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Psycholinguistic techniques in second language acquisition research

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This article presents the benefits of using online methodologies in second language acquisition (SLA) research. It provides a selection of online experiments that have been widely used in first and second language processing studies that are suitable for SLA research and most importantly discusses the hardware and software packages and other equipment required for the setting-up of a psycholinguistics laboratory, the advantages and disadvantages of the software packages available and what financial costs are involved. The aim of the article is to inspire researchers in second language acquisition to embark on research using online methodologies.

I Introduction

One of the major differences between first language (L1) and second language (L2) acquisition relates to the level of ultimate attainment. Children acquiring their native language manage within a relatively short period of time to acquire fully the language they are exposed to, whereas this is not the case for adults acquiring an L2. Adult L2 learners typically do not manage to achieve the full acquisition of the L2 grammar irrespective of the amount of exposure they have in the L2.

Traditionally, L2 research has focused on the acquisition of grammar. Making use of offline techniques, such as grammaticality judgement, elicitation and comprehension tasks, researchers have investigated issues such as whether Universal Grammar (UG) is available to L2 learners, whether the source of divergence between L2 grammars and native grammars is the inability to reset UG parameters, and whether there is transfer from the first language to the second. In contrast, very little is known as to how learners process an L2 online. Language processing here refers to the mental processes involved while reading or listening to words or sentences in real time, which is also known as 'parsing'.

A considerable amount of research has been carried out in the

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last few decades investigating how native speakers process sentences in real time through the use of various online methodologies, such as self-paced reading and listening, cross-modal priming, eye-tracking and neurophysiological techniques. As research in online processing has been conducted in several typologically related and unrelated languages, it has become apparent that mature readers or listeners do not employ the same processing strategies across languages. Thus, language variation does not involve only the grammatical system of language, but also the language processing mechanism.

A logical consequence of the above is that L2 learners do not only have to acquire the grammar of the L2. In addition, they have to discover the processing strategies of that particular L2, which may differ from the ones they have developed for their native language. Hence, differences in linguistic proficiency between L1 and L2 learners and the failure of L2 learners to achieve ultimate success can be the result of the L2 learners' failure to acquire the processing strategies of the target language and not the result of their inability to acquire its grammar. Alternatively, these two issues may be interconnected. Difficulties in processing may result in the inability to acquire the grammar of the target language.

The aim of the present article is to illustrate through an example the benefits of using online experimental methodologies in SLA research, to expand the readers consciousness about what can be done through the use of online methodologies by presenting some well established experiments that could be used in L2 research and crucially to show how L2 researchers can employ online methodologies by discussing what hardware, software packages and other equipment are required for setting up a psycholinguistics laboratory.

The article is organized as follows. Section II illustrates one issue that has provided controversial results in SLA research based on offline experiments and how it has been elucidated through the use of online sentence processing methodologies. Section III provides a selection of well established online experiments that are suitable for research in SLA and Section IV gives an overview of the equipment that is necessary for running online psycholinguistic experiments as well as information on how to set up a psycholinguistics laboratory. Finally, a summary of the article is given in Section V.

II Advantages of using online techniques in investigating L2 acquisition

One of the issues that has drawn much attention within the last decade concerning whether or not L2 learners have access to UG, is the principle of Subjacency. Subjacency has been claimed to be relevant for this debate because it is instantiated in some languages, like English, whereas it is not instantiated in other languages, like Chinese. Hence, data from L2 learners of English whose L1 does not instantiate Subjacency has been thought to provide evidence as to whether or not L2 learners have access to UG principles.

A lot of research has been carried out since the late 1980s looking at whether L2 learners of English whose L1 does not have overt *wh*-movement have acquired the constraints of *wh*-movement imposed by Subjacency in English. One group of studies seems to provide evidence that L2 learners of English whose L1 does not show Subjacency do not apply constraints on *wh*-movement whereas another group of studies seems to provide evidence for the opposite claim. A review of the extensive literature on the acquisition of *wh*-movement and Subjacency in L2 acquisition is beyond the scope of this article. Instead, this section discusses representative studies from both groups in order to illustrate the debate and to show how the use of online psycholinguistics methodologies has been able to shed light on the above-mentioned debate.

Within the first group of researchers, Schachter (1989; 1990) looked at the acquisition of *wh*-movement in two groups of learners. She compared Chinese, Korean, Indonesian and Dutch learners of English to English natives. Chinese, Korean and Indonesian do not have overt *wh*-movement, unlike Dutch and English. Schachter found significant differences between the two groups with respect to identifying subjacency violations in English. Dutch speakers of English were much better at judging ungrammatical sentences involving *wh*-movement in English than Chinese, Korean and Indonesian learners. The interpretation of this result by Schachter was that *wh*-movement in Chinese, Korean and Indonesian learners of English (unlike in Dutch learners of English) is not constrained by the principle of Subjacency. Based on this data Schachter concluded that L2 learners do not have access to UG. Similar results to the ones in Schachter have been reported by Brey-Vroman *et al.* (1988) and Johnson and Newport (1991) among others.

In contrast to the above mentioned studies, Martohardjono and Gair (1993) showed that Indonesian learners of English were very accurate in judging both grammatical and ungrammatical sentences involving *wh*-movement and questioned the idea of unavailability of Subjacency in L2 learners whose L1 does not have overt *wh*-movement. White and Juffs (1998) found similar results with Martohardjono and Gair. By testing Chinese learners of English, White and Juffs found that they were very accurate in rejecting ungrammatical sentences involving Subjacency violations. However, they were less accurate in judging grammatical sentences involving *wh*-movement. Interestingly, there was a principled difference in their accuracy results. Chinese learners had difficulty accepting sentences involving subject extraction, whereas they were quite accurate in accepting sentences involving object extraction. Importantly, White and Juffs also measured the time taken by the subjects to judge the grammaticality of the sentences. Both natives and Chinese learners of English took more time to read and judge subject extractions than object extractions. This led the authors to hypothesize that the difference in the accuracy of sentences involving subject vs. object extraction is due to processing difficulties rather than due to the competence of the learners.

Decisive evidence as to whether grammar or processing difficulties is the factor that makes L2 learners fail to judge the grammaticality of *wh*-questions correctly can be provided by online studies. Hence, Juffs and Harrington (1995; 1996) used online techniques to investigate this issue further. More specifically, they measured the reading times of grammatical and ungrammatical sentences involving long-distance subject and object extractions in Chinese learners of English and English controls. The most revealing result of the studies that aim to determine whether difficulties in judging the grammaticality of sentences involving *wh*-movement in L2 learners is due to competence or processing difficulties comes from the experiment involving word-by-word presentation (self-paced reading experiment)[1] of grammatical sentences that involve subject extraction from infinitival sentences; an example of subject extraction from infinitival sentences is as follows:

(1) Who_i does Tom expect t_i to fire the manager?

Here the two groups (Chinese and English) showed distinct patterns. Whereas reading times following the infinitival verb *to fire* increased in the group of English natives, they decreased in the group of Chinese learners. As increase in reading times is often

[1] For details about this methodology, see Section III.

associated with the process of reanalysis, shorter reading times after the verb in the Chinese group indicates that Chinese learners of English do not go through a reanalysis process at this point in the sentence.

This is supported by the analysis of the data from their inaccurate responses. If Chinese learners attempt to perform a reanalysis but fail, their pattern should resemble the pattern of English controls. This is, indeed, what Juffs and Harrington found in the case of inaccurate responses of the Chinese learners.

In sum, Juffs and Harrington using a word-by-word online reading task demonstrated that lower accuracy of L2 learners whose L1 does not have overt *wh*-movement is not due to their lack of competence, because their accuracy in judging sentences involving Subjacency violations did not differ significantly from the accuracy of the natives. Instead, their lower accuracy is due to processing difficulties. More specifically they are not able to go through a reanalysis process required in subject extraction from infinitival clauses.

Additional evidence that Chinese learners of English have difficulties in processing *wh*-questions is provided in a recent study by Marinis *et al.* (2002) who looked at the processing of long-distance *wh*-movement in the speech of Chinese learners of English and English controls. Marinis *et al.* used sentences involving intermediate *wh*-traces, as in (2):

(2) The nurse who_i the doctor argued t_i that the rude patient had angered t_i is refusing to work late.

Making use of a phrase-by-phrase self-paced reading task, Marinis *et al.* demonstrated that Chinese learners, unlike English controls, do not posit an intermediate *wh*-trace after the verb *argued*. Instead, they keep the *wh*-word in memory until they integrate it with the verb *had angered*. Additionally, Chinese learners of English differed from English natives in that they did not integrate the *wh*-word immediately after encountering the lexical verb *had angered*, but they delayed the integration until the end of the sentence.

III Online techniques suitable for SLA research

This section introduces two sets of online experiments with the aim of illustrating some well established experiments that can be used in L2 research. The first experiment – the moving window technique – has been used recently in the area of SLA in the experiments presented in the previous section (Juffs and Harrington, 1995; 1996;

Marinis *et al.*, 2002). The second experiment – cross-modal priming – has been used mainly in studies with adult natives but also in first language acquisition (FLA) research.

1 Self-paced reading/listening, or moving window technique

In the self-paced reading technique subjects have to read a sentence in a word-by-word or phrase-by-phrase fashion. Subjects are asked to read each word or phrase as fast as possible and press a push button in order to receive the next word or phrase. Sentences are often followed by comprehension questions in order to impose online comprehension of the sentence and to avoid mechanical pressing of the push button. This technique has been widely used in online processing studies in SLA, such as Juffs and Harrington, 1995; 1996; Marinis *et al.*, 2002; Felser *et al.*, 2003; Papadopoulou and Clahsen, 2003.

As far as visual presentation is concerned, there are three main types of presentation: the cumulative presentation, the noncumulative presentation and the centre noncumulative presentation. In both the cumulative and noncumulative presentations, the sentence appears on the screen with all nonspace characters replaced by dashes. Upon pressing the push button, the first word or phrase is displayed, replacing the corresponding dashes. When the subject presses the push button for a second time, the next word or phrase appears on the screen and this goes on until the end of the sentence. The difference between the cumulative and the noncumulative presentation is that in the cumulative presentation, previous words or phrases remain displayed on the screen, whereas in the noncumulative presentation previous words or phrases disappear and only one word or phrase is displayed on the screen at a time. The noncumulative centre presentation is similar to the noncumulative presentation, but without dashes on the screen, so the subject is not aware of the length of the sentence and does not know how many words are still to follow. Moreover, words or phrases are presented in the centre of the screen. The noncumulative and noncumulative centre presentations are the most appropriate for tapping syntactic processing in real time, as subjects are unable to go back and re-read words that have been presented previously in the sentence. Moreover, presentation without dashes does not enable subjects to make predictions about the continuation of the sentence, and it is therefore preferable to presentation with dashes.

The self-paced listening technique is similar to the self-paced reading technique, but with auditory presentation instead of visual presentation. In both the self-paced reading and self-paced listening techniques, the software package records the reading or listening time of each word or phrase by means of recording how fast subjects press the button on the push button box. This gives a measure of how fast subjects comprehend the sentence online as it unfolds. From this we can infer:

- which points in the sentence are difficult to process;
- at which points the reader/listener is surprised or encounters an unexpected word or phrase; and
- when the reader/listener has to reanalyse his or her initial interpretation of the sentence.

Comparison between the reading times of L2 learners and native controls can provide insights into language specific processing strategies, but also into strategies that hold across languages (see Felser *et al.*, 2003; Papadopoulou and Clahsen, 2003).

Apart from the task of reading/listening and comprehending the sentence, a second task can be added in this experiment. This can be:

- a comprehension question at the end of the sentence, as in Marinis *et al.*, 2002; Felser *et al.*, 2003; Papadopoulou and Clahsen, 2003);
- judgement of the grammaticality of the sentence, as in Juffs and Harrington, 1995; 1996; or
- a stop-making-sense task, as in Boland *et al.*, 1995.

These three tasks are discussed in turn below. Through the comprehension question task, the experimenter can make sure that the subject comprehended the sentence properly and, thus, the reading times of the segments correspond to the correct parsing of the sentence. This is extremely important, as reading times from sentences that have been misinterpreted may have a completely different pattern than reading times from sentences that have been interpreted properly. This has been illustrated in the previous section on the basis of the study of Juffs and Harrington (1995), whose analysis of the misinterpreted sentences provided additional evidence for their claim that Chinese learners of English have processing difficulties with sentences involving subject extraction of infinitival sentences.

A further task that can be combined in this experiment is a grammaticality judgement task. After reading each sentence, subjects have to judge the grammaticality of the sentences (as in Juffs and Harrington, 1995; 1996). The grammaticality judgement task provides an extra measure that can be evaluated independently or in relation to the reading times data. Adding a grammaticality judgement task makes the experiment more demanding, as subjects have to read/listen comprehend and perform a meta-linguistic task at the same time. If the complexity of the sentences involved is very high, it is possible that this task will be too demanding for L2 learners. However, several studies (see Juffs and Harrington, 1995; 1996) have shown that L2 learners are able to perform both tasks successfully. In this task, apart from the reading times and grammaticality judgement data, comprehension data are also provided, albeit indirectly. Grammatical sentences that have been judged as ungrammatical and the opposite indicate that the subjects have not processed the sentences properly.

Finally, this experiment can include the stop-making-sense task. In this task, subjects have to identify at which point the sentence becomes implausible; hence, it forces subjects to use plausibility information. When a sentence becomes implausible, the subject has to press a different button, in which case the presentation of the sentence stops. This measure provides insight in plausibility judgements, and can be used to infer subjects' preferences and their biases toward specific interpretations. The method was used among others by Boland *et al*. (1995) in order to identify whether readers use argument structure information in order to generate and evaluate syntactic alternatives.

2 *Cross-modal priming technique*

The cross-modal priming experiment (Swinney, 1979; Swinney *et al*., 1979) has been widely used to investigate antecedent reactivation in adult native speakers (see, amongst others, Nicol *et al*., 1994; Love and Swinney, 1996; Clahsen and Featherston, 1999; Shapiro *et al*., 1999; Nakano *et al*., 2002) and in FLA studies (see, amongst others, McKee *et al*., 1993).

Shapiro *et al*. (1999), for example, used sentences such as (3), in order to test whether there is reactivation of the antecedent at the gap position.

(3) The soldier is pushing *the unruly student* violently into the street.
Who is the soldier pushing t_i violently into the street?

In this example the *wh*-word *who* has moved out of its base position (after the verb *pushing*), leaving a trace behind. Additionally, the *wh*-word refers to the object of the previous sentence, *the student*.

In this experiment, subjects listened to sentences such as (3) over headphones. At one of the four points indicated in (4) below, a word appeared on the screen. Words were of three types: a) words that are semantically related to the antecedent (in this example the word *school*); b) words that are unrelated to the antecedent; and c) nonwords.

(4) *Who* [1] is the soldier [2] pushing t_i [3] violently [4] into the street?

On reading the word on the screen, subjects had to perform a lexical decision task as to whether this was a word or a nonword, and reaction times of this second task were recorded by the computer. If the antecedent is reactivated at the position of the gap, the prediction is that reaction times for the semantically related words at the gap position (position [3]) will be significantly shorter in comparison to the reaction times for the semantically unrelated and nonwords, whereas no such difference is expected at positions [2] and [4]. Moreover, reactivation may possibly take place also at position [1], as *who* refers to the antecedent *student* in the previous sentence, although the listener cannot 'know' that at this point. The underlying idea is that reaction times will be shorter in syntactically relevant positions, such as the position of the gap.

Shapiro *et al.* indeed found a priming effect at position [3], that is at the position of the gap and also at position [1], which shows that there is mental reactivation of the antecedent at the position of the gap and at the *wh*-word that acts as a pronoun and activates its antecedent.

As far as the methodology of the cross-modal priming experiment is concerned, as mentioned above, two tasks have to be performed by the subject. One task is to listen to a sentence and in addition to that the subject has to perform a second task upon seeing a visual target. In order for the subject to pay attention to the sentences, comprehension questions have to be asked after every few sentences. This keeps their attention on the first task of listening and comprehending the sentence.

In the second task, the visual targets may be words (and nonwords), as in the experiment of Shapiro *et al.*, or pictures as in McKee *et al.* (1993). In both cases, the semantically related and control words have to be matched for frequency, number of syllables and number of letters in order to ensure that differences in the reaction times are not due to any factors unrelated to the test hypothesis. In the case of nonwords, these should be orthographically, phonologically and morphologically legal forms in the target language, otherwise they may result in longer reaction times because of their illegal form in this language.

The second task can be a lexical decision task, in which subjects have to decide whether the word presented is a word or a nonword, or it can be a task of classification in the case of picture presentation. In the latter case, the subject has to decide whether the picture represents an animate vs. inanimate, eatable vs. uneatable, male vs. female object, etc.

Finally, several studies have used identical targets instead of semantically related ones, that is the word/picture presented visually was identical to the word in the sentence, with similar results (e.g., Clahsen and Featherston, 1999). With respect to the position of the word/picture within the sentence, this should be presented at least seven syllables after the antecedent. The idea is that distance between the antecedent and the target should be such that the antecedent has been removed from active short-term memory. Otherwise there might be no difference in the priming effect between the theoretically relevant position and the control position.

The cross-modal priming technique represents the preferred methodology for the investigation of antecedent reactivation because it excludes effects based on pure short-term memory within a single modality (auditory or visual), it permits presentation of the prime without interruption of the stimulus input and it allows the subject to parse the sentence at normal speed, as opposed to other experiments, such as the self-paced reading/listening experiment.

Until now, cross-modal priming experiments have been performed predominantly with adult natives, but also in the area of FLA research. SLA studies would benefit from the use of this methodology because research based on this technique could answer questions such as whether L2 learners form chains between the antecedent and the gap and whether the parser reconstructs the semantic, syntactic (number, case, gender) and the phonetic features of the antecedent.

IV Setting up a psycholinguistics laboratory

This section provides information about how to set up a psycholinguistics laboratory in terms of the hardware and software required and how much this could cost. It is not an exhaustive list of all hardware and software packages available, but it includes the ones that are most widely used in language comprehension studies.[2]

[2] The presentation of software available for production experiments is beyond the scope of this article. However, it is worth mentioning the program ScriptLog that enables research on the online process of writing by keeping a record of all events on the keyboard, the screen position of these events and their temporal distribution (see Holmqvist *et al.*, 2002 and the website of the program http://www.scriptlog.net).

Needless to say, a prerequisite for setting up a psycholinguistics laboratory is the availability of a quiet room. Depending on space availability in the department, this might be the most challenging difficulty to tackle, but it is worth fighting for, as running experiments in an office is possible but unsustainable in the long run.

Concerning hardware, software and other equipment, setting up a psycholinguistics laboratory for online experiments is relatively easy and it does not require a very large budget. The absolutely necessary equipment is a desktop PC or laptop, along with software that controls the presentation of the visual and/or auditory stimuli and records the reaction times of the subjects; hardware and software for recoding and preparing auditory and/or visual stimuli is also a prerequisite.

The type of computer (PC or Mac) and the requirements (processor, RAM memory, capacity of the hard disc) depend on the software chosen. At the moment the most widely used software packages are PsyScope for Macs and Nesu and E-prime for PCs. All three software packages are capable of presenting visual and auditory stimuli including videos, and so they are suitable for running online psycholinguistic experiments. Choosing which one of the three software packages to buy depends mainly on the specific conditions in the department, such as using Macs or PCs, price, availability of technical staff, etc. Advantages and disadvantages of the three programs are discussed in turn with the aim of helping researchers to decide which of the three is most suitable for them.

1 PsyScope

PsyScope was developed at Carnegie Mellon University, it is available for free and it can be downloaded from the internet from http://psyscope.psy.cmu.edu. As its development has ceased, it is compatible with all Mac systems from OS7 to OS9, including the Classic environment under OSX, and it is compatible with all Apple hardware produced in the last six years, but it does not work with Mac OSX.

No additional hardware is needed for running online experiments apart from a push-button box for measuring reaction times.[3] The push button-box can be purchased from New Micros http://newmicros.com and it costs from $400 to $550 depending on

[3] It is also possible to record reaction times by pressing a key on the keyboard or using the mouse instead of using a push-button box. However, reaction times on the keyboard are not very reliable due to the existence of the other keys that may act as distracters.

whether the purchaser is in the USA or another country and on the mode of payment. The price includes a cable for connecting the push-button box to the Mac, a cable for power supply, shipping and handling.

A manual for the software is available to download from the internet with information about requirements, functions, how to set up and run an experiment, and troubleshooting. Knowledge of programming is not necessary, as the designing of experiments takes place through a graphical interface. For experiments that cannot be accommodated through this graphical interface, users have to construct their own script in *PsyScript*. A detailed introduction and a reference guide to this language are given in the manual, and several scripts can be downloaded from the PsyScope website.

As far as technical support is concerned, there is no user support but users can exchange insights through the Info-PsyScope mailing list info-psyscope@mail.talkbank.org, and an archive of previous emails from the list can be retrieved from the LinguistList website at http://listserv.emich.edu/archives/info-psyscope.html. At the moment there is no alternative to PsyScope if one wants to run experiments on a Mac, but note that several users are currently involved in a project designed to update PsyScope for MacOSX,[4] and E-prime is also in the process of designing a version for Macs.

2 *Nesu*

Nesu was developed at the Max Planck Institute for Psycholinguistics in Nijmegen and it can be downloaded for free from the internet at http://www.mpi.nl/tools/nesu.html. Until recently it ran under Dos, but the new version (Nesu2000) runs on Windows (but only on Windows2000). For the control of experiments, it requires additional hardware: the Nesu-Box that plugs into the printer port and a push-button box.

There are currently two Nesu-Boxes available, NesuBox2 and PC-Box. NesuBox2 can be purchased from Hasomed (http://www.hasomed.de) and its current price is €2812 (plus tax, shipping and handling, and there is a 5% discount for universities). The PC-Box can be purchased from the Max Planck Institute (http://www.mpi.nl/world/tg/experiments/devices_nesu.html) and costs €400. NesuBox2 has more functions than PC-Box with respect to how many devices it can accommodate, PC-Box does not have power supply and it does not have a microphone amplifier. For a basic psycholinguistics laboratory the number of devices is not very

[4] For more details, see the PsyScope website and the archive in the LinguistList.

important because a psycholinguistics experiment typically involves one subject and, thus, one push-button box and one voice key are mostly sufficient. The major difference between the two boxes concerns the microphone amplifier. As PC-Box does not have a microphone amplifier, in order to run voice key based experiments one has to use a digital recorder, which will amplify the microphone signal. There is one type of push-button box available for both boxes. The push-button box has been developed by the Max Planck Institute and it has two keys, one in red and one in green. It costs €100.[5]

The manual for the Nesu software can be downloaded from the internet. However, the manual that is currently on the internet is for the Dos version of the program and not for the Windows version. As several features have changed in the new version, this means that for somebody who is not familiar with the Dos version it is very difficult to follow the manual. Moreover, there is very little information about installation and how to establish the communication between the Nesu-Box and the PC; for somebody who has never worked with the system this provides insufficient information for getting Nesu to work.

Simple experiments are easy to design through a graphical interface, but complicated experiments have to be programmed by the user. The language for programming is *SmallTalk*, the basic functions of which are given in the manual. Basic knowledge of the language by some technical staff in the department is desirable but not absolutely necessary, as the technical staff of the Max Planck Institute are very helpful, and they help with constructing a script upon request.

Support is available via email from the technical team of the Max Planck Institute, who are indispensable if there is no technical staff available in your laboratory. The Max Planck Institute periodically organizes introductory courses to the Nesu system for new users, and it also hosts an emailing list for the users of Nesu (majordomo@mpi.nl). Participating in an introductory course and email contact with the technical team and other Nesu users can compensate for the insufficient information of the manual.

The current version of Nesu is much more user-friendly than the old one because it runs in Windows. However, it is a beta-version with the pertaining problems of beta-versions. Installing the software is easy, but making the Nesu-Box communicate with the PC is not a trivial task.

[5] As with PsyScope, the keyboard and the mouse can also be used for recording reaction times instead of a push button (but see footnote 3).

3 *E-prime*

E-prime (http://www.pstnet.com/e-prime) is a commercial program and at the moment the most user-friendly software for PCs. It runs on Windows 95/98/ME/2000/XP, and it does not need extra hardware apart from a push-button box. The cost for purchasing E-prime ranges from $695 for a single user system (plus shipping and handling) to $3000 for a multi-pack system, plus $400 for each licence beyond five (plus shipping and handling).

The push-button box (PST Response Box) has five keys and the number of keys can be increased to eight via an integrated expansion port. The keys can be labelled in accordance to the experiment and labels are provided with every push-button box set. Additionally, it has five lamps and the set includes five coloured lamp covers. Finally, it has an integrated voice key that allows for vocal latencies to be collected (but it does not record vocal responses). The price of the push button box is currently $450 (plus shipping and handling). An alternative to a key press and to collection of vocal latencies is provided in E-prime with a foot pedal.[6] The foot pedal connects to the PST Response Box and enables collection of the subject's foot responses to stimuli. The foot pedal currently costs $39 (plus shipping and handling).

On purchasing E-prime, a manual is sent with detailed information about installation, functions, how to set up and run an experiment, data analysis, troubleshooting, etc. Designing experiments is very easy and takes place through a graphic interface. If the user has some special needs that cannot be covered in the graphical interface, he or she has to write his or her own script in *E-basic*. An introduction to programming, an introduction to *E-basic* and a reference guide are included in the manual that covers a wide range of issues. As with Nesu, technical staff are willing to help with constructing tailor-made scripts.

Support is available over the internet at http://www.pstnet.com/e-prime/support/. An emailing list is available for exchange of information between users (http://step.psy.cmu.edu) and there is an archive with previous emails at LinguistList (http://listserv.linguistlist.org/archives/eprime.html).

E-prime is the most user-friendly software package running on PCs. Consequently, it is the best choice within the Windows environment if the department does not have technical staff that will support a psycholinguistics laboratory.

Apart from the computer and the software, depending on the

[6] Another alternative, as with PsyScope and Nesu, is using the keyboard or the mouse (but see footnote 3).

type of experiment some other equipment is necessary. For an auditory experiment, a digital recorder and a microphone should be used for recording the auditory stimuli and software that creates and enables editing of auditory files. Headphones (or loudspeakers) are necessary for presentation of auditory stimuli. A second set of headphones is useful so that the experimenter is able to follow the experiment. Pictures for visual experiments can be downloaded from the internet, as there are several archives on the internet that can be used in online experiments. A scanner is necessary for digitalizing drawings/pictures that are not available from the internet.

V Conclusions

Within the last decade, a handful of studies in second language acquisition have used online techniques to investigate how second language learners process sentences in real time. The results, such as the ones reported in Section II, have been able to elucidate long lasting debates. However, for the use of online techniques in second language research, setting up a psycholinguistics laboratory is necessary.

The goal of the present article is to inspire researchers in second language acquisition to embark on research using online methodologies. This has been undertaken by presenting the benefits of using online processing experiments in second language research, by illustrating a few widely used online experiments that are suitable for research in second language acquisition, and most importantly by presenting the facts as to what is needed with respect to hardware and software and the financial costs of setting up a psycholinguistics laboratory.

As shown in this article, the setting-up of a psycholinguistics laboratory is neither difficult nor very expensive. By combining traditional research methods with online techniques, deficits of grammatical competence can be distinguished from processing deficits, as limiting factors in second language learners' ultimate attainment. Hence, online research provides insights into the relationship between grammar and processing, and thus to a range of learnability issues, including the accessibility of UG, the role of transfer and the critical period in second language acquisition.

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VII Useful websites

PsyScope

- http://psyscope.psy.cmu.edu (website of the software)
- http://newmicros.com/ (website of New Micros that develops the push-button box)
- http://listserv.emich.edu/archives/info-psyscope.html (archive of the emailing list)

Nesu

- http://www.mpi.nl/tools/nesu.html (website of the software)
- http://www.hasomed.de/ (website of Hasomed that develops NesuBox2)
- http://www.mpi.nl/world/tg/experiments/devices_nesu.html (website of the Max Planck Institute with information about the PC Box, push-button box and other devices)

E-prime

- http://www.pstnet.com/e-prime (website of the software)
- http://step.psy.cmu.edu (emailing list)
- http://listserv.linguistlist.org/archives/eprime.html (archive of the emailing list)

ScriptLog

- http://www.scriptlog.net (website of the software)