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Morphological and semantic priming in word recognition

Imprimación morfológica y semántica en el reconocimiento de palabras

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ABSTRACT

Word recognition is investigated along with semantic priming. While semantic priming has received attention among scholars investigating language processing in the last five decades, the literature lacks an investigation of semantic priming in word recognition among native and non-native German-speakers. To investigate the differences in how native speakers (L1) and non-native speakers (L2) of recognize words, and their corresponding speed, we designed two experiments consisting of two conditions; when the primes are associated with the target word, and when the primes are not related to the target word. For the semantic category, identical conditions were designed; when the primes are associated with the target word, and when they are not related to the target word. Reaction Time (RT) and accuracy were obtained during the experiments on both groups (L1 and

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L2). The experiment was controlled by the DMDX software package. The results indicate that there are no such differences among native speakers (L1) and non-native speakers of the German language unless in individual choices. There are similarities among first language speakers (L1) and second language speakers (L2) in both categories —morphology and semantics. The delay would occur when non-native speakers see a word in morphological and semantic priming.

1. INTRODUCTION

Word recognition plays a great role in understanding the way humans process language (Khatin-Zadeh et al., 2022a, b). Word recognition is described as letters serving as the building blocks of words in alphabetic writing techniques, which shows the recognition of letters in the central models of visual word processing (Yab & Balota, 2015). Word recognition is investigated along with semantic priming (Banaruee et al., 2017), concepts meaning is derived from a suppressive-oriented process, where unnecessary features of a concept in a relevant context are filtered out, thus primes can initiate which salient feature is primarily considered during the process (Khatin-Zadeh et al., 2017; 2019a, b). In this vein, priming has received attention for use in morphology, semantics, and phonology. Semantic priming has received attention among scholars investigating language processing in the last five decades (e.g., Khatin-Zadeh, 2023; McNamara, 2005; McDonough & Trofimovich, 2011; Meyer & Schvaneveldt, 1971). To study semantic priming, the participants are provided with a cue word (e.g., TREE) followed by either a semantically related (e.g., PLANT) or unrelated (e.g., TRAM) target word. It is considered as the decrease in the response latency for the target words that are semantically related to their cue words in comparison to unrelated items (Meyer & Schvaneveldt, 1971).

McClelland and Rumelhart (1981, 1982) investigated the effect of words on letter recognition. They present a model with three layers: one layer each for features, letters, and words. In addition, several models for visual word recognition in human language processing have been described (see McClelland & Rumelhart, 1981; Jacobs & Grainer, 1994; Coltheart et al., 1977; Forster, 1976; Grossberg & Stone, 1986; Carr & Pollasteck, 1985). Moreover, a compelling discussion has recently covered the investigation of word recognition with priming in the native (L1) and non-native language (L2), particularly in morphology and semantics; in the context of German (e.g., refer to Askari et al., 2017; Bayen & Smolka, 2020; Hasenäcker et al., 2016; Lüttmann et al., 2011) and in English (e.g., see Jiang & Wu, 2022; Diependaele et al., 2011). The related literature lacks sufficient support in comparing the speed of native and non-native German speakers in word recognition, and the potential differences among the first language and second language speakers in word recognition based on the semantic priming effects. Hence, this study aimed to examine how morphological and semantic priming affects word recognition among native and non-native German speakers. It might be assumable that native speakers (L1) and non-native speakers (L2) of a language would differ in their word recognition abilities, and native speakers would relatively be quicker and more accurate that the L2 learners. The delay would occur when non-native speakers see a word in morphological and semantic priming. The current investigation employed two experiments (similar to Lüttmann et al., 2011, and Diependaele et al., 2011) and two conditions: 1. when the primes are associated with the target word (e.g., aufstehen-STEHEN), and 2. when the primes are not related to the target word (e.g., prestehenis-STEHEN). For the semantic category, identical conditions were designed; 1. when the primes are associated with the target word (e.g., mitteilen-KOMMUNIZIEREN), and 2. when they are not related to the target word (e.g., tecommunizlos-KOMMUNIZIEREN).

1.1. Word Recognition

Word recognition is described as the building blocks of words are letters in alphabetic writing approaches, which shows the recognition of letters in the central models of visual word processing (Yab &

Balota, 2015). In other words, the letters are the core in the model of word recognition that constructs a word to be formed. McClelland and Rumelhart (1981,1982) investigated the impact of words on letter recognition. They present a model that includes three layers: one layer represents features, one represents letters, and one layer represents words. The word level exists in the model so as to permit word representations to affect letter recognition (Schade, 2023). The model represents two kinds of linkages, which are facilitation and inhibition. Moreover, a number of basic approaches are involved in successful word recognition within a lexicalist framework (e.g. Jacobs & Grainger, 1994). First, it is essential for the reader to encode the input stimulus by constructing some representation of the sensory input signal. Second, the input code must be matched against abstract long-term memory representations, which is a lexical code. Lastly, some matching must be met in the reader's vocabularies (Davis, 2010). According to Carr and Pollatsek (1985), the model of visual word recognition can be attached to many features. For instance, the category of models of word recognition includes the essential difference between identical coding systems versus lexical instance models.

Moreover, Jacobs and Grainger (1994) divided the visual word recognition model into several families: Logogen and multi-component models, Serial search and verification models, Dual-route models, Resonance, Interactive-activation, and Parallel distributed processing models (It describes the prototype of a canonical resonance model of McClelland and Rumelhart, 1981), Parallel coding systems models, and Fuzzy logical models. First, the *Logogen and multi-component model* is described by Morton (1969), which is mathematical as a format, perceptual identification as in a task, and percentage correct in the dependent variable. Also, it is a deterministic, localist, macro, modular, interval, performance, parallel, and static model. The model includes the frequency effect. Rumelhart and Siple (1974) described the model as Morton's (1969), except in adding the word superiority effect. However, Coltheart et al. (1977) explained the model somewhat different in format (verbal), task (lexical decision task), and dependent variable (reaction time correct). Their model also includes frequency effect and orthographic neighborhood. Second, *Serial search and verification model* is explained by Forster (1976). It is verbal in format. Its task is lexical decision task, and its dependent variable is reaction time correct. The model is a deterministic, localist, macro, modular, ordinal, performance, serial, and static. It includes the frequency effect. Paap et al. (1982) described the Serial search and verification model differently: the model is based on algorithm(format), perceptual identification and lexical decision task(task), percentage correct and reaction time correct (dependent variable). The model also includes micro as a modular. It has frequency effect, word superiority effect, and orthographic neighborhood. Third, the *Dual route model* in visual word recognition is represented by Coltheart and Rastle (1994), which is based on an algorithm as a format, lexical decision task and naming task (as a task), and correct reaction time (as a dependent variable). The Dual route includes deterministic, localist, micro, interval, performance, parallel, and dynamic features. Most importantly, frequency effect, word superiority effect, orthographic neighborhood, and regularity or consistency existed in the Dual route model. Fourth, *Resonance, interactive-activation, and parallel distributed processing model*: McClelland and Rumelhart (1981) described the model as depending on an algorithm in format, perceptual identification in a task, and percentage correct in the dependent variable. According to McClelland and Rumelhart, the model is deterministic. It is localist, micro, and interactive. It also covers interval, parallel, performance, and dynamic features. The model contains the frequency effect, word superiority effect, and orthographic neighborhood effect. Grossberg and Stone (1986) provided a different explanation of the model in several features and formats. As they explained, it is verbal in formatting, lexical decision task in tasking, perceptual correct and correct reaction time in the dependent variable. The features of the model compared to McClelland and Rumelhart include macro, distributed, ordinal, and static. However, Jacobs and Grainger (1992) developed the Resonance, interactive-activation, and parallel distributed process model in format (algorithm) and a task (lexical decision task and perceptual identification) specifically. The model has involved the word superiority effect and orthographic neighborhood (for a recent review of the psychological models in language processing, see Banaruee et al., 2023 a). Fifth, the *Parallel coding system model*, is defined by Carr and Pollasteck (1985), which is based on verbal (format), lexical decision tasks, naming tasks, perceptual identification (tasks), and correct percentage and correct reaction time (dependent variable). The model attached to several features: macro, modular, deterministic, localist, ordinary, parallel, and static. It holds the frequency effect, word superiority effect, and regularity or consistency effect. Besner and McCann (1987) have shown some fluctuations to the Parallel coding system in the task (e.g., lexical decision and naming tasks) and in the dependent variable (e.g., correct reaction time). Their model has an orthographic neighborhood effect, but it does not have a word superiority effect. Lastly, *Fuzzy logical model* illustrated by Massaro and Cohen (1991), its format is based on mathematics, its task is perceptual identification, its dependent variable is the correct percentage, and the correct reaction time frame. It is dynamic and it contains only the word superiority effect. Finally, visual word recognition functions, as it is a computational model (as presented by McCelland & Rumelhart, 1981), but not in all languages; for instance, Arabic and Kurdish: pronounce the word as it is. If their speakers hear a word (a word they have not heard for years), they would easily write a word without spelling errors. The speakers memorize the word according to how it sounds not how it is written (shape). In contrast, the languages such as English, French, and German, the speakers memorize the shape and the sound of the word at the same time; therefore, errors in the spelling occur when a word is rarely used.

1.2. Priming: Morphology, Semantic, Orthographic

Orthographic neighborhood is a word that could be replaced by a single letter of a target word (Coltheart, et al., 1977). For instance, the neighbors of a German word *lassen* would be *fassen, lessen, passen, and nassen*. However, Yates (2005) explained that the quickened pronunciation, semantic classification, and reading, from which the words with multiple phonological neighbors react quicker than those words within which have few phonological neighbors in a lexical decision. Some scholars (e.g., see Banaruee et al., 2022; Forster, 1998; Kinoshita & Lupker, 2004) argued that the primes could be masked —conscious processing is concisely minimized. Also, the prime could be unmasked, which is consciously available. When the masked priming paradigm is performed by the participants, they are not conscious of the connection between the prime and the target. The two-word row is introduced in the priming paradigm that enables somewhat similar dimensions, such as in morphology (sleeping-SLEEP), in phonology (deep-SLEEP), in semantic (bed-SLEEP), and in orthography (bleep-SLEEP). Furthermore, Rastle et al. (2000) claim that the masked morphological priming paradigm is a tool of a morphological process that investigators trust, by which the recognition of the target word is facilitated. For instance, the word *SLEEP* is facilitated by the word *sleeper* —masked presentation of related words morphologically. Also, Rastle et al. (2004) noted that masked morphological priming effects are identical in extent for transparent (e.g., cleaner—CLEAN) and opaque (e.g., corner—CORN). Regardless, Meyer and Schvaneveldt (1971) hold the view that the semantic priming effect directs to the concentrated result when words are remembered faster, which are prime-related semantically, such as tea-COFFEE. The pair words (target specifically) are slower identified when they are prime-unrelated (e.g., salt-COFFEE). The semantic priming effect is mostly a vivid amenity when the effect reflects between the two words that are connected (Khatin-Zadeh et al., 2023a, b, c; McNamara, 2005). Nevertheless, vocabulary plays an important role in semantic priming, especially with second language speakers. Yap et al. (2009) claimed that vocabulary knowledge affects the effects of priming and word frequency. Lastly, priming effects are crucial in all aspects of identifying word recognitions task, specifically morphology and semantic.

1.3. German: Second Language/Bilingual

The study by Baayen and Smolka (2020) conveys modeling morphological priming in German: naive discriminative learning. They investigated the priming experiment for transparent and opaque pairs. They show the results of a model that includes computational implementation of Word and Paradigm Morphology (WPM) and Naive Discriminative Learning (NDL). As they claimed, the semantic similarity measure is emanated from distributional semantics that enables the prediction of lexical decision latencies, from where a naive discriminative learning network is derived. In addition, they suggested that several studies revealed the German language shows identical priming for transparent and opaque prime-target pairs, which signifies the intervention of lexical accessibility in the stem, and an independent of degrees of semantic formatting. More, in the study by Hasenäcker, Beyersmann, and Schroeder (2016), they examined masked morphological priming effects on German adults and children. They ran an experiment with comparable suffixes such as suffixed word primes: *herzlein-HERZ*, suffixed non-word primes: *herztum-HERZ*, non-suffixed non-word primes: *herzekt-HERZ*, and unrelated controls*: kraftlos-HERZ*. As they argued, priming in adults directed to facilitation from suffixed conditions relative to non-suffixed non-words, which delivers evidence for embedded stem priming and morpho-orthographic stem priming. On the other hand, children demonstrated facilitation somewhat in the same as adults, but they did not show the difference between the suffixed and non-suffixed conditions, which shows that the children did not make use of morpho-orthographic segmentation. Moreover, Lüttmann, Zwitserlood, and Bölte (2011) researched the effect of derived verbs on the production and recognition in morphology: related simple verbs using a production and a comprehension task. The target verb such as *zählen* was primed by morphologically related verbs: semantically transparent as in *verzählen,* semantically opaque as in *erzählen,* semantically related as in *rechnen*, and phonologically related as in *zähmen*. The results indicated that morphologically related complex verbs delivered faster picture naming latencies in the production task and faster lexical decision latencies in the comprehension task. On the contrary, the verbs that are related semantically did not reveal any reliable effects.

Furthermore, Jiang and Wu (2022) studied the first and second-language differences by reaching English native speakers and non-native speakers in the masked priming paradigm using a lexical decision task. They did not use any semantic or morphological connection. Their stimuli contained prime-target pairs with orthographical overlapping at the *pre and post-position* of a word, such as *rubber-rub* and *stage-age*. There are two interpretations of the first and second language difference: one focusing on the representational aspect and another concentrating on the processing characteristics of the second language speakers' lexicon. Their results show that orthographic priming with second language speakers for words was with both overlap positions. However, Heuven et al. (1998)'s study on bilinguals (English and Dutch speakers) showed that the orthographic neighbors in Dutch delayed in responses times to the target word when it was an English word in Dutch. They use progressive demasking and lexical decision experiments. The facilitation was shown by Monolingual English speakers because of English neighbors not because of the effect of Dutch neighbors. Besides, examining a second language or bilingual speakers, Diependaele et al. (2011) used three experiments by masked morphological priming lexical decision task on English native speakers, Spanish-English, and Dutch-English bilinguals. They used stem priming with transparent suffixed primes such as *viewer-view,* opaque suffixed, or pseudo-suffixed primes as in *corner-corn,* and form control primes like *freeze-free.* Their data do not indicate significant distinctions among the three experiments. Their data verified that bilinguals mainly choose the same processing techniques as native speakers as Lemhöfer et al. (2008) hypothesized it.

However, morphology, semantics, and phonology in priming affect a speaker who understands more than one language. The processing of identifying a word delays because a speaker judges a word that has been seen or heard, and thinks to which language that word belongs, especially when a speaker is familiar with German, French, English, Spanish, or a very identical language in alphabetic writing system; for instance, German, French, Spanish, English, Italy, all of which have almost similar alphabets. A speaker who knows two or more such languages delays in word recognition even if it is a single millisecond second. But a speaker who knows only a mother tongue language (e.g., German). A speaker would be faster at recognizing German words than those who know more languages. At the same time, if a speaker were familiar with only Japanese, English, and Arabic, a speaker would not have problems with word delaying recognition; instead, a speaker would recognize a word as a native speaker does.

2. METHODOLOGY

This section contains the study's design, which includes the layout of the two experiments. The participants are also detailed along with information about their age and language abilities. The procedure demonstrates the control that was applied to the experiments. Further, this section includes the research questions and the null hypothesis. It contains the prediction, which foresees the investigation's findings. Finally, the methods used for data analysis in this study are explained.

2.1. Design

This study was designed similar to the research by Lüttmann et al. (2011) and Diependaele et al. (2011). Hence, two experiments were designed. In experiments, there were (40) German words employed as word targets. Each target had a pair with two primes: a related and an unrelated word. The unrelated primes were non-words that shared the stem of the target word: the beginning and the end of the target word were manipulated. There were words matched to the related primes on length and frequency for all items consistently. Related primes were either a morphological relative of the target (e.g., aufstehen-STEHEN) or a word that shared the same stem as existed in the target(verstehen-STEHEN), or unrelated such as prestehenis-STEHEN.

The semantic category contained verbs that are semantically related to the target such as mitteilen-KOMMUNIZIEREN, and all words for the semantic category come from German online dictionary (https://synonyme.woxikon.de/) as synonyms. It also included primes verbs that were not semantically related to the target as in tecommunizlos-KOMMUNIZIEREN. The morphology package contained (20) target words: (10) primes were related to the target and (10) primes were not related to the target. The semantics package also included (20) target words; (10) primes were related, and (10) primes were not related to the target word. In both experiments, all primes and targets were represented in the infinitive form; for example, kauf+en. There were morphological and semantic priming related and unrelated primes to the target.

2.2. Participants

In the present study, there were two groups of participants: German native speakers and non-native speakers of the German Language –whose first language was not German. In experiment one, there were (25) German native speakers aged (25 to 31). There were non-native speakers of the German language in the second experiment. Their mother tongue was not German, they were (27) participants aged (22 to 33). The second group was formed by participants who had lived for more than six years in Germany (only two subjects lived in Germany for five years). The subjects, who lived for more than five years in Germany, showed their language proficiency level in German language (e.g., B2 in TELC and some showed C1). The participants who live in Germany for five years (only two participants) showed their proof of German language proficiency (e.g., B1 in TELC). Each group of German native speakers (L1) and German non-native speakers (L2) participated in both experiments. The participants agreed the digital consent form (in German language) before participating in the experiments (see appendix).

2.3. Procedure

Forster and Davis (1984) used the strategies of masked priming in visualization experiments. There were two experiments in the present study —each experiment consisted of two trials: morphology and semantic priming. First, a hash sign acted as the focal point for 500 ms. Second, a row of hash signs for 500 ms acted as the mask. Third, the stimuli occurred on a computer screen in black letters in Times New Roman font, size 36 with a white background. Fourth, the primes were shown in lowercase and the targets are in uppercase. Fifth, each experiment session contained 40 prime-target pairs: 20 morphological primes (10 related and 10 unrelated to the target) and 20 semantic primes (10 related and 10 unrelated to the target). Lastly, the subjects were asked to act as quickly and accurately as possible to press a button if the target was a word and avoid any action when the target was a non-word. Participants were tested individually in a quiet room by using a Dell laptop screen. The instructions were provided to the participants before running the experiments. Reaction Time (RT) and accuracy were obtained during the experiments on both groups (L1 and L2). The experiment was controlled by the DMDX software package similar to Forster and Forster (2003).

2.4. Research Questions/Null Hypothesis

The research questions of the study are described as follows:

- What are the differences among the first language and second language speakers in word recognition priming; to what extent their choices on accuracy are similar or different in deciding on words?
- Are second-language speakers of German (L2) as fast as native speakers of German (L1) in word recognition?

The null hypothesis: there would be a difference between the native speakers (L1) and non-native speakers (L2) in word recognition. Native speakers would be faster and more accurate than non-native speakers. The non-native speakers would be delayed because when they see (hear) a word, the input word would activate many related words that are connected to the target at the same time. The non-native speakers would be in the inhibition process to decide on the target word; in this process, they would be delayed.

2.5. Prediction

The prediction was that the L1 speakers would recognize the words more accurately and fluently in the morphological priming of the prime-related target. They would also be quicker in the semantic-related priming target than second language (L2) participants. Unrelated priming targets in German L1 would be a few milliseconds slower than related priming targets. Their reaction time and accuracy would be superior to those of second group participants. On the other hand, the non-native group (L2) would have some delays in recognizing words in both morphology and semantic primes. The second language speakers would be slower because when they see the words, they have to categorize in their minds which word belongs to which language; thus, deciding on words so fast would be delayed. In other words, when a word is seen, the inhibition would activate the word relatedness (specifically morphologically) in the mind. In the activation process (because the German language is not usually used at first), there would be a delay for the non-native group in word recognition (even if in 00001 ms). However, the L1 speakers of German would not have such difficulties because of the cultural effect (what they see and hear is German, and the German language is usually at the first to be used); and because of the times they speak it the most. The cultural effect for non-native speakers' group is the same in many ways (depending on which language comes first for them), but L1 is more experienced than L2 are in German.

2.6. Analyzing the Data

The reaction time (RT) and accuracy were main focus for analyzing the data. The priming effect is generally taken into accounts. The accuracy of the data was based on participants' responses below (10,000 <) milliseconds. For the morphological and semantic primes-related, the answers (10,000 < ms) were considered accurate (e.g., 7,000 ms). The responses were considered not accurate when a participant spent more than (10,000 > ms). For the morphological and semantic not prime-related, the accuracy was measured below (13,000 < ms), such as (11,000 ms), which was considered accurate. The reaction was not accurate when they were above (13,000 > ms). Reaction time for both groups was analyzed in linear regression using *JASP* software. Accuracy and priming effect were quantified in *Microsoft Excel.*

3. RESULTS

The two experiments analyses are included in this part. In the first experiment, there are morphological primes that are (un)related to the target, and semantic primes that are (un)related to the target. The second experiment contains morphological primes (un)related target (L2), and semantic primes (un)related target (L2). Additionally, the joining analyses of the two groups—native German speakers (L1) and non-native speakers (L2) are included in this section. This section concludes with a discussion, that connects the findings of the current study to previous researches in the field.

3.1. Experiment One

The native German group is involved in experiment one. They have been tested on morphological priming lexical tasks: primes (un)related to the target. They also have been tested on a semantic lexical task, which includes primes (un)related to the target. More, table (1) indicates the age and number of participants in experiment one.

Table 1 Descriptive Statistics

	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Age	24	0	25.542	3.934	20.000	33.000
Native speakers (L1)	24	0				

3.1.1. Morphological Primes Related Target (L1)

The results of native speakers of German in morphological primes related to reaction time show that the responses out of (10) primes that are connected to the target are between (6-12 ms) as presented in chart (1), which points fast responses in word recognizing.

However, table (2) of German native speakers suggests the participants' reaction time in *mean*, *standard deviation (SD)*, and *standard errors (SE)*. The *mean* reveals that most of the responses are close to one another since the *standard deviation* and *standard error* are transient.

Chart 1

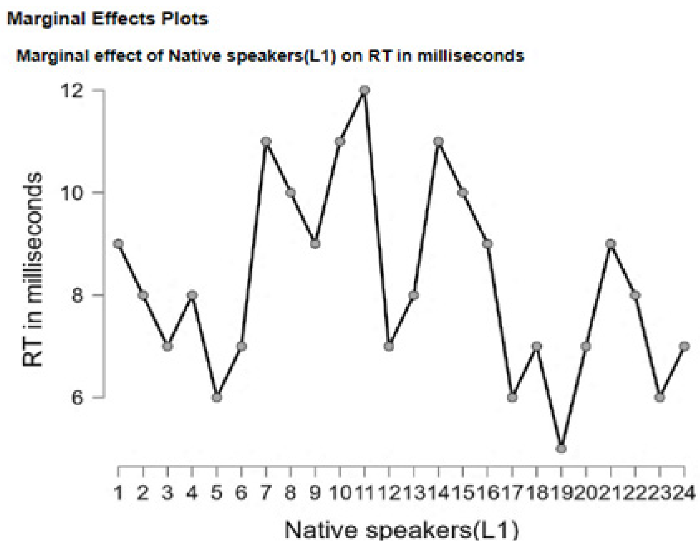


Table 2 Descriptives

	N	Mean	SD	SE
RT in milliseconds	24	8.250	1.871	0.382

Moreover, table (3) implies when the participants (N=24) decided on priming-related to target in morphological lexical task experiment. The *t-value* (21.604) in a table (3) approves the reaction of the participants in determining whether the prime-related pair (e.g., anmachen-MACHEN) is a German or not a German word. It assures most German native speakers are fast since *the p-value* is <.001, which confirm significant results. Table (3) below is a short summary of two participants in the reaction time. For all (24) participants' reaction time, see the appendix (table 3) for details.

Table 3 Coefficients

Model		Unstandardized	Standard Error	Standardized	
				t	p
H_0	(Intercept)	8.250	0.382	21.604	< .001
H_1	(Intercept)	9.000	NaN	NaN	NaN
	Native speakers(L1) (2)	-1.000	NaN	NaN	NaN
	Native speakers(L1) (24)	-2.000	NaN	NaN	NaN

3.1.2. Morphological Primes Not Related Target (L1)

Native speakers (L1) reveal different results when the primes are not related to the target, as illustrated in a chart (2). The participants were delayed in making a decision on German words. The fastest reaction time is (11,000 ms), and the delaying process is (19,000 ms). It makes clear the effect of priming when primes are not related to the target. There is no a participant that could finish (10) unrelated words trial in less than (10,000 ms). The reaction times with German native speakers are delayed when the primes are not target related.

Furthermore, table (4) displays somehow distinctions from the prime morphological-related target. It illustrates that the *mean* is large; the reaction time of participants' responses is fairly close to one another. However, there is a difference in *means*, *standard deviation (SD)*, and *standard errors (SE)*, which reveal participants are faster when the primes are associated with the target, and they are somewhat slower when the primes are not related to the target in the morphological priming category.

Chart 2

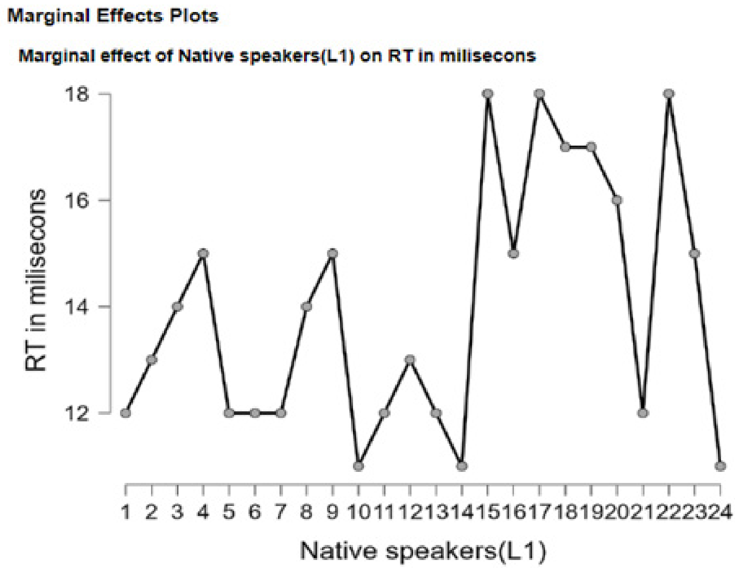


Table 4 Descriptives

	N	Mean	SD	SE
RT in milliseconds	24	13.958	2.386	0.487

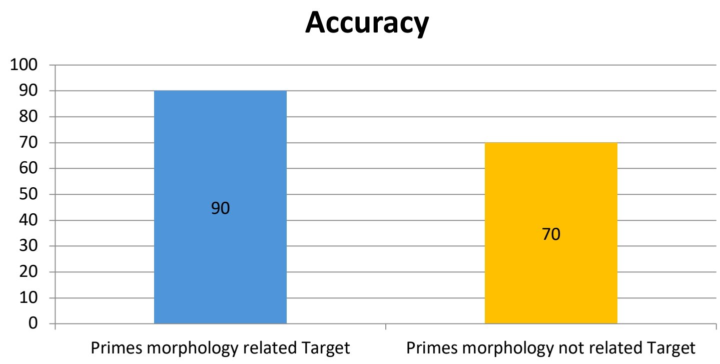
Besides, the *t-value* (28.657) in table (5) points to the reaction of the participants, which assures that the responses are somehow fast, but not fast as the primes target related. The *p-value* is <.001, which comforts that the participants are rather fast-not fast enough as primes related to target. The *p-value* indicates the significant results (For all the participants' reaction time, see table (5) in appendix).

Table 5 Coefficients

	Model	Unstandardized	Standard Error	Standardized t	p	95% CI Lower	Upper
H_0	(Intercept)	13.958	0.487	28.657	< .001	12.951	14.966
H_1	(Intercept)	12.000	NaN	NaN	NaN	NaN	NaN
	Native speakers (L1) (2)	1.000	NaN	NaN	NaN	NaN	NaN
	Native speakers (L1) (24)	-1.000	NaN	NaN	NaN	NaN	NaN

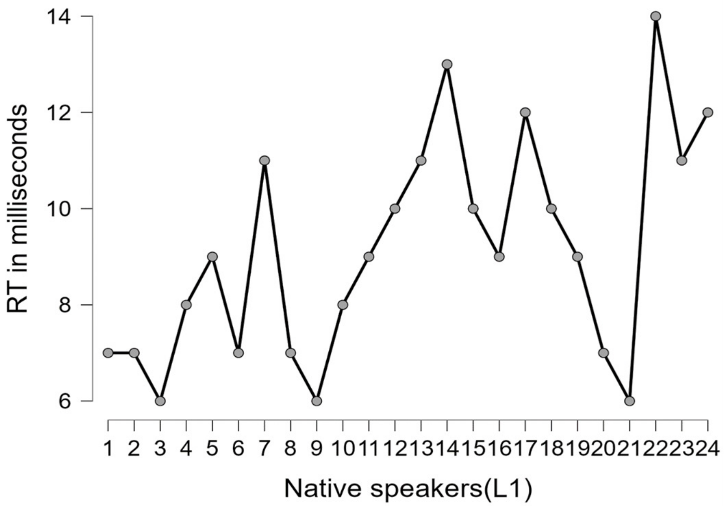
Furthermore, the accuracy of native speakers (L1) in the prime's morphological-related-to-the-target category shows (90%) accuracy, as shown in chart (3). However, it is (70%) when the primes are not related to the target.

Chart 3 Native Speakers (L1)



3.1.3. Semantic Primes Related Target (L1)

Chart 4



German native speakers are quick in the semantic category when the primes are linked to the target. Fourteen subjects determined (10) target words in less than (10,000 ms), as shown in chart (4).

However, in table (6), the *mean* is enormous than the *standard deviation* and *standard errors*, which suggests the reaction time of group one in semantic primes linked to the target. Furthermore, the *t-value* in a table (7) notices that the reaction time of all participants is neighbored since the *t-value* is large (19.360). However, the p-value with (<.001) confirms that the participants' responses are so tight to one another. It reveals the significant results (see detail of table (7) in the appendix).

Table 6 Descriptives

	N	Mean	SD	SE
RT in milliseconds	24	9.125	2.309	0.471

Table 7 Coefficients

	Model	Unstandardized	Standard Error	Standardized	
				t	p
H_0	(Intercept)	9.125	0.471	19.360	< .001
H_1	(Intercept)	7.000	NaN	NaN	NaN
	Native speakers (L1) (2)	9.002×10^{-16}	NaN	NaN	NaN
	Native speakers (L1) (24)	5.000	NaN	NaN	NaN

3.1.4. Semantic Primes Not Related Target (L1)

German native speakers present their reaction time from (12.000 ms) to (20.000ms) when the primes are not connected to the target words. As the chart (5) indicates, the native group of Germans in the semantic category did not complete the (10) unrelated primes to the target in less than (10,000 ms). Moreover, the *mean* is extensive, as demonstrated in table (8). Regardless, it does not explain that native speakers of German are fast in the semantic category when the primes are not associated with the target. However, German native speakers are fast in their reaction time in the semantic prime related target. The standard error (SE) is larger (0.642) in primes-not-related-target than primes-related-target (0.471). Further, the t-value in table (9) shows the responses of native speakers of German are related to one another since the *t-value* is immense (25.889). The *p-value* (<.001) assures that the responses are tied (the reaction time of all participants of table (9) can be seen in appendix). The results are recognized as significant.

Chart 5

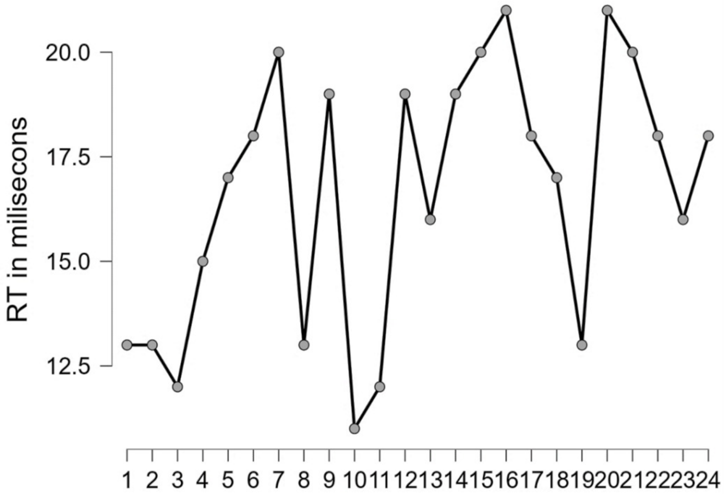


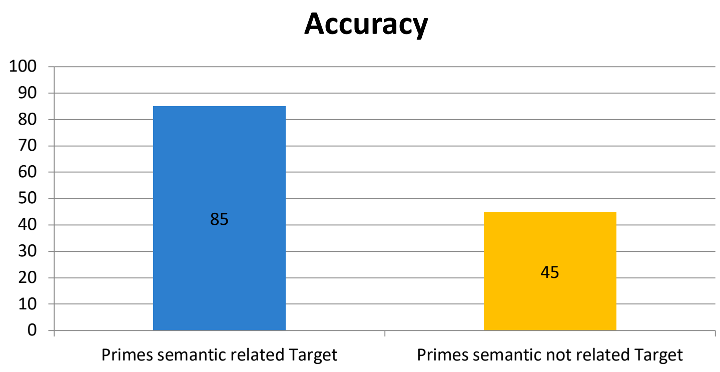
Table 8 Descriptives

	N	Mean	SD	SE
RT in miliseconds	24	16.625	3.146	0.642

Table 9 Coefficients

	Model	Unstandardized	Standard Error	Standardized	
				t	p
H_0	(Intercept)	16.625	0.642	25.889	< .001
H_1	(Intercept)	13.000	NaN	NaN	NaN
	Native speakers (L1) (2)	2.750×10^{-15}	NaN	NaN	NaN
	Native speakers (L1) (24)	5.000	NaN	NaN	NaN

Chart 6 Native Speakers (L1)



Furthermore, the accuracy of the German group (L1) in semantic category: primes (un)related to the target is shown below (chart 6). The participants are more accurate when the primes are target-related (85%). The participants are less accurate (45%) when the primes are not associated with the target.

3.2. Experiment Two

The second group (L2) of German participated in the second experiment. They tested (similar as experiment one) on morphological and semantic priming-(un)related. Table (10) indicates the age and number of participants in experiment two.

Table 10 Descriptive Statistics

	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Age	24	0	25.833	4.459	14.000	35.000
Second Group (L2)	24	0				

3.2.1. Morphological Primes Related Target (L2)

The second speakers of the German show (8000ms-14000ms) in morphological priming in target related. It also shows that the second language (L2) speakers are fast when (12) participants determine (10) morphological primes in less than (10,000 ms), as illustrated in *standard error*, which implies that the reaction time of L2 is tight to one another in the morphological category in primes connected to chart (7). Also, table (11) indicates the *mean* is higher than the *standard deviation* and the target words. Nevertheless, table (12, details in appendix) indicates the confirmation of reaction time of the second group (L2) through *t-value* and *p-value* The reaction time of the participants are connected to one another as the t-value is large (25.748), and it is confirmed when the p-value is small (<.001) and indicates the significant results.

Chart 7

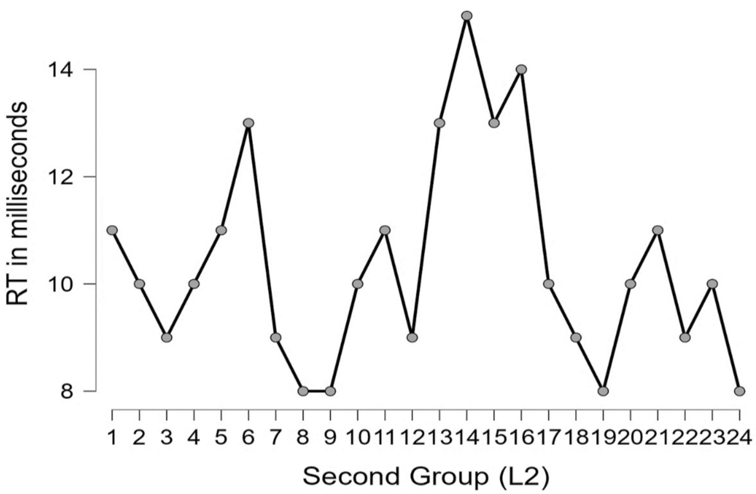


Table 11 Descriptives

	N	Mean	SD	SE
RT in milliseconds	24	10.375	1.974	0.403

Table 12 Coefficients

	Model	Unstandardized	Standard Error	Standardized	
				t	p
H_0	(Intercept)	10.375	0.403	25.748	< .001
H_1	(Intercept)	11.000	NaN	NaN	NaN
	Second Group (L2) (2)	-1.000	NaN	NaN	NaN
	Second Group (L2) (24)	-3.000	NaN	NaN	NaN

3.2.2. Morphological Primes Not Related Target (L2)

As shown in chart (8), the second group of non-native speakers (L2) has demonstrated (15,000ms to 20,000ms) in deciding on words when the primes are not associated with targets. The participants do not complete the (10) unrelated primes in less than (10,000ms). This indicates the priming effect is influential. Nevertheless, when the primes are not associated with the target, the participants' reaction time is delayed.

Chart 8

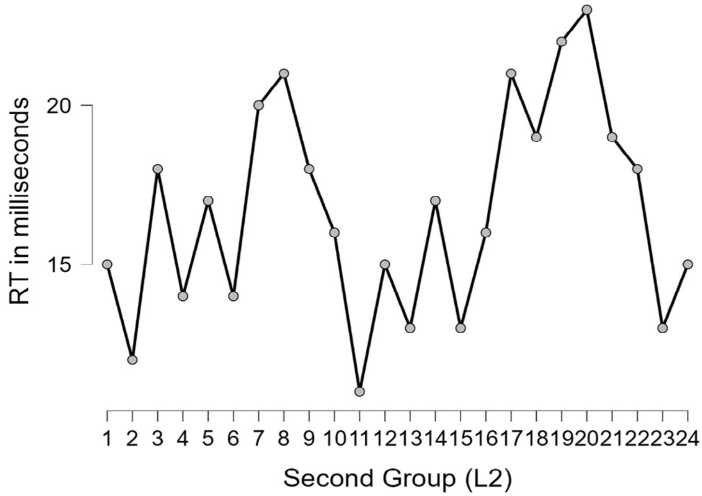


Table (13) demonstrates that the *mean* is more considerable than the *standard deviation* and *standard error.* It shows that the reaction time of participants is related, but not fast since the standard error is high. The responses of second-language participants are close to one another not in a quick reply: instead, their reactions are more relative to slower responses. Moreover, table (14 the details of all L2 reaction time is in appendix) assures that the non-native speakers are retarded when the primes are not associated to the target in the morphological category since the t-value is high (24.700) and the p-value is low (<.001). It confirms the outcomes as significant.

Table 13 Descriptives

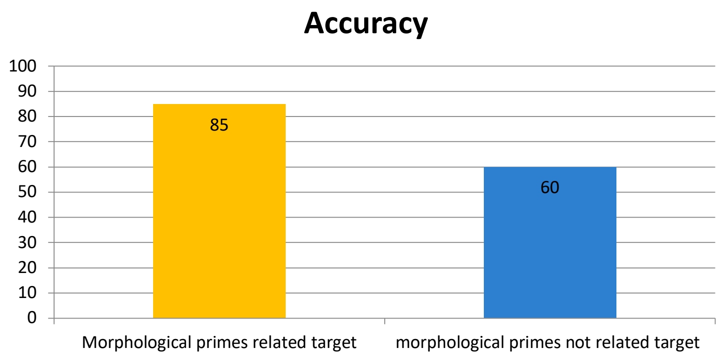
	N	Mean	SD	SE
RT in milliseconds	24	16.667	3.306	0.675

Table 14 Coefficients

	Model	Unstandardized	Standard Error	Standardized	
				t	p
H_0	(Intercept)	16.667	0.675	24.700	<.001
H_1	(Intercept)	15.000	NaN	NaN	NaN
	Second Group (L2) (2)	-3.000	NaN	NaN	NaN
	Second Group (L2) (24)	-4.239×10^{-15}	NaN	NaN	NaN

Moreover, chart (9) demonstrates the accuracy of non-native speakers (L2) in the morphological category: primes related and unrelated to the target. The accuracy of morphological primes target related is (85%). The morphological primes not associated with the target is (60%) accurate.

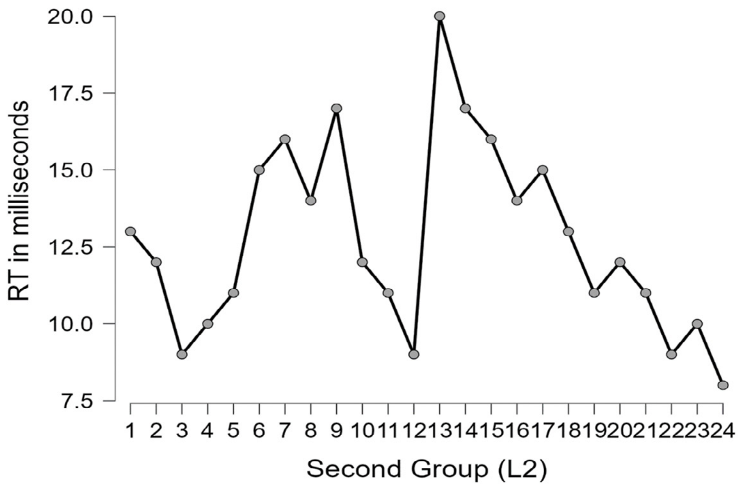
Chart 9 Non-native Speakers (L2)



3.2.3. Semantic Primes Related Target (L2)

The second group (L2) shows (7000ms to 2000ms) in reaction times in the semantic category: primes-related target. More than (6) participants completed the task in less than (10,000ms) when the (10) related primes are shown, as chart (10) displays. The reaction time of most of the participants is between (11,000ms to 16,000ms). It indicates the semantic category is more difficult than the morphological category in priming related to second-language speakers. The effect of priming is not as high as all participants could be delayed in determining on words.

Chart 10



Moreover, in table (15), the *mean* is (12.708) higher than the *standard deviation* and *standard error*. It explains that the responses of the second language speakers are near one another in semantic primes-target related. Furthermore, as shown below in table (16), the reaction time of the second language speakers (L2) is fixed when the t-value is high (20.271). Since the p-value (<.001), it assures the second language speakers' (L2) reaction time. It also indicates that the results of reaction time are significant (the reaction time of all second language speakers (L2) of table (16) is in the appendix).

Table 15 Descriptives

	N	Mean	SD	SE
RT in milliseconds	24	12.708	3.071	0.627

Table 16 Coefficients

Model		Unstandardized	Standard Error	Standardized	
				t	p
H_0	(Intercept)	12.708	0.627	20.271	< .001
H_1	(Intercept)	13.000	NaN	NaN	NaN
	Second Group (L2) (2)	-1.000	NaN	NaN	NaN
	Second Group (L2) (24)	-5.000	NaN	NaN	NaN

3.2.4. Semantic Primes Not Related Target (L2)

The L2 participants determined on (10) irrelevant primes from (14,000ms) to (22,000ms). It proves that the participants are not as quick as in semantic primes related. It also reveals the impacts of priming non-words related to the target-the effect are influential. There is no participant who could manage (10) unrelated primes in less than (10,000ms). Chart (11) shows the reaction time of the second group. Moreover, table (17) explains the *mean* (18.167) of non-native participants, which unfolds the proximity of the participants' responses in the semantic category when the primes are irrelevant to the target. The standard error in priming not associated with the target is higher than the priming associated with the target. More, the increasing of *t-value* (38.433) indicates that the responses of the participants are entangled with one another. The *p-value* (<.001) ensures that the participants' responses are the same if even the identical experiment is repetitive. The *p-value* also confirms the results to be significant.

Chart 11

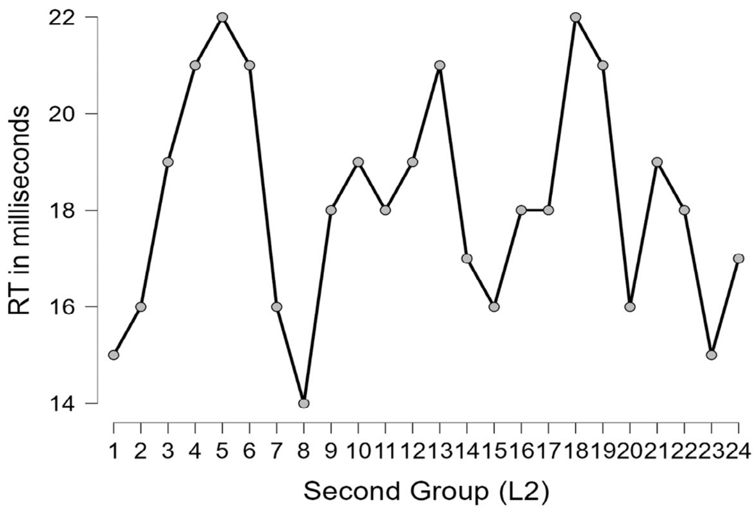


Table 17 Descriptives

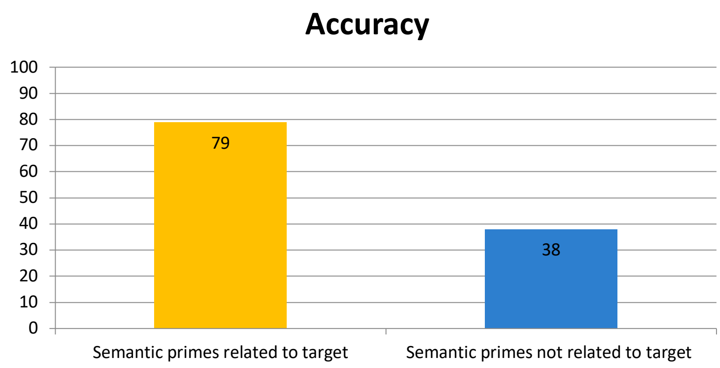
	N	Mean	SD	SE
RT in milliseconds	24	18.167	2.316	0.473

Table 18 Coefficients

	Model	Unstandardized	Standard Error	Standardized	
				t	p
H_0	(Intercept)	18.167	0.473	38.433	< .001
H_1	(Intercept)	15.000	NaN	NaN	NaN
	Second Group (L2) (2)	1.000	NaN	NaN	NaN
	Second Group (L2) (24)	2.000	NaN	NaN	NaN

Moreover, chart (12) represents the accuracy of non-native speakers (L2) in the semantic category-primes related and unrelated to the target. The accuracy is (79%) in the semantic primes associated with the target. The accuracy is (38%) in the semantic primes that are not connected to the target.

Chart 12 Non-native Speakers (L2)



3.3. Joining Analyses

Reaction time, accuracy, and priming effect are the three main factors that are considered in the analyses of the results. Two morphological primes (related and unrelated) and two semantic primes (un)related are used in each of the four trials in Experiment 1. First, when primes are associated to the target words, German native speakers (L1) demonstrate quick responses (6,000-12,000 ms) in the morphological category. The native speakers (L1) also indicate rapid reactions (6,000 to 14,000 ms) for the semantic category. In the morphological category, the *mean* has increased (8.250) while the *standard error* has decreased (0.382). Likewise, the semantic category has a *mean* (9.125) and a *standard error* of (0.471). The *t-value* is (21.604) and the *p-value* (<.001) assures that the reaction time of the participants is short in a morphological category. The *t-value* is also heightened (19.360) in a semantic category, and the p-value certifies the results. The accuracy of the participants is (90%) in the morphological category, while the accuracy is (85%) in the semantic category. Nevertheless, the results demonstrate that the native speakers of German (L1) are more rapid in a morphological category than the semantic category when the primes are related to the target. For accuracy, the native speakers (L1) are (5%) more accurate in a morphological category than the semantic category. The results are certified significant since the *p-value* (<.001) for both categories (morphology and semantic).

Second, the native speakers (L1) in experiment one when the primes are not related to the target in a morphological and semantic category: the native speakers (L1) are rather delayed in their responses (11,000 to 19,000ms) in a morphological category. Likewise, in the semantic category, the native speakers (L1) are directed to slower responses (12,000 to 20,000ms) of their reaction times. The *mean* is high (13.958) and the *standard error* is small (0.487) in the morphological category. Yet, in a semantic category, the *mean* is (16.625) and the *standard error* is (0.642). The *t-value* (in morphological category) is (28.657) and the *p-value* (<.001) confirms the reaction time of the participants. The *t-value* is also high (25.889) in the semantic category, and *the p-value* ensures the results. The accuracy of the participants is (70%) in the morphological category. In contrast, the accuracy is (45%) for the semantic category. Moreover, the outcomes of semantic and morphological categories (when primes are not associated with the target) reveal that the native speakers of German (L1) are delayed in the morphological category. They become more slower in the semantic category. The accuracy shows that the native speakers (L1) are (70%) accurate in the morphological category. Contrary, in the semantic category, the accuracy is (45%). The results are confirmed significant since *the p-value* (<.001) is small for both categories.

In summary, the native speakers are more frequent and accurate in both categories-semantic and morphological when primes are linked to the target (but the frequency and accuracy of the participants are effective in the morphological category. The native speakers (L1) are delayed and slowed in morphological and semantic categories in primes that are not associated with the target. In the semantic primes-not-related, the native speakers were affected. They have only (45%) accuracy while in the morphological category is (70%).

Experiment two includes non-native speakers (L2) experimented on morphological and semantic priming-(un)related to the target.

First, when the primes associated with the target in morphological and semantic categories, the second language speakers (L2) present (8,000 to 14,000ms) in the morphological category. However, in the semantic category, the second group (L2) demonstrates frequent responses (7,000 to 20,000ms) in the reaction times. The responses of the second group (L2) in the morphological category are quicker than in the morphological category. The *mean* is high (10.375) and the *standard error* is small (0.403) in the morphological category. Similarly, the *mean* is high (12.708) in the semantic category, but the *standard error* (0.627) is higher than in the morphological category. The *t-value* with (25.748) unfolds the results to be standard while the *p-value* (<.001) affirms the participants' reaction time in the morphological category. Nevertheless, the *t-value* is also high (20.271) in the semantic category, which provides the results rather significant, and *the p-value* ensures the results. The accuracy of second group is (85%) in the morphological category, and it is (79%) in the semantic category. In short, second-language speakers are fast and accurate in the morphological and semantic category when primes are associated with targets. They are faster in the morphological category (6%) than in the semantic category.

Second, when the primes are not associated to the target in morphological and semantic categories: in the morphological category, the second language speakers (L2) present (15,000 to 20,000ms) in their reaction time. Regardless, in the semantic category, the non-native speakers (L2) are directed to slower replies (14,000 to 22,000ms) in the reaction times. The *mean* is high (24.667) and the *standard error* is small (0.675) in the morphological category. Besides, the *mean* is increased (18.167), but the *standard error* is lower (0.473) in the semantic category. The *t-value* of (24.700) clarifies the results to be typical while the *p-value* (<.001) supports the participants' reaction time in the morphological category. More, the *t-value* also describes the high number (38.433) in the semantic category, which allows the *p-value* to ensure the results are rather significant. The accuracy of the second group participant is (60%) in the morphological category, and it is (38%) in the semantic category.

In summary, the second language speakers (L2) are rather delayed in morphological category, and they are more delayed in the semantic priming category. In both categories, the second language speakers' reaction time is intervened when they see the unrelated primes to the target, specifically in the semantic category.

To sum up, in the morphological and semantic categories (primes related to the target) both groups (native speakers L1 and non-native speakers L2) reveal rapid responses in reaction times. For instance, the native speakers (L1) do their experiment task in (6,000–12,000 ms) while the second speakers (L2) do their experiment in (8,000ms to 14,000ms). The accuracy of the native group (L1) is (90%) for the morphological category and it is (85%) for the semantic category. For the non-native group, the accuracy is (85%) in the morphological category and (79%) in the semantic category. There are no dissimilarities between the two groups, whereas the native group is partially quicker. When the primes are not associated with the target, the native group (L1) and non-native group (L2) were delayed in reaction time. For example, the native group show (11,000 to 19,000ms) in a morphological category and (12,000 to 20,000ms) in the semantic category. The non-native group (L2) indicates (15,000 to 20,000ms) in the morphology category and (14,000 to 22,000ms) in the semantic category. The native group's (L1) accuracy when the target is not related is (70%) in the morphological category, and (45%) in the semantic category. The non-native group's (L2) accuracy is (60%) in the morphological category, and (38%) in the semantic category. Both groups are not fast in the semantic category, they seem rather quick and accurate in the morphological category.

3.4. Discussion

The results of Baayen and Smolke (2020) discussed in terms of prime-target pairs in the semantic condition, which contains the responses of the participants that are less quick than prime-target pairs in the unrelated condition. The current results in the semantic unrelated primes agree with the Baayen and Smolke (2020) study. As they suggested, *pure morphological priming* structures present stem access independent of semantic compositionality in German, which is contracted to French and English. In the present study, the morphological category is more facilitated than the semantic category.

Furthermore, in Hasenäcker et al. (2016) study, they examined masked morphological priming effects on German adults and children. Their results indicate a strong priming effect for suffix words (kleidchen-KLEID), non-word suffixes (kleidtum-KLEID), non-suffixed non-words (kleidekt-KLEID), and unrelated words (träumerei-KLEID) when they illustrated the adults' responses. Adults also show equal facilitation from suffix words and non-suffix words. The current study's results can be agreed with suffix words, especially morphological primes related to the target, such as *anrufen-RUFEN.* It also agrees with non-suffix nonwords as primes not related to the target in the morphological category (e.g., mitruhlos-RUHEN).

Moreover, the outcomes of the current analysis are closely matched with Lüttmann et al. (2011) study. As they argued, the findings showed that complex verbs with close morphological relationships sped up the production task's picture naming latencies, and the comprehension task's lexical decision latencies. The verbs that are semantically related, on the other hand, did not show any consistent effects. Furthermore, the present study results contradicted Jiang and Wu (2022) study in several aspects. They argued that the effects of priming in the orthographic condition are more effective on non-native speakers (NNS) than native speakers (NS). Besides, the present outcome is consistent with Diependaele et al.'s (2011) study when they presented no interaction with native speakers in reaction time and accuracy. Their data also supports the results of the current study when they concluded that there are no qualitative differences in the semantic transparency between first language (L1) and second language (L2) speakers. They also claimed that with increasing prime frequency, priming increased in the transparent condition. However, the data of the present investigation definite that morphology for both groups (L1 and L2) are the same. The native(L1) and non-native groups (L2) testify to the sameness in semantic and morphological categories. In the morphological primes (related target), the reaction time and accuracy of both groups (L1 and L2) are raised. The responses of both groups are small and decreased when the primes are not associated with the target. In the semantic priming category, both groups are in the shortage of accuracy, and reaction time-the morphological categories for both groups are straightforward.

As Diependaele et al. (2011) claimed the bilingual interactive activation model + (by Dijkstra Van Heuven 2002) activates many related words in a language-independent manner simultaneously, which interacts with the word choices in the bilingual's mind. The data of the current study does not support this model. The findings of the current study undermine the null hypothesis, which was based on the bilingual interactive model. The null hypothesis is that the second language speakers (L2) would be delayed in word recognition in terms of reaction time and accuracy: when the second language speakers see or hear a target word as an input, the input word would activate many related words, and the speaker would be delayed in deciding to which category is the input word belongs. The null hypothesis is rejected based on the data of the current study. It is convincing because the human mind does not work as AI software.

Finally, the mother tongue is considered the base of all languages a speaker knows. For instance, when a speaker (in Germany) sees the word *Tag,* they would immediately recognize the word because of the cultural effect-the word is seen/heard/used numerous times. If the same speaker (in England) sees the word *Tag,* a speaker would immediately recognize the word as an English word. The culture and the environment of the speaker play a crucial role to determine which language comes first to be used (Banaruee et al., 2019a, b; Banaruee et al., 2023b). Mother tongue does not come first to be used most of the time.

4. CONCLUSION

The study's conclusion is explained in this section, and the research questions and null hypothesis are answered according to the data gathered. The recommendation for further research is also included.

4.1. Conclusion of the Paper

The paper can be concluded according to the outcome of the study. The study tries to find answers to the research questions and null hypothesis. The findings of the study verify the answers to the first research question (What are the differences among the first language and second language speakers in word recognition priming; to what extent their choices on accuracy are similar or different in deciding on words?): the results indicate that there are no such differences among native speakers (L1) and non-native speakers of the German language unless in individual choices. There are similarities among first language speakers (L1) and second language speakers (L2) in both categories-morphology and semantics. The native speakers (L1) in the morphological category present (90%) accuracy; in the semantic category, they demonstrate (85%) accuracy when the primes are associated with the target. Similarly, the non-native speakers (L2) confirm a very close number to native speakers (L1) in accuracy. For non-native speakers (L2), the accuracy is (85%) in the morphological category, and (79%) in the semantic category when the primes are related to the target. When the primes are not related to the target, the native group (L1) indicates (70%) for morphology and (45%) for the semantic category. Similarly, the non-native speakers (L2) show (60%) in morphology and (38%) in semantics when the primes are not associated with the target.

The results of the study provide answers to the second research question (Do second-language speakers of German (L2) are fast as native speakers of German (L1) in word recognition?) To answer the second research question, the outcome of the reaction time of both groups has to be illustrated. The native speakers (L1) and non-native speakers (L2) are quick in morphological and semantic categories when the primes are connected to the target. The native group (L1) shows (6,000 -12,000ms) of their reaction time when they have been tested on (10) primes related to the target in the morphological category. In the same experiment, the non-native group (L2) presented (8,000 -14,000ms) of their reaction time.

These advanced results answer the first part of the second research question: the non-native speakers of German (L2) are fast in word recognition as native speakers (L1). The native speakers are more exact, which is based on individual abilities. When the primes are not associated with the target, both groups (L1&L2) are delayed, and their responses are so close to one another. The native group (L1) reveals (11,000-19,000ms) of their reaction time when they tested on (10) unrelated primes in the morphological category. By the exact experiment, the non-native group (L2) presents their reaction time in (15,000-20,000ms). In the semantic unrelated primes, the native group with (12,000-20,000ms) completed their trial. Also, the second group completed their trial with (14,000-22,000ms) in unrelated primes in the semantic category.

This outcomes response the second part of the second research question: there is closeness in the responses of participants of both groups (L1&L2). There are only individual characteristics with some native speakers when their responses rather faster than non-native speakers. Moreover, the null hypothesis (states that word recognition would vary between native (L1) and non-native (L2) speakers. Compared to non-native speakers, native speakers would be quicker and more accurate. Non-native speakers would be delayed as they go through the inhibition process to choose the target word) as previously mentioned, the results of the study reject the null hypothesis. The conclusion of the study is directed to the similar conclusion of Diependaele et al.'s (2011) study. As they claimed, "the language itself primarily determines the functional properties of process in L2."

4.2. Research Suggestions

After the concluded research, some points have been taken into account for future research: if languages function in this way, learning multiple languages is akin to dressing in various suits, and people's differences in the intellectual complexity of the languages they know do not significantly affect how languages are processed. Researching a language ought to include additional perspectives, like the neurobiological perspective. Furthermore, more research should be focused on morphology, semantics, and phonology, especially on bilinguals (on languages that have the neighborhood effect, such as English, German, French, Spanish, and Italian) in terms of priming in word recognition if human language functions as AI software as in the computational model, as described by McClelland and Rumelhart (1981). In particular, bilinguals' ability to recognize the same sounds in words in two different languages is greatly influenced by phonology. For instance, the word *Tag* is a German word; it is spelled and pronounced the same in English (as previously mentioned).

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Appendix

Words used in the experiments:

Semantic

Related	Unrelated
mitteilen-KOMMUNIZIEREN	tecommunizlos-KOMMUNIZIEREN
liefern-REICHEN	derahmlos-RAHMEN
erschießen-UMBRINGEN	unschatnis-SCHÄTZEN
durchführen-UMSETZEN	entspechvolieren-SPEICHERN
raten- EMPFEHLEN	wertschutlosiren-STÜTZEN
lassen-ERLAUBEN	kauberscheinis-ÜBERSCHREIEN
gelingen- FUNKTIONIEREN	anverdielosiren-VERDIENEN
entstehen-ENTWICKELN	impverwaltlichlos-VERWALTEN
abstimmen- ENTSCHEIDEN	beanwartlosen-WARTEN
fassen- FANGEN	wertziehieren-ZIEHEN

Morphology

Related	Unrelated
Verstehen-STEHEN	mitadeniren-BADEN
anbieten-BIETEN	vereinärgern-ÄRGERN
anfragen-FRAGEN	untwachvoiren-AUFWACHEN
anmachen-MACHEN	teilmachnis-AUSMACHEN
Anmelden-MELDEN	einpassiren-AUFPASSEN
anrufen-RUFEN	ziehrien-AUSZIEHEN
Antworten-WORTEN	mitruhlos-RUHEN
aufstehen-STEHEN	prestehenis-*STEHEN*
Aufhören-HÖREN	versehenis-AUSSEHEN
aufmachen-MACHEN	ausarbeitiren-ARBEITEN