On Modes and Waves.
The Impact of Learning Modes on Foreign Language Representation and Learning.

Martin G. Döpel
Centre for Language Studies, National University of Singapore

Abstract

In foreign language acquisition research, two variables are well-investigated: Age of Acquisition (AOA) and Proficiency Level (PL) (e.g., Hahne, 2001; Wartenburger et al., 2003). The impact of different learning modes has not been investigated yet. However Osterhout and colleagues recently reported brain changes resulting from foreign language learning (Osterhout et al. 2006, 2008).
For the purpose of the investigation in this poster two groups of students learned a certain German grammar feature in two distinct modes. After the instruction, subjects participated in a grammaticality judgment experiment while an EEG was recorded. The EEG was then analyzed for event-related potentials.

1 Introduction

As neuroscientific research progressed, it has gained increasing attention from educators (e.g., Blakemore & Frith, 2005). Although the results in neuroscientific second language acquisition research are interesting, they are somewhat unsatisfactory to foreign language educators, as there are only two variables, namely, Age of Acquisition and Proficiency Level, which are well-investigated (e.g., Hahne, 2001; Wartenburger, 2003). Within the last years, however, the focus of research shifted to the learning process itself. Osterhout and colleagues (2006) proposed a long-term paradigm to investigate the process of second language acquisition. First results (Osterhout et al., 2008) show that there are changes in processing and brain structure resulting from foreign language learning. Earlier, the team was able to show that semantic processing in early learners evokes a N400 effect (McLaughlin, Osterhout, & Kim, 2004). Mueller, Girgsdies and Friederici (2008) reported a N400-like negativity and a P600 for subjects trained semantic-free, whereas previous studies with instructions including semantic information showed only a P600 (Mueller et al. 2005).

So far, only Mueller and her colleagues (2008) have compared different learning modes. However, semantic-free learning cannot be found in any language classroom.

This study investigates two learning modes that are close to "real-life" classroom instructions.

2 The outline of the study

In this study, two groups of subjects learned declension of German adjectives either explicitly or implicitly. The instruction was carried out with handouts and computer programs to ensure consistent instruction for all subjects. Immediately after the instruction, participants were subjected to a grammaticality judgment experiment while their brain waves were recorded. The vocabulary used in training and the grammaticality judgment experiment known to the subjects.

2.1 Adjective declination as learning problem in German

If an adjective is positioned in front of a noun, it is declined according to the gender and number of the following noun, case of the NP and the type of article attached to the NP (see fig. 1). This makes the adjective declination a well-known learning problem, and even high-proficient speakers continue to have problems applying it correctly (e.g., Diehl, 1999).

For this reason, the declension of German adjectives was identified as an ideal learning matter for this study. It allows even subjects with considerable prior knowledge of the language but not previous knowledge of this particular grammatical structure to participate in the study.

As the adjective declination is a very complex issue and therefore takes longer to learn, we decided to teach a part of it, namely he declension with an indefinite article (*ein*, *eine*, *einen* = a(n)) in nominative and accusative case. As the indefinite article lacks plural forms, only the singular forms needed to be learnt as summarized in table 1.

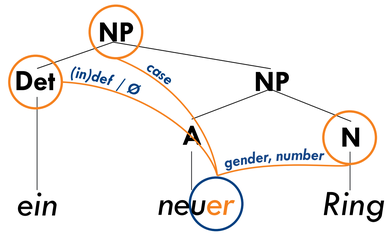

Figure 1: The adjective declination and its determining factors

2.2 Outline of the experiment and instruction

This experiment consisted of two parts: an instructional phase and a testing phase (see fig. 2).

The participants were allocated to one of the two groups.

Group E learnt the learning matter explicitly. In detail, they were first exposed to a small text enriched with the matter. Then the rule was explained to them. After this, they did a matching task. In this task, the subjects were given the abstract grammar information (e.g. "nominative-feminine") and had to click on the button with the correct ending (in this case "-e"). If they pressed the wrong button, a short text in red appeared, explaining the rule once more. After this task, they had to fill in the correct endings in the blanks (10 word groups and 10 sentences).

case	*feminine*	*masculine*	*neuter*
Nominative	**-e** (eine neue Tasche)	**-er** (eine neuer Ring)	**-es** (ein neues Kleid)
Accusative	**-e** (eine neue Tasche)	**-en** (einen neuen Ring)	**-es** (ein neues Kleid)

Table 1: The adjective declination and its determining factors

Group I learnt implicitly. Participants were given two longer descriptive texts about two people cooking. Next, they were required to answer open questions on the texts. One of the texts included a short recipe. The subjects were given a shopping list and were instructed to add the missing information. After this, they read a dialogue in which a salesman describes certain food items. The participants were asked to match the food items with the adjective given by the salesman. The last exercise was content-focused, too. On a computer screen, subjects read statements and were asked to click on the best paraphrase. All texts were enriched with the learning matter.

2.3 Grammaticality judgment experiment

The GJE contained four conditions (nominative/accusative - correct/false, see fig. 2). As can be seen in table 1, the indefinite article is a reliable indicator of the ending in three out of six instances. For this reason, the sentences used in the experiment contained no neuter nouns. Hence, all endings are indicated by the preceding article (eine "triggers" –e, ein "triggers" –er and einen "triggers" –en). The sentences in the nominative condition began with "Das ist …" ("This is …") followed by the phrase, the sentences in the accusative condition began with a name (choice of Clara, David, Jane, Lisa, Max and Peter) and a transitive verb (either "hat" (= has) or "kauft" (= buys)). The critical word (i.e., the adjective) was in all conditions the fourth word. All nouns used were inanimate.

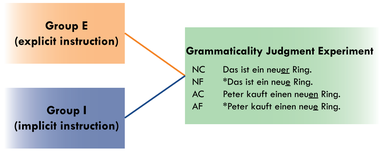

Figure 2: Outline of the experiment

Each condition contained 50 sentences. The false conditions were derived from the correct ones by applying the ending of the opposite gender. Therefore, this task can be best described as gender-matching.

The sentences were presented word-by-word with a timing of 600 ms/word on a white background with black font color in Arial with a size of 54 pt. Each sentence was preceded by a 1450 ms fixation time (in which the subjects were allowed to blink) and followed by a additional response time frame of 2000 ms.

Subjects were requested to press a button, if the sentence shown was correct and another one, if the sentence was false. The position of the buttons was altered between the subjects.

3 The present study

3.1 Subjects

All subjects were right-handed undergraduate students of the NUS. They learnt German for two semesters at the Centre for Language Studies. None of the participants had taken any German language courses outside NUS. Therefore, it can be assumed that none of the participants had prior knowledge regarding the learning matter.

Unfortunately, the number of subjects is small, as the "pool" of eligible students was rather small due to organizational matters and time constraints. Furthermore, there are a limited number of male students in both groups. For demographic information, refer to table 2.

3.2 Data collection

The instruction was supervised and recorded by the author or a student assistant. Each subject took about 25 minutes in the instruction phase.

The stimulus was presented using *Presentation 12.1*. The subject sat at a distance of about 30 cm in front of a CRT. Responses were collected using a response box and were recorded by Presentation. EEG was acquired using the 64+8 channel ActiveTwo tool by *Biosemi*.

3.3 Data processing and analysis

Perl scripts were used to summarize the behavioral data and to remove triggers of incorrect classified trials from the EEG data. The ERP analysis was carried out using *EEProbe 3.3.122*. First, the BDI files were converted to CNT files, then artifacts were identified and the trials were averaged. The averages were re-referenced to the right mastoid and filtered with a 0.1-30Hz band-pass filter. Data for statistical analysis was retrieved using the filtered average files. After visual inspection, four regions of interest (ROIs) were identified. ROI 1 includes channels AF3, F3, F5, F7, FC3 and FC5. ROI 2 contains the channels AF4, F4, F6, F8, FC4 and FC6. ROI 3 includes P1 and P3. ROI 4 contains P2 and P4. Refer to figure 3 for an illustration. Two time windows for statistical analysis were identified: 300-500ms for ROI 1 and ROI 2 to analyze the negativity found there, and 500-900ms for ROI 3 and ROI 4 to analyze the positivity.

For statistical analysis, R was used.

group	*N*	*females*	*age*		*year of study*	
			Mean	*SD*	*Mean*	*SD*
all	18	15	20.7	1.15	2.4	1.15
E	10	8	20.7	1.27	2.2	0.4
I	8	7	20.7	0.99	2.8	0.83

Table 2: Subjects' demographic data

3.4 Behavioral results

Overall, there were 200 trials. The behavioral results are summarized in table 4. t-test revealed that the explicit group performed significantly better than the implicit ($t=4.4025$, $p < 0.002$ for correctly classified trials and $t=-4.4939$, $p<0.002$ for incorrectly classified trials). The "best" subject in the implicit group, however, classified 177 trials correctly. There are no significant differences in terms of reaction time.

3.5 ERP results

As it can be seen in fig. 3, there are no clear differences between the two groups.

There is a negativity around 200 ms for all conditions and both groups. As this negativity can be found again around 800 ms (i.e., the presentation of the following noun), it can be assumed that this negativity, this negativity is rather linked to .

For the nominative conditions NC and NF, there is a small negativity around 400 ms in frontal areas. Taken into account that morphosyntactic processing is connected with a LAN (e.g. Newman et al., 2007), it could be described as a "bilateral-anterior negativity". However, this negativity cannot be found for the accusative conditions AC and AF.

Posterior electrodes show a positivity of around 600 ms, which is very dominant. Both groups show a clear P600 for all conditions.

ANOVA carried out within- and between-groups, however, revealed no significant differences.

4 Discussion and conclusion

This study investigated the influence of different learning modes on the representations and processing of the structure learnt. The behavioral results show that the explicit group was more successful in acquiring the knowledge needed to succeed in the GJE.

ERPs reveal no differences in the processing between and within group comparisons. The pattern (an anterior negativity around 400 ms) and a P600 can be found in both groups in all four conditions.

There are two possible explanations.

1. There is no measureable difference in the representation and processing. The lack of differences between the correct and the false conditions might be due to a "ceiling effect".
2. Taken into account that the subjects knew the adjectives used already, this pattern could not be the result of learning, but of processing due to the added ending. This assumption, however, cannot be tested as there was no test group (GJE without instruction). But a single-subject-analysis of the "worst" performers in the implicit group might give an additional insight.

group	*correctly classified*		*incorrectly classified*		*RT*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
E	174.7	12.57	23	12.37	1909.5	300.42
I	121.5	32.44	75.6	31.21	2092.4	165.13

Table 3: Summary of the behavioral data

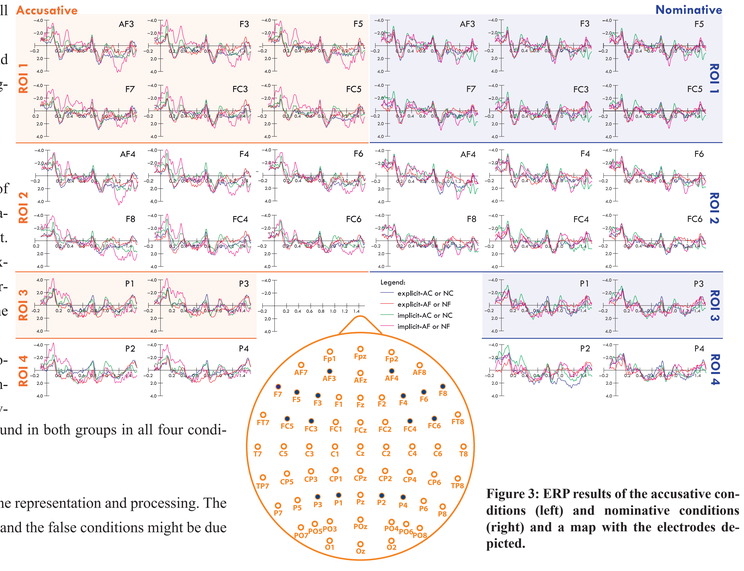

Figure 3: ERP results of the accusative conditions (left) and nominative conditions (right) and a map with the electrodes depicted.

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National University of Singapore
Faculty of Arts and Social Sciences
Centre for Language Studies
9 Arts Link, AS4 #05-20, Singapore 117570

doepel@nus.edu.sg