ($t(14) = 2.83, p < .05$) and the CP ($t(14) = 2.87, p < .05$) ROIs. For L3 speakers, the effect was significant in the LP ($t(14) = 2.38, p < .05$), the CP ($t(14) = 2.55, p < .05$) and the RP ($t(14) = 2.30, p < .05$) ROIs.

Somewhat unexpectedly, verb congruencies seem to engender an enhanced positivity peaking in the 200-300 ms time window, in comparison to verb incongruencies. An across-ROI analysis in the 200-300 ms time window found a significant main effect of Congruence ($F(3, 84) = 5.76, p < .05$). Within-ROI analyses found a significant Congruence effect in the CP ($F(1, 28) = 4.48, p < .05$) and the RP ($F(1, 28) = 4.54, p < .05$) ROIs. Follow-up t-tests found the difference to be significant only in the CP ROI of the L1 speakers, however ($t(14) = 2.8, p < .05$).

3.3. Copula incongruities

Copula incongruities appear to engender a late positive deflection that is most pronounced in the 450-750 ms time window. For L1 speakers, this effect has a centro-frontal scalp distribution, and for L3 speakers, it has a centro-parietal distribution. An across-ROI analysis in the 450-750 ms time window confirmed this. It found a significant main effect of Congruence ($F(1, 28) = 6.69, p < .01$), as well as Congruence \times ROI \times Language interaction ($F(3, 84) = 3.98, p < .01$), indicating that the scalp distribution of the effect differs between L1 and L3 speakers. Within-ROI analyses found a Congruence main effect in the CF ($F(1, 28) = 5.7, p < .05$), the CP ($F(1, 28) = 5.00, p < .05$), and RP ($F(1, 28) = 5.14, p < .05$) ROIs. Follow-up t-tests showed that, for L1 speakers, the effect is only significant in the CF ROI ($t(14) = -2.16, p < .05$), and for L3 speakers, it is significant in the CP ($t(14) = -2.37, p < .05$) and the RP ($t(14) = -2.37, p < .05$) ROIs.

For both L1 and L3 speakers, copula incongruities also

seem to engender an enhanced positivity in the 200-300 ms time window. The across-ROI analysis in this time window found a significant main effect of Congruence ($F(28, 1) = 11.06, p < .01$). Within-ROI analyses found a Congruence main effect in the CF ($F(1, 28) = 14.00, p < .001$), the LP ($F(1, 28) = 7.71, p < .01$), the CP ($F(1, 28) = 5.28, p < .05$) and the RP ($F(1, 28) = 5.74, p < .05$) ROI. For L1 speakers, follow-up analyses found this positivity to be significant in the CF ($t(14) = -3.06, p < .01$) and the RP ($t(14) = -2.48, p < .05$) ROIs. For L3 speakers, it is significant in the CF ($t(14) = -2.21, p < .05$) and the LP ($t(14) = 2.97, p < .01$) ROIs.

4. Discussion

Using ERP methodology, this study investigated whether transfer into L3 is equally strong from L1 and L2, or whether transfer into L3 primarily occurs from L2. L3 learners of Spanish' response to agreement incongruencies that either exist in their Swedish L1 but not their English L2 (i.e., subject-adjective incongruencies) or in their English L2 but not in their Swedish L1 (i.e. subject-verb incongruencies) were compared to the responses of Spanish L1 speakers.

Subject-verb incongruencies engendered similar effects both in L1 speakers and L3 learners. Lexical verb incongruencies (the VerbInc condition) engendered a negative deflection with a centro-parietal scalp distribution. For L1 speakers, this effect had a somewhat more local, left-lateralised scalp distribution and a greater amplitude in comparison to L3 learners, who, on the other hand showed a broader, centro-parietal distribution. Overall, however, both L1 speakers and L3 learners show a fairly similar response pattern. This effect is, in particular for the L1 speakers, similar to, but not identical with, the LAN effect that has been observed as a response to both verb and adjective incongruencies in many other studies [7, 8]. Also in contrast to earlier studies, lexical verb incongruencies did not engender a P600 effect for any of the groups.

Copula incongruencies (the PredInc condition), on the other hand, engendered a late positive effect in the 450-750 ms time window. For L1 speakers, this effect had a centro-frontal scalp distribution. For L3 speakers, it appeared in the centro-parietal region. Copula incongruencies also engendered an enhanced positivity in the 200-300 ms time window. This effect had a centro-frontal and a right-parietal scalp distribution in L1 speakers but a centro-frontal and left-parietal distribution in L3 learners. Overall, the response pattern to copula incongruencies is very similar in both groups. The late positivity is similar to the P600 found in earlier studies [7, 8]. The response difference between verb and copula incongruencies is probably due to processing differences between function (such as copula verbs) and content words (such as lexical verbs), the latter engendering a more pronounced N400 wave than the former [12].

Adjective incongruencies (the AdjInc condition), on the other hand, only engendered an effect in L1 speakers – a negativity with a local left-parietal scalp distribution in the 450-550 ms time window. Although not reported in the results section, for L1 speakers adjective incongruencies also engendered a positivity with a right parietal scalp distribution that was found to only be marginally significant. In other words, the response pattern to adjective incongruencies in L1 speakers is very similar to that found in earlier studies. Thus the response pattern to adjective incongruencies is different for the L1 speakers and the L3 learners. Perhaps more strikingly, adjectives in the AdjCon as well as the AdjInc conditions engendered a much more pronounced positivity in the 200-300 ms time window in L3 learn-

ers in comparison to L1 speakers. This difference was primarily significant in the centro-parietal scalp region. This effect, often referred to as the P300, has been assumed to index updating of the mental model of the environment [13]. Crucially, the effect is engendered by stimuli that are predictable and relevant for experimental task performance [13, 14]. As such, it correlates with task-related, strategic processing. This in turn suggests that the processing of subject-adjective agreement is processed in a less automatic mode in L3 learners in comparison to L1 speakers. L3 learners need to recruit more attentional resources than L1 speakers in order to determine whether the adjective at hand agrees with the sentence subject, presumably because their knowledge of subject-adjective agreement in their L3 is less implicit. Both lexical and copula verbs, on the other hand, did not engender any L1 versus L3 group differences in the 200-300 ms time window. This suggests that, contrary to the processing of subject-adjective agreement, subject-verb agreement is processed more 'native-like' by L3 learners in terms of not requiring them to allocate additional attentional resources. These findings indicate that L3 learning benefits more from L2 knowledge than L1 knowledge: grammatical features available in L3 learners' L2 (e.g., subject-verb agreement) are processed more native-like than features that are available in their L1 (e.g., subject-adjective agreement). In other words, transfer of grammatical features into L3 is preferable from L2 than from L3, and this preference might be due to the L2 Status Factor [2].

It should be noted that there is an alternative interpretation of the difference in the ERP response to subject-adjective agreement between the speaker groups, compared to the between-group response similarity to subject-verb agreement. In order to detect subject-verb agreement incongruencies, participants need to retrieve person and number features, but in order to identify subject-adjective incongruencies, they need to retrieve gender features. Whereas the former features are *grammatically* encoded with pronominal forms and/or inflections, the latter are *lexically* specified in the lexical entries of individual nouns. Detecting the latter type of incongruencies might therefore be more difficult for L3 learners, because the gender of many nouns either is unknown to them, or not as entrenched as it is for L1 speakers. If L3 learners do not know the gender of many of the nouns, and therefore are unable to detect incongruencies in a large portion of the trials, either a smaller or no incongruence effect at all can be expected. Further, if their knowledge of gender is less entrenched than it is for L1 speakers, they might require additional attentional resources in order to retrieve this information, which might result in an enhanced P3 wave. In other words, the observed effects (no adjective incongruence effect but an enhanced P3 wave to adjective agreement in L3 learners) might stem from the grammatical difference between subject-verb agreement and subject-adjective agreement, rather than reflecting a preference for L2-to-L3 transfer over L1-to-L3 transfer.

5. Conclusions

The findings of this study indicate that L3 learners' processing of grammatical incongruencies are more native like for incongruencies available in their L2 rather than their L1. L3 learners' also seem to process L1 incongruencies in a more strategic and less automatic processing mode. This suggests that transfer of grammatical features into L3 is preferable from L2 than from L3 in line with the L2 Status Factor [2]. In sum, L3 learners' seem to benefit more from their knowledge of their L2 than from L1 knowledge of their L2.

6. References

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