Linear Distance, Agreement Attraction, and WM Effects on L1 Thai Learners' Processing of L2 English Third-Person Singular Subject-Verb Agreement

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Abstract

*This study investigated the effects of linear distance, agreement attraction, and working memory (WM) on the processing of English third-person singular subject-verb agreement by second language (L2) learners whose first language (L1) is Thai. Grounded in the Linear Distance Hypothesis (Gibson, 1998, 2000), the study hypothesized that linear distance, agreement attraction, and WM would affect L1 Thai/L2 English learners' processing of the agreement in question. Thirty Thai-speaking nonnative speakers (NNSs) with advanced L2 proficiency and 30 native speakers (NSs) were included. A word-by-word self-paced reading task was employed to determine the three effects. The results revealed longer reading times (RTs) in the long-distance context (e.g., 'The leaders in the cars meet on a monthly basis.') compared to the short-distance counterpart (e.g., 'The waiter lives in a small town.') in the critical region, i.e., the verb, for both the NNSs and the NSs. The agreement attraction effect was not observed in either the NS or the NNS data as similar RTs were obtained between the matched (e.g., 'The teen on the ladder works on her summer break.') and mismatched (e.g., '*The lawyers on the ship travels from city to city.') conditions. This was speculated to be due to the mismatch asymmetry effect (Barker & Nicol, 2000). WM and its interaction effects with linear distance and agreement attraction were partially observed as the low WM group exhibited shorter RTs in the ungrammatical-mismatched compared to the high WM counterpart. The effect of WM was assumed to be moderated by the NNSs' high proficiency.*

INTRODUCTION

In the realm of second language acquisition (SLA), second language (L2) learners across first language (L1) backgrounds have been reported to face difficulties acquiring functional morphology (e.g., Chen et al., 2007; Nicol & Greth, 2003; Rankin et al., 2019). Among such morphology, agreement in L2 sentence processing has been widely examined (e.g., Chen et al., 2007; Rankin et al., 2019; Rattanasak et al., 2024). More particularly, an investigation into sensitivity, or lack thereof, to agreement violations during real-time L2 processing has been carried out (e.g., Keating, 2009; Lim & Christianson, 2015; Rattanasak et al., 2024; Shibuya

& Wakabayashi, 2008; Siriwittayakorn & Miyamoto, 2019). Different contributing factors have been speculated to account for the (in)sensitivity in question. Among these are L1-L2 divergence in morphosyntactic processing (Clahsen & Felser, 2006b), cross-linguistic influence (e.g., Chen et al., 2007; Jackson & Dussias, 2008), working memory (WM) capacity (e.g., Dussias & Piñar, 2010; Rattanasak et al., 2024), long-distance dependencies (LDDs) (e.g., Keating, 2010; Rattanasak et al., 2024), and L2 proficiency (e.g., Ahn, 2021; Hopp, 2010).

Subject-verb number agreement is one of the agreement aspects which has been frequently and widely studied as this linguistic feature has continued to present challenges to learners of L2 English (e.g., Hoshino et al., 2010; Ionin & Wexler, 2002; Ocampo, 2013). Particularly, certain sentence constructions like long-distance agreement (e.g., 'the lawyers on the ship travel from city to city') may be more difficult to process than others (e.g., 'the lawyers travel from city to city') (O'Grady, 2006). Long-distance agreement or dependency (LDD) describes the relationship between two dependent linguistic units like 'the lawyers' and 'travel' whose dependency is disrupted by the distance created by other sentential elements like the nominal post-modifying prepositional phrase 'on the ship' in the example provided previously (Hsu & Chen, 2013). According to the Dependency Locality Theory (DLT) (Gibson, 1998, 2000), to process complex linguistic structures like LDDs, working memory (WM) is key. WM, also referred to as cognitive resources, is a psychological construct which has recently been demonstrated to play a role in distance-based complexity (e.g., Coughlin & Tremblay, 2013; Dussias & Piñar, 2010; Keating, 2010; Kim & Christianson, 2017; Rattanasak et al., 2024). Essentially, parsers with a bigger pool of WM are believed to be more successful in processing LDDs than those with limited WM capacity.

Long-distance dependencies can become particularly challenging when agreement attraction is involved (Wager et al., 2009). Agreement attraction refers to a linguistic phenomenon where an agreement-bearing element like the verb 'are' in '*The key to the cabinets are missing.' erroneously checks for agreement with a nearby attractor like 'the cabinets' instead of its grammatical controller 'the key' (Bock & Miller, 1991). This grammatical number feature mismatch has been attested to interfere with the processing of LDDs for both production (e.g., Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock & Miller, 1991; Vigliocco & Nicol, 1998) and comprehension (e.g., Barker & Nicol, 2000; Jiang, 2004; Pearlmutter et al., 1999) and in both L1 and L2 processing.

Despite the reported effects of distance, number mismatch interference, and WM, in L2 sentence processing, limited research has exclusively set out to determine such effects in the Thai context (e.g., Rattanasak et al., 2024; Siriwittayakorn & Miyamoto, 2019). To contribute to this literature, the present study was conducted to investigate the extent to which the effects of linear distance, agreement attraction, WM, and their interaction psychologically impact the processing of English third-person singular (3SG) subject-verb agreement by Thai-speaking L2 learners whose L1 lacks subject-verb agreement. In this study, only the inflection –s was considered because this linguistic feature of L2 English has been reported to be comparatively more problematic to L1 Thai learners (e.g., Kampookaew, 2020; Pongpairoj, 2002; Timyam, 2018) and that auxiliary and copula 'be' were found to be easier to acquire in past studies (e.g., Ionin & Wexler, 2002; Lardiere, 1998). In so doing, the findings of this study would hopefully provide better understanding of the more complex 3SG –s morpheme in the literature of L2 agreement processing. The results from a non-cumulative self-paced reading task were discussed based on the Linear Distance Hypothesis (Gibson, 1998, 2000) and agreement attraction (e.g., Bock & Cutting, 1992; Bock & Miller, 1991).

LITERATURE REVIEW

Working memory and L2 sentence processing

WM generally refers to one's ability to mentally hold information which can be accessed during the processing of new information (Conway et al., 2005). Various aspects of human cognition including language learning and processing require WM to operate (Wen et al., 2022). For years, this fundamentally-required memory in human cognition has attracted a great deal of attention in the SLA arena (Gass et al., 2013). The cognitive system in question has become a useful tool in research on both L1 and L2 acquisition (e.g., Baddeley, 2003; Juffs & Harrington, 2011; Kim & Christianson, 2017; Rattanasak et al., 2024). This psychological construct is, however, limited and is said to differ from person to person (Wen, 2016). As a result of such individual differences, variability in the ability to tackle a series of linguistic tasks among individuals is deemed to occur (Gass et al., 2013). In fact, variable L2 development has been reported to be associated with individual differences in WM in the literature (e.g., Ellis & Sinclair, 1996; Miyake & Friedman, 1998).

As far as L2 sentence processing is concerned, Jiang (2018) pointed out three stages that L2 learners must undergo to process a sentence. These stages consist of word recognition, parsing, and semantic integration, and they take place in succession and in a rapid manner. Such a demanding processing requirement seems to imply that the parsers are in need of great mental efforts to comprehend a single sentence, particularly sentences that are not in their native language. Furthermore, this means that the more complex the sentence is, the more cognitive resources are fundamentally necessary to successfully process it. For example, in comprehending the temporarily ambiguous sentence 'the horse raced past the barn fell', the parser is likely to misanalyze the reduced relative clause (RC) 'raced past the barn' and initially interpret it as the predicate before resolving the ambiguity upon reaching the matrix verb 'fell' (Bever, 1970, as cited in Jiang, 2018, p. 246). Complex sentence structures such as that and LDDs are believed to heavily tax WM capacity which may result in a depletion in WM (Kim & Christianson, 2017). Such a depletion has been shown to lower a level of sensitivity to syntactic and morphosyntactic violations (e.g., Coughlin & Tremblay, 2013; Hopp, 2010; Rattanasak et al., 2024; Sagarra & Herschensohn, 2010).

In this study, WM capacity was examined as one of the potentially contributing factors in L1 Thai learners' processing of L2 English 3SG subject-verb agreement, given the reported WM influence in the literature (e.g., Coughlin & Tremblay, 2013; Hopp, 2010; Rattanasak et al., 2024; Sagarra & Herschensohn, 2010).

Long-distance dependency

Long-distance dependencies or LDDs describe a linguistic phenomenon whereby a flow of dependency between a grammatical controller and an agreement-bearing entity is disrupted by other linguistic entities (Hsu & Chen, 2013). An investigation into the processing of LDDs is usually done on sentence structures featuring a Wh-movement such as RCs. Such LDD structures are then also referred to as the filler-gap dependency in which the filler is a relative pronoun while the gap is either the subject in a subject relative clause (SRC) or the object of the embedded verb in an object relative clause (ORC). The distance created by the two types of RCs is argued to be of different lengths. Consider the SRC and ORC in (1a) and (1b), respectively:

(1) a. The guy *that* _ knows the driver wants to buy a new car.
b. The guy *that* the driver knows _ wants to buy a new car.
(Rattanasak et al., 2024, p. 1157)

In (1), the distance between the filler 'that' and the gap '_' is said to be greater in the ORC in (1b) than in the SRC in (1a). It is believed so because the number of the intervening elements linearly formed between the filler and the gap in (1b) is bigger than those in (1a). Thus, sentences like (1b) are claimed to be more challenging to process than those like (1a) due to the length of the distance between the dependency according to the Linear Distance Hypothesis, which is represented by the dependency locality theory (DLT) (Gibson, 1998, 2000). According to the hypothesis, the key to successful LDD processing lies in a pool of cognitive resources available to the parser. In essence, to incorporate the agreement-bearing element with its agreement controller in the long-distance agreement scenario, a larger number of such resources are required for the storing of information of each element in the string. Hence, parsers with a bigger pool of the aforementioned resources are claimed to be more successful than those with limited resources. Meanwhile, instead of cognitive resources, one's syntactic ability is deemed to play a major role in the processing of LDDs based on the Structural Distance Hypothesis (e.g., Hawkins, 1999, 2004; O'Grady et al., 2003). According to this account, the more capable a person is in syntactically internalizing the LDDs, the more successful he or she will be. Not only are the two theories different in the tenets of their accounts, they also differ in how they measure the distance. Within the Structural Distance Hypothesis, distance is structurally defined, with the number of intervening nodes representing the length of the distance. The distance in the Linear Distance Hypothesis is, on the other hand, measured linearly, implying that the more the intervening words in a linear string, the longer the distance is.

Adopting the Linear Distance Hypothesis, the present study treated linear distance as another factor which potentially gave rise to processing difficulties in L2 sentence processing. In this study, the raw number of words linearly strung between the subject and the verb equaled the length of the distance. The quantification of distance in this study is provided in (2):

(2) a. The waiter *[ ]* lives in a small town.
b. The girl *[at the door]* reads with a quick pace.

In (2a), the distance between the subject 'waiter' and the verb 'lives' is zero words while that between the subject 'girl' and the verb 'reads' in (2b) is three words. According to the Linear Distance Hypothesis, the processing of long-distance agreement in (2b) would present a greater level of processing difficulties to the parsers as such agreement was argued to require more cognitive resources.

Agreement attraction

Agreement attraction or broken agreement arises when a nearby element to an agreement-bearing feature interferes with the agreement checking process between the agreement-bearing feature and its grammatical controller (Bock & Miller, 1991). Consider the subject noun phrases in (3):

(3) a. The key to the cabinets
b. The key to the cabinet

In the complex subject NPs like (3), non-head nouns like 'cabinets' in (3a) have a stronger tendency to interfere with the computation of subject-verb agreement than those like 'cabinet' in (3b) (ibid.). The claim is made on the ground of the grammatical number of the two nouns in the subject NPs, i.e., the head noun and the non-head noun, which is considered a distractor or attractor. More precisely, while the head noun 'key' is singular, the local attractor noun 'cabinets', which sits more closely to the verb, is plural. The immediate adjacency of the non-head noun 'cabinets' to the verb potentially gives rise to faulty agreement checking, leading to agreement errors (e.g., '*The key to the cabinets *were*…') in production but bringing ease to the processing of such errors in comprehension (Pearlmutter et al., 1999; Wagers et al., 2009).

As far as the number mismatch is concerned, the singular-plural mismatch (e.g., 'The key to the cabinets') has been reported to show the strongest agreement attraction effect in both production research (e.g., Bock & Miller, 1991; Eberhard et al., 2005) and comprehension research (e.g., Nicol et al., 1997; Pearlmutter et al., 1999; Wagers et al., 2009). This asymmetry in agreement attraction effects is speculated to result from the plural markedness in that plural nouns are more marked than singular nouns, hence being more disruptive (Bock & Eberhard, 1993; Eberhard, 1997). Put simply, when the agreement attractor is plural in the singular-plural combination (e.g., 'The key to the *cabinets*'), it is more likely to successfully attract the agreement than when it is singular in the plural-singular combination (e.g., 'The keys to the *cabinet*').

Research on agreement attraction has documented the effect of a number mismatch on sentence processing. The agreement attraction effect has been observed to interfere with L2 agreement processing for both production (e.g., Hoshino et al., 2010; Nicol & Greth, 2003) and comprehension (e.g., Bian et al., 2021; Jegerski, 2016; Lim & Christianson, 2015). These previous L2 studies discovered greater processing difficulties when the grammatical number mismatch was involved. The findings of these past L2 studies were also in line with the findings obtained by a number of past studies on agreement attraction in L1 processing (e.g., Bock &

Miller, 1991; Eberhard et al., 2005; Nicol et al., 1997; Pearlmutter et al., 1999; Staub, 2009; Wagers et al., 2009).

To contribute to this line of research, the present study aimed to test whether and to what extent agreement attraction put effects on the cognitively demanding long-distance agreement. Based on the agreement attraction account (Bock & Miller, 1991), we hypothesized that agreement attraction would intensify the effect of linear distance. That is, despite the shared length of distance, the mismatched conditions (e.g., 'The key to the cabinets' and 'The keys to the cabinet') would present a greater level of difficulties to the processing than the matched conditions (e.g., 'The key to the cabinet' and 'The keys to the cabinets').

METHODOLOGY

Participants

The participants of this study comprised 30 native speakers of English (NSs) and 30 nonnative speakers (NNSs) with L1 Thai background. The NSs recruited from multiple sources (e.g., social media platforms and word-of-mouth) participated in the study as native controls to provide the baseline data to the analysis. All of the NSs speak English as their L1 and hold a bachelor degree at a minimum. The NNSs' proficiency level was advanced as determined by their standardized test scores, including TOEFL iBT (94-114), IELTS (7-8), CU-TEP[1] (99-120) scores. They were recruited from two institutions – Chulalongkorn University and Mahasarakham University. The NNSs took a grammaticality judgment task (GJT) to ensure their understanding of the agreement feature under investigation, with all participants meeting the accuracy cut-off threshold (80%). The NNSs also completed a reading span task (RST) for their working memory size. Both the NS and NNS participants were naïve to the purpose of the research. The demographical data of the participants and the NNS participants' GJT and RST mean scores are presented in Table 1.

Table 1
Demographical data of the participants

	n	*Mean age (yrs)*	*Gender (M, F, X)*	*Mean GJT score (Max = 24)*	*Mean RST score (Max = 75)*
Native speakers	30	28.53 (21-55)	12, 18, 0	n/a	n/a
Nonnative speakers	30	20.80 (18-23)	15, 13, 2	21.13 (20-23)	63.67 (49-75)

Research instruments

All three instruments used in the study were computerized and run on SuperLab 6.0 software by Cedrus Corporation. It should be noted that all of the experimental stimuli in the GJT and SPRT were normed using a 5-point Likert scale by 15 native speakers who were not part of the

[1] CU-TEP was developed and provided by Chulalongkorn University Language Institute and is used as a standardized test for English proficiency. According to Wudthayagorn (2018), the score range between 99-120 represents the advanced level, which is equivalent to CEFR C1.

native control group. Additionally, a pilot study was carried out prior to the main study to ensure the feasibility of the study, and the data collected were not included in the main study.

1. Reading span task

Adopted from Phinitkit (2015), the Thai reading span task (RST) was employed as a measure of the NNSs' WM capacity levels: high and low. The task included 75 sentences, grouped into sets of three to seven sentences each. The NNSs read each sentence on a computer screen and judged whether it was semantically plausible. They then memorized a single Thai letter at the end of the sentence which they had to recall later. After the last letter of the set disappeared, the NNSs recalled and selected the letters of the set they had seen from the set. A partial-credit scoring method was adopted, meaning that one point was given to each correct recall in a sentence set. The median analysis yielded the median of 62.5, resulting in 14 low WM capacity NNSs and 16 high WM capacity NNSs. The mean score of the low WM capacity group was 57.71 with a range between 49-62 while that of the high WM capacity counterpart was 68.88 with a range between 64-75.

2. Grammaticality judgment task

A grammaticality judgment task (GJT) was included to examine the NNSs' understanding of the 3SG subject-verb agreement. The NNSs read a sentence on a computer screen, judged whether the underlined verb was grammatical, and provided a correction in the box at the bottom of the screen if required. The accuracy cut-off threshold was set at 80% and all of the NNS participants met this requirement. An example of the GJT is provided in Figure 1.

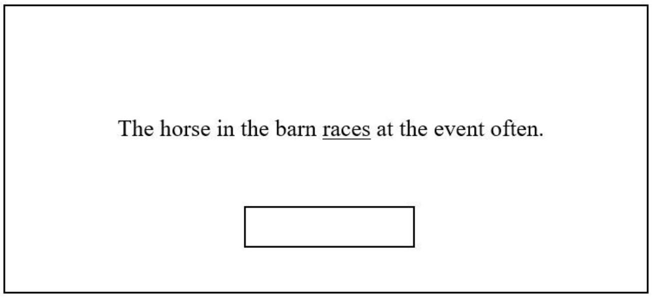

Figure 1 Illustration of experimental items in the GJT

3. Self-Paced Reading Task (SPRT)

A non-cumulative word-by-word self-paced reading task was administered to both the NSs and the NNSs to elicit reading times (RTs) at two regions, namely the critical region, i.e., the verb, and the spillover region, i.e., the word immediately following the verb. The spillover region was included as it may reflect delayed processing (Marsden et al., 2018). Twenty-four experimental items, half of which were ungrammatical, and 40 fillers were pseudo-randomized – manually entered into the software – to ensure that no two experimental items appeared in succession. Each experimental sentence had either a simple or complex subject NP; the former represented the short-distance agreement context and the latter the long-distance agreement context. The manipulation of long-distance agreement was achieved through a prepositional phrase headed by one of the three prepositions of place, namely 'in', 'on', or 'at' (e.g., 'at the lifts' and 'on the train'). Agreement attraction was manipulated by means of the (mis)matching of head-local noun number features, resulting in four grammatical number combinations: singular-singular (SS), plural-plural (PP), singular-plural (SP), and plural-singular (PS). The SS and PP combinations were categorized as 'matched' and the SP and PS combinations 'mismatched' (See Table 2).

Linguistic variables which may interfere with the interpretations of the results were carefully controlled. Every word in the stimuli was selected from the first 10,000 BNC/COCA headword list (Nation, 2016), and each contained either one or two syllables (e.g., 'cat' and 'waiter'). The head noun and the non-head local noun were always animate and inanimate nouns, respectively. This animate-inanimate sequence (e.g., 'the leaders in the cars') was employed as it is claimed to not cause an animacy priority conflict for the cognitive resources to resolve during the semantic-syntactic processing. This allows all the available resources to the assigning of agreement control to the head noun (Lempert, 2016). The head and non-head nouns were always modified by the definite article 'the' so that either singular or plural nouns were grammatically allowed (e.g., 'the cat' and 'the pillows'). All of the nouns used were regular nouns to ensure the overt –s marking for plurality (e.g., 'cars' and 'golfers'). All the verbs were intransitive verbs (e.g., 'live' and 'smile') and always post-modified by a four-word prepositional phrase (e.g., 'on a monthly basis' and 'with a strict routine'). The length of the intervening prepositional phrase was kept constant at three words (e.g., 'in the cars') and that of the sentence was done so at seven and 10 words for the simple and complex subject NPs, respectively. The verb was always placed in the critical region, which was the third and sixth regions in the simple and complex subject NPs, respectively. The spillover region was always occupied by one of the three aforementioned prepositions of place and was always the fourth and seventh regions in the simple and complex subject NPs, respectively. Examples of the dissection of regions in the simple subject NP and complex subject NP contexts are shown in (4a) and (4b), respectively:

(4) a. The_1 | waiter_2 | $\textit{lives}_3$ | $\textit{in}_4$ | a_5 | small_6 | town_7.
b. The_1 | leaders_2 | in_3 | the_4 | cars_5 | meet_6 | on_7 | a_8 | monthly_9 | basis_{10}.

Examples of each subject NP type and condition in the stimuli are provided in Table 2.

Table 2

Examples of the stimuli in the SPRT

Examples of the stimuli	Subject NP type	Condition
a. The waiter lives in a small town.	Simple	G
b. *The doctor smile with her whole face.	Simple	UG
c. The leaders in the cars meet on a monthly basis.	Complex	G-M
d. *The orphan on the train roam from town to town.	Complex	UG-M
e. The cat on the pillows sleeps on its soft tummy.	Complex	G-MM
f. *The golfers in the room practices with a strict routine.	Complex	UG-MM

Note: G, grammatical; UG, ungrammatical; M, head-local noun number feature matched; and MM, head-local noun number feature mismatched.

Regarding task-taking procedure, there were 10 practice items to familiarize the participants with the task procedure before they began the actual task. The '+' symbol appeared on a computer screen for 500 milliseconds before the first word of the sentence to draw the reader's attention to the task and then disappeared on its own. The participants pressed the spacebar key to proceed from one word to the next at their own pace and then answered a comprehension WH-question at the end of each sentence. RTs at the two regions of interest, i.e., the critical and spillover regions, were automatically recorded and drawn out later for the analysis.

Data analysis

The analysis of the main task, the SPRT, consisted of the preliminary trimming process and the statistical analyses. Raw reading times (RTs) in milliseconds (ms) in the critical and spillover regions extracted were put into this initial trimming process to eliminate any outliers which would potentially affect the RTs. RTs which were below 100 ms or above 2000 ms were removed as these numbers were not reflective of normal reading speed (Rattanasak et al., 2024). The data trimming removed 0.72% and 1.84% of the NS and NNS data, respectively. The trimmed RTs were then analyzed via both descriptive and inferential statistical analyses. Two- and three-way ANOVAs in SPSS (version 24) were performed to examine the effects of linear distance, agreement attraction, and WM on the processing of the agreement under investigation.

RESULTS

The results, overall, revealed that both the NSs and the NNSs spent more time in the long-distance conditions than the short-distance conditions as shown in Tables 3 and 4, for the critical and spillover regions, respectively.

Table 3
Mean (SD) of the RTs in milliseconds in the critical region in relation to distance for native speakers (NSs) and nonnative speakers (NNSs)

	NS		NNS	
	Simple	**Complex**	**Simple**	**Complex**
Grammatical	489(156)	596(187)	555(167)	652(151)
Ungrammatical	588(219)	692(259)	606(141)	647(155)

In the critical region, the NSs exhibited longer RTs in the grammatical long-distance condition (*M* = 596, *SD* = 187) compared to the grammatical short-distance counterpart (*M* = 489, *SD* = 156). Similarly, they also took longer to read the ungrammatical long-distance condition (*M* = 692, *SD* = 259) than they did the ungrammatical short-distance condition (*M* = 588, *SD* = 219). Likewise, the NNSs read the grammatical long-distance condition more slowly (*M* = 652, *SD* = 151) than the grammatical short-distance condition (*M* = 555, *SD* = 167). Also, they displayed longer RTs in the ungrammatical long-distance condition (*M* = 647, *SD* = 155) compared to the ungrammatical short-distance condition (*M* = 606, *SD* = 141).

Table 4

Mean (SD) of the RTs in milliseconds in the spillover region in relation to distance for native speakers (NSs) and nonnative speakers (NNSs)

	NS		NNS	
	Simple	**Complex**	**Simple**	**Complex**
Grammatical	451(95)	502(110)	492(119)	551(117)
Ungrammatical	618(223)	615(137)	609(193)	546(97)

Regarding the spillover region, the NSs showed longer RTs in the grammatical long-distance condition (*M* = 502, *SD* = 110) compared to the grammatical short-distant condition (*M* = 451, *SD* = 95). In the ungrammatical condition, however, the NSs spent slightly less time in the long-distance condition (*M* = 615, *SD* = 137) than they did the short-distance condition (*M* = 618, *SD* = 223). Similar to the NSs, the NNSs read the grammatical long-condition more slowly (*M* = 551, *SD* = 117) than the grammatical short-distance condition (*M* = 492, *SD* = 119). In the ungrammatical condition, the NNSs were found to take less time in the long-distance condition (*M* = 546, *SD* = 97) compared to the short-distance condition (*M* = 609, *SD* = 193).

Regarding the agreement attraction effect, both groups seemed to experience processing difficulties in the mismatched contexts as seen in Tables 5 and 6, for the critical and spillover regions, respectively.

Table 5

Mean (SD) of the RTs in milliseconds in the critical region in relation to agreement attraction for native speakers (NSs) and nonnative speakers (NNSs)

	NS		NNS	
	Matched	**Mismatched**	**Matched**	**Mismatched**
Grammatical	561(231)	630(202)	612(179)	692(189)
Ungrammatical	675(272)	710(280)	649(204)	645(151)

Concerning the critical region, the NSs exhibited longer RTs in the grammatical-mismatched conditions (*M* = 630, *SD* = 202) compared to the grammatical-matched conditions (*M* = 561, *SD* = 231). They also took more time in the ungrammatical-mismatched conditions (*M* = 710, *SD* = 280) than in the ungrammatical-matched conditions (*M* = 675, *SD* = 272). For the NNSs, longer RTs were also observed in the grammatical-mismatched conditions (*M* = 692, *SD* = 189) compared to the grammatical-matched conditions (*M* = 612, *SD* = 179). In the ungrammatical context, however, the NNSs read the mismatched conditions slightly more quickly (*M* = 645, *SD* = 151) than the matched conditions (*M* = 649, *SD* = 204).

Table 6

Mean (SD) of the RTs in milliseconds in the spillover region in relation to agreement attraction for native speakers (NSs) and nonnative speakers (NNSs)

	NS		NNS	
	Matched	**Mismatched**	**Matched**	**Mismatched**
Grammatical	481(110)	523(144)	521(125)	580(163)
Ungrammatical	586(127)	644(178)	548(96)	544(132)

In the spillover region, both groups showed similar processing patterns found in their critical region data. The NSs were observed to read the grammatical mismatched conditions more slowly (*M* = 523, *SD* = 144) than the grammatical-matched conditions (*M* = 481, *SD* = 110). Also, they exhibited longer RTs in the ungrammatical-mismatched conditions (*M* = 644, *SD* = 178) compared to the ungrammatical-matched conditions (*M* = 586, *SD* = 127). In the NNS data, RTs in the grammatical-mismatched conditions were longer (*M* = 580, *SD* = 163) than those in the grammatical-matched conditions (*M* = 521, *SD* = 125). However, RTs in the ungrammatical-mismatched conditions appeared to be slightly shorter (*M* = 544, *SD* = 132) compared to those in the ungrammatical-matched conditions (*M* = 548, *SD* = 96).

Two- and three-way ANOVAs were performed to determine the effects of each factor: linear distance, agreement attraction, and WM, as well as their interaction effects. The results of a two-way ANOVA for the NSs' RTs with respect to linear distance in the critical and spillover regions are presented in Table 7.

Table 7
Results of the two-way ANOVA for RTs in relation to distance for native speakers

	Source	Sum of squares	*df*	Mean square	*F*	Sig.
Critical region						
	Distance	465109.130	1	465109.130	8.387	**.004**
	Grammaticality	402626.520	1	402626.520	7.260	**.008**
	Distance × Grammaticality	87.682	1	87.682	.002	.968
Spillover region						
	Distance	21216.260	1	21216.260	.872	.352
	Grammaticality	790000.326	1	790000.326	32.477	**.000**
	Distance × Grammaticality	30173.659	1	30173.659	1.240	.267

For the critical region data, a significant main effect for distance, $F(1, 176) = 8.387$, $p < .05$ was observed, suggesting that the NSs found it more difficult to process the long-distance subject-verb agreement. Also, the results also revealed a significant main effect for grammaticality, $F(1, 176) = 7.26$, $p < .05$. This could mean that the NSs were able to detect the ungrammaticality at the verbs. However, the interaction between distance and grammaticality was non-significant, $F(1, 176) = .002$, $p > .05$. AS for the spillover region data, the analysis revealed a non-significant main effect for distance, $F(1, 176) = .872$, $p > .05$, but a significant main effect for grammaticality, $F(1, 176) = 32.477$, $p < .001$. There was a non-significant interaction between distance and grammaticality, $F(1, 176) = 1.240$, $p > .05$.

The effect of agreement attraction on the NSs' long-distance agreement processing was determined via a two-way ANOVA. The results can be seen in Table 8.

Table 8

Results of the two-way ANOVA for RTs in relation to agreement attraction for native speakers

	Source	Sum of squares	*df*	Mean square	*F*	Sig.
Critical region						
	Grammaticality	310948.102	1	310948.102	4.812	**.030**
	Agreement Attraction	77563.200	1	77563.200	1.200	.276
	Grammaticality × Agreement Attraction	10559.379	1	10559.379	.163	.687
Spillover region						
	Grammaticality	383540.978	1	383540.978	18.312	**.000**
	Agreement Attraction	76591.690	1	76591.690	3.657	.058
	Grammaticality × Agreement Attraction	2026.778	1	2026.778	.097	.756

Regarding critical region, Table 4 shows a significant main effect for grammaticality, $F(1, 116) = 4.812$, $p < .05$, suggesting the NSs' retention of sensitivity to agreement violations. The results showed a non-significant main effect for agreement attraction, $F(1, 116) = 1.2$, $p > .05$. The interaction between grammaticality and agreement attraction was non-significant, $F(1, 116) = .163$, $p > .05$. Concerning the spillover region, there was a significant main effect for grammaticality, $F(1, 116) = 18.312$, $p < .001$ but a non-significant main effect for agreement attraction, $F(1, 116) = 3.657$, $p > .05$. The interaction between grammaticality and agreement attraction was found to be non-significant, $F(1, 116) = .097$, $p > .05$.

A three-way ANOVA was launched to examine the effects of linear distance, WM, and their interaction on RTs for the NNSs. Table 9 shows the results of the analysis.

Table 9

Results of the three-way ANOVA for RTs in relation to distance and WM for nonnative speakers

	Source	Sum of squares	*df*	Mean square	*F*	Sig.
Critical region						
	Grammaticality	17468.391	1	17468.391	.558	.456
	Distance	192598.479	1	192598.479	6.155	**.014**
	WM	1.607	1	1.607	.000	.994
	Grammaticality × Distance	32012.064	1	32012.064	1.023	.313
	Grammaticality × WM	65498.524	1	65498.524	2.093	.150
	Distance × WM	18753.429	1	18753.429	.599	.440
	Grammaticality × Distance × WM	6610.314	1	6610.314	.211	.646
Spillover region						
	Grammaticality	117394.670	1	117394.670	5.660	**.018**
	Distance	58.072	1	58.072	.003	.958
	WM	35790.239	1	35790.239	1.726	.191
	Grammaticality × Distance	153559.224	1	153559.224	7.404	**.007**
	Grammaticality × WM	28871.817	1	28871.817	1.392	.240
	Distance × WM	22680.900	1	22680.900	1.094	.297
	Grammaticality × Distance × WM	11658.962	1	11658.962	.562	.454

Pertaining to the critical region, the results revealed a non-significant main effect for grammaticality, $F(1, 172) = .558$, $p > .05$; a significant main effect for distance, $F(1, 172) = 6.155$, $p < .05$, and a non-significant main effect for WM, $F(1, 172) = .000$, $p > .05$. For the interaction effects, the results showed a non-significant interaction between grammaticality and distance, $F(1, 172) = 1.023$, $p > .05$; a non-significant interaction between grammaticality and WM, $F(1, 172) = 2.093$, $p > .05$; a non-significant interaction between distance and WM, $F(1, 172) = .599$, $p > .05$; and a non-significant interaction between grammaticality, distance, and WM, $F(1, 172) = .211$, $p > .05$. As for the spillover region, the three-way ANOVA revealed a significant main effect for grammaticality, $F(1, 172) = 5.660$, $p < .05$, meaning that the NNSs had a tendency to show sensitivity to agreement violations. There was a non-significant main effect for distance, $F(1, 172) = .003$, $p > .05$, and a non-significant main effect for WM, $F(1, 172) = 1.726$, $p > .05$. The results also indicated a significant interaction between grammaticality and distance, $F(1, 172) = 7.404$, $p < .05$; a non-significant interaction between grammaticality and WM, $F(1, 172) = 1.392$, $p > .05$; a non-significant interaction between distance and WM, $F(1, 172) = 1.094$, $p > .05$; and a non-significant interaction between grammaticality, distance, and WM, $F(1, 172) = .562$, $p > .05$.

The effects of agreement attraction and its interaction effect with WM were determined using a three-way ANOVA. The results are illustrated in Table 10.

Table 10

Results of the three-way ANOVA for RTs in relation to agreement attraction and WM for nonnative speakers

	Source	Sum of squares	*df*	Mean square	*F*	Sig.
Critical region						
	Grammaticality	1639.250	1	1639.250	.048	.828
	Agreement Attraction	37985.793	1	37985.793	1.103	.296
	WM	14326.688	1	14326.688	.416	.520
	Grammaticality × Agreement Attraction	50200.400	1	50200.400	1.457	.230
	Grammaticality × WM	85293.375	1	85293.375	2.476	.118
	Agreement Attraction × WM	10916.551	1	10916.551	.317	.575
	Grammaticality × Agreement Attraction × WM	597.025	1	597.025	.017	.895
Spillover region						
	Grammaticality	1818.232	1	1818.232	.106	.746
	Agreement Attraction	21044.593	1	21044.593	1.224	.271
	WM	1116.387	1	1116.387	.065	.799
	Grammaticality × Agreement Attraction	36607.670	1	36607.670	2.129	.147
	Grammaticality × WM	57918.707	1	57918.707	3.368	.069
	Agreement Attraction × WM	10172.593	1	10172.593	.592	.443
	Grammaticality x Agreement Attraction × WM	76244.920	1	76244.920	4.434	**.037**

For the critical region, the results of the three-way ANOVA indicated a non-significant main effect for grammaticality, $F(1, 112) = .048$, $p > .05$; a non-significant effect for agreement attraction, $F(1, 112) = 1.103$, $p > .05$; and a non-significant effect for WM, $F(1, 112) = .416$, $p > .05$. The results also revealed a non-significant interaction between grammaticality and agreement attraction, $F(1, 112) = 1.457$, $p > .05$; a non-significant interaction between grammaticality and WM, $F(1, 112) = 2.476$, $p > .05$; a non-significant interaction between agreement attraction, and WM, $F(1, 112) = .317$, $p > .05$; and a non-significant interaction between grammaticality, agreement attraction, and WM, $F(1, 112) = .017$, $p > .05$. As for the spillover region, the three-way ANOVA showed a non-significant main effect for grammaticality, $F(1, 112) = .106$, $p > .05$; a non-significant effect for agreement attraction, $F(1, 112) = 1.224$, $p > .05$; and a non-significant effect for WM, $F(1, 112) = .065$, $p > .05$. For the interaction effects, the results revealed a non-significant interaction between grammaticality and agreement attraction, $F(1, 112) = 2.129$, $p > .05$; a non-significant interaction between grammaticality and WM, $F(1, 112) = 3.368$, $p > .05$; a non-significant interaction between agreement attraction, and WM, $F(1, 112) = .592$, $p > .05$; and a significant interaction between grammaticality, agreement attraction, and WM, $F(1, 112) = 4.434$, $p < .05$.

Due to the observed significant interaction, a subsequent post hoc Bonferroni test was carried out to examine which mean scores were significantly different. The results are provided in Tables 11 and 12.

Table 11

Results of the Bonferroni's pairwise comparisons of means of the RTs in the spillover region regarding the grammaticality-distance interaction effect for nonnative speakers

Grammaticality	(I) Distance	(J) Distance	Mean difference (I-J)	Std. error	Sig.	95% Confidence interval for difference	
						Lower bound	Upper bound
Ungrammatical	Short	Long	63.756	32.294	**.042**	.021	127.490
	Long	Short	-63.756	32.294	**.042**	-127.490	-.021
Grammatical	Short	Long	-58.158	32.294	.073	-121.893	5.576
	Long	Short	58.158	32.294	.073	-5.576	121.893

Table 12

Results of the Bonferroni's pairwise comparisons of means of the RTs in the spillover region regarding the distance-grammaticality interaction effect for nonnative speakers

Distance	(I) Grammaticality	(J) Grammaticality	Mean difference (I-J)	Std. error	Sig.	95% Confidence interval for difference	
						Lower bound	Upper bound
Short	Ungrammatical	Grammatical	117.047	37.290	**.002**	43.453	190.641
	Grammatical	Ungrammatical	-117.047	37.290	**.002**	-190.641	-43.453
Long	Ungrammatical	Grammatical	-4.867	26.368	.854	-56.906	47.172
	Grammatical	Ungrammatical	4.867	26.368	.854	-47.172	56.906

The post-hoc Bonferroni testing indicated significant differences of the mean RTs between the ungrammatical-short condition ($M = 609$, $SD = 193$) and the ungrammatical-long condition ($M = 546$, $SD = 97$) ($p < .05$) as illustrated in Table 11. The post-hoc test also revealed significant differences of the mean RTs between the grammatical-short condition ($M = 492$, $SD = 119$) and the ungrammatical-short condition ($M = 609$, $SD = 193$) ($p < .05$) as shown in Table 12.

DISCUSSION

The primary aim of this study was to examine the effects of linear distance, agreement attraction, and WM on L1 Thai learners' processing of L2 English 3SG subject-verb agreement. The central question the present study sought to answer was whether and to what extent the three variables previously mentioned affected L1 Thai learners' processing of the agreement under investigation. The findings were discussed in light of of the Linear Distance Hypothesis (Gibson, 1998, 2000) and agreement attraction (Bock & Miller, 1991).

Regarding the effect of linear distance, both the NSs and the NNSs were observed to experience a higher level of processing difficulties in the long-distance context. To be more precise, both groups exhibited longer RTs in the long-distance context compared to the short-distance counterpart. This implies that the long-distance agreement was more cognitively demanding, leading to the observed longer RTs in the long-distance agreement condition. The finding further corroborated previous studies on long-distance agreement (e.g., Keating, 2010; Rattanasak et al., 2024). According to the Linear Distance Hypothesis (Gibson, 1998, 2000), the NSs and the NNSs were believed to find the long-distance agreement more cognitively demanding. That is, the NNSs had to hold the subject's information while actively parsing the intervening materials. This means that, as the NNSs reached the verb, they needed to retrieve the subject's information, which had been parsed much earlier, to check for agreement. This possibly led them to read more slowly in the long-distance context compared to the short-distance counterpart, suggesting the interference of linear distance. The finding, thus, provided support for the Linear Distance Hypothesis (Gibson, 1998, 2000).

Regarding grammaticality, the NSs showed sensitivity to agreement violations in the critical region as well as the spillover region, regardless of distance. To elaborate, reading slowdowns were observed in both the short- and long-distance contexts, indicating that the NSs were able to detect the agreement violations even when the subject and the verb were a few words apart. Keating (2010) also reported sensitivity to agreement violations in the condition where the grammatical controller was one to four words from the agreement-bearing element. The ability to maintain sensitivity to agreement violations revealed by the NSs was possibly aided by their routinized/automatized L1 processing which is claimed to be less cognitively demanding than L2 processing (Dussias & Piñar, 2010). Given this claim, it was believed that the availability of the NSs' cognitive resources enabled them to recover from processing difficulties in time to recognize the ungrammaticality in the critical region, thereby extending their sensitivity to agreement violations to the spillover region (Just & Carpenter, 1992; Kim & Christianson, 2017; MacDonald et al., 1992). Similarly, the NNSs' sensitivity to agreement violations was observed but only in the spillover region. Having a smaller pool of cognitive resources left to spend based on the aforementioned claim, the NNSs were argued to take relatively longer to recover, hence showing delayed sensitivity to agreement violations in the subsequent region, i.e., the spillover region. The NNSs were found to read the ungrammatical long-distance context more quickly than the ungrammatical short-distance counterpart. This was speculated to reflect a decline in the NNSs' sensitivity to agreement violations as the distance progressed as manifested in shorter RTs in the ungrammatical long-distance context. Such a decline has also been reported in the L2 long-distance dependency processing literature (e.g., Rattanasak et al., 2024; Siriwittayakorn & Miyamoto, 2019).

The present work also attempted to test the extent to which agreement attraction influenced the processing of the agreement in question. The results, surprisingly, showed that neither the NS nor NNS participants were affected by the agreement attraction effect as their RTs in both the critical and spillover regions stayed approximately the same regardless of the head-local noun number (mis)matched conditions. Put simply, the amount of time that the two groups spent reading the mismatched conditions (e.g., 'the cat on the pillows') was roughly the same as they did in the matched conditions (e.g., 'the leaders in the cars'). This phenomenon was believed to result from the mismatch asymmetry effect (Barker & Nicol, 2000; Kaan, 2002). The mismatch asymmetry effect refers to an asymmetric level of agreement attraction effects found when the head noun is singular and the local noun plural (SP) (e.g., 'the cat on the pillows'). In the agreement attraction literature, the SP combination has been attested to create a comparatively larger agreement attraction effect than the plural-singular (PS) counterpart (e.g., 'The golfers in the room') for both production (e.g., Bock & Cutting, 1992; Bock & Eberhard, 1993; Vigliocco & Nicol, 1998) and comprehension (e.g., Barker & Nicol, 2000; Jiang, 2004; Pearlmutter et al., 1999). One explanation to such an asymmetry is based on the notion of plural markedness. According to Bock and Eberhard (1993), plural nouns are more marked than singular nouns, hence creating more noise to disrupt and attract the agreement (See Bock & Eberhard, 1993; Eberhard, 1997, for further discussion). Thus, compared to a plural local noun in the SP subject NP, a singular local noun in the PS subject NP in our study was likely to show very little effect, if any. Given that the mismatched conditions in our study were made up of both the SP and PS combinations, the aforementioned asymmetry potentially caused a decrease in the overall effect size of agreement attraction, with the effect being primarily driven by the SP combination. As a result, the effect of agreement attraction was absent from both the NS and the NNS data.

Pertaining to grammaticality, our prediction was that the participants would spend comparatively less time in the ungrammatical-mismatched conditions compared to the ungrammatical-matched counterparts as the former has been observed to facilitate the processing (Pearlmutter et al., 1999; Wagers et al., 2009). According to this observation, in the ungrammatical-mismatched conditions, the verb shared the same grammatical number with the local noun, creating what looked like a correct subject-verb agreement. Thus, we expected to obtain shorter RTs in the ungrammatical-mismatched conditions due to the agreement attraction effect. The results of the NS data, however, revealed reading slowdowns in the ungrammatical conditions regardless of whether the grammatical number of the head and local nouns matched. The NSs' routinized L1 processing, as previously discussed, was believed to enable the NSs to maintain sensitivity to agreement violations in the ungrammatical-mismatched conditions. However, the effect of agreement attraction in the ungrammatical condition was observed in the NNS data but only when it interacted with the NNSs' working memory (WM), as discussed in the next section.

In addition to the effects of linear distance and agreement attraction, the effect of WM on L2 processing of long-distance 3SG subject-verb agreement was also of interest in the present study. More precisely, the NNSs' WM capacity was examined to determine whether it modulated the NNSs' processing in question and to what extent it interacted with the linear distance and agreement attraction effects. As the results showed, by itself, WM did not affect the NNSs' agreement processing. To elaborate, the low WM capacity NNSs took roughly the same amount of time in both the critical and spillover regions as the high WM capacity NNSs. This means that, regardless of their WM capacity size, the NNSs processed the 3SG subject-verb agreement in a cognitively similar manner.

Regarding the WM-distance interaction effect, there was no significant difference in RTs in the long-distance agreement condition between the two WM capacity groups. The results revealed that both the low and high WM groups displayed similar RTs in the long-distance agreement condition, suggesting that both processed the long-distance agreement similarly regardless of their WM size. This finding could possibly be accounted for by the NNSs' high L2 proficiency level. To be more precise, it was speculated that the NNSs' high proficiency level potentially lowered the WM effect, possibly resulting in a decline in WM as the L2 proficiency advanced. Serafini and Sanz's (2016) study on L2 Spanish morphosyntactic development also reported the moderating L2 proficiency effect. The results in their study indicated that WM effects were observed in the low proficiency participants but such effects showed a decline as their proficiency developed. In this study, the high L2 proficiency of the NNSs was assumed to promote L2 processing patterns similar to native speakers' processing automatization, which, as previously discussed, is argued to be less cognitively demanding (Li, 2023). As such, the NNSs' high proficiency was likely to override the WM effect. This possibly led to the WM effect not being observed in the present study as WM effects are claimed to depend on other factors, especially L2 proficiency (Manchón et al., 2023).

With respect to the WM-agreement attraction interaction effect, the results revealed a significant interaction between WM, grammaticality, and agreement attraction in the spillover region. The low WM capacity group was found to suffer from the agreement attraction in the ungrammatical context as indicated by shorter RTs in the ungrammatical-mismatched conditions compared to the high WM capacity group. This finding was consistent with the observation made in Pearlmutter et al. (1999) and Wagers et al. (2009). That is, the ungrammatical-mismatched conditions (e.g., '*The key to the cabinets were…') were assumed to aid the parsing due to the shared grammatical number between the preverbal non-head attractor noun and the verb. It was possible that the low WM capacity NNSs experienced a greater level of difficulties in retrieving the information of the head noun, which was farther back, during the agreement checking at the verb due to their smaller pool of WM capacity. This, in turn, potentially made them susceptible to the agreement attraction effect manifesting in the agreeing number between the preverbal non-head noun and the verb in the ungrammatical-mismatched conditions. As a result, the low WM capacity NNSs exhibited a decline in sensitivity to agreement violations as indexed by short RTs in the ungrammatical-mismatched conditions.

CONCLUSION

The present study set out to test whether and to what extent linear distance, agreement attraction, and WM interfered with L1 Thai learners' processing of 3SG subject-verb agreement. The results provided evidence to fully support the Linear Distance Hypothesis (Gibson, 1998, 2000) and partially support the agreement attraction and WM predictions. Both the NSs' and the NNSs' processing was affected by the long distance between the subject and the verb as evident in longer RTs in the long-distance agreement context. While the NSs exhibited reading slowdowns for agreement violations in both the critical and spillover regions regardless of the distance, the NNSs did so only in the spillover region and in the short-distance context. The NNSs' sensitivity to agreement violations seemed to be modulated by longer recovery time and distance as reflected in a delay and a decline in such sensitivity, respectively. The agreement attraction was not found to intensify the existing processing difficulties in long-distance agreement processing. This was assumed to be due to the mismatch asymmetry effect of the singular-plural number combination, rendering the overall effect size of agreement attraction. The diminished effect of WM was likely to be ascribed to the NNSs' high L2 proficiency as high levels of L2 proficiency were believed to associate with processing automatization in L1 processing. The NNSs' agreement processing was shown to be guided by WM only when it interacted with the agreement attraction effect and only in the ungrammatical context, suggesting the influence of other moderating factors on WM effects.

The implications provided by the findings in this study are believed to benefit theories and research in L2 morphology processing as they revealed factors involved in such processing. The revelation hopefully enhances the understanding of how L2 learners process L2 morphology and how L2 processes in the mind function in general. The findings regarding the modulating effects of the three factors can also be taken into consideration during L2 classroom lesson planning to enhance the effectiveness of teaching materials.

Limitations of this study have been recognized and recommendations for further studies are provided accordingly. As only advanced L2 learners took part in the present study, future studies are recommended to include L2 learners of different levels of proficiency so that a more conclusive argument on the relationship between L2 proficiency and WM can be put forward. Additionally, to confirm whether the mismatch asymmetry effect can be used to account for the presence or absence of agreement attraction effects, further research is suggested to test the number mismatched conditions not only as a combined unit but also separate units. Future studies are also recommended to consider testing the distance-based complexity using clausal post-modifiers like relative clauses to see whether structural differences between phrasal and clausal post-modifiers will vary the distance effect. Additionally, including L2 participants with an L1 background which instantiates tense and agreement similar to English (e.g., Spanish and French) can reveal whether their L2 agreement processing is modulated by the effects of distance, agreement attraction, and WM in a similar fashion as that of those whose L1 lacks the agreement in question.

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Ethical approval

Prior to data collection, this study's research ethics had been approved by the Research Ethics Review Committee for Research Involving Human Subjects: The Second Allied Academic Group in Social Sciences, Humanities and Fine and Applied Arts from the authors' institution.

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Appendix

Below is the list of the SPRT experimental stimuli. The asterisk '*' specifies the ungrammaticality.

1. The waiter lives in a small town.
2. The duck swims in extra slow motion.
3. *The butcher smoke at the same spot.
4. *The doctor smile with her whole face.
5. The babies cry in their cribs often.
6. The nurses respond in a quick manner.
7. *The students studies in the same class.
8. *The dolphins sings on a nightly basis.
9. The girl at the door reads with a quick pace.
10. The teen on the ladder works on her summer break.
11. *The tiger in the cage lie on its great back.
12. *The orphan on the train roam from town to town.
13. The cat on the pillows sleeps on its soft tummy.
14. The guide at the machines arrives with a bright smile.
15. *The agent at the coolers talk with a firm voice.
16. *The author on the boxes write with a fountain pen.
17. The members on the floor dance with a straight face.
18. The sellers in the shop stand in a strange way.
19. *The lawyers on the ship travels from city to city.
20. *The golfers in the room practices with a strict routine.
21. The leaders in the cars meet on a monthly basis.
22. The rabbits in the boxes nap with their heads touching.
23. *The nurses at the machines acts in a calm fashion.
24. *The bankers at the lifts eats at twelve every day.