INDIVIDUAL DIFFERENCES IN PREDICTIVE PROCESSING: EVIDENCE FROM SUBJECT FILLED-GAP EFFECTS IN NATIVE AND NONNATIVE SPEAKERS OF ENGLISH

BY

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Abstract

This study examined whether native and non-native speakers of English show evidence of predictive processing in the domain of syntax, and investigated the extent to which linguistic and non-linguistic factors modulate prediction (e.g., Grüter et al., 2014; Hopp, 2013; Kaan, 2014). Using self-paced reading, this study examined wh- dependencies, focusing on filled-gap effects in the pre-verbal, subject position. Specifically, this study manipulated the distance between the filler and potential gap position to investigate the proposal that increasing the distance between the filler and potential gap may force the parser to strongly commit to the subject gap analysis (e.g., Clifton & Frazier, 1989; Lee, 2004). A clear subject filled-gap effect was found in the condition in which the filler was immediately adjacent to the potential subject gap position for both English native speakers and Korean learners of English. Thus, both native and non-native speakers of English are able to immediately predict subject gaps and do not need additional distance. No effects were found in the long-distance condition for either natives or non-natives, suggesting that the increased processing burden may have hindered rather than facilitated the generation of a strong prediction for a subject gap. Greater attentional control, as measured by the Stroop task, was associated with larger subject filled-gap effects for both populations. Thus, these results provide evidence that non-native speakers are able to predict syntactic structure and actively resolve wh- dependencies and that the cognitive abilities that impact prediction are qualitatively similar in both native and non-native speakers (Kaan, 2014).

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1. Introduction

There is a debate regarding whether native sentence processing relies on fundamentally different mechanisms, as compared to non-native sentence processing. In particular, theories such as the *Shallow Structure Hypothesis* (Clahsen & Felser, 2006a,b) claim that whereas native speakers are able to utilize knowledge of syntactic structure during online sentence processing, non-native speakers rely primarily on non-syntactic information, even at high proficiency levels. This claim is based on the assumption that the language learning process for adults is fundamentally different from the language learning process for child L1 learners. That is, even though both child and adult language learners exhibit language patterns different from adult native speakers, the differences observed in children are often attributed to developmental or processing-based explanations (e.g., Clahsen & Felser, 2006a,b; Crain, 1991; Newport, 1990). In contrast, the differences found between native and non-native processing are claimed to be the result of an inability to ever fully acquire or access components of the language itself (e.g., Clahsen & Felser, 2006a,b; Felser et al., 2012). However, still other proposals suggest that children and adult learners may have similar grammatical representations, but differ in their ability to access and use that information during online processing due to limitations in cognitive or predictive abilities (e.g., Hopp, 2010; McDonald, 2006; Phillips & Ehrenhofer, 2015; Grüter et al., 2014). The current study aims to more fully consider the role of both linguistic factors and individual differences in cognitive capacities in non-native language acquisition by examining how each contributes to both native and learners' abilities to use prediction during online sentence processing.

During real-time language processing, the parser must rapidly and accurately process and interpret complex linguistic input. Therefore, the ability to predict upcoming words or even grammatical structure in written or spoken dialogue could assist in this process. However, while there is strong evidence that the parser can predict upcoming words in a sentence (e.g., Altmann & Kamide, 1999), the extent to which a native or non-native parser is able to predict grammatical structure is still uncertain. One test case for examining whether native and non-native speakers are able to similarly predict grammatical structure during online sentence processing involves the phenomenon of *wh*- dependencies in English (1b).

(1)

a. Diana kicked *the ball* in the park.

b. I asked what$_i$ Diana kicked _____$_i$ in the park.

According to movement-based accounts of *wh*-question formation (e.g., Chomsky, 1977), to form an embedded *wh*- question as in (1b), the *wh*-word *what* originates in the object position of the verb *kicked* and is then moved to a complementizer position higher in the structure. The *wh*-word is referred to as the "filler" and the canonical position from which the noun phrase in (1a) was moved is called the "gap." The relationship between the filler and the gap is referred to as a *filler-gap dependency*. Importantly, upon encountering a *wh*- filler in a sentence, as in (1b), the parser could theoretically predict that the filler is associated with a canonical gap later in the sentence.

According the *Active Filler Strategy* (Frazier & Clifton, 1989), during online sentence processing, the parser is thought to actively seek to resolve this dependency as soon as possible.

This means that as soon as the parser encounters the *wh*-filler, it immediately begins searching for the associated gap position. Thus, these syntactically-based accounts of filler-gap dependency resolution claim that, upon encountering a *wh*-filler, the native parser develops an expectation as to where the gap will occur in the sentence (e.g. Stowe, 1986). As such, if non-native speakers are, indeed, native-like in their processing, they would be predicted to show a similar pattern of anticipatory structure building during online processing.

There is some debate, however, as to whether the surface interpretation of (1b) is necessarily reliant on the presence of an abstract "gap" position, or whether a simpler explanation based on the semantic relationship between the *wh*-word and the subcategorizing verb *kicked* would sufficiently explain how a sentence like (1b) is processed (Pickering and Barry, 1991). That is, during online sentence processing, upon encountering the *wh*-word *what*, the parser interprets this extracted element as an argument of a verb and begins to search for a possible subcategorizer. The extracted element (e.g. *what*) is then *directly associated* with the verb *kicked*, as the external argument of that verb. Thus, in the *Direct Association* account, the semantic dependency between the verb and its arguments is sufficient to explain the link between these elements; there is no need to posit syntactic gaps. This model also allows for anticipatory processing in that individuals, upon encountering a filler, can predict upcoming elements in a sentence, such as the presence of an argument-taking verb, without assuming the sentence contains abstract filler-gap dependencies.

Relevant to the current study, even if native speakers are shown to use the syntactic mechanisms assumed by the *Active Filler Strategy*, it is possible that non-native speakers process sentences using mechanisms similar to those described in the *Direction Association Hypothesis*. In both cases, the speakers would ultimately arrive at the same surface interpretation in (1b);

however, the native and non-native speakers would arrive at that interpretation using different mechanisms. In fact, this is precisely what theories such as the *Shallow Structure Hypothesis* predict, that non-native speakers of a language rely on semantic and pragmatic information even in cases where native speakers use syntactic information. Thus, an additional aim of the current study is to examine whether non-native speakers of English demonstrate evidence of gap-driven *wh*- dependency resolution similar to native speakers of English.

In order to distinguish between online dependency resolution that is driven by semantic associations, as predicted by the *Direct Association Hypothesis,* and gap-based dependency resolution, the current study examines the processing of filler-gap dependencies in a pre-verbal, subject position (2).

(2)

a. I asked *what* **Marie** ate ___ yesterday.

b. I asked *if* **Marie** ate **carrots** with apples yesterday.

An active parser will ultimately associate the *wh*- filler (e.g. *what*) in (2) with the position following the verb (e.g. *ate*). However, evidence of an association at this position can be explained by both the *Direct Association* and *Gap-Based* accounts. Therefore, the current study will focus on the possible association between the *wh*- filler and the *subject position* (e.g. *Marie*). Recall that upon encountering the *wh*- filler, the *Active Filler Strategy* predicts that the parser will immediately begin searching for a possible gap position. The first of these possible gap positions is the subject position. Importantly, at this *pre-verbal* subject position, no subcategorizing information is available and thus any attempt to resolve the *wh*- dependency at

this position cannot be explained by the *Direct Association Hypothesis*. Rather, evidence that the parser attempts to posit a gap at this subject position would provide strong support for the existence of abstract syntactic gaps. Such evidence would also provide support for theories claiming that online processing involves syntactically-based, predictive processing. In this case, because the subject position in (2a) is already filled with another lexical item (e.g. *Marie*) and thus ultimately not available for the wh- dependency resolution, a reading time slowdown is expected at *Marie* in (2a), as compared to the same subject position in (2b). This reading time slowdown is referred to as a *subject filled-gap effect* and assumed to indicate that the parser is reanalyzing an earlier, incorrect prediction. Critically, such an effect would indicate that the parser attempted to resolve the dependency at this subject position in advance of confirmatory information that the position was, in fact, available.

Evidence of *pre-verbal* gap-filling during online processing is mixed for studies of both native and non-native speakers. There is some evidence that the parser actively posits gaps in advance of confirmatory subcategorizing information (e.g., Nakano et al., 2002; Omaki et al., 2015; Aldwayan et al., 2010; Canales, 2012). Additionally, there is also evidence that the processing of pre-verbal gaps may be influenced by non-linguistic factors (e.g., Johnson et al. 2013). Therefore, the current study aims to more closely examine the processing of pre-verbal gap-filling by manipulating linguistic factors, such as the distance between the filler and the gap, while also examining non-linguistic factors (e.g., the general cognitive capacities of the participants).

The structure of this dissertation is as follows. The first section will discuss evidence that native speakers use syntactic mechanisms to resolve *wh*- dependencies during online language processing. This section will also further discuss the linguistic phenomenon (i.e. pre-verbal

filler-gap dependencies) and the linguistic manipulation (i.e. the distance between the *filler* and the *gap*) used in this study. A review of studies which test non-native speakers' ability to use syntactic knowledge during online sentence processing will follow. This review will be followed by a discussion of studies which have linked individual differences in cognitive capacities to the type of predictive processing addressed in this study. Finally, the design of the current study will be outlined, followed by the results and discussion.

2. Literature Review

2.1. Native Language Processing

A native speaker of a language does not wait until the end of the sentence to try to understand it. Rather, as studies of online processing demonstrate, the native speaker rapidly processes each new word as it is encountered (e.g., Kutas & Hillyard, 1980; Van Berkum et al., 2005; Wicha et al., 2004). Furthermore, previous research (e.g., Altmann & Kamide, 1999) has found that with each new word in the sentence, the native speaker quickly predicts upcoming words or phrases. Altmann & Kamide (1999) presented native speakers of English with a visual scene of a boy in a room with a cake and three other, inedible objects (e.g., a ball, a shoe, and a kite). They then measured participants' eye movements as they listened to one of the sentences shown in (3). According to a predictive approach to language processing, participants should show more looks to the only edible item in the scene (e.g., *cake*) when they hear *eat* as compared to the other objects, even before hearing the actual noun.

(3)

a. The boy will *move* the cake.

b. The boy will *eat* the cake.

When their eye movements were measured starting at the onset of the verb (e.g., *move/eat*), Altmann & Kamide (1999) found that native speakers of English looked at *cake* more often when hearing the verb *eat* (3a) than the verb *move* (3a), prior to even hearing the determiner (e.g., *the*). This study provides strong evidence that the participants are using the verbs' selectional restrictions to predict upcoming words. However, an open question remains as to whether native speakers are additionally able to preemptively build and access syntactic structure during online processing.

In order to determine to what extent native speakers build and access syntactic structure during online sentence processing, consider the phenomenon of *filled-gap effects*. Recall that a *filler-gap dependency* is created when the *wh*-phrase (e.g. *what*) in (4b) is moved from its original position in the declarative sentence (4a) to a position earlier in the sentence. The moved *wh*-word is referred to as a *filler*, while the position from which the *wh*-word was moved is referred to as a *gap*.

(4)

a. Marie ate apples yesterday.

b. I asked *what* **Marie** ate ___ yesterday.

c. I asked *what* **Marie** ate **carrots** with _____ yesterday.

d. I asked *if* **Marie** ate **carrots** with apples yesterday.

The *Active Filler Strategy* (Frazier & Clifton, 1989), is an extension of the *Active Filler Hypothesis* (Frazier, 1987; Frazier & Flores D'Arcais, 1989), as stated in (5).

(5) Active Filler Hypothesis: When a filler has been identified, rank the option of assigning it to a gap above all other options.

Thus, according to this hypothesis, once the parser encounters a filler, it predicts that an upcoming phrase where a gap is possible will actually contain such a gap, as opposed to a complete lexical phrase (Clifton & Frazier, 1989). Therefore, according to the *Active Filler Strategy,* the parser will proactively search for potential gap positions, *predicting* upcoming phrases with potential gaps at each grammatically accurate position in the sentence, until the filler-gap dependency is resolved. In order to accomplish this predictive process, the parser must rapidly build a mental representation of the possible structure in advance of confirmatory information that there is actually a gap in the upcoming phrase. For example, the potential gap positions in (4c) include the subject position (e.g., *Marie*) and the object position (e.g., *carrots*), both of which are filled with other lexical material. The actual gap position in (4c) follows the preposition (e.g., *with*). If the parser is predictively building syntactic structure, evidence of processing difficulty is expected at *Marie,* the subject position, because this would be the first possible, grammatically licensed gap position; however, because this position is already filled with an overt subject, the parser would be forced to reanalyze its prediction. In a self-paced reading study, where reading times are measured at each word, this difficulty is known as a

filled-gap effect and manifests as a slowdown in reading time at the filled-gap positions in (4c) as compared to reading times at matched positions in declarative sentences (e.g.,4d).

Stowe (1986) found evidence of these *filled-gap effects* in native speakers of English using sentences similar to (6b), in which there are three potential gap positions, as described above: the subject position (e.g. *Barbara*), the direct object position (e.g. *Sam*), and the actual gap position (e.g. following *beside*). If the parser begins predictively building syntactic structure upon encountering the filler (e.g. *who*), then a *subject filled-gap effect* is expected at *Barbara*, and an *object filled-gap effect* is expected at *Sam.*

(6)

a. *Declarative/if*

My brother asked *if* **Barbara** will photograph **Sam** beside mom at the graduation.

b. *Wh-extraction*

My brother asked *who* **Barbara** will photograph **Sam** beside __ at the graduation.

In measuring reading times at the critical subject and object regions, as well as the spillover regions (i.e. the words following the critical region), Stowe (1986) found evidence of *object filled-gap effects*, but, relevant to the current study, did not find the expected *subject filled-gap effects*[1].

To further examine whether the native parser is grammatically constrained during online processing, Stowe ran a second experiment examining whether native speakers of English avoid positing gaps in positions not licensed by the grammar. For instance, in (7b) the preposition

[1] Stowe (1986) did find some evidence that the participants attempted to posit a gap at the subject position, which will be discussed in the later section on *subject filled gaps.*

about is a potential gap licensor. However, this potential gap licensor is within an *island*, or a syntactic structure from which movement is not permitted (see Ross, 1967). Thus, because a gap is not permitted at this position (e.g. *Greg's*), a grammatically constrained parser is expected to avoid positing a gap at this position and no reading time difference is expected at *Greg's* in (7b) as compared to (7a).

(7)

a. *Declarative/if*

The teacher asked ***if*** the silly story about **Greg's** older brother was supposed to mean anything.

b. *Wh-extraction*

The teacher asked ***what*** the silly story about **Greg's** older brother was supposed to mean _____.

As predicted, Stowe (1986) found no evidence of a *filled-gap effect* at the prepositional object position (e.g., G*reg's*) in (7). There was no reading time slowdown for native speakers at this position in (7b) as compared to (7a), suggesting that native speakers are not only incremental processors, but also grammatically constrained during online processing.

Stowe's (1986) interpretations of these *filled-gap effects* are not without controversy. Stowe's interpretations are based on the claim that, upon encountering a *wh*-filler, the parser predicts abstract potential gap positions (e.g., Bever & McElree, 1988). However, as mentioned earlier, these results can also be explained by a process of *direct association* between the extracted *wh*-word and the subcategorizing verb or preposition that licenses it (e.g., Gibson et al.

1994; Gorrell, 1998; Pickering & Barry, 1991). That is, upon encountering the *wh*-word (e.g. *what*), it is possible that the processor simply predicts that this *wh*- word is an extracted argument and thus begins searching for a potential argument position, such as the direct object position following the verb (e.g. *ate*) in (8).

(8)

a. I asked [*what*]$_1$ Marie [ate]$_1$ yesterday.

b. I asked [*what*]$_1$ Marie ate *carrots* [with]$_1$ yesterday.

c. I asked *if* Marie ate *carrots* with apples yesterday.

Pickering & Barry (1991) note that *filled-gap effects* such as those observed in Stowe (1986), namely the reading time slowdown at *carrots* in (8b) as compared to the same position in (8c), could also be explained via a basic thematic argument relationship. Specifically, according to the *Direct Association Hypothesis*, the *wh*-word would be directly associated as an argument of the verb (e.g., *ate*) in (8a) or preposition (e.g., *with*) in (8b). Importantly, this direct association explanation is sufficient to explain Stowe's (1986) results, without assuming the existence of an abstract syntactic gap, or *filler-gap* dependency. This is because if the parser is expecting to associate the *wh*-word with the first available subcategorizer (e.g., *ate*), then it would be forced to reanalyze its expectation upon finding the potential argument position filled, causing a reading time slowdown similar to that seen in Stowe (1986). Furthermore, the lack of a *subject filled-gap effect* in Stowe (1986) is predicted by this *Direct Association Hypothesis* as no subcategorizer is available at this subject position. Thus, while the presence of a *filled-gap effect* only in the grammatically licensed object position (e.g., Experiment 1, but not Experiment

2) suggests that the parser is relying on syntactic structure, these results are not sufficient to tease apart the claims of *Gap-Based* accounts and *Direct Association* accounts of *wh*-dependencies. Therefore, stronger evidence is needed to support the claim that the parser utilizes syntactically based gaps to predictively build syntactic structure during online *wh*-dependency resolution. One possible source of evidence could come from *pre-verbal* gap-filling, which involves potential gap positions that occur before a subcategorizing verb. Evidence of filler-gap dependency resolution at these positions, which cannot be attributed to associations between a subcategorizing head and its arguments, would strengthen the claims of the *Gap-Based* accounts.

2.1.1. Pre-verbal gap-filling in native speakers

Evidence for pre-verbal gap-filling can be found in studies of head final languages (e.g. Aoshima et al., 2004; Nakano et al., 2002). Nakano et al. (2002) examined gap-filling in Japanese, a verb final, *wh-in situ* language. The authors argued that while movement in Japanese is primarily the result of a process known as scrambling, where entire arguments are moved, such movement can also result in filler-gap dependencies. Thus, Nakano et al. (2002) used a cross-modal lexical priming paradigm to examine whether the parser would reactivate a scrambled, or moved, NP (e.g. *remon, 'lemon'*) at the NP's canonical gap position (e.g., following *hito-ni*), as in (9). Critically, this gap position occurred prior to the sentence final verb (e.g., *kotae*).

(9) Suruto **remon**-o_i [CP/IP futari-me-no hito-ga shikai-sha-ni
And then **lemon**-ACC the second person-NOM M.C.-DAT
[CP sono kodomo-ga** onna-no hito-ni ***t*$_i$ *** nedatte-iru to] kotae-ta]
that child-NOM female person-DAT ***t*** asking COMP] answered]
Lit. "And then, a lemon, the second person answered to the Master of Ceremonies that that child was asking the woman for."

In this paradigm, participants listened to a sentence (9) and then were required to make a lexical decision when they saw a visual probe. The visual probes were presented at either the gap (e.g. following *hito-ni* *) or a pre-gap (e.g. 500 ms before the gap **) position and the probes were either words identical to the moved filler or words unrelated to the moved filler. Reaction times for the lexical decision task were then compared. According to gap-based accounts, participants were expected to demonstrate priming effects in which the reaction times for the lexical decision task were faster for the identical targets, as compared to the unrelated targets, at the gap position, but not the pre-gap position. Such evidence of position dependent priming would indicate that the filler is reactivated at the gap position, thus priming the identical target visual probe.

In the first of two experiments using the design described above, Nakano et al. (2002) found main effects of probe type (e.g., the reaction time was faster for identical targets as compared to unrelated targets) and position (e.g. the reaction times for the pre-gap position were faster than the actual gap position), but they did not find the expected interaction. That is there was no difference in priming effect at the gap position, as compared to the pre-gap position. In order to further explore the results, participants were divided into two groups, based on "mean

reaction times for 106 nonexperimental target words" (545). A separate analysis of participants with faster reaction times did show the predicted interaction in which reaction times for identical visual probes were faster at the gap position than the pre-gap position. No interaction was found for the participants with slower overall reaction times. The authors suggested that the complexity of the sentences, as created by the long-distance dependencies, was overly taxing on the processing abilities of the participants with slower overall reaction times. Specifically, the authors hypothesized that the participants with overall faster reaction times had greater working memory resources, resulting in their ability to accurately reactivate the filler at the pre-verbal gap position.

In order to directly test their prediction that working memory resources affect participants' ability to reactivate a filler at a pre-verbal gap position, Nakano et al. (2002) repeated their first experiment, adding a working memory measure that was a Japanese version of Daneman & Carpenter's (1980) reading span test (Osaka, 1998, Osaka & Osaka, 1992). To analyze the results of this second experiment, the authors divided the participants into three groups (e.g. low span, medium span, high span) based on their working memory scores. They found a three-way interaction between group (high span vs. low span), position (gap vs. pre-gap), and type (identical vs. unrelated). Follow-up analyses revealed that high span participants showed the interaction predicted by gap-based accounts, but low span participants did not. Specifically, Nakano et al. (2002) found that participants with high working memory spans had greater priming effects at the gap position, as compared to the pre-gap position. In contrast, there was no significant interaction for the low working memory span participants. Nakano et al. (2002) used these results as evidence for pre-verbal gap-filling, at least in native speakers of Japanese with high working memory.

Relevant to the current study, the evidence of filler-gap dependency resolution found in Nakano et al. (2002) cannot be explained by the *Direct Association Hypothesis* because it occurs in the pre-verbal position, before any subcategorizing verb information is available. Importantly, this study also provides evidence that, even in native adult speakers of a language, sentence processing at the syntactic level can be influenced by general cognitive capacities. However, as Omaki et al. (2015) suggest, the verb-final nature of Japanese may result in a reliance on different mechanisms and information during sentence processing than would be used by a native speaker of a verb medial language like English. Therefore, more evidence of preverbal gap-filling in additional languages is needed.

To investigate whether adult native speakers of English are able to demonstrate evidence of pre-verbal object-gap dependency resolution, Omaki et al. (2015) compared the predictions of a *conservative active gap-filling* mechanism where gaps are filled immediately upon encountering an available gap-licensor, but not before, to a *hyper-active gap-filling* mechanism, where potential gap positions are predicted in advance of confirmatory linguistic cues. In both accounts, upon encountering a filler, the parser will begin actively searching for the associated gap position. However, the accounts differ in terms of whether the parser predicts the specific structural location of this gap or not. According to the conservative gap-filling view, upon encountering a pre-verbal filler, the parser will not predict where that filler originated. Rather, the parser will wait for confirmatory evidence of a potential gap, such as a transitive verb phrase which could contain an object gap. Critically, any evidence of dependency resolution at or after the verb would also be in line with the claims of the *Direct Association Hypothesis*, which predicts that the parser will only attempt to integrate an extracted element upon encountering a subcategorizing verb. In contrast, once a *hyper-active gap-filling* mechanism has encountered a

filler and a subject noun phrase (i.e. to rule out the possibility of a subject gap), it will then immediately predict that the filler is potentially associated with an object gap position. As Omaki et al. (2015) argue, because the hyper-active parser is predicting an object gap, it will also predict a transitive verb to precede this gap, even before seeing the actual verb. Therefore, if the hyper-active parser encounters a verb that is not transitive, it will need to reanalyze its predictions. Evidence of such reanalysis would take the form of a reading time slowdown at the intransitive verb (e.g., *chatted*) in (10c) as compared to the transitive verb (e.g. *wrote*) in (10a).

(10)

a. Transitive verb, Non-island

   The *city* that the author **wrote** regularly about was named for an explorer.

b. Transitive verb, Island

   The *city* that <u>the author who **wrote** regularly</u> saw was named for an explorer.

c. Intransitive verb, Non-island

   The *city* that the author **chatted** regularly about was named for an explorer.

d. Intransitive verb, Island

   The *city* that <u>the author who **chatted** regularly</u> saw was named for an explorer.

Using self-paced reading, Omaki et al. (2015) manipulated the transitivity of the first, critical verb, such that a gap position was possible after the critical transitive verb *wrote* in (10a), but not after the critical intransitive verb *chatted* in (10c). To examine whether the *hyper-active* parser was grammatically constrained, the authors added two additional conditions in which the critical verb occurred within an island structure (e.g. 10b and 10d). Because no extraction is

possible within an island structure and, thus, no gap can follow the critical verb, no reading time slowdown is expected at either verb in these conditions.

In all conditions, the moved NP filler (e.g. *city*) was an implausible filler for the critical verb (e.g. *wrote, chatted*). Therefore, if the parser is hyper-active and, thus, actively predicts a transitive verb (i.e. which could take the filler as a direct object), then a plausibility mismatch effect is expected, in the form of a reading time slowdown at the transitive verb in (10a) as compared to (10b). In other words, the parser would accurately predict a transitive verb, but be 'surprised' when the filler could not be a plausible argument of that verb. According to the hyper-active gap-filling account, a slowdown at the critical intransitive verb is also expected in (10c) as compared to (10d), but in this case the slowdown would be due to the unexpected presence of the intransitive verb. Therefore, the hyperactive gap-filling account predicts a reading time slowdown at both the transitive verb and intransitive verb in the non-island conditions (e.g., 10a and 10c), as compared to the matched positions in the island conditions (e.g., 10b and 10d). In the transitive conditions, this reading time slowdown would be the result of a plausibility mismatch effect, while in the intransitive conditions the reading time slowdown would be the result of the parser predicting a transitive verb and unexpectedly encountering an intransitive verb.

The predictions of the hyper-active gap-filling account are in contrast to the predictions of the conservative gap-filling account, which predicts an interaction between the four conditions. Specifically, a plausibility mismatch effect is expected in the transitive conditions (e.g., a reading time slowdown in (10a) where a gap is possible as compared to (10b) where a gap is prohibited by island constraints). However, no plausibility mismatch effect at the verb is expected in the intransitive conditions (e.g., no difference in reading times at *chatted* in (10c) as

compared to (10d)). Because the conservative parser would not attempt to proactively associate the filler with the intransitive verb, no reanalysis by the parser would be required.

As predicted by the hyper-active gap-filling account, Omaki et al. (2015) found a slowdown in both (10c) as compared to (10d) and (10a) as compared to (10b), in the spillover regions following the critical verbs. However, while finding effects in the spillover region of a self-paced reading study are very common, the timing of this effect is also consistent with predictions of the conservative gap-filling account because it occurs after the verb has been presented. Thus, Omaki and colleagues ran a second experiment using eye-tracking and modified stimuli (e.g., unaccusative intransitive verbs and all plausible fillers), as in (11).

(11)

a. Intransitive, non-island

   The *opponent* that the veteran tennis player **prevailed** skillfully over during the tournament was very gracious.

b. Intransitive, island

   The *opponent* that <u>the veteran tennis player who **prevailed** skillfully over</u> beat during the tournament was very gracious.

c. Transitive, non-island

   The *opponent* that the veteran tennis player **played** skillfully with during the tournament was very gracious.

d. Transitive, island

   The *opponent* that <u>the veteran tennis player who **played** skillfully with</u> beat during the tournament was very gracious.

Because all verbs could be plausibly associated with the filler in this second experiment, unlike in the first experiment, the predictions differed from the first experiment. Specifically, the hyper-active account predicted an interaction in which a reading disruption was expected at the critical intransitive verb in (11a) as compared to (11b) due to a transitivity mismatch effect, but no reading differences were expected at the critical transitive verb in (11c) as compared to (11d). In contrast, the conservative account did not predict any reading disruptions at the critical verb for either the transitive or intransitive conditions. This is because, prior to the verb position, the conservative parser would not predict a specific type of verb and therefore would not need to reanalyze predictions upon encountering an intransitive verb, as would occur in a hyper-active gap-filling mechanism.

Using eye-tracking data, Omaki et al. (2015) found additional support for the hyper-active gap-filling hypothesis in the form of increased first fixation durations at the unexpected intransitive verb in the non-island condition (11a) in comparison to the island condition (11b); no differences in first fixation were observed in the transitive conditions. The authors note that first fixation is a strong measure with which to examine the predictions of the hyper-active account because first fixation is thought to reflect early levels of lexical access (Rayner, 1998; Staub & Rayner, 2007). Furthermore, Omaki and colleagues (2015) were able to replicate these results, in a third experiment which used further improved stimuli and different participants.

To sum up the discussion thus far, there is evidence that native speakers of English appear able to rapidly build syntactic structure, in advance of bottom-up confirmatory information. However, one specific area which merits further investigation is that of native English speakers' processing of subject filled-gap effects, where previous evidence has failed to strongly support the predictions of gap-based processing theories. Thus, the current study aims

to consider additional factors which may account for the previous findings. Such factors, both linguistic and non-linguistic, may influence an individual's ability to predictively build the syntactic structure required to posit potential subject gap positions.

2.1.2. Subject filled-gap effects

As discussed previously, upon encountering a filler (e.g. *who*), an active and predictive parser is expected to posit a gap at each potential gap position (e.g. *Barbara, Sam*) until it encounters the actual gap (e.g. following *beside*) in (12b).

(12)

a. *Declarative*

My brother asked *if* Barbara will photograph Sam beside mom at the graduation.

b. *Wh-*

My brother asked *who* **Barbara** will photograph **Sam** beside __ at the graduation.

However, Stowe (1986) did not find the expected *subject filled-gap effect*, as defined by a reading time slowdown at *Barbara* in (12b) as compared to the same position in the declarative condition (12a). Such an absence of a subject filled-gap effect would be predicted by the *Direct Association Hypothesis*. This is because, the critical subcategorizing information provided by the verb is not yet available and, thus, the parser would have no reason to predict that the extracted element belongs in this subject position.

Crucially, despite the absence of subject filled-gap effects, Stowe (1986) did find some evidence that the participants attempted to posit a gap at the subject position. This evidence was

found in additional analyses in Stowe's study, comparing sentences which contained filled subject-gap positions, as in (13a), and sentences with 'doubtless' subject gaps (Fodor 1978), where there was an actual gap in the subject position, as in (13b).

(13)

a. My brother wanted to know *who* **Ruth** will bring <u>us</u> home to ____ at Christmas.

b. My brother wanted to know *who* ____ will bring <u>us</u> home to Mom at Christmas.

c. My brother wanted to know *if* Ruth will bring <u>us</u> home to Mom at Christmas.

Stowe (1986) found that when a doubtless gap was available in the subject position, as in (13b), reading times at the filled object gap position (e.g. *us*) were not significantly different from reading times at this same direct object position in a sentence without any gaps (13c). However, when no 'doubtless gap' was previously available, as in (13a), there was a significant reading time slowdown at the filled object gap position, as compared to the same position in a sentence without any gaps (13c). These results suggest that once a 'doubtless' gap position is found, the parser stops searching for other, additional gaps. Thus, after a filler-gap dependency is resolved, the processing of the remainder of the sentence progresses much the same as the processing of a sentence without gaps. Importantly, the fact that the existence of a 'doubtless' subject gap can affect individuals' processing indicates that the parser is, indeed, able to resolve filler-gap dependencies in the subject position. However, because this 'doubtless gap' evidence occurred far after both the potential subject gap and the verb, these effects are of little help when attempting to distinguish between the *direct association* and *gap-based* accounts of processing.

Thus, the question remains as to why the specific subject filled-gap effects predicted by the gap-based processing accounts were not found.

Stowe (1986) suggests two possibilities to explain the lack of subject filled-gap effects. One possibility is that the parser treats the subject position as the 'default' position and does not even begin searching for a gap unless this position is filled. If this was true, then the parser would not be able to show evidence of predictive processing at the subject position. Another possibility is that the parser is more easily able to revise erroneous predictions at the subject position because the parser has not fully committed to a full semantic proposition at this early position in the sentence. Thus, if this position is filled, the parser must only revise the syntactic expectations and not the semantic expectations as well, as it must do at the object position (see Stowe 1986 for further discussion).

Stowe (1986) and others (e.g., Clifton & Frazier, 1989; Clifton & De Vincenzi, 1990; De Vincenzi, 1991; Gibson et al., 1994) suggest that the lack of a subject filled-gap effects could be due to the reader having insufficient time to either develop or commit to a prediction for a subject gap. Recall that in (13a), the subject position (e.g. *Ruth*) is immediately adjacent to the filler (e.g. *who*). Therefore, it is possible that in Stowe's (1986) experiment, participants' parsers were not able to build structural predictions quickly enough for subject filled-gap effects to emerge. Another possibility is that a prediction for a subject gap requires a low level of commitment because the parser could maintain multiple predictions in mind (e.g. those with subject gaps and those without) for a short time, with little processing cost. Thus, when one prediction is incorrect, the reanalysis cost is too minimal to cause a significant reading time slowdown at this position. To investigate these possibilities, Lee (2004) examined whether manipulating the distance between the filler and the subject position, as in (14), affected the

processing of subject filled-gaps in adult native speakers of English. By manipulating the distance between the filler and the potential subject gap position, Lee (2004) was able to both increase the time available for a parser to posit a potential subject gap and, at the same time, increase the complexity of this region, therefore increasing the "reanalysis difficulty" (59) of the subject position (see also Frazier & Rayner, 1982; Ferreira & Henderson, 1991; Warner & Glass, 1987).

(14)

a. Subject Gap/Short

   That is the laboratory *which* **Irene** used a courier to deliver the samples to __.

b. No Subject Gap/Short

   That is the laboratory *to which* **Irene** used a courier to deliver the samples.

c. Subject Gap/Long

   That is the laboratory *which*, <u>on two different occasions</u>, **Irene** used a courier to deliver the samples to ___.

d. No Subject Gap/Long

   That is the laboratory *to which*, <u>on two different occasions</u>, **Irene** used a courier to deliver the samples.

Using a self-paced reading paradigm similar to Stowe (1986), Lee tested 24 native speakers of English, comparing their reading times at the subject positions (e.g. *Irene*) in (14a) and (14c) where gaps were possible, with their reading times at the matched position in sentences where no subject gaps were possible, (14b) and (14d). Lee additionally manipulated the distance

between the filler and potential subject gap position by creating conditions where the filler and potential gap were adjacent (14a-b) or nonadjacent (14c-d). Lee (2004) predicted that if the parser was able to posit a potential subject gap position, but simply needed more time to do so, participants would show a subject filled-gap effect in the *Long* conditions, (14c) as compared to (14d), but not in the *Short* conditions, (14a) as compared to (14b).

Lee (2004) found an overall subject filled-gap effect across all conditions and, while there were no interactions between distance and condition, he analyzed the *Long* and *Short* conditions separately, finding a marginal ($p < .08$) subject filled-gap effect in the *Long* conditions (e.g. a slowdown in (14c) as compared to (14d)). There was no significant subject filled-gap effect in the *Short* conditions only (no reading time difference in (14a) vs. (14b)). Lee's (2004) findings suggest that native English speakers are able to form a structural prediction for a gap in the subject position, but may be limited by processing-based restrictions, such as the time needed for the parser to build and commit to such structure. In terms of the effects of increasing the difficulty of reanalysis at the subject region, Lee (2004) suggests that more investigation is needed to determine whether the increased working memory load caused by increasing the complexity of this critical region (e.g. by adding an additional adjunct clause between the filler and subject gap) affects the maintenance and revision of online predictions.

While Lee's (2004) findings provide a possible explanation as to why the predicted subject filled-gap effects were not found in Stowe's (1986) study, a number of concerns exist. Most importantly, a closer examination of the statistical analysis in the paper reveals alternative interpretations. For one, the lack of an interaction in Lee (2004) between the distance manipulation and the subject gap conditions indicates that the pairwise comparisons by length were not motivated. Indeed, it appears from the statistics that distance did not have a significant

effect on the participants' ability to posit a subject filled-gap; rather, they showed a reading time slowdown in the gap conditions regardless of the distance manipulation. One may argue that the additional analyses of the *Long* vs. *Short* conditions is still helpful to our understanding of the factors related to predictive processing, as it appears that time to make such a prediction may be an important consideration. However, in Lee's (2004) study, participants also showed a slowdown in reading times in a pre-critical region (i.e. at the word *which*), resulting in uncertainty as to whether the slowdown observed in the subject gap positions was due to an attempt to posit a gap at the subject position or a possible spillover effect from a previously read region. These issues, as well as others found in the experimental design, motivate further investigation regarding the nature of subject filled-gap effects in native speakers of English. One possible concern with Lee's design is that all of the target stimuli began with the highly marked phrase "*That is NP (to) which . . . .*" This structure, in combination with a low ratio of target sentences to filler sentences (28:51) could have drawn participants' attention to the critical region or otherwise affected the participants' natural processing mechanisms. Furthermore, there were insufficient controls in the target regions, resulting in highly varied intervening phrases in the *Long* conditions, as well as different word lengths in the critical subject region. These variances could have significantly affected participants' reading times. Finally, there is the possibility that with a larger group of participants, a significant interaction between distance and subject gap conditions could emerge. Thus, the current study, in part, aims to revisit Lee's (2004) study, using improved experimental design and statistical analysis.

2.1.3. Native speaker summary

Native speakers of a language appear able to predict syntactic structure in advance of confirmatory information during online sentence processing. Such prediction-based strategies for language processing may help the native speaker to efficiently process the language, even though there is a risk that such predictions may ultimately prove to be incorrect, as in the case of subject filled-gaps. However, native speakers' ability to utilize syntactic information during online processing may also be influenced by processing factors such as working memory (e.g., Nakano et al., 2002) and linguistic distance between the filler and the potential gap position (e.g., Lee, 2004). Therefore, not only is a better understanding of how and when native speakers of a language are able to use structural prediction during language processing needed, but such an improved understanding of native language processing may also provide further insight on how second language learners process their non-native language(s).

2.2. Non-native Sentence Processing

While there is evidence that adult learners of a second language (L2) are able to attain native-like levels of proficiency after puberty (e.g., White & Genesee, 1996; Cranshaw, 1997; Bongaerts, 1999; Abrahamsson & Hyltenstam, 2008), some proposals suggest that these L2 learners process language differently than native speakers. For instance, the *Shallow Structure Hypothesis* claims that while native speakers of English use abstract syntactic information during online sentence processing, L2 learners rely primarily on semantic or pragmatic information in the language.

For instance, Marinis et al. (2005) found that, unlike native speakers of English, non-native speakers of English from various L1 backgrounds (Greek, German, Chinese, Japanese) do not appear able to access or use abstract syntactic information. Marinis et al. (2005) replicated a self-paced reading study of native English speakers by Gibson & Warren (2004) that tested participants' use of *intermediate gaps* (Chomsky, 1977), which are posited via successive cyclic movement in sentences such as (15a). Specifically, in (15a) the filler (e.g. *who*) is reactivated at the intervening clause boundary (e.g. following *claimed*) creating an intermediate gap; however, no intermediate gap is available in (15b) where the filler extraction is across a complex NP.

(15)

a. The manager who$_i$ the consultant claimed *e'*$_i$ that the new proposal had pleased *e*$_i$ will hire five workers tomorrow.
b. The manager who$_i$ the consultant's claim about the new proposal had pleased *e*$_i$ will hire five workers tomorrow.

Gibson & Warren (2004) found that native English speakers showed faster reading times at the actual gap position (e.g. following *pleased*) when an intermediate gap was present (15a), as compared to reading times at the same position when an intermediate gap was not present (15b). Their conclusion was that the processing of the ultimate gap position was facilitated by the presence of the intermediate gap for the native speakers of English.

Marinis et al. (2005) replicated Gibson & Warren's (2004) results for native speakers, but found different patterns in the L2 learners. Specifically, Marinis et al. (2005) found that both native speakers of English and adult L2 learners showed a reading time slowdown at the actual

gap position, indicating that both the native speakers and learners were accurately integrating the filler in its canonical position. However, while Marinis et al. (2005) found that native English speakers' reading times at the actual gap position were facilitated by the intermediate gap (e.g., faster reading times in (15a) as compared to (15b)), adult L2 learners showed no difference in reading times at this critical gap position. Importantly, the reading time slowdown at the post-verbal gap position, as observed in both native and non-native participants, can be explained by the *Direct Association Hypothesis* because the observed slowdown could be the result of the parser incorporating the filler as an argument of the verb. Therefore, critical evidence of gap-based processing in L2 learners would have to come from a facilitation effect as a result of the intermediate gap, similar that observed in native speakers of English in Gibson & Warren (2004). The absence of such an effect suggests that the L2 learners were not able to utilize the abstract intermediate gap to facilitate their processing of the ultimate gap position. In fact, L2 learners did not benefit from this intermediate gap regardless of whether their L1 instantiated *wh*-movement or not.

More recent proposals by Felser and colleagues suggest that while L2 learners may be able to use syntactic information during on-line processing, they are primarily reliant on non-syntactic information. Felser et al. (2012) examined whether adult L2 learners' processing of syntactically constrained *wh* dependencies (e.g., by *island constraints*) follows the same time-course as native speakers of English. Specifically, the authors used eye-tracking and a plausibility mismatch design to test whether native English speakers and high intermediate to advanced native German L2 learners of English showed a plausibility mismatch effect in sentences with (16c-d) or without (16a-b) island constraints.

(16)

a. No constraint, plausible

   Everyone liked the *magazine* that the hairdresser **read** extensively and with such enormous enthusiasm about _____before going to the salon.

b. No constraint, implausible

   Everyone liked the *shampoo* that the hairdresser **read** extensively and with such enormous enthusiasm about _____ before going to the salon.

c. Island constraint, plausible

   Everyone liked the *magazine* that the hairdresser who **read** extensively and with such enormous enthusiasm bought _____ before going to the salon.

d. Island constraint, implausible

   Everyone liked the *shampoo* that the hairdresser who **read** extensively and with such enormous enthusiasm bought _____before going to the salon.

Consistent with the predictions of a parser that is able to accurately use grammatical information, both native English speakers and L2 learners showed evidence of a plausibility mismatch effect at the verb in the *no constraint* conditions only. However, Felser et al. (2012) found that native speakers showed evidence of a plausibility mismatch in measures of later processing (i.e. rereading times), while the plausibility mismatch effect for L2 learners emerged in measures of early processing (i.e. first pass reading times). Felser and colleagues (2012) argue that these results suggest that L2 learners demonstrate immediate use of plausibility information,

whereas native speakers do not use plausibility information until later stages of processing. These results were supported in a follow-up experiment in which they used a filled-gap paradigm, as in (17).

(17)

a. No constraint, gap

   Everyone liked the *magazine* that the hairdresser **read** _____ quickly and yet extremely thoroughly about before going to the beauty salon.

b. No constraint, filled-gap

   Everyone liked the *magazine* that the hairdresser **read** articles with such strong conclusions about before going to the beauty salon.

c. Island constraint, gap

   Everyone liked the *magazine* that the hairdresser who **read** _____ quickly and yet extremely thoroughly bought before going to the beauty salon.

d. Island constraint, filled-gap

   Everyone liked the *magazine* that the hairdresser who **read** articles with such strong conclusions bought before going to the beauty salon.

In this experiment, native English speakers showed an interaction in first pass reading times at the critical region (i.e. the verb *read* and the immediately following word) and in regression path durations at the critical and spillover region, with evidence of reading disruption at the filled-gap position in non-constraint condition (17b) only. In contrast, there was a significant interaction in rereading times at the spillover region, but not the critical region, for L2

learners. Thus, the authors claim that because the interaction occurred later, in the spillover region only, for L2 learners, the learners must rely more on plausibility information at early stages of processing, while native speakers rely primarily on syntactic information at these early stages (see also Boxell & Felser, 2013). However, it is important to note that in both experiments, reading disruption effects emerge only in the *no constraint* conditions for both native speakers and learners, indicating that learners are similarly sensitive to syntactic constraints.

To address the more recent findings that, in some cases, non-native speakers appear to use similar information as native speakers, but on a different time-course, Grüter et al. (2014) developed the *Reduced Ability to Generate Expectations (RAGE)* hypothesis. The RAGE hypothesis states that non-native processing is based on *reactive* use of linguistic information, while native processing is based on *proactive* use of linguistic information. Grüter et al. (2014) base their hypothesis on findings regarding predictive processing in the domain of discourse. They specifically compared native English speakers' ability to generate coreference expectations using a story continuation task to the performance of Korean and Japanese learners of English on the same task. To test discourse-level predictive processing, Grüter et al. manipulated grammatical aspect of the verb (perfective/imperfective) and referential form of the prompt (pronoun/free), as in (18).

(18)

a. Patrick gave a towel to Ron. (He) _____ [perfective]

b. Patrick was giving a towel to Ron. (He) _____ [imperfective]

c. Patrick gave a towel to Ron. _____ [perfective]

d. Patrick was giving a towel to Ron. _____ [imperfective]

Participants were instructed to complete the sentences as naturally as possible. Continuations of sentences were coded *goal, source, ambiguous,* or *other* according to the intended reference of the syntactic subject. The referential expression for the subject in the free prompt conditions (18c-d) was coded as *pronoun, name,* or *other.* Coding examples are provided in (19).

(19) Context: Patrick gave/was giving a towel to Ron. (He) _____

a. He made sure to give him a clean dry one. (Source continuation)

b. He said "Thank you." (Goal continuation)

c. He did not notice the puddle of water on the floor. (ambiguous)

d. The towel was still warm from the drying machine. (other)

Grüter et al. (2014) found that native and non-native speakers similarly preferred *source* continuations for pronoun prompts (18a-b). However, L2 learners had an overall bias across conditions for *goal* continuations, unlike native English speakers. The authors suggest that this *Goal* bias is the result of a recency bias (i.e. the goal *Ron* was mentioned immediately prior to the target response). Thus, the authors claim that their findings demonstrate non-native speakers' inability to use event structure, or aspect (i.e. perfective vs. imperfective verbs) to generate predictions for upcoming discourse. Grüter et al. (2014) used an additional off-line task

to demonstrate that these L2 learners were equally proficient to native speakers in their ability to use aspect. Thus, the authors claim that the results were driven by L2 learners' diminished ability to generate predictions, as opposed to a lack of aspectual knowledge.

Research on L2 learners' ability to use prediction during online sentence processing is limited, but growing. Whereas some previous studies have failed to find evidence that L2 learners are able to utilize predictive sentence processing on par with native speakers (e.g., Kaan, et al., 2014; Grüter et al., 2012; Kaan, 2014; Kaan et al., 2010; Martin et al., 2013), Kaan and colleagues suggest that L2 learners' ability to use prediction in sentence processing may be dependent on their proficiency in the language, as well as other typological factors (e.g., Kaan, et al., 2010; Kaan, et al., 2014; Dussias et al., 2013; Hopp, 2013). Specifically, it is possible that at early levels of proficiency, L2 learners' ability to make predictions is hindered by their still developing lexicon and insufficient cognitive resources due to the difficulty of processing in a second language. If this is true, then it may be possible for some higher proficiency L2 learners, under some conditions, to pattern like native speakers. Therefore, the current study aims to further investigate whether L2 learners of English are able to demonstrate syntactically-driven, predictive processing, as well as examine possible factors which may affect such processing.

In sum, there is evidence that non-native speakers are able to use syntactic information during online sentence processing, counter to the core claims of the *Shallow Structure Hypothesis*. However, there is evidence that such use of structural information comes at a delay, or is otherwise limited, as compared to native speakers (e.g., Felser et al., 2012). Furthermore, recent proposals (e.g., Grüter et al., 2014) claim that while non-native speakers show evidence of using structural information during online processing, they are unable to use this information to make predictions, on par with native speakers. More investigation is needed, however, to

determine what factors may be affecting non-native speakers' reduced ability to demonstrate predictive online processing. In particular, the current study aims to build on previous evidence of predictive, syntactically-based sentence processing in the L1 literature, in the form of subject filled-gap effects, to examine whether similar effects can be found in L2 learners.

2.2.1. Subject Filled-gap Effects in L2 learners

Using a design similar to Stowe (1986), Aldwayan et al. (2010) and Canales (2012) found that L1 Najdi Arabic L2 English and L1 Spanish L2 English learners respectively, attempt to actively posit object gaps at potential, grammatically licensed gap positions (e.g. *Tom*) in (20b), but avoid positing object gaps at potential gap positions which occur within island structures (e.g. *Henry*) (21b).

(20) Experiment 1, Non-Island

a. Declarative/if

The instructor wondered *if* **Chris** will film **Tom** with Susan at the reception.

b. *Wh*-extraction

The instructor wondered *who* **Chris** will film **Tom** with ____ at the reception.

(21) Experiment 2, Island

a. Declarative/if

My brother questioned *if* **the journalist** that followed **Henry** last Saturday provoked the guard at the store.

b. *Wh*-extraction

My brother questioned *who* **the journalist** that followed **Henry** last Saturday provoked _____at the store.

In both studies, both native and non-native participants showed an object filled-gap effect at the spillover region (e.g. at *with*) in Experiment 1, but showed no difference in reading times at the potential gap licensor (e.g. *Henry*), nor the spillover region, within the island condition in Experiment 2. These results replicate those of Stowe (1986) for native English speakers, and demonstrate that L2 learners are similarly accurate and grammatically constrained during online sentence processing. Furthermore, these finding are inconsistent with the basic predictions of the Shallow Structure Hypothesis which would predict that learners would attempt to posit gaps at all potential gap positions, irrespective of syntactic island constraints.

As discussed in relation to Stowe (1986) and relevant to the current study, the fact that both native and non-native speakers show evidence of filled-gap effects at the object-gap region in Experiment 1 is not sufficient evidence to claim that either group engages in *gap-based*, predictive structure-building. Given that *direct association* accounts claim that object filled-gap effects can be explained by a direct association between the filler and bottom-up verb information, stronger evidence for *gap-based* accounts would come from structural predictions that must occur in advance of the verb. Evidence of pre-verbal gap filling in L2 learners would also better test the predictions of the Shallow Structure Hypothesis. Unlike a filled-gap effect in the direct object position, where semantic or pragmatic information could be used to associate an extracted argument with a thematic role, a pre-verbal filler-gap dependency resolution would depend on knowledge and access to abstract syntax. Therefore, the current study aims to directly

test whether both native and non-native speakers are able to resolve pre-verbal *wh*-dependencies, specifically in the subject position.

In contrast to Stowe (1986) who did not find evidence of subject filled-gap effects in native speakers, Aldwayan et al. (2010) found marginal subject filled-gap effects in Experiment 1 for both native English and L2 participants, and a significant subject filled-gap effect for L2 learners only in Experiment 2. Canales (2012), found significant subject filled-gap effects for both L2 learners and native speakers in Experiment 2, but no significant subject filled-gap effects for Experiment 1. Thus, there is some evidence that L2 learners are able to make syntactic predictions during online processing, in the form of subject filled-gap effects, though the inconsistent patterns merit further investigation.

As discussed previously, one possibility for the lack of subject filled-gap effects in some studies, even for native English speakers, is that the parser does not have enough time generate or commit to a prediction for a gap at the subject position (e.g., Clifton & Frazier, 1989; Clifton & De Vincenzi, 1990; De Vincenzi, 1991; Gibson et al., 1994; Lee, 2004; Stowe, 1986). However, these proposals do not fully account for why subject filled-gap effects emerge for some participants, in some studies, but not others. Thus, the current study investigates the possibility that both native and non-native speakers of English are able to make syntactic predictions during online processing, as evidenced by subject filled-gap effects, but their ability to do so is mediated in part by individual differences in processing abilities.

2.3. Individual Differences in Predictive Processing

Numerous studies have proposed a link between domain general measures of working memory capacity and filler-gap dependencies (e.g., Gibson, 1998; Gordon et al., 2002,

Haarmann & Cameron, 2005; King & Just, 1991), as well as language complexity in general (e.g., Kemper & Sumner, 2001). Indeed, there is some online evidence linking working memory to the processing of complex sentences (e.g., Fedorenko et al., 2006) and the processing of long distance dependencies (e.g., Fedorenko et al., 2013). However, previous online studies examining prediction of upcoming words in a discourse have found no relation between prediction and working memory (e.g., Otten & Van Berkum, 2009). Additionally, some researchers claim that working memory is not critical to online syntactic processing at all (e.g., Caplan et al., 2011). Thus, further investigation into the role of individual differences is critical to our understanding of language processing.

Measures of working memory involve a storage component and a simultaneous processing component, as opposed to measures of short term memory which involve only a storage component (e.g., Conway et al., 2005). Thus, theories relating working memory capacity to the processing of filler-gap dependencies claim that holding a filler in memory while processing a sentence and searching for a gap is taxing on the parser. As a result, similar to the predictions of the *Active Filler Strategy*, the parser is predicted to attempt to associate a filler with the earliest potential gap position in order to resolve the dependency as quickly as possible (e.g., Frazier & Clifton, 1989; Gibson, 1998). This first potential gap position would be the subject position in the current study. Given the fact that in the current study the filler and critical gap position are potentially adjacent, one might predict that working memory is not a factor in such processing. However, another possible source of 'processing' difficulty in terms of working memory may come from the parser's attempt to immediately build upcoming structure upon encountering the filler, while still maintaining that filler in memory. Such a view would be consistent with the predictive view of language processing. However, more research is needed to

determine what role working memory has in relation to syntactic prediction during online sentence processing.

Even if a relationship between working memory and filler-gap effects is found to exist, such a relationship could be due to the existence of an underlying common cause. Kane and Engle (2002) propose that evidence relating working memory capacity to measures of higher level thinking (e.g., Conway et al., 2002; Engle et al., 1999) is due specifically to the fact that working memory tasks involve keeping information in memory while processing interfering information at the same time. They cite the fact that short term memory measures, which lack correlations with higher level processing, also lack a processing component and only require the parser to engage in short-term storage. Thus, Kane & Engle (2002) claim that the source of the correlations between working memory and other tasks are due to another, closely related cognitive capacity: attentional control. The authors cite findings which show that the prefrontal cortex is activated in both working memory and attentional control tasks, such as the Stroop task and antisaccade task. This evidence is directly relevant to the current study, because there is also evidence linking predictive processing to the pre-frontal cortex (e.g., Fogelson et al., 2009; Bar, 2009). This link between attentional control, working memory capacity, and predictive processing has been explored elsewhere in the literature. For instance, Hutchison's (2007) lexical decision task study found that participants with high levels of attentional control (as measured by Operation Span, antisaccade, and Stroop tasks) were better able to use contextual clues to facilitate an expectation for the upcoming, target word. In contrast, those with lower levels of cognitive abilities showed no benefit of context. This evidence that some individuals may be better 'predictors' than others, perhaps due to their levels of attentional control and working memory, is supported elsewhere in the literature (e.g. Slevc & Novick, 2013). Other

online studies support a general link between prediction and attention (e.g. Asthemeimer & Sanders, 2011; Van Ede et al., 2012; see also Summerfield & Egner, 2009).

Finally, there is evidence linking verbal fluency and prediction (DeLong et al., 2012). Studies in the fields of aging (Kemper et al., 2009) and language impairment (Leonard et al., 2007) have also found evidence linking processing speed and complex sentence processing. As Leonard et al., (2007) note, processing speed and working memory may be closely related because a faster processing speed may lead to faster rehearsal and thus improved memory abilities, but the processes are not completely identical. Thus, the current study aims to examine the effects of related, but also distinct cognitive abilities, including working memory capacity, attentional control, and processing speed, during online processing of filler-gap dependencies.

2.3.1. Subject Filled-gap Effects and Individual Differences

Few studies have explicitly examined the relationship between individual differences during online, predictive syntactic processing in native speakers and even fewer have investigated the role of individual differences in predictive L2 processing. However, in a study directly relevant to the current proposal, Johnson et al. (2013) examined individual differences in working memory in relation to native and non-native processing of syntactically constrained filler-gap dependencies. As a follow-up study to Aldwayan et al. (2010) and Canales (2012), Johnson et al. (2013) replicated the syntactically constrained, object-filled-gap effects for both native English speakers and non-native, L1 Korean learners of English. Also similar to these previous studies, Johnson et al. (2013) found some evidence of subject filled-gap effects. Specifically, in their second experiment, a comparison of reading times at the filled subject

position (e.g., *the*) in (22b) as compared to the same position in (22a), revealed subject filled-gap effects for native English speakers, but not for L2 learners.

(22) Experiment 2, Island Constraint

a. Declarative/if

My brother questioned *if* **the journalist** that followed **Henry** last Saturday provoked the guard at the store.

b. *Wh*-extraction

My brother questioned *who* **the journalist** that followed **Henry** last Saturday provoked _____at the store.

These findings are interesting given that both Canales (2012) and Johnson et al. (2013) used the same stimuli, but the subject filled-gap effect patterns were different. Thus, this study reinforces the open question regarding why subject filled-gap effects are only found for some participants, in some conditions. This question may be partially addressed by additional findings in the Johnson et al. (2013) study.

In contrast to previous studies, and critical to the current proposal, both native and non-native participants in Johnson et al. (2013) also completed measures of general cognitive abilities, which were found to correlate with processing at licit gap positions. Specifically, in addition to the self-paced reading experiment, participants completed two working memory measures, a verbal, reading span task (e.g., Daneman & Carpenter, 1980; Conway et al., 2005; Kim, 2008) and a nonverbal, counting span task (Case et al., 1982), which were given in the participants' native languages. Using these additional measures, the authors found that in the

licit subject gap position of Experiment 1, an increase in working memory predicted increased reading time slowdown, for native speakers of English only. Also in Experiment 1, at the spillover region of the licit object gap position, an increase in working memory predicted a reduced reading time slowdown, for Korean learners of English only.

In regards to the relationship between subject gap-filling and working memory for native English speakers, Johnson et al. (2013) propose that participants who have greater working memory capacity are better able to handle the processing demands needed to immediately predict a potential gap in subject position. That is, if participants are better able to predict a subject gap, they are more likely to experience a reading time slowdown when the position is filled, thus explaining the increased reading time slowdown for native English speakers with higher working memory scores. In short, it is possible that the reason some individuals were better able to form an expectancy for a subject gap than others was dependent on their ability to quickly process the filler and make the relevant prediction. If this is true, and some participants simply need more time to predict a subject gap, in line with Lee's (2004) proposal, then those participants should benefit from a linguistic manipulation such as that used in the current study where the filler and subject gap are nonadjacent. The absence of a relationship between working memory and subject filled-gap effects in L2 learners could be explained by a lack of variability in participants' scores, though more research is needed to confirm this.

In sum, the findings of Johnson et al. (2013) suggest that inconsistent evidence for subject filled-gap effects in previous studies may be driven not only by the nature of the linguistic stimuli itself, but also by individual differences in general cognitive abilities. Thus, the current study aims to examine the effects of both linguistic distance between the filler and possible gap and individual differences in cognitive capacities on the processing of pre-verbal

filler-gap dependencies in both native and non-native speakers. The next section will provide background information on question formation in Korean, which, unlike English, does not involve the creation of filler-gap dependencies.

3. Korean Linguistic Background

Korean is a *wh*- in-situ language (Sohn, 1999; Sohn, 1980). Therefore, to form questions in Korean, as in (23b) and (23c), a *wh*- word simply replaces a constituent in a declarative sentence (23a), and remains in the ssame position. Because there is no *wh*- movement involved, no gaps are created in the formation of matrix questions.

(23)

a. Mary가 우리에게 **John을** 내일 **공원**에서

Maeri-ga uri-ege **Chahn-ŭl** nael **kongwŏn**-esŏ

Mary-sub [us-to] [**JOHN**-obj] [tomorrow] [**PARK**]-in

만나냐고 물었다.

mannanyago murŏtta.

[to meet] asked

"Mary asked us to meet [John] tomorrow [in the park]."

b. Mary가 우리에게 **John**을 내일 **어디서** 만나냐고 물었다.

Maeri-ga uri-ege **Chahn**-ŭl nael **ŏdi-sŏ** mannanyago murŏtta.

Mary-sub [us-to] [**JOHN**-obj] [tomorrow] [**WHERE**]-in [to meet] asked

"Where did Mary ask us to meet John tomorrow ___?"

c. Mary가 우리에게 **누구**를 내일 **어디서** 만나냐고 물었다.

Maeri-ga uri-ege **nugu**-rŭl naeil **ŏdi-sŏ** mannanyago murŏtta.

Mary-sub [us-to] [**WHO**-obj] [tomorrow] [**WHERE**]-in [to meet] asked

"Where did Mary ask us to meet who tomorrow _____?"

Because Korean does not involve movement of a *wh*-filler in order to create a question, it is also not thought to be subject to island constraints (e.g., Kim, 2013). Thus, while the structure in (24c) is considered ungrammatical in English because a *wh*-element has been moved out of a relative clause island, the same sentence in Korean is considered grammatical.

(24)

a. Amy는 공을 던진 아이를 쫓아갔다.

Ami-nŭn kong-ŭl tŏnjin ai-rŭl tchoch′agatta

[Amy-top] [ball-obj] [throw child-obj] [chase-past]

Amy chased [the child that/who threw the ball].

b. Mary 가 쫓아간 아이가 누구니?

Maeri-ga tchoch′agan ai-ga nugu-ni

[Mary-sub] [chase] [child-sub] [who-question]

Who was the child that Mary chased?

c. Mary 가 쫓아간 아이가 던진 것은 무엇이니?

Maeri-ga tchoch′agan ai-ga tŏnjin gŏt-ŭn muŏt-ini?

[Mary] [chase] [child-sub] [throw] [thing-top] [what-question]

*What did Mary chase [the child that/who threw *t*]?

While Korean does not have *wh*-movement similar to English, some researchers have proposed that Korean has 'covert' *wh*-movement, at a level beyond syntax (after 'spellout' at LF) (Tomioka, 2007). This debate is beyond the scope of this paper and will not be discussed further. It is important to note, though, that theories such as the Shallow Structure Hypothesis claim that that L2 learners are unable to access syntactic properties in their second language, regardless of the features of their first language. Thus, according to the Shallow Structure Hypothesis, Korean learners of English would not be expected to show evidence of subject filled-gap effects, regardless of whether Korean has *wh*-movement or not.

Korean also has a resumptive pronoun, *saram* (사람), meaning "person," which is required in sentences with subordinate clauses (25-26).

(25)

a. 진수는 민수한테 *전화한* **사람**이다.

Chinsu-nŭn minsu-hant′e chŏnhwahan **saram**-ida

[Chinsu-sub] [Minsu-to] [call-past] [**person**-be]

Chinsu is the person who called Minsu.

b. 민수한테 *전화한* **사람**이 누구니?

Minsu-hant′e chŏnhwahan **saram**-i nugu-ni

[Minsu-to] [call-past] [**person**-be] [who-question]

Who is the person [who called Minsu]?

c. *민수한테 *전화한* 누구니?

Minsu-hant′e chŏnhwahan nugu-ni

[Minsu-to] [call-past] [who-question]

Who called Minsu?

(26)

a. 이 남자가 우리가 한국 음식점에서 *본* **사람**이다.

i namja-ga uri-ga han′guk ŭmsiktchŏm-esŏ pon saram-ida

[This man-sub] [we-sub] [Korean restaurant-at] [saw] [person-be]

This is the man [that/who we saw at the Korean restaurant]

b. 우리가 한국 음식점에서 *본* **사람**이 누구지?

uri-ga han′guk ŭmsiktchŏm-esŏ pon saram-i nuguchi

[we-sub] [Korean restaurant-at] [saw] [person-be] [who-question]

Who was the person that we saw at the Korean restaurant?

c. *우리가 한국 음식점에서 *본* 누구지?

uri-ga han´guk ŭmsiktchŏm-esŏ pon nuguchi

[we-sub] [Korean restaurant-at] [saw] [who-question]

Who did we see at the Korean restaurant?

To form a subordinate clause in Korean, the use of a noun plus a noun-modifying form *n/ŭn/nŭn* ㄴ/은/는 (shown in italics in the examples) is required. Without the resumptive pronoun, *saram* (사람) in the case of a person or *kŏt* (것) in the case of object, there would be no complete noun to modify in the subordinate clause. Specifically, in (25a), the resumptive pronoun is used to clarify that the person doing the calling was Chinsu. Similarly, when a wh-question is formed (25b), the resumptive pronoun refers to the unknown person doing the calling. Just as the resumptive pronoun is required in a declarative sentence, eliminating it from an interrogative sentence, as in (25c) is considered ungrammatical in Korean.

4. Current Study

The current study examines pre-verbal, subject filled-gap effects in both native speakers of English and adult Korean learners of English. Specifically, this study aims to address the following questions: (a) Are native and non-native speakers similarly able to resolve pre-verbal (e.g., subject position) filler-gap dependencies? (b) Does increasing the distance between the filler and the gap improve participants' ability to predict a subject gap? (c) Is the processing of subject filled-gap effects modulated by domain general cognitive capacities, in either native or non-native speakers of English?

Because the subject position occurs before any subcategorizing verb information, proponents of the *Direct Association Hypothesis* (Pickering & Barry, 1991) would not predict evidence of subject filled-gap effects for either native or non-native speakers of English. However, gap-based accounts such as the *Active Filler Strategy* (Frazier & Clifton, 1989) predict that native speakers of English would show evidence of attempted gap-filling in the subject position. Proponents of the *Shallow Structure Hypothesis* (SSH; Clahsen & Felser, 2006a,b) would also predict subject filled-gap effects in native speakers of English; however, they would expect no such effects for adult learners of English. This is because, according to the SSH, native speakers of English rely on abstract syntactic information during online processing and would therefore be expected to utilize the *Active Filler Strategy*. In contrast, the SSH claims that second language learners rely primarily on pragmatic or semantic information, and are unable to access the abstract syntactic information that is required to posit a subject gap.

In addition to the debate regarding the use of syntactic information to resolve filler-gap dependencies, the current study aims to contribute the discussion as to whether native and non-native speakers are similarly able to make syntactic *predications* during online sentence processing. Specifically, the *Reduced Ability to Generate Expectations* (RAGE) proposal claims that native speakers use predictive mechanisms during online processing, but non-native speakers rely on more reactive mechanisms (Grüter et al., 2014). Therefore, upon encountering a filler, a native speaker would be expected to immediately predict a potential gap in the subject position and show a subject filled-gap effect because it must reanalyze its prediction. According to the RAGE hypothesis, however, learners are not predicted to proactivity associate the filler with the subject position and, thus, may not be expected to show subject filled-gap effects because they are not forced to reanalyze any incorrect predictions. Importantly, though, there is

limited evidence that some speakers (both native and non-native), under some conditions, can predict subject gaps (e.g., Alwayan et al., 2010). Therefore, it is also possible that factors such as the time available to make a prediction (e.g., Lee, 2004) or the cognitive resources of the individual speaker may play an important role in the predictive process. The current study directly addresses those two potential factors. While the Shallow Structure and Direct Association Hypotheses would predict that no participant would show subject filled-gap effects, regardless of cognitive resources, it is possible that those participants with greater cognitive resources, greater language proficiency, or sufficient time to make a prediction would show subject filled-gap effects, regardless of native language (Kaan et al., 2014; Kaan, 2014; Dussias et al., 2013; Hopp, 2013; Hopp, 2014; Johnson et al., 2013).

The current study examines each of the above predictions, as well as adds to the processing literature by testing whether native and non-native speakers' processing of subject filled-gap effects is influenced by individual differences in proficiency, working memory, processing speed, or attentional control. This study specifically examines native and non-native speakers' ability to predict syntactic structure in *wh*-dependencies by manipulating the linguistic distance between the wh- filler and the potential subject gap position, similar to Lee (2004) as in (27).

(27)

a. Subject Gap/Short

That is the laboratory *which* **Irene** used a courier to deliver the samples to __.

b. Subject Gap/Long

That is the laboratory *which*, on two different occasions, **Irene** used a courier to deliver the samples to ___.

While the linguistic manipulation used in this study is similar to that used in Lee's (2004) study of native English speakers, the current study utilizes modified stimuli and design, as well as a much larger participant pool to address possible limitations in the previous Lee (2004) study. Additionally, the current study extends this line of research to second language learners of English in order to address both the linguistic and the cognitive factors which may impact the processing of wh-dependencies in both native and non-native speakers of English.

4.1. Materials and Methods

4.1.1. Participants

A total of 108 adult Korean learners of English participated in this study. Eight participants were excluded because they had participated in more than 5 hours a week of English language study or been immersed in an English speaking environment before age 10. The remaining 100 participants (65 female; mean age 24.64) did not receive any significant English language instruction or participate in immersion activities prior to age 10[2]. Data was collected in Seoul, South Korea, at Sogang University and the surrounding area. Participants were paid ₩15000. In addition to the Korean speakers, 110[3] native speakers of English (81 female; mean

[2] Beginning in the third grade, all Korean students begin taking English classes.
[3] 127 Native speakers of English were tested. Of these, 16 participants were excluded from the data analysis because of significant early exposure to, or immersion in, a language other than English before age 10, including

age 19.62) completed the experiment. Native English speakers were recruited from undergraduate courses at the University of Kansas and were given extra credit for their participation. English proficiency for all participants', both native English (mean proficiency score = 45.85) and Korean learners of English (mean proficiency = 28.66), was measured using a 50 point paper and pencil proficiency test the adapted from the *Examination for the Certificate of Proficiency in English* from the University of Michigan (2003). This test included 30 questions on English vocabulary and 20 questions on various aspects of English grammar. All proficiency levels were included in the data analysis.

4.1.2. Stimuli

The current experiment examined native and non-native English speakers' processing of wh- filler-gap sentences by manipulating the linguistic distance between the wh- filler and potential subject gap position. Forty sets of target stimuli were created (see Appendix A), with four versions of each sentence, as in (28).

(28)

a. No Subject Gap/Short

The$_{1}$ principal$_{2}$ questionned$_{3}$ *if*$_{4}$ **Diana**$_{5}$ will$_{6}$ put$_{7}$ the$_{8}$ girl$_{9}$ near$_{10}$ Elliot$_{11}$ for$_{12}$ the$_{13}$ exam$_{14}$.

b. No Subject Gap/Long

The$_{1}$ principal$_{2}$ questionned$_{3}$ *if*$_{4}$, during$_{5}$ the$_{6}$ difficult$_{7}$ test$_{8}$, **Diana**$_{9}$ will$_{10}$ put$_{11}$ the$_{12}$ girl$_{13}$ near$_{14}$ Elliot$_{15}$ for$_{16}$ the$_{17}$ exam$_{18}$.

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simultaneous bilingualism. One additional participant was excluded due to incorrectly following the directions on one of the individual difference tasks.

c. Subject Gap/Short

The$_{1}$ principal$_{2}$ questionned$_{3}$ *who*$_{4}$ **Diana$_{5}$** will$_{6}$ put$_{7}$ the$_{8}$ girl$_{9}$ near$_{10}$ _____ for$_{12}$ the$_{13}$ exam$_{14}$.

d. Subject Gap /Long

The$_{1}$ principal$_{2}$ questionned$_{3}$ *who*$_{4}$, during$_{5}$ the$_{6}$ difficult$_{7}$ test$_{8}$, **Diana$_{9}$** will$_{10}$ put$_{11}$ the$_{12}$ girl$_{13}$ near$_{14}$ _____ for$_{16}$ the$_{17}$ exam$_{18}$.

The experiment manipulated two factors, Sentence Type (Subject Gap vs. No Subject Gap) and Length (Long vs. Short). The *Subject Gap* sentences, (28c) and (28d), contained filled subject gap positions. These were matched with *No Subject Gap*, declarative sentences, (28a) and (28b), that did not contain any *wh*- dependencies. For the *Long* versions of the sentences, an extra PP with the structure "*during* + *the* + adjective + noun" was inserted between the *filler* (e.g., *who*) and the potential subject *gap* position (e.g., *Diana*) in line with Lee (2004). Reading times were measured at each word and comparisons made at the critical subject position (e.g. *Diana*), Region 5 in (28a) and (28c) and Region 9 in (28b) and (28d). Reading times were also compared at the spillover region, following the critical subject position (e.g., *will*), Region 6 in (28a) and (28c) and Region 10 in (28b) and (28d), and the pre-critical region, Region 4 in (28a) and (28c) and Region 8 in (28b) and (28d).

All sentences used in the experiment were grammatical. For each target sentence, the actual gap position in the *Subject Gap* conditions occurred in a prepositional phrase later in the sentence. An additional prepositional phrase was also added to the end of each sentence to ensure that sentences sounded natural. Importantly, a number of controls were included in the current stimuli that were not included in the stimuli used in Lee (2004). For instance, stimuli in

the current experiment were controlled such that the adjectives and nouns included in the intervening prepositional phrase in the Long Distance conditions were not used elsewhere in the stimuli or the fillers. Additionally, the intervening phrase consistently followed the "*during* + *the* + adjective + noun" structure[4]. Finally, all of the proper nouns used in the critical subject region were unique, five letter common names[5].

Four lists with 40 target sentences (10 from each condition) and 80 fillers, for a total of 120 stimuli per list, were created. Participants were randomly assigned to each list. Within each list, target and filler sentences were randomized. The lists followed a Latin Square design for the target sentences, such that every participant saw one version of each of the 40 sentences, but never more than one version of the same sentence.

The filler sentences were adapted from the sentences used in Aldwayan et al. (2010). These 80 fillers included *wh*- words and complementizers, such as *what, that,* and *whether*. Additionally, intervening phrases similar to those used in the *Long* sentences in the target stimuli were added to some of the filler sentences. Finally, all fillers were carefully controlled such that the proper names, adjectives, and nouns in the critical intervening phrase and subject regions of the target sentences were not repeated, so as to avoid possible priming effects.

4.2. Procedure

All participants completed the self-paced reading task first. Following the self-paced reading task, participants completed a series of tasks measuring general cognitive capacities,

[4] In Lee (2004), the adjunct phrases all consisted of four words, but there were no noticeable controls for those words, other than that they formed a grammatically accurate phrase. For instance, phrases included *once in a while, much to everyone's disgust, from time to time,* and *about a fortnight ago*.
[5] The critical, subject region names in Lee (2004) varied in length from four to seven letters.

language proficiency, and background information. The measures of general cognitive capacity included a counting span task, a number Stroop task, and a set of two symbol matching tasks, measuring working memory, attentional control, and processing speed, respectively. These tasks were presented in counterbalanced order and are described in detail below.

The self-paced reading task, counting span task, and number Stroop task were all administered using *Paradigm* presentation software (Tagliaferri, 2005). The processing speed tasks were completed using paper and pencil. Finally, all participants, both Korean learners of English and native speakers of English also completed a background questionnaire and a paper-based English proficiency test, adapted from the *Examination for the Certificate of Proficiency in English* from the University of Michigan (2003). Participants were given short breaks between each task. The experimental session lasted approximately 75 to 90 minutes for Korean learners of English and 60 to 75 minutes for native speakers of English.

Self-paced reading task. Sentences were presented on a computer using a non-cumulative moving window self-paced reading paradigm in which participants read each successive word of a sentence by clicking a mouse button (Just et al. 1982). In this paradigm, for each trial, each word of the sentence is masked by a series of dashes. Participants click a mouse button to reveal the first masked word of the sentence. They then continue clicking the mouse button to reveal each successive word in the sentence. After each click of the mouse button, the previously read word is masked by dashes again, and the next word is revealed. Reading times for each word or region are tracked to the millisecond.

To ensure that participants were attending to the sentences, at the end of each sentence the same sentence, fully unmasked, was displayed again with one word missing. Below the sentence, two words were provided side by side. For example, after reading the sentence, *My*

cousin wondered who David will put the intern near for the discussion word by word, participants saw then saw this same sentence again with a blank replacing the word *intern* (e.g. *My cousin wondered who David will put the ------ near for the discussion*). Participants were asked to indicate the missing word by choosing between two possible options (e.g. *intern* or *roommate*) by pressing a key on the keyboard marked "L" for the word on the left of the screen or "R" for the word on the right of the screen. Prior to beginning the experiment, participants completed a practice session consisting of five practice sentences. Participants were given breaks after trial 40 and trial 80.

Working Memory Task. In order to measure working memory capacity, participants completed a counting span task (Case et al., 1982) which measures non-verbal working memory. This task includes both a processing and memory component, and thus is different from measures of short-term memory which only include a memory component. Because it has been argued that participants' proficiency in a language can affect their scores on working memory measures (e.g., Juffs & Harrington, 2011; Harrington & Sawyer, 1992), participants completed the task in their respective native languages.

In the counting span task, for each trial participants saw a visual display on the computer screen with different shapes of various colors (e.g., blue circles, blue squares, and green circles) and were instructed to count only the target shapes (i.e. the blue circles). The number of target shapes on each screen ranged from three to nine, with two to fourteen distractor shapes. After a series of two to six trials, participants were prompted to enter the total target shapes they counted in each trial, in order. Thus, if the first trial had two blue circles, the second trial had four blue circles, and the last trial had seven blue circles, the participants would type "2 – 4 – 7". Korean participants were asked to count out loud using the Sino-Korean counting system to facilitate

recall[6]. Participants were instructed to use a period (.) as a place holder for numbers they could not recall. Participants were instructed to complete the task, both counting and recall, as quickly and accurately as possible. Participants were told to not try to recall the numbers until the end-of-trial prompt appeared. All participants saw the same 15 series of trials, which were presented in a random order of less versus more trials per series.

This task was experimenter-paced to ensure that participants were not rehearsing the total target shapes shown in each trial before they were asked to recall in each series (Engle et al., 1992; Friedman & Miyake, 2004; Turley-Ames & Whitfield, 2003). Thus, as soon as participants counted the final target shape and repeated the total out loud, the experimenter immediately entered that final number, which triggered the next screen to appear. Participants were instructed to begin counting target shapes on the new screen immediately when the next screen appeared. If they did not begin counting immediately, or appeared to pause to recall previous numbers, they were prompted to start counting immediately. This task was presented using *Paradigm* presentation software (Tagliaferri, 2005).

Attentional Control Task. To test attentional control, participants completed a number Stroop task, which measures participants' ability to attend to a target task despite interfering visual information. As with the counting span task, both native English and Korean learners of English completed the tasks in their native languages so that performance was not dependent on proficiency in the second language (e.g. Juffs & Harrington 2011; Harrington & Sawyer 1992).

[6] Native Korean speakers typically use the native Korean counting system to count out for numbers from 0-99, but use the Sino-Korean system for number strings such as phone numbers, addresses, or money. In pilot testing, participants indicated a preference for entering numbers while thinking of the Sino-Korean system. Additionally, the Sino-Korean numbers from 0-9 are single syllables, similar to English, while most of the native Korean numbers from 0-9 are two syllables. Thus, to create an equivalent task in both languages and eliminate a potential extra processing step that would be needed to transfer numbers counted out loud in the native Korean system, to numbers recalled in the Sino-Korean system, participants were instructed to use the Sino-Korean system to count and recall the target shapes. After the initial practice trials, all participants were able to complete the task fluently and without confusion.

This task was designed based on the guidelines provided in Bush et al. (1998) and Bush and Shin (2006), and subsequently translated into Korean[7]. The number Stroop task was presented using *Paradigm* presentation software (Tagliaferri, 2005).

In the number Stroop task, participants saw eight blocks of 20 trials each, with the blocks alternating between congruent and incongruent trials. In each trial, between one and four identical nouns were shown on the computer screen, simultaneously. Therefore, a participant might see a visual such as this: *dog dog dog dog*. Participants were instructed to count the number of words they saw in the visual and type the corresponding number on the computer keyboard as quickly and accurately as possible. In the congruent trials, the nouns were common animal names (e.g., *cat, dog, bird,* or *mouse*); in the incongruent trials, the nouns were numbers (e.g. *one, two, three,* or *four*). All nouns were one syllable[8] long. Importantly, in congruent trials, the animal names (e.g. *dog dog dog*) did not interfere with the target counting task. However, in incongruent trials, the repeated number words in the visual were incongruent with the actual number of words on the screen (e.g. *two two two*). Therefore, if participants saw "two two two", they had to press the number "3," inhibiting the inclination to press the number "2" based on the nouns shown in the visual.

For the number Stroop task, two lists were created, counterbalancing the alternating order of congruent versus incongruent blocks, and participants were randomly assigned to the lists. Participants had two full practice blocks of 20 trials each, one for congruent trials and one for incongruent trials. The congruent trial practice block was untimed. The incongruent practice trial was timed similar to the main task in which participants had a maximum of 1500 ms to press

[7] The nouns used in the Korean task were not direct translations of those used in the English task. Rather, common, one syllable animal names were used in both language versions.
[8] To ensure that the numbers were also only one syllable each, the Sino-Korean counting system was used.

the button indicating the number of words they saw in the visual before the next trial began. Accuracy rates and reaction times for individual trials within all blocks were recorded, resulting in two distinct variables: Stroop accuracy interference effect and Stroop reaction time interference effect. For each variable the average accuracy rate or reaction time for the trials within the congruent blocks were subtracted from the average accuracy rate or reaction time within the incongruent blocks, respectively. Participants were instructed to answer as quickly as possible, but not to sacrifice accuracy for speed. The entire task lasted approximately 5 minutes and participants were given a break halfway through the task, after four blocks.

Processing Speed Tasks. To test processing speed, participants completed two timed paper-based tasks from the WAIS-IV (Wechsler, 1981): a Symbol Search task and Coding. In the Symbol Search task, participants were given a paper packer with 60 target symbols listed in a column along the left side of the pages. In rows next to each target symbol, were a series of five additional symbols and the word "NO". For each target symbol, participants needed to search from among these five possible symbols for a match. If a match was found, participants were instructed to draw a line through the match; if no match was found, participants were asked to mark "NO". Participants were given two minutes to complete the task, as timed by the experimenter. A total score was obtained by subtracting erroneous matches from the total correct matches made within the time allotted.

In the Coding task, participants were provided with a one single sheet of paper with a number-symbol key at the top and 135 boxes in an array below that key. The number-symbol key contained nine unique symbols matched to the numbers one through nine. For each box in the array of boxes, a number between one and nine was indicated at the top of the box. Participants were instructed to use the number-symbol key as a guide to draw as many symbols

as possible in the boxes, matching the symbols to their corresponding digits, in two minutes. The total score was equal to the number of correctly drawn symbols within the two minutes time limit.

4.3. Predictions

The Direct Association Hypothesis predicts that no evidence of subject filled-gap effects for either native or non-native speakers of English will be found. In contrast, Gap-Based accounts predict that native speakers of English will show subject filled-gap effects, or reading time slowdowns at the subject position (e.g. *Diana*) in the Subject Gap conditions (29c,d) as compared to the matched positions in the No Subject Gap conditions (29a, b), regardless of the distance between the filler and the gap.

(29)

a. No Subject Gap/Short

The$_{1}$ principal$_{2}$ questionned$_{3}$ *if*$_{4}$ **Diana**$_{5}$ will$_{6}$ put$_{7}$ the$_{8}$ girl$_{9}$ near$_{10}$ Elliot$_{11}$ for$_{12}$ the$_{13}$ exam$_{14}$.

b. No Subject Gap/Long

The$_{1}$ principal$_{2}$ questionned$_{3}$ *if*$_{4}$, during$_{5}$ the$_{6}$ difficult$_{7}$ test$_{8}$, **Diana**$_{9}$ will$_{10}$ put$_{11}$ the$_{12}$ girl$_{13}$ near$_{14}$ Elliot$_{15}$ for$_{16}$ the$_{17}$ exam$_{18}$.

c. Subject Gap/Short

The$_{1}$ principal$_{2}$ questionned$_{3}$ *who*$_{4}$ **Diana**$_{5}$ will$_{6}$ put$_{7}$ the$_{8}$ girl$_{9}$ near$_{10}$ _____ for$_{12}$ the$_{13}$ exam$_{14}$.

d. Subject Gap/Long

The$_{1}$ principal$_{2}$ questionned$_{3}$ *who*$_{4}$, during$_{5}$ the$_{6}$ difficult$_{7}$ test$_{8}$, **Diana$_{9}$** will$_{10}$ put$_{11}$ the$_{12}$ girl$_{13}$ near$_{14}$ _____ for$_{16}$ the$_{17}$ exam$_{18}$.

In contrast, the Shallow Structure Hypothesis (Clahsen & Felser, 2006a,b) predicts that native speakers of English will be able to predict subject gaps, in line with Gap-Based accounts, but predicts that non-native speakers will pattern in line with the Direct Association accounts, failing to show evidence of a subject filled-gap effect. This is because, according to the SSH, non-native speakers can only directly associate a filler with a subcategorizer, such as a verb or a preposition. However, such thematic information is not available at the pre-verbal subject-gap position. Thus, according to the SSH, no reading time slowdown is expected at the subject position in Subject Gap conditions, as compared to the No Subject Gap conditions, for non-native speakers. Similar to the SSH, theories which claim that non-native speakers have a reduced ability to engage in predictive processing (e.g., Grüter et al., 2014) predict that non-native speakers will not show subject filled-gap effects because they are unable to make the syntactic predictions required to anticipate a gap at the subject position.

If the processing of subject filled-gaps is dependent on the distance between the filler and the potential subject gap position, then a reading time slowdown, or filled-gap effect, is expected at the subject position (e.g. *Diana*) in (29d) as compared to the same position in (29b). However, a subject filled-gap effect would not be expected to emerge at the subject position in (29c) as compared the same position in (29a). This pattern is predicted because, in (29d), the participants have more time to process the *wh*- dependency than in (29c) due to the additional adjunct phrase (e.g., *during the difficult test*) in (29d). The addition of this adjunct phrase would also induce a

greater processing burden and thus possibly force the parse to commit to the subject gap analysis, increasing the likelihood of a reading time slowdown when that subject gap interpretation is reanalyzed. Therefore, if the parser needs additional time to process a filler-gap dependency, a *Sentence Type* by *Length* interaction is expected in which a greater slowdown is expected at the potential subject gap position (e.g. *Diana*) in the *Long* conditions as compared to the *Short* conditions (Lee, 2004), in both populations.

However, rather than facilitate the processing of a subject position filler-gap dependency, the addition of an additional adjunct phrase could overwhelm the processor and prevent successful resolution of this dependency. As claimed by Gibson (1998, 2000), the longer an unresolved syntactic dependency must be maintained in working memory, the more that processing costs increase. Therefore, it is possible that both native and non-native speakers will show a subject filled-gap effect in the *Short* conditions, with a reading time slowdown at *Diana* in (29c) as compared to (29a), but not in the *Long* conditions (e.g. no reading time slowdown in (29d) as compared to (29b)). Such a pattern would indicate that native and non-native speakers are able to access and use the structural knowledge needed to make predictions in the subject position, even when the filler and potential gap position are immediately adjacent, counter to the claims of Lee (2004), as well as both the Shallow Structure and RAGE hypotheses.

Because a subject filled-gap effect is necessarily reliant on the ability to make predictions and use syntactic structure, the SSH would predict no subject filled-gap effects for non-native speakers, regardless of the distance between the filler and the potential subject gap. The RAGE hypothesis would similarly predict no effects of distance. However, according to the theories that proficiency or processing demands may affect predictive abilities (e.g., Dussias et al., 2013;

Hopp, 2013; Johnson et al., 2013; Kaan et al., 2010; Lee, 2004), advanced L2 learners may show subject filled-gap effects in the *Long* conditions, on par with native speakers.

In terms of individual differences, the current study will also examine whether increased working memory, processing speed, attentional control, or language proficiency facilitate participants' ability to predict and process subject filled-gaps. For native speakers of English, if subject filled-gap processing is mediated by general cognitive capacities, participants with greater working memory, attentional control, and/or processing speed are predicted to show evidence of subject filled-gap effects in both the *Short* and *Long* distance conditions (Johnson et al., 2013). Because of their increased general cognitive capacities, they may not need the increased linguistic distance between the filler and potential gap position to posit and process a potential subject gap. If, in line with Kaan (2014), native and non-native speakers show qualitative similarities in terms of the cognitive abilities that impact prediction, then non-native speakers with higher proficiency levels or greater cognitive abilities are expected to pattern on par with native speakers, in both the *Short* and *Long* conditions.

5. Analyses

In order to ensure that participants were reading the sentences carefully and staying on task, each sentence was followed by a basic comprehension question, as described in the methods section. Only participants with overall accuracy rates of 80% or above on the comprehension probes were included in the data analyses. Furthermore, for each participant, only those trials that were answered correctly were included in the final statistical analysis.

Additionally, participants whose average reading times were faster than 200ms were excluded due to the possibility that they were reading too fast for comprehension. Finally,

reading times at individual regions that were two standard deviations above or below a participant's overall reading time mean were excluded from further analyses. A residual reading time (RRT) analysis was then performed on the remaining data for the 110 native English speakers and 100 Korean learners of English. In this analysis, participants' expected reading times at each region, for each sentence, were subtracted from their actual reading times to control for individual differences in reading speed.

To examine the effects of individual differences in cognitive abilities on the processing of subject filled-gaps, participants' working memory capacity, attentional control, and processing speed were assessed. Working memory capacity was determined by the total recall accuracy on all of the 15 series of trials in the counting span task[9]. Attentional control was determined by two variables collected in the number Stroop task: Reaction Time Interference Effect and Accuracy Interference Effect. For each measure, performance in the congruent trials was compared to performance in the incongruent trials. Specifically, to determine the Stroop Reaction Time Interference Effect, mean reaction times in the congruent trials were subtracted from mean reaction times in the incongruent trials. Therefore, slower reaction times in the incongruent conditions, as compared to the congruent conditions, would result in a more highly *positive* Stroop Reaction Time Interference Effect score, indicating *lower* levels of attentional control. To determine the Stroop Accuracy Interference Effect, overall accuracy in the congruent trials was also subtracted from overall accuracy in the incongruent trials. In this case, participants with lower levels of attentional control are expected to have lower accuracy rates in the incongruent conditions, as compared to the congruent conditions. As such, more highly

[9] Partial credit scoring was used such that any number within a trial that was recalled in the correct position was assigned one point (Conway et al., 2005)

negative Stroop Accuracy Interference Effect scores are indicative of lower levels of attentional control.

Processing speed was determined by the number of accurately completed items on two measures: a Symbol Search task (60 points possible) and Coding (135 points possible). A higher score in either of these measures is indicative of greater processing speed. Finally, both native English and Korean learners of English completed a written English proficiency test (50 points possible), providing a proficiency score based on accuracy. All individual difference scores, as well as participants' ages, were transformed into z-scores in order to analyze all data points on a comparable scale.

In order to determine whether native English and Korean learners of English demonstrated subject filled-gap effects, residual reading times were analyzed using linear mixed models (e.g., Baayen, 2008). Three models were run, examining reading times at the critical, potential subject gap regions, as well as both the spillover and pre-critical regions. For each model, both native and non-native speakers were initially analyzed together, using *Language Group* (Korean or Native), *Sentence Type* (Subject Gap or No Subject Gap), *Distance* (Short or Long) as fixed effects. Models were subsequently tested to determine if any of the individual difference measures significantly improved the predictive capability of the models and thus impacted participants' ability to predict subject gaps.

For the first model, the dependent variable was the residual reading time (RRT) at the critical, potential subject gap, regions (Region 5 in the Short conditions and Region 9 in the Long conditions). This model included three main fixed effects and the two-way and three-way interactions between the fixed effects: *Language Group* (Korean or Native), *Sentence Type* (Subject Gap or No Subject Gap), *Distance* (Short or Long). *Item* and *Participant* were also

included as random variables. Based on model testing, *Stroop Accuracy Interference Effect* significantly accounted for additional variance, thus this variable was added to the model as an additional fixed effect (the interaction of Stroop Accuracy Interference Effect with the other fixed variables was also included). No other individual difference scores significantly accounted for more of the variability in the model. For the discrete variables, the following baselines were used: No Subject Gap (Sentence Type), Long (Distance), and Korean (Language Group).

A second set of analyses examined residual reading times at the *spillover* regions, or the regions following the critical, potential subject gap regions (Region 6 in the Short conditions and Region 10 in the Long conditions). This model also included three main fixed effects and the related, potential interactions: *Language Group* (Korean or Native), *Sentence Type* (Subject Gap or No Subject Gap), *Distance* (Short or Long). *Item* and *Participant* were also included as random variables. Based on model testing, *Proficiency* significantly accounted for additional variance when interactions were included and *Stroop Accuracy Interference Effect* improved the model when added as a simple term, thus these variables were added to the model accordingly. No other individual difference scores significantly accounted for more of the variability in the model. As in the first model, the following baselines were used for the discrete variables: No Subject Gap (Sentence Type), Long (Distance), and Korean (Language Group).

To investigate the possibility that any effects at the critical regions may be driven by effects in the pre-critical regions, as seen in previous studies (e.g., Lee, 2004)[10], a linear mixed model was created to examine the pre-critical regions (Region 4 for the Short conditions and Region 8 for the long conditions) across all conditions. This model included three main fixed effects and the related, potential interactions: *Language Group* (Korean or Native), *Sentence*

[10] See discussion of the statistical analysis used in Lee (2004) in the literature review

Type (Subject Gap or No Subject Gap), *Distance* (Short or Long). *Item* and *Participant* were also included as random variables. As in the previous models, the following baselines were used for the discrete variables: No Subject Gap (Condition), Long (Distance), and Korean (Language Group).

6. Results

6.1. Comprehension Probe

All participants included in the final analyses had overall accuracy rates above 87%, indicating that participants were attending to the self-paced reading task. The overall mean accuracy rate for all participants was 94.49% (SD 2.28; range 87.50-99.16). When comparing the mean accuracy scores for the native and non-native speakers using a two-tailed, independent *t*-test, native speakers' mean accuracy scores (M 96.14; SD 3.86; range 90.00-99.16) were found to be significantly higher than the scores of the Korean learners of English (M 94.78; SD 5.23; range 87.5-99.16), $t(182) = 1.97$, $p < .01$. However, while Korean speakers' accuracy rates were slightly lower than native English speakers, all but two participants had accuracy rates above 90%[11].

6.2. Subject Gap Effect Results

Linear mixed models were run in order to answer the following questions: (a) Are native and non-native speakers similarly able to resolve pre-verbal (e.g., subject position) filler-gap dependencies? (b) Does increasing the distance between the filler and the gap improve

[11] One Korean participant scored 87.5% and one scored 88.33%

participants' ability to predict a subject gap? (c) Is the processing of subject filled-gap effects modulated by domain general cognitive capacities, in either native or non-native speakers of English? To preview the findings reported in this section, subject filled-gap effects were found, but only in the Short condition. Additionally, higher levels of attentional control predicted a greater reading time slowdown in the Short, Gap condition. No subject filled-gap effects were found in the Long conditions. These effects were the same for both native and non-native speakers. Results for the critical region will be presented first, followed by the spillover region and, finally, the pre-critical region. For each region, the results of the model which combines participant groups, across conditions will be presented first. Main effects for the included factors will be reported, as well as any interactions. In order to interpret any significant ($p < .05$) or moderately significant ($p < .10$) interactions, subsequent smaller models (e.g., examining effects only in the Short conditions) were run and the results are reported accordingly.

6.2.1. Individual Differences

Individual difference data was collected for each participant in the following areas: English proficiency, age, working memory (counting span task), processing speed (symbol search and coding tasks), and attentional control (number Stroop task). In total, the effects of seven distinct variables on the processing of subject filled-gap effects were explored: English proficiency, age, counting span, symbol search, coding, Stroop Reaction Time Interference Effect, and Stroop Accuracy Interference Effect. Descriptive statistics for each of these variables are provided in Table 1 for native English speakers and Table 2 for Korean learners of English.

Table 1. Native English Individual Difference Measures.

	Minimum	Maximum	Mean	Standard Deviation
Proficiency	32	50	44.85	4.335
Age	17	31	19.62	1.867
Working Memory: Counting Span	26	85	56.28	13.723
Processing Speed: Symbol Search	23	56	38.23	6.406
Coding	53	105	79.02	12.325
Attentional Control: Stroop Reaction Time Interference Effect (incongruent – congruent)	-48	164	47.38	40.938
Stroop Accuracy Interference Effect (incongruent – congruent)	-16	9	-1.90	4.162

Table 2. L1 Korean L2 English Individual Difference Measures.

	Minimum	Maximum	Mean	Standard Deviation
Proficiency	12	46	28.66	7.64
Age	20	42	24.64	3.675
Working Memory: Counting Span	17	88	58.15	14.975
Processing Speed: Symbol Search	24	60	47.46	6.952
Coding	68	134	103.31	12.524
Attentional Control: Stroop Reaction Time Interference Effect (incongruent – congruent)	-62	129	34	40.520
Stroop Accuracy Interference Effect (incongruent – congruent)	-20	24	-2.07	5.711

6.2.2. Model #1: Critical Regions, SHORT and LONG

Results for the first model examining residual reading times (RRT) at the potential subject gap region (Region 5 in the Short conditions and Region 9 in the Long conditions) are

presented first. This linear model revealed a significant effect of Language Group, $t(11571) = -2.540$, $p < .05$, indicating that native English speakers' RRT was overall faster than Korean speakers' RRT. There was also a moderately significant effect of Sentence Type, $t(11571) = -1.745$, $p = .08$, in which RRT in the Gap conditions was overall faster than in the No Gap conditions. Thus, no subject filled-gap effect was found across language groups when the critical, subject regions of the Short and Long conditions were combined. However, there were significant two-way interactions between Sentence Type and Distance, $t(11571) = 3.129$, $p < .01$, indicating that the effect of Sentence Type was not the same in the Long and Short comparisons, and between Distance and Language Group, $t(11571) = -3.494$, $p < .001$, indicating that the effect of distance was not the same for Korean and native English speakers. There was also a moderately significant three-way interaction between Sentence Type, Distance, and Accuracy Interference Effect, $t(11571) = 1.904$, $p < .06$, indicating that the interaction between Sentence Type and Distance was further influenced by participants' *Stroop Accuracy Interference Effect*. Given these two- and three-way interactions, follow-up analyses were conducted by running separate linear mixed models for the Short and Long conditions. The significant effects found in the subsequent mixed models for the Critical Regions, in the Short conditions as compared to the Long conditions, are reported in Table 3 and discussed in the paragraphs that follow.

Table 3. Follow-up Mixed Models for Critical Regions

Variable	SHORT Conditions			LONG Conditions		
	df	*t*	*P*	*df*	*t*	*p*
Sentence Type	5846	2.574	<.05	5723	-1.310	=.19
Language Group	5846	-5.909	<.001	5723	-2.556	<.05
Stroop Accuracy Interference Effect	5846	0.964	= .34	5723	1.434	=.15
Sentence Type x Stroop Accuracy Interference Effect	5846	2.170	<.05	5723	-0.456	= .64

(No significant interactions were found between other variables)

Model #1 Critical Region: SHORT conditions only. As can be seen in Table 3 and Figure 1, the results for the Critical Region 5 in the Short conditions indicate a clear subject filled-gap effect for both native and non-native speakers. Thus, in the subject region, reading times in the Gap condition were significantly slower than reading times in the No Gap condition. Additionally, residual reading times were overall faster for native speakers of English than Korean learners of English. Crucially, though, there is no interaction by Language Group, indicating that both native speakers of English and Korean learners of English showed the same subject filled-gap effects.

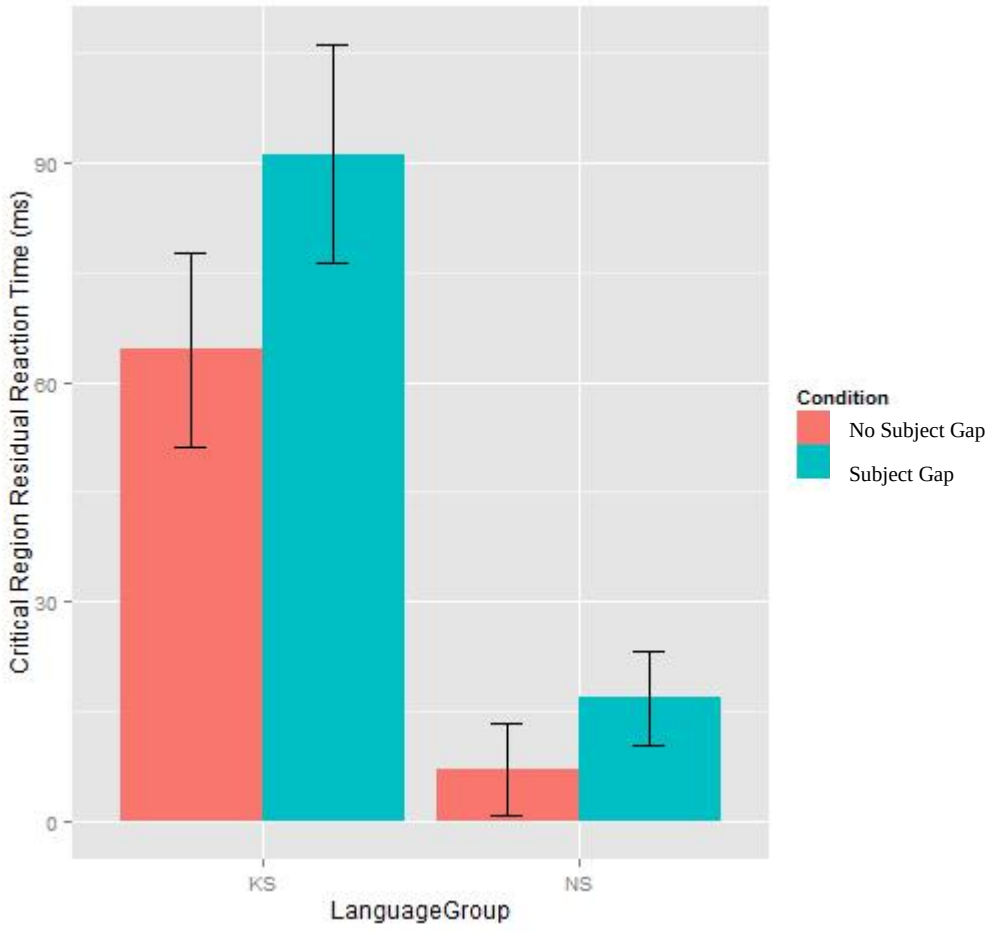

Figure 1. Critical Region for Short Conditions Only.

To probe the interaction between Sentence Type and Stroop Accuracy Interference Effect, as shown in Table 3, additional follow-up analyses which examined the effects of the Stroop Accuracy Interference Effect on RRT in the Gap and No Gap conditions separately was conducted. These analyses indicate that the interaction between Sentence Type and Stroop Accuracy Interference Effect was driven by the Gap condition, $t(2914)= 3.032$, $p<.01$, in which for every 20.16 point increase in Stroop Accuracy Interference Effect, RRT is predicted to increase by one millisecond, as shown in Figure 2.

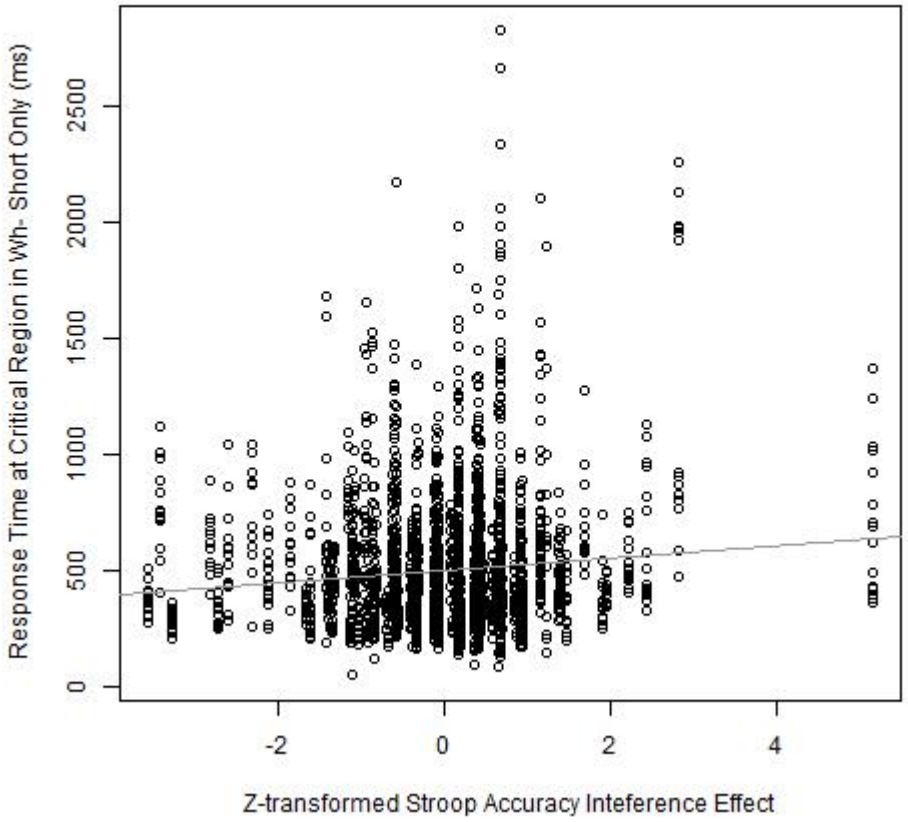

Figure 2. Short Conditions, Gap Only

As participants' Stroop Accuracy Interference Effect scores increase, their RRT also increases in the Gap condition only, indicating that those participants with greater attentional control are more likely to show a greater reading time slowdown in the critical region of the Short Gap condition. Crucially, there was no effect of Stroop Accuracy Interference Effect in the No Gap condition and no interaction between Stroop Accuracy Interference Effect and

Language Group[12] in either the Gap or No Gap models. Thus, there is no indication that the effects were the result of participants with greater attentional control having overall slower residual reading times, nor are there any significant differences between the participant groups in terms of the effects of attentional control on RRT in the critical region of the short condition.

Model #1 Critical Region: LONG conditions only. In contrast to the critical region in the Short condition, there is no evidence of a subject filled-gap effect in the critical region 9 in the Long condition for either native English speakers or Korean learners of English (Figure 3). The only significant effect in this region was that of Language Group, $t(5723)= -2.556$, $p<.05$, showing that native English speakers had overall faster residual reading times as compared to Korean learners of English.

[12] In both the Gap condition, $t(2914)= -7.119$, $p<.001$ and No Gap condition, $t(2931)= -6.753$, $p<.001$, there was a significant main effect of Language Group indicating that Native English speakers were overall faster readers as compared to Korean learners of English.

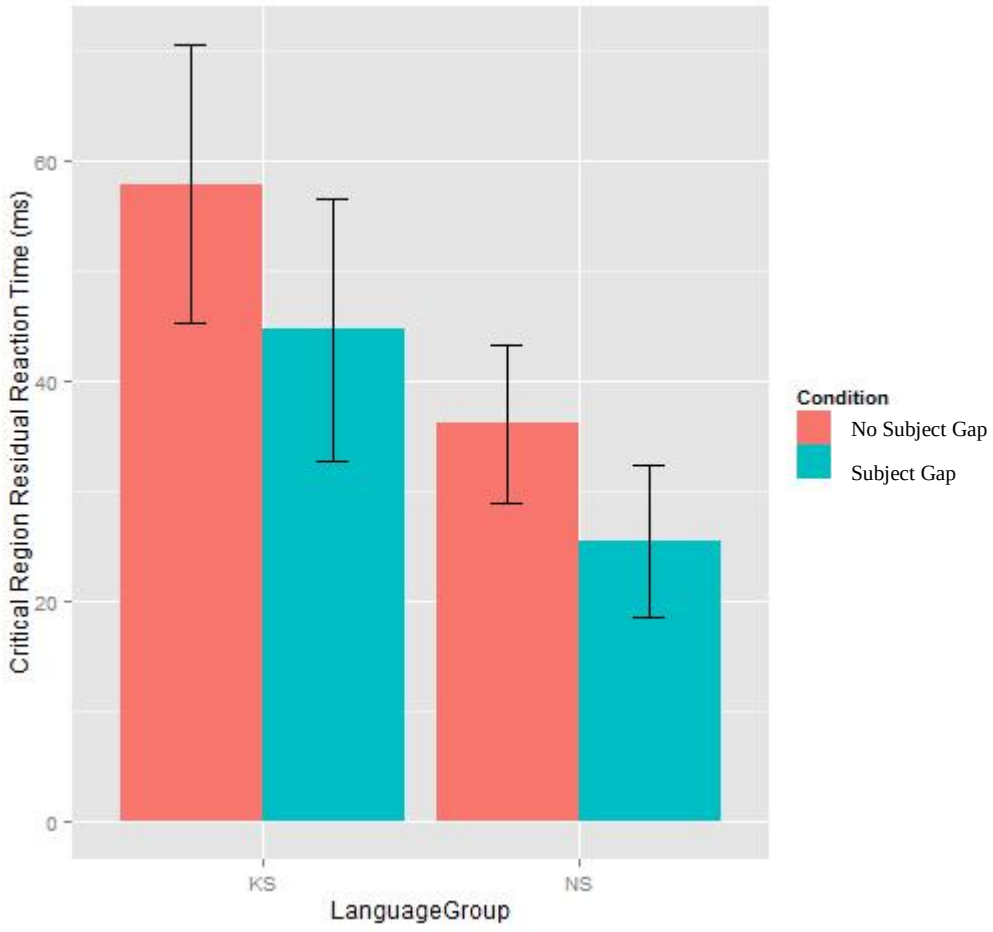

Figure 3. Critical Region for the Long Conditions Only.

To summarize the results of this first set of analyses for the critical region, both native and non-native speakers of English are able to predict gaps in the subject position when the filler and the gap are adjacent. There was no evidence of any subject filled-gap effects when an intervening phase was inserted between the filler and the gap. Finally, participants' levels of attentional control predict their ability to make posit a gap in the subject position, when the filler and gap are adjacent.

6.2.3. Model #2 Spillover Regions, SHORT and LONG

Because a subject filled-gap effect was found for all participants in the Short condition, but not the Long condition, and effects in the Spillover region for a self-paced reading experiment are common in the literature, further analyses of this region were conducted. This second set of analyses also used a linear mixed model to examine the spillover regions (Region 6 for the Short conditions and Region 10 for the long conditions) across all conditions. A significant effect of Proficiency, $t(11617)= 3.755$, $p<.001$, indicates that for every 21.13 point increase in Proficiency, RRT is predicted to increase by one millisecond; therefore, as participants' proficiency increases, they experience an overall greater reading time slowdown, though there were multiple interactions between Proficiency and other variables to consider, as explained below.

A moderately significant effect of Stroop Accuracy Interference Effect, $t(11617)= -1.691$, $p<.10$, indicates that for every 3 point decrease in Stroop Accuracy Interference Effect scores, RRT is predicted to increase by one millisecond. Therefore, there is some indication that participants with lower levels of attentional control had slower residual reading times, overall, at the spillover region across both Short and Long conditions. Finally, this model revealed a significant effect of Sentence Type, $t(11617)= -4.125$, $p<.001$, in which RRT in the Gap conditions was overall faster than in the No Gap conditions. Thus, there was no indication of a subject filled-gap effect across all conditions and language groups, though interactions in the following paragraph indicate differences between these factors that require further analyses.

As noted, this second model analyzing the spillover region revealed numerous two- way interactions between the included variables. There were significant two-way interactions between Sentence Type and Distance, $t(11617)= 2.624$, $p<.01$, indicating that the effect of

Sentence Type was not the same in the Long and Short comparisons, and between Sentence Type and Language Group, $t(11617)= 2.329$, $p<.05$, indicating that the effect of Sentence Type was not the same for Korean and Native English speakers. Additional significant two-way interactions emerged between Sentence Type and Proficiency, $t(11617)= -2.618$, $p<.01$, indicating that the effect of Sentence Type differed by Proficiency and between Distance and Proficiency, $t(11617)= -2.967$, $p<.01$, indicating that the effect of Sentence Type differed by Proficiency. A moderately significant effect emerged between Language Group and Proficiency, $t(11617)= -1.915$, $p<.10$, indicating that Proficiency differed by Language Group. To probe these interactions, additional mixed models were conducted, analyzing the Spillover Regions in the Short conditions and the Long conditions separately, the results of which are reported in Table 4.

Table 4. Follow-up Mixed Models for Spillover Regions

Variable	SHORT Conditions			LONG Conditions		
	df	*t*	*p*	*df*	*t*	*p*
Sentence Type	5813	-0.697	= 0.49	5801	-3.935	<.001
Language Group	5813	-0.885	= 0.37	5801	-1.311	= 0.19
Proficiency	5813	-0.073	= 0.94	5801	3.546	<.001
Accuracy Interference Effect	5813	-1.198	= 0.23	5801	-1.328	= 0.18
Sentence Type x Language Group	5813	0.640	= 0.52	5801	2.505	< 0.05
Sentence Type x Proficiency	5813	-2.619	< .01	5801	-2.747	< 0.01
Language Group x Proficiency	5813	0.116	= 0.90	5801	-1.800	< 0.10

(No significant interactions found between other variables)

Model #2 Spillover Region: SHORT conditions only. The analyses for the Short conditions, in the spillover region, show no lingering subject filled-gap effects, nor any main effects by Sentence Type, Language Group, Proficiency, or Stroop Accuracy Interference Effect. The follow-up analysis of the interaction between Sentence Type and Proficiency in the Short conditions revealed that this interaction is driven by the Gap condition, $t(2927)= -3.329$, $p<.01$. That is, in the Gap condition, for every 20.36 point decrease in proficiency, RRT is predicted to increase by one millisecond. This suggests that participants from both participant groups with lower proficiencies in English read the spillover region in the Short, Gap condition slower than higher proficiency readers. These data do not indicate that lower proficiency readers had overall slower residual reading times, though, as were no significant effects of proficiency on residual

reading times in the No Gap condition. In fact, recall that according to the linear model examining effects on RRT in the spillover region across all conditions, participants with lower proficiencies in English had faster residual reading times in the spillover region, as compared to higher proficiency readers. Thus, it is possible that while there was an overall subject filled-gap effect, those participants with lower proficiencies may be delayed in showing a subject filled-gap effect.

Model #2 Spillover Region: LONG conditions only. As shown in Table 4, the results for the spillover region 10 of the Long conditions indicate a number of significant effects, though there was no evidence of a subject filled-gap effect in this region. Rather, reading times at this spillover region in the Gap condition were significantly faster as compared to the No Gap condition for all participants. The main effect of Proficiency indicates that, overall, participants with higher proficiencies had residual reading times that were slower in the spillover region, as compared to participants with lower proficiencies.

The interactions between Sentence Type and Language Group, Sentence Type and Proficiency, and Language Group and Proficiency, as shown in Table 4 for the Long conditions, were probed using subsequent linear models. The follow-up model examined the effects of Sentence Type and Proficiency on RRT by Language Group. This model included *Sentence Type* (Subject Gap or No Subject Gap) and *Proficiency* as fixed effects, with *Item* and *Participant* included as random variables. The results of this model are reported in Table 5.

Table 5. Follow-up Mixed Models for Spillover Regions-Long Conditions only

Variable	Native Speakers			Korean Speakers		
	df	*t*	*p*	*df*	*t*	*p*
Sentence Type	3056	-0.247	=0.805	2745	-2.994	<.01
Proficiency	3056	0.057	=0.955	2745	2.932	<.01
Sentence Type x Proficiency	3056	-0.296	=0.767	2745	-2.240	<.05

(No significant interactions found between other variables)

As Table 5 shows, no significant effects for native speakers of English were found in the Long conditions for the Spillover region, indicating that all effects of Sentence Type and Proficiency in the spillover region were driven by Korean learners of English. Overall, Korean learners of English read the spillover region in the Gap conditions significantly faster than in the No Gap conditions. This pattern is in the opposite direction of the expected subject filled-gap effect. Additionally, Korean learners who were more proficient in English showed a greater overall reading time slowdown in this spillover region than those with lower proficiencies. However, there was a significant interaction for Korean learners between Sentence Type and Proficiency. Thus, to probe this interaction, separate models for the No Gap and Gap conditions were created. This subsequent analysis revealed that, in the No Gap condition only, Korean learners with higher English proficiency read this region significantly slower than Korean learners with lower English proficiency, $t(1389)= 3.263$, $p<.01$. There were no effects of proficiency for Korean learners of English in the Gap condition. Because the effect of proficiency only occurred in the No Gap condition, this finding has little relevancy to the current study's research questions.

6.2.4. Model #3 Pre-critical Region, SHORT and LONG.

In order to determine whether the subject filled-gap effects see in the Short conditions were driven by any slowdowns in the pre-critical region, a third set of analyses examined the pre-critical regions across all conditions (Region 4 for the Short conditions and Region 8 for the Long conditions). This model revealed a moderately significant effect of Sentence Type, $t(11507)= -1.843$, $p = .07$, in which the residual reading times in the Gap conditions were overall faster at this pre-critical region as compared to the No Gap conditions. Thus, there was no overall reading time slowdown prior to the critical region. An additional significant main effect of Distance, $t(11507)= 8.848$, $p<.001$, indicates that reading times at the pre-critical region in the Short conditions were overall slower than in the Long conditions. This is unsurprising as the pre-critical region was the word *if* in the Short conditions and the final noun of the intervening adjunct phrase in the Long condition. Finally, a significant main effect of Language Group, $t(11507)= -2.628$, $p<.01$, indicates that native speakers of English had overall faster residual reading times, as compared to Korean learners at this pre-critical region.

In addition to the main effects at the pre-critical region, this model revealed a two- way interaction between Distance and Language Group, $t(11507)= -5.821$, $p<.001$, indicating that the effect of Distance differed by Language Group. To probe this interaction, an additional mixed model analyzing Korean and native English speakers separately was created. This analysis revealed that Korean speakers read the pre-critical region more slowly in the Short conditions than in the Long conditions, $t(5420)= 6.752$, $p<.001$. As noted previously, this pre-critical region differed for the Short and Long conditions. There were no significant differences for the native English speakers only in this pre-critical region. Importantly, none of the analyses of the pre-critical regions indicate any slowdown in the Gap conditions, prior to the critical subject

region. Thus, the subject filled-gap effect found in the Short conditions was due to participants' attempts to posit a subject gap at this position, and then being forced to reanalyze their predictions.

7. Discussion

The current study examined whether native and non-native speakers are similarly able to resolve pre-verbal (e.g., subject position) filler-gap dependencies, as well as whether any predictive abilities might be mediated by the time available to make the prediction or general cognitive abilities. In answer to the primary question of native and non-native structural prediction, both participant groups are able to similarly predict subject gaps, as evidenced by subject filled-gap effects in the Short conditions. Participants from both groups were able to quickly build the syntactic structure needed to make such predictions even when given relatively little time (i.e. when the filler was immediately adjacent to the potential gap position). In fact, the addition of intervening material between the filler and the potential gap appears to have hindered, rather than helped, the participants' ability to predict a subject gap. Additionally, there is evidence that individual differences in attentional control abilities similarly modulate predictive abilities in both native and non-native speakers of English. Each of these findings, as well as their implications on current theories and suggestions for future research, will be explored in the sections that follow.

7.1. Research Question #1: Subject filled-gap effects in native and non-native speakers.

This study provides clear evidence that both native English speakers and adult Korean learners of English are able to actively predict abstract syntactic structure during online sentence processing. Evidence of syntactically driven subject filled-gap effects counters the predictions of the *Direct Association Hypothesis* (e.g., Pickering & Barry, 1991). According to the predictions of the Direct Association Hypothesis, participants were not expected to show evidence of attempting to associate the filler with the subject position because no subcategorizer (e.g., a verb or a preposition) was available at this position. However, participants in the current study were clearly able to posit such gaps in the Short condition, suggesting that they were able to rapidly build a prediction of a subject gap immediately upon encountering the filler.

Previous studies investigating filler-gap dependencies have relied on effects at or after the subcategorizing verb (e.g., Stowe, 1986; Omaki et al., 2015; Felser et al., 2012), in which participants have been argued to be relying, at least in part, on lexical or semantic information. Additionally, previous evidence of preverbal gap-filling in native speakers has been largely restricted to verb final languages (e.g., Aoshima et al., 2004; Nakano et al., 2002). Therefore, the current findings fill an important gap in the literature, showing that native speakers of English, a verb medial language, can also show evidence of pre-verbal gap-filling, in line with the predictions of *Gap-Based* accounts (e.g., Frazier & Clifton, 1989).

Crucially, adult Korean learners of English were indistinguishable from native English speakers in showing subject filled-gap effects for sentences in which the filler and the potential gap position were immediately adjacent. This finding is in direct contrast to the predictions of the *Shallow Structure Hypothesis* (Clahsen & Felser, 2006a,b; Felser et al., 2012), which, similar to the *Direct Association Hypothesis*, predicts that adult second language learners will not be

able to resolve filler-gap dependencies in the subject position because of the absence of pragmatic or semantic cues in this position. Similarly, the current findings are also in conflict with the *RAGE Hypothesis* (Grüter et al., 2014), which claims that differences in native and non-native processing abilities can be explained by non-native speakers' reduced ability to generate predictions. As the current study finds, not only are non-native speakers ability to generate predictions, but their predictive abilities mirror those of native speakers in terms of quality and time-course, at least in the domain of subject position filler-gap dependencies.

Evidence of native-like predictive processing in adult Korean learners of English is further strengthened by the fact that similar, subject position filler-gap dependencies do not exist in the Korean learners' native language. A number of theories predict that features not instantiated in the L1 are not acquirable to native levels in the L2 past a critical age of acquisition (e.g., *Interpretability Hypothesis*; Tsimpli & Dimitrakopoulou, 2007). Even researchers who claim that non-native speakers of a language possess the same structural representations as native speakers, and are able to utilize the same predictive mechanisms as native speakers, claim that non-native speakers may nevertheless be limited by competing features in their first language (Kaan, 2014). Thus, the ability of adult Korean learners of English to make structurally-based predictions, based on features not present in their first language, is strong evidence that native-like predictive processing is possible in second language learners. In fact, prediction of syntactic structure may not only be possible for second language learners, but may be simpler than prediction which involves other domains, such as those involving discourse or pragmatics.

Discourse or pragmatic predictions often require integration knowledge from various domains, including structural domains. Therefore, if the second language learner is limited not by core access to linguistic knowledge, but by general cognitive processing capacities, one

would expect that the complex integration of linguistic knowledge from various domains would prevent native-like predictive processing. That is, during real-time language processing, native speakers must rapidly integrate information from various linguistic domains in order to make accurate predictions. Therefore, in order to demonstrate native-like predictive processing, non-native learners would be similarly expected to rapidly integrate information from multiple domains in order to make a discourse or pragmatic predictions. However, given that non-native speakers are limited by the same general cognitive abilities as native speakers, and have less experience with the language, it may be expected that native-like discourse or pragmatic predictive processing is possible, but unlikely, due to the speed at which such predictions would have to occur. Thus, more research is needed to determine if, with sufficient cognitive resources second language learners are able to make predictions in domains which require integration of knowledge from multiple sources. Additionally, future research should further consider how the speed at which a prediction is expected impacts learners' ability to make complex predictions. While the current study demonstrated that native-like prediction at the structural level is possible in learners, even when rapid predictions are required, the additional distance manipulation used in this study (i.e. the intervening PP) also included additional linguistic complexity. Therefore, future research investigating the speed at which a prediction must be made should take care to manipulate the time needed for prediction, without adding additional linguistic complexity.

7.2. Research Question #2: Role of distance in filler-gap dependency resolution

The current study finds that neither native, nor non-native speakers of English needed additional time or processing difficulty in order to posit a gap in the subject position. Indeed, a clear subject filled-gap effect in the Short condition indicates that predictive processing for both

participant groups includes the ability to rapidly build syntactic structure in advance of confirmatory information. The current findings are in contrast to those of previous studies which either failed to find subject filled-gap effects (e.g., Stowe, 1986), only found subject filled-gap effects in conditions where there was an intervening phrase between the filler and the gap (e.g., Lee, 2004), or found such effects only for some participants, in some conditions (all of which used sentences in which the filler was adjacent to the potential subject gap; e.g., Aldwayan et al., 2010; Canales, 2012). Thus, the current study provides further insight into the nature of subject filled-gap effects and predictive abilities in both native and non-native speakers.

Subject filled-gap effects for both native and non-native speakers are clearly possible. Moreover, they are possible without additional linguistic manipulations such as increasing the time available to make such a prediction (e.g., Clifton & Frazier, 1989; Clifton & De Vincenzi, 1990; De Vincenzi, 1991), or increasing the processing difficulty of the filler-gap dependency. Stowe's (1986) proposal that a subject filled-gap effect requires a commitment by the parser for a subject position filler-gap dependency resolution, and that the lack of an effect in this region is due to an insufficient commitment to such an analysis, does not appear to be correct. The additional processing burden induced by adding an intervening phrase between the filler and gap (e.g., Lee, 2004), with the goal of forcing a commitment to the subject position analysis, appears to be unnecessary and even detrimental to both native and non-native prediction of a subject gap. In fact, the absence of subject filled-gap effects in previous studies may be accounted for by factors which have little to do with either participants' structural representations or predictive abilities.

The carefully controlled design of the current study, statistical analysis used, and the large number of participants, may be sufficient to explain why subject filled-gap effects were

found in the current study, with adjacent fillers and potential gaps, but not in previous studies. Recall that an overall subject filled-gap effect was found in Lee's (2004) study of the native English speakers, though there is a question as to whether the slowdown in the filled subject position was driven by a slowdown in the critical region or in the pre-critical region. Another alternative explanation for the overall subject filled-gap effect observed in Lee (2004) was that participants' attention could have been drawn to the subject region due to two issues in the experimental design. First, the stimuli used in Lee's study could be considered to be marked or infrequent (e.g., *That is NP (to) which …*). Thus, it could be argued that these unusual sentence structures could have drawn participants' attention to the target manipulation, resulting participants' overt attention to the subject position. Participants may have noticed the pattern of the sentences and thus were more likely to expect a subject gap, showing subject filled-gap effects which may not have appeared if more natural sentences had been used. Another issue that could have resulted in focused attention on the target region was an insufficient numbers of fillers, a ratio of 28 target stimuli to 51 fillers, in which the fillers were used for another experiment and thus may not have sufficiently distracted from the target sentences. These issues were addressed in the current study, which used more natural sentences and a 1:2 ratio of target to filler sentences[13]. Thus, the appearance of subject filled-gap effects in the current study cannot be claimed to be an artifact of insufficient experimental design. Additionally, while Lee (2004) reported a subject filled-gap effect in the Long conditions, but not the Short conditions (the opposite pattern of the current study), the analysis that resulted in this pattern was statistically unmotivated.

[13] In addition to other sentence types, the fillers in the current study included sentences with intervening adjunct phrases, wh-fillers, and 'doubtless' subject gaps (i.e. in which the wh- filler immediately precedes an actual subject gap), to specifically distract from the target sentences included in this study.

As such, there is little reliable evidence, even using Lee's (2004) results, that participants need additional time or processing burden to predict a subject gap. In fact, the lack of a subject filled-gap effect in the Long conditions is consistent with Gibson's (1998, 2000) proposal, which claims that processing costs increase the longer that an unresolved syntactic dependency must be maintained in working memory. This theory is also supported by studies such as Hara's (2009) study which found that adult advanced Korean learners of Japanese were able to accurately process sentences involves short distance scrambling, but not long distance scrambling. Hara proposed that the long distance scrambling overloaded the participants' computational resources. Thus, the lack of a facilitative effect of adding an intervening phrase between the filler and potential gap is in line with previous research.

In terms of the inconsistent findings for subject filled-gap effects across conditions and participant groups reported in other previous studies (e.g., Aldwayan et al., 2010; Canales, 2012; Stowe, 1986), there may be another relatively simple explanation. That is, the number of native (110) and non-native (100) participants included in this study was much higher than any of the related studies discussed in this section. This fact is important given proposals by Kaan (2014) and others (e.g., Hopp, 2010; MacDonald, 2006) that differences between native speakers and non-native speakers may be driven by individual differences in cognitive or processing abilities. If individual variability plays a role in predictive processing, then such variability is much more likely to affect the outcome of a study with a small number of participants as opposed to a larger number of participants. Evidence for subject filled-gap effects in the form of reading time slowdowns in self-paced reading studies are very subtle and thus such patterns require a large participant population for statistically significant effects to emerge.

In sum, both native and non-native speakers of English show evidence of being equally able to immediately predict a subject gap in advance of confirmatory lexical or semantic information. These predictions are made quickly and efficiently, as soon as a filler is encountered. There is little, if any, evidence that the absence of subject filled-gap effects in previous studies is due to the parser needing more time or additional processing difficulty in order to make a prediction for a potential subject gap. Moreover, the current study provides further insight into why, given the strong evidence of subject filled-gap effects in the current study, previous studies may have failed to find consistent subject filled-gap effects.

7.3. Research Question #3: Role of individual differences in cognitive capacities

The final question addressed by the current study is whether prediction in native and non-native sentence processing is modulated by individual differences in general cognitive capacities. The current findings indicate that participants with greater attentional control, as measured by the Stroop task, are more likely to show a reading time slowdown, or subject filled-gap effect, in the Short, Gap condition. Importantly, this effect did not also occur in the Short, No Gap condition and, thus, cannot be attributed to these participants' overall slower residual reading times. Additionally, this effect was found across participant groups, suggesting that attentional control influences participants' ability to predict the syntactic structure required to posit a subject gap, regardless of native language. These results are in line with previous studies of predictive processing in native speakers which found that higher levels of attentional control facilitate the ability to generate and maintain predictions for upcoming words in word-pair priming tasks (e.g., Hutchison, 2007; see also Slevc & Novick, 2013).

Attentional Control. The link between attentional control and prediction is not surprising as this finding is in line with previous studies linking these factors in both linguistic domains, as well as non-linguistic fields, particularly in visual (e.g., Kok et al., 2011; Summerfield & Egner, 2009) and other sensory (e.g., van Ede et al., 2012) processing areas. A common proposal in the literature is that attentional control abilities facilitate predictive processing by limiting the potential stimuli to which the participant must attend and increasing the precision of such predictions (e.g., Summerfield & Egner, 2009; Tsotos, 1997; Rao, 2005; Friston, 2009). Indeed, as discussed in the literature review, brain imaging studies also link both expectation driven processing and attentional control with the pre-frontal cortex (e.g., Kane & Engle, 2002, Fogelson et al., 2009; Bar, 2009). Thus, these factors are clearly closely linked in general processing, but the specific model by which they are involved in creating and processing syntactic predictions is still unclear. A tentatively proposed model would be as follows, beginning with the process of resolving a subject filled-gap and then followed by the possible contributions of attentional control.

Upon encountering a cue (i.e. the *wh*- filler), the parser is forced to maintain an unresolved dependency in memory, which requires additional processing resources and effort (e.g., Gibson, 1998; Fedorenko et al., 2013). Thus, in an attempt to resolve this dependency as quickly as possible, an efficient parser will make a prediction for the associated gap. As the current study demonstrates, a prediction will be made for the earliest possible gap position, in line with the *Active Filler Strategy*, even if that position is immediately adjacent to the filler, as is the case with a potential subject gap. It is possible, as suggested by Gibson et al. (1994), that upon encountering the *wh*- filler, the parser may create multiple representations for where the filler-gap dependency can be resolved. Individuals with higher levels of attentional control may

be better able to focus attention on the most immediate potential gap site. Furthermore, if the potential gap site is filled with lexical material, those individuals with greater attentional control may be better able to handle the effortful task of immediately generating a new prediction for where the wh- extraction may have originated from.

Proficiency. Theories which claim that non-native speakers may be able to engage in predictive processing often suggest that such native-like processing may be dependent on proficiency (e.g., Dussias et al., 2013; Hopp, 2013; Kaan, 2014). The current study demonstrates that high proficiency is not necessarily a pre-requisite of predictive processing in a second language, though it is an important factor to consider. All participants, regardless of proficiency, showed a subject filled-gap effect in the Short condition. However, further analyses revealed that participants with lower proficiencies in English showed a greater subject filled-gap effect in the spillover region of the Short condition, as compared to participants with higher proficiencies. One possible explanation for this finding is that while the majority of participants in both participant groups demonstrated an immediate subject filled-gap effect, those participants with lower proficiency experienced a processing-driven delay at some stage of the dependency resolution process (e.g., generation, activation, or resolution stage). Interestingly, this effect of proficiency is the same for both native and non-native speakers of English, in line with Kaan's (2014) proposal that differences in predictive behaviors for native and non-native speakers can be accounted for by similar factors. Other researchers have similarly challenged the practice of using 'native speakers' of a language as unified comparison group; treating native speakers as a homogeneous group inaccurately assumes that all native speakers of a language are equally proficient in their native language (e.g., Dabrowska, 2012). Therefore, future research should be framed in terms of examining whether linguistic and cognitive variability observed within the

two populations is similar, and whether patterns observed in the two populations are modulated by similar abilities and limitations.

Working Memory. The lack of a relationship between the other individual difference measures, particularly working memory span, and predictive abilities could be due to any number of factors. For one, the manner in which working memory is measured varies widely across studies (Conway et al., 2005). Thus, comparing studies in which working memory effects emerge in relation to subject filled-gap effects (e.g., Johnson et al., 2013), to the current study fails to account for differences in the task or scoring method used. For instance, the current study uses a counting span task, while the Johnson et al. (2013) study discussed in the literature review used a combined score from two highly correlated working memory measures (reading span and counting span). Additionally, it is possible that the underlying common cause for previously found effects of working memory was attentional control. Furthermore, working memory may be more relevant in linguistic tasks which require integration of multiple sources of information, as opposed to primarily syntactic information. In sum, as researchers aim to include individual difference measures in more language processing research, careful attention to task selection and scoring is needed to ensure the reliability and validity of the measures are maintained (see Conway et al. 2005 for further discussion). Caution is also needed when comparing studies which report the presence or absence of an effect of individual differences, particularly if distinct measures, procedures, or scoring methods are employed.

7.4. Implications

The current study provides further evidence regarding when predictive processing is possible, both for native and non-native speakers. Such evidence can be used to refine proposals

regarding what mechanisms are available during online sentence processing and the time-course by which such mechanisms are employed. In particular, there is a need to examine language processing along a continuum, where a variety of factors affect individuals to a greater or lesser extent, as opposed to making broad generalizations about groups of individuals, such as native speakers or non-native speakers. The current study broadly supports Kaan's (2014) proposal that there are a number of diverse factors which affect predictive processing, many of which are similar for both native and non-native speakers. However, in light of the current findings, a modification to this proposal is needed, as well.

Kaan's (2014) proposal relies heavily on a framework in which increased exposure to language improves speakers' abilities to make predictions because the speakers use that exposure to build a database of which words, phrases, structures, and rules co-occur (e.g., Elman, 1991; MacDonald, 2013; MacDonald et al., 1994; Tabor & Tanenhaus, 1999). Speakers then make predictions based on these co-occurring frequencies, making stronger predictions for words or constructions which are more likely to occur together. However, given that even low and intermediate proficiency learners were not distinguishable from native speakers of English in their ability to make predictions, a wider range of factors needs to be considered. The effects of cognitive differences on subject filled-gap effects in the current study and the absence of filled-gap effects in previous studies (as well as the Long condition in the current study) indicates that processing difficulties can mask the immediate use of grammatical knowledge in both natives and learners. One interesting possibility that could be explored in a future study is whether difficulties that have been observed in children in the processing of wh- dependency resolution could also potentially be due to their still-developing attentional control abilities.

Although there is no known study examining subject filled-gap effects in children, previous research has found that children struggle with wh-dependency resolution, in comparison to adults (Atkinson et al., 2013). Thus, it is possible that not only are differences in predictive abilities in native and non-native speakers driven by similar factors, but that adult and child language learning may be more closely related than previously thought (e.g., Gabriele, Fiorentino, & Johnson, to appear 2015). As Philips & Ehrenhofer (to appear 2015) suggest, comparing evidence of predictive processing in the same context for children, adult native speakers, and adult non-native speakers will ultimately lead to a better understanding of the underlying mechanisms which guide predictive processing.

8. Conclusion

Previous studies have failed to consistently find subject filled-gap effects in English for both native and non-native speakers. Evidence from the current study addresses these concerns by, first, confirming that subject filled-gap effects in English are possible for both native and non-native speakers, and, secondly, that a complex set of factors can influence the appearance of such effects. Importantly, this study provides evidence that native and non-native speakers are similarly able to make syntactic predictions and are also similarly affected (or not affected) by linguistic and non-linguistic factors. Thus, this study motivates the need to examine all participants as individuals, with widespread variability in abilities and resources, as opposed to simply grouping them according to native language or age at which they learned the language.

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Appendix A

Target Stimuli

Conditions:
a – Short, No Subject Gap
b – Long, No Subject Gap
c – Short, Subject Gap
d – Long, Subject Gap

1a. My father asked if Peter will see the boss with Alexis at the bar.
1b. My father asked if, during the company party, Peter will see the boss with Alexis at the bar.
1c. My father asked who Peter will see the boss with at the bar.
1d. My father asked who, during the company party, Peter will see the boss with at the bar.

2a. My brother asked if Eddie will photograph the bride beside Trisha for the album.
2b. My brother asked if, during the fancy wedding, Eddie will photograph the bride beside Trisha for the album.
2c. My brother asked who Eddie will photograph the bride beside for the album.
2d. My brother asked who, during the fancy wedding, Eddie will photograph the bride beside for the album.

3a.My classmates guessed if Kelly will photograph the professor with Edward for the website.
3b. My classmates guessed if, during the quiet discussion, Kelly will photograph the professor with Edward for the website.
3c. My classmates guessed who Kelly will photograph the professor with for the website.
3d. My classmates guessed who, during the quiet discussion, Kelly will photograph the professor with for the website.

4a. My sister wondered if Roger will find the baby with Nancy in the hallway.
4b. My sister wondered if, during the family gathering, Roger will find the baby with Nancy in the hallway.
4c. My sister wondered who Roger will find the baby with in the hallway.
4d. My sister wondered who, during the family gathering, Roger will find the baby with in the hallway.

5a. The principal questioned if Alexa will put the girl near Elliot for the exam.
5b. The principal questioned if, during the difficult test, Alexa will put the girl near Elliot for the exam.
5c. The principal questioned who Alexa will put the girl near for the exam.
5d. The principal questioned who, during the difficult test, Alexa will put the girl near for the exam.

6a. My friend wondered if Julie will recommend the doctor to Hayley in the letter.
6b. My friend wondered if, during the review process, Julie will recommend the doctor to Hayley in the letter.
6c. My friend wondered who Julie will recommend the doctor to in the letter.
6d. My friend wondered who, during the review process, Julie will recommend the doctor to in the letter.

7a. My mother asked if Robby will place the judge beside Thomas in the back.
7b. My mother asked if, during the fun contest, Robby will place the judge beside Thomas in the back.
7c. My mother asked who Robby will place the judge beside in the back.
7d. My mother asked who, during the fun contest, Robby will place the judge beside in the back.

8a. My aunt guessed if Nicky will film the groom with Janice at the restaurant.
8b. My aunt guessed if, during the delicious meal, Nicky will film the groom with Janice at the restaurant.
8c. My aunt guessed who Nicky will film the groom with at the restaurant.
8d. My aunt guessed who, during the delicious meal, Nicky will film the groom with at the restaurant.

9a. My grandmother knew if Tracy will find the instructor with Rachel in the library.
9b. My grandmother knew if, during the important class, Tracy will find the instructor with Rachel in the library.
9c. My grandmother knew who Tracy will find the instructor with in the library.
9d. My grandmother knew who, during the important class, Tracy will find the instructor with in the library.

10a. My uncle questioned if Shane will see the helper with Alexis outside the studio.
10b. My uncle questioned if, during the first session, Shane will see the helper with Alexis outside the studio.
10c. My uncle questioned who Shane will see the helper with outside the studio.
10d. My uncle questioned who, during the first session, Shane will see the helper with outside the studio.

11a. My cousin wondered if David will put the intern near Maggie for the debate.
11b. My cousin wondered if, during the long meeting, David will put the intern near Maggie for the debate.
11c. My cousin wondered who David will put the intern near for the debate.
11d. My cousin wondered who, during the long meeting, David will put the intern near for the debate.

12a. The manager asked if Ethan will place the salesman with Miguel at the entrance.
12b. The manager asked if, during the clothing sale, Ethan will place the salesman with Miguel at the entrance.
12c. The manager asked who Ethan will place the salesman with at the entrance.
12d. The manager asked who, during the clothing sale, Ethan will place the salesman with at the entrance.

13a. The students guessed if Nancy will introduce the player to Denise after the practice.
13b. The students guessed if, during the fall training, Nancy will introduce the player to Denise after the practice.
13c. The students guessed who Nancy will introduce the player to after the practice.
13d. The students guessed who, during the fall training, Nancy will introduce the player to after the practice.

14a. The teachers questioned if Caleb will discover the cheerleader with Jordan in the stadium.
14b. The teachers questioned if, during the exciting show, Caleb will discover the cheerleader with Jordan in the stadium.
14c. The teachers questioned who Caleb will discover the cheerleader with in the stadium.
14d. The teachers questioned who, during the exciting show, Caleb will discover the cheerleader with in the stadium.

15a. The secretary asked if Shawn will introduce the president to Justin in the elevator.
15b. The secretary asked if, during the quick break, Shawn will introduce the president to Justin in the elevator.
15c. The secretary asked who Shawn will introduce the president to in the elevator.
15d. The secretary asked who, during the quick break, Shawn will introduce the president to in the elevator.

16a. The instructor wondered if Kenny will film the artist with Jessie by the painting.
16b. The instructor wondered if, during the short ceremony, Kenny will film the artist with Jessie by the painting.
16c. The instructor wondered who Kenny will film the artist with by the painting.
16d. The instructor wondered who, during the short ceremony, Kenny will film the artist with by the painting.

17a. The babysitter guessed if Aimee will discover the boy with Kellie in the closet.
17b. The babysitter guessed if, during the playful game, Aimee will discover the boy with Kellie in the closet.
17c. The babysitter guessed who Aimee will discover the boy with in the closet.
17d. The babysitter guessed who, during the playful game, Aimee will discover the boy with in the closet.

18a. The employee questioned if Katie will recommend the waiter to Gibson for the position.
18b. The employee questioned if, during the easy interview, Katie will recommend the waiter to Gibson for the position.
18c. The employee questioned who Katie will recommend the waiter to for the position.
18d. The employee questioned who, during the easy interview, Katie will recommend the waiter to for the position.

19a. My grandfather guessed if Angie will seat the lawyer by Dustin for the dessert.
19b. My grandfather guessed if, during the tasty dinner, Angie will seat the lawyer by Dustin for the dessert.
19c. My grandfather guessed who Angie will seat the lawyer by for the dessert.
19d. My grandfather guessed who, during the tasty dinner, Angie will seat the lawyer by for the dessert.

20a. The professors wondered if Harry will seat the senior by Rachel in the classroom.
20b. The professors wondered if, during the boring lecture, Harry will seat the senior by Rachel in the classroom.
20c. The professors wondered who Harry will seat the senior by in the classroom.
20d. The professors wondered who, during the boring lecture, Harry will seat the senior by in the classroom.

21a. My brother questioned if Maria will find the farmer with Sydney in the field.
21b. My brother questioned if, during the sunny spring, Maria will find the farmer with Sydney in the field.
21c. My brother questioned who Maria will find the farmer with in the field.
21d. My brother questioned who, during the sunny spring, Maria will find the farmer with in the field.

22a. The secretary knew if Henry will see the assistant near Roger in the room.
22b. The secretary knew if, during the useful project, Henry will see the assistant near Roger in the room.
22c. The secretary knew who Henry will see the assistant near in the room.
22d. The secretary knew who, during the useful project, Henry will see the assistant near in the room.

23a. My uncle knew if Timmy will seat the musician by Sophie in the theater.
23b. My uncle knew if, during the music concert, Timmy will seat the musician by Sophie in the theater.
23c. My uncle knew who Timmy will seat the musician by in the theater.
23d. My uncle knew who, during the music concert, Timmy will seat the musician by in the theater.

24a. My sister knew if Dylan will photograph the performers near Shelby on the stage.
24b. My sister knew if, during the bad audition, Dylan will photograph the performers near Shelby on the stage.
24c. My sister knew who Dylan will photograph the performers near on the stage.
24d. My sister knew who, during the bad audition, Dylan will photograph the performers near on the stage.

25a. The teachers knew if Ellie will recommend the photographer to Shanon for the job.
25b. The teachers knew if, during the staff picnic, Ellie will recommend the photographer to Shanon for the job.
25c. The teachers knew who Ellie will recommend the photographer to for the job.
25d. The teachers knew who, during the staff picnic, Ellie will recommend the photographer to for the job.

26a. My aunt knew if Susan will put the teenager near Olivia on the plane.
26b. My aunt knew if, during the bumpy flight, Susan will put the teenager near Olivia on the plane.
26c. My aunt knew who Susan will put the teenager near on the plane.
26d. My aunt knew who, during the bumpy flight, Susan will put the teenager near on the plane.

27a. My mother questioned if Diana will discover the neighbor with Sandra under the umbrella.
27b. My mother questioned if, during the sudden storm, Diana will discover the neighbor with Sandra under the umbrella.
27c. My mother questioned who Diana will discover the neighbor with under the umbrella.
27d. My mother questioned who, during the sudden storm, Diana will discover the neighbor with under the umbrella.

28a. My friend wondered if Molly will place the lady beside Monica on the couch.
28b. My friend wondered if, during the safety video, Molly will place the lady beside Monica on the couch.
28c. My friend wondered who Molly will place the lady beside on the couch.
28d. My friend wondered who, during the safety video, Molly will place the lady beside on the couch.

29a. My grandmother guessed if Peggy will introduce the lifeguard to Morgan at the pool.
29b. My grandmother guessed if, during the swim lesson, Peggy will introduce the lifeguard to Morgan at the pool.
29c. My grandmother guessed who Peggy will introduce the lifeguard to at the pool.
29d. My grandmother guessed who, during the swim lesson, Peggy will introduce the lifeguard to at the pool.

30a. The students asked if Lucas will film the pilot beside Martha in the airport.
30b. The students asked if, during the final month, Lucas will film the pilot beside Martha in the airport.
30c. The students asked who Lucas will film the pilot beside in the airport.
30d. The students asked who, during the final month, Lucas will film the pilot beside in the airport.

31a. My cousin knew if James will find the director beside Kristy at the desk.
31b. My cousin knew if, during the research study, James will find the director beside Kristy at the desk.
31c. My cousin knew who James will find the director beside at the desk.
31d. My cousin knew who, during the research study, James will find the director beside at the desk.

32a. The manager questioned if Aaron will put the engineer beside Oliver in the lab.
32b. The manager questioned if, during the new experiment, Aaron will put the engineer beside Oliver in the lab.
32c. The manager questioned who Aaron will put the engineer beside in the lab.
32d. The manager questioned who, during the new experiment, Aaron will put the engineer beside in the lab.

33a. My classmates wondered if Becky will see the dancer by Lauren in the line.
33b. My classmates wondered if, during the big performance, Becky will see the dancer by Lauren in the line.
33c. My classmates wondered who Becky will see the dancer by in the line.
33d. My classmates wondered who, during the big performance, Becky will see the dancer by in the line.

34a. The principal guessed if Megan will place the singer by Kerrie in the front.
34b. The principal guessed if, during the holiday song, Megan will place the singer by Kerrie in the front.
34c. The principal guessed who Megan will place the singer by in the front.
34d. The principal guessed who, during the holiday song, Megan will place the singer by in the front.

35a. My father asked if Alisa will photograph the politician by Jennie near the sign.
35b. My father asked if, during the close election, Alisa will photograph the politician by Jennie near the sign.
35c. My father asked who Alisa will photograph the politician by near the sign.
35d. My father asked who, during the close election, Alisa will photograph the politician by near the sign.

36a. The instructor knew if Tyler will recommend the nurse to Jeremy in the office.
36b. The instructor knew if, during the hospital visit, Tyler will recommend the nurse to Jeremy in the office.
36c. The instructor knew who Tyler will recommend the nurse to in the office.
36d. The instructor knew who, during the hospital visit, Tyler will recommend the nurse to in the office.

37a. The babysitter questioned if Jason will seat the children beside Harold on the floor.
37b. The babysitter questioned if, during the scary movie, Jason will seat the children beside Harold on the floor.
37c. The babysitter questioned who Jason will seat the children beside on the floor.
37d. The babysitter questioned who, during the scary movie, Jason will seat the children beside on the floor.

38a. The employee wondered if Billy will discover the chef with George in the kitchen.
38b. The employee wondered if, during the cooking show, Billy will discover the chef with George in the kitchen.
38c. The employee wondered who Billy will discover the chef with in the kitchen.
38d. The employee wondered who, during the cooking show, Billy will discover the chef with in the kitchen.

39a. My grandfather guessed if Marty will introduce the man to Gloria in the basement.
39b. My grandfather guessed if, during the happy event, Marty will introduce the man to Gloria in the basement.
39c. My grandfather guessed who Marty will introduce the man to in the basement.
39d. My grandfather guessed who, during the happy event, Marty will introduce the man to in the basement.

40a. The professors asked if Laura will film the guide near Jackie in the museum.
40b. The professors asked if, during the school trip, Laura will film the guide near Jackie in the museum.
40c. The professors asked who Laura will film the guide near in the museum.
40d. The professors aske nhjd who, during the school trip, Laura will film the guide near in the museum.