ABSTRACT

Title of Thesis:	EFFECTS OF STATISTICAL LEARNING ON THE ACQUISITION OF GRAMMATICAL CATEGORIES THROUGH QUR'ANIC MEMORIZATION: A NATURAL EXPERIMENT
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This study investigated the effects of ambient exposure to Arabic through Qur'anic memorization versus formal classroom exposure to Arabic on the ability to acquire knowledge of Arabic grammatical categories. To do this, we exposed participants to a 5-minute familiarization language of Arabic phrases. Then, we measured accuracy on a two-alternative forced choice grammatical judgment task, which required participants to identify a grammatical phrase based on rules that followed the statistical properties of items in the familiarization language. We compared results of this task with those of language background surveys, and found that memorizers were more accurate than non-memorizers in distinguishing between novel grammatical phrases and ungrammatical phrases. While classroom experience had no effect on accuracy, naïve listeners also experienced statistical learning. Thus, semantic representations are not

required to abstract rules of Arabic grammar. We discuss possible explanations for these findings and implications for language acquisition.

EFFECTS OF STATISTICAL LEARNING ON THE ACQUISITION OF
GRAMMATICAL CATEGORIES THROUGH QUR'ANIC MEMORIZATION:
A NATURAL EXPERIMENT

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Effects of statistical learning on the acquisition of grammatical categories through

Qur'anic memorization: A natural experiment

1. Introduction

A child's acquisition of grammatical categories in their native language is usually guaranteed in the presence of consistent, implicit and/or passive exposure to language in the environment. This process is phenomenal but raises important questions about the mechanisms that support acquisition. For example, exactly how does a child learn that a certain vocabulary word is a noun, and cannot be conjugated and used as a verb, when he is not being instructed this information? Recent studies have investigated the precise processes through which syntax and grammatical categories are implicitly found and learned during first language acquisition, and they have concluded in two main theories (Thompson & Newport, 2007).

The first centers on the importance of semantics in the acquisition of grammar, and emphasizes the fact that a referent is needed in order to categorize a word (e.g., Pinker, 1984). For example, a child learns the meanings of objects like *cat, bike*, and *train*, and concludes that they all belong to the same grammatical category (i.e., nouns) since they behave similarly. She might then also infer that words of action like *run, cry,* and *eat* belong to the same category (i.e., verbs). This process is often called "semantic bootstrapping" (Pinker, 1984). A second account, posited by Saffran, Newport, and colleagues (1997), is the idea that knowledge of grammatical categories is learned statistically (Mintz, Newport, & Bever, 2002) and acquired from distributional cues known as transitional probabilities (Saffran, Aslin, & Newport, 1996). In other words, grammar is deduced using probability to predict the occurrence of certain words within

the same phrase. Infants and adults are sensitive to these probabilities, which provide insight into frequencies of occurrence for words in a phrase, and tell us that words that often co-occur will probably comprise the same phrase.

Distributional analyses have most often been studied using artificial grammar learning (AGL) tasks, which began in the 1960s (e.g., Reber, 1967). In AGL tasks, participants are asked to listen to a fluent stream of language (e.g., nonsense words, letter streams) that was carefully constructed according to a set of artificial grammar rules. They are then presented with new strings of language and are asked whether or not the new strings follow the rules of the first language. These studies established the importance of phrase structure in the acquisition of syntax, as well as cues relevant to phrase structure, such as within-phrase indicators (e.g., statistical properties), prosody, and function words (Thompson & Newport, 2007). These studies have also increased our knowledge of other aspects of language acquisition, such as how children identify word boundaries in a stream of speech (Mintz, Newport, & Bever, 2002), word boundaries with respect to lexical acquisition (Christope, Dupoux, Bertoncini & Mehler, 1994), and phonological representations (Maye & Gerken, 2001).

Although the studies on statistical properties and learning thus far are promising, they come with several limitations that feed a disconnect between language acquisition in the real world and in the laboratory. The current study intends to explore a naturalistic test case of statistical learning, by asking: Are adolescent and young adult non-Arabic speakers, who memorize the Qur'an, able to abstract Arabic grammatical category knowledge via transitional probabilities? Memorizers of the Qur'an first learn to read

Arabic and recite[1] the text, and then review memorized sections regularly, all over

several years[2]. Thus, they are constantly receiving statistical cues. Furthermore, many

memorizers, particularly those who are not of Arab descent, are not exposed to the Arabic

language outside of the Qur'an, and thus are not receiving explicit semantic cues.

Answers to this question could help accelerate the way children, and even adults, acquire

language.

In the remainder of the Introduction, we will discuss similar phenomena in other

populations and investigate how children acquire the grammatical categories of their first

language through statistical learning and artificial language learning paradigms. Then,

we will consider some advantages and limitations of previously conducted language-

learning methods. Finally, we will address how Qur'anic memorizers provide an

interesting test case for examining naturalistic effects of statistical learning.

1.1 Child Acquisition of Grammatical Categories

It is well-known that knowledge of grammatical categories is essential to the

language acquisition process (Robins, 1952; Gentner, 1982; Tomasello, Akthar, Dodson,

& Rekau, 1997). However, precisely how grammatical categories are deduced remains

unknown. Although students learn rules and patterns while receiving classroom

instruction for second language acquisition, children acquiring their first language are not

explicitly instructed on which words belong to the same grammatical category. This

study examines how language learners use statistical properties within their ambient input

to acquire knowledge of grammatical categories.

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[1] I.e., using the rules of Qur'anic recitation (*tajweed*)
[2] Often, their exposure to the new language increases with greater, non-secular devotion to the Qur'an.

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1.1.1 Statistical Language Learning and Artificial Languages

As mentioned previously, there are two main ideas regarding the mechanism through which children find grammatical categories, semantic cues versus distributional (statistical) cues. One possibility is that a child needs to have an approximate meaning of a word to place it in a syntactic category. She may hear words her mother uses at home (e.g., *blanket, cup, book*), associate them with physical objects, and then determine that since they act similarly linguistically, they must be from the same grammatical category (i.e., nouns). She will then do this with an unlimited amount of words in her environment, and will be able to categorize them, for example, as actions (i.e., verbs), objects, people, places, or animals (i.e., nouns), or characteristics (i.e., adjectives), as long as she continues to receive clues to their meanings (Gentner, 1982).

A second possibility is that she subconsciously analyzes cues called transitional probabilities that indicate which words are from the same category, and thus which words are likely to appear together in a phrase. For example, she may hear "*let's go" and "come here,"* which may or may not be paired with a gesture, and reason that if she hears the first word in the phrase (i.e., *let's* or *come*), the second word will likely follow and she needs to prepare to follow a command. Infants have been found to use transitional probability to accomplish passive learning and differentiate words from parts of words (Aslin, Saffran, & Newport, 1998). Specifically, transitional probability is the calculations made by listeners to predict what words and syllables will follow others in a stream of speech (Kuhl, 2004). It is also defined as "a conditional probability statistic that measures the predictiveness of adjacent elements" (p. 4) and is expressed by the following equation (Thompson & Newport, 2007):

$$\text{Probability of Y|X} = \frac{\text{frequency of XY}}{\text{frequency of X}}$$

The probability of a target word (Y) given its preceding word (X) can be calculated as the chance of the frequency of a phrase containing X and Y divided by the frequency of X occurring alone. High transitional probabilities (e.g., 1.0) are cases where Y is always preceded by X. Low transitional probabilities (e.g., 0) are cases where Y is never preceded by X. Studies have revealed that adults (Thompson & Newport, 2007), young children (Mintz, Newport, & Bever, 2002), and infants (Aslin, Saffran, & Newport, 1998) all calculate transitional probabilities, and use statistics from those calculations to combine "adjacent syllables into word-like units" (Newport & Aslin, 2004, p. 127).

Learners' use of statistical learning has been applied to several studies of artificial grammar learning, or AGL. These studies involve the presentation of a unique, lab-created language made of nonsense words (e.g., "kof," "hox," "jes" in Thompson & Newport's study; 2007) to participants, who have included infants, adults, and non-human primates (Hauser, Newport, and Aslin, 2001). Participants observe a legal training sequence and then use what they potentially learned to judge novel sequences as being legal or illegal. Reber (1967) originally called this ability to judge legality an implicit behavior because participants are often not able to explicitly specify what makes a legal sequence different from an illegal one.

Statistical learning and artificial language studies on grammatical categories began with the analysis of word segmentation and word boundaries, and these studies further developed the statistical analysis concept and preceded the identification of transitional probabilities. After a long period during which studies predominantly observed adults (Esper, 1925; Reber, 1967), infants were shown to have an incredible

ability to employ statistical analysis for the purposes of grammar learning (Saffran, Aslin, & Newport, 1996). Saffran, Aslin, and Newport exposed eight-month-olds to a continuous stream of four tri-syllabic nonsense words for 2 minutes, in which the only word boundary cues were "transitional probabilities between syllable pairs, which were higher within words…than between words" (p. 1927). They then presented repetitions of one tri-syllabic word heard previously and one that used the same syllables but in a different order, and found that the infants listened longer to the novel nonsense words. Thus, they were able to parse words from fluent speech based on statistical relationships in phonological neighborhoods with certain speech sounds occurring next to others. Saffran and colleagues (1997) then extended these findings to adults and first-grade children and found that they were equally able to passively learn some aspects of language (i.e., word segmentation from a continuous stream, basic word order) just by hearing the language. In addition, statistical learning abilities do not just operate with presentations of linguistic stimuli. Saffran and colleagues (1999) replaced each of the 11 nonsense word syllables from a previous study (e.g., bupada) with a distinct musical note (e.g., DFE) to make tone sequences, and presented these tones in a stream. They found that adults and 8-month-old infants segmented continuous streams of these non-linguistic tones as well as they could nonsense word streams.

Most applicable to this study is that transitional probabilities and statistical learning have greatly aided the study of grammar learning. After being exposed to one training grammar for less than two minutes, 12-month-old infants preferred new grammatical strings containing units that occurred in the training grammar over ungrammatical strings (Gomez & Gerken, 2000). Similarly, Marcus and colleagues

(1999) exposed seven-month-olds to three minutes of speech that followed an ABA or ABB word pattern, and found they were able to discriminate between two test languages using the same patterns despite vocabulary differences. In addition, Mintz (2003) emphasized the importance of word placement within a phrase in grammatical category acquisition, stating that infants and adults are conscious of the words immediately before and after a target word, and these "frames" help adults assign a grammatical category to the target word in the middle.

Finally, Thompson and Newport (2007) found that the same statistical analyses used with word segmentation studies could apply to phrase structure learning through the transitional probabilities of word classes in a miniature artificial language. They presented a brief recording of a simple training language to undergraduate student participants, and then had them complete a sentence task that presented control grammatical sentences and similar but ungrammatical sentences, and a phrase task that presented novel grammatical and ungrammatical word combinations. Using the results from these tasks, the authors confirmed that in order to understand a miniature artificial grammar, participants must first learn about its phrases' components and structure. They also found that over four experiments, their undergraduate adult participants exhibited better learning of syntactic properties (e.g., optional phrases, moved phrases) after listening to complex but highly rule-governed and consistent samples of artificial language that incorporated all four target syntactic properties, than when they listened to a language addressing only one syntactic property. Better learning occurred when participants were presented with a more complex language. This suggests that adults,

young children, and infants should be able to acquire word classes through these analyses of distributional cues.

1.2 Limitations of Previous Work and Advantages of the Present Study

There are, however, several limitations to the evidence that has been published on grammatical category learning thus far. The languages used in statistical learning studies are artificial and very simple, in order to feasibly be acquired in the lab, and they do not always include the intricacies or validity of real language. Thompson and Newport's (2007) language, for instance, had a simple structure, and its sole sentence type (ABCDEF) was made of six word class units (e.g., noun, verb), each comprised of only three words. Another acquisition language involved just 10 grammatical strings made of five reoccurring units (Gomez & Gerken, 1999). In addition, the learning contexts are very brief, as participants in these studies are usually presented with a constant stream of speech for only a few minutes, or no more than a few days. For example, Saffran, Aslin, and Newport (1996) and Gomez and Gerken (1999) both presented their languages for about 2 minutes, while Saffran and colleagues (1997) used a 21-minute sample. Thompson & Newport (2007) exposed their participants to an artificial language over 5 days. These short lengths of exposure for in-lab training are not likely to produce lasting effects in terms of language acquisition, and a natural language certainly cannot be acquired in such a short time frame. Finally, although participants in AGL studies have included infants (Saffran, Aslin, & Newport, 1996; Gomez & Gerken, 1999), they have been conducted on adults for several more decades (Esper, 1925; Reber, 1967; Mintz, 2003; Thompson & Newport, 2007). Studies have not investigated adolescents in higher grade levels (i.e., in the middle school and high school range).

These limitations all feed a discrepancy between real world child language acquisition and laboratory findings. The current study aims to minimize this gap by pairing a naturalistic test case of statistical learning with the lab-feasible stimuli and methods that have been used thus far. This can be achieved by focusing the study on a real language that is exposed to learners over the course of several years, or at least several months, outside of the lab and by involving participants who were children when they started exposure to the aforementioned real language. This combination is precisely what we find with non-Arabic speaking students who memorize and study the Qur'an, the primary religious text of Islam. These students, who are predominantly adolescents, are exposed to an unfamiliar language's (i.e., Classical Arabic's) grammatical categories indirectly over the course of several years, through the constant recitation and memorization of Qur'anic written text[3], usually without simultaneous language instruction[4]. Thus they are receiving an abundance of distributional cues from repetitive exposure to the text, but have limited semantic correlates[5] with which to acquire grammatical categories and rules of Arabic syntax.

Thus, the aim of this study is to ask: Are adolescent and young adult non-Arabic speakers, who memorize the Qur'an, able to abstract Arabic grammatical category knowledge that is comparable to that of students taking Arabic language classes? If semantic cues are all that is required to find and learn grammatical categories of a language, then the memorizers of the Qur'an are not expected to abstract knowledge of

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[3] Students typically graduate to Qur'anic memorization only once they have mastered how to read and recite the text.

[4] Often, non-Arabic speaking parents of young children do not prioritize the ability to understand the Qur'an, as they do the ability to read and memorize it.

[5] From exposure to Islamic culture, e.g., "Allah" (God), "Muhammad" (the last Prophet), which appear in the Qur'an

Arabic grammatical categories over the years they spend studying the text. However, if distributional (statistical) cues are sufficient for grammar learning, and probabilities inform the speaker that certain words belong in the same category, the memorizers will demonstrate knowledge of Arabic grammatical categories. Furthermore, this study examines whether one aspect of a learner's background (e.g., age, proficiency) can provide an advantage for grammar learning, or even interfere with learning.

1.3 Arabic and the Qur'an

Populations who are exposed to the Arabic language can be roughly divided into two groups, those who are not Muslim and those who are Muslim. Non-Muslims exposed to Arabic are usually familiar with it on strictly linguistic terms, either as native or second language learners, through environmental exposure or explicit instruction. They may speak a colloquial dialect (e.g., Egyptian, Lebanese) and/or Modern Standard Arabic (MSA), the standard formal version of the language used in literature and the media. However, Arabic plays a much larger role in the lives of Muslims whether they are native Arabic speakers or not, due to the recitation and memorization of the Qur'an and its meaning, which are sacred activities that lie at the core of Islam. In addition to reading the text as part of a daily or weekly schedule, Muslims memorize passages of the Qur'an to recite them in daily prayers, and become familiar with the text to implement its teachings into daily life[6]. Muslims usually learn to read and memorize the Qur'an by one

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[6] This is not a unique phenomenon. Similar populations can be found with Catholic memorizers of Latin catechisms and their ambient classroom exposure to Latin, or Jewish students' memorization of the Torah and their Hebrew classroom experience. Although we did not find any research conducted on the effect of Torah or catechism memorization on Hebrew and Latin language learning, respectively, related instances of learning have been found with respect to the memorization of these religious texts. For example, Malin (2011) discusses the ability of regular Torah reciters to use statistical learning to predict and differentiate the patterns and intonations of

of two different ways: 1) From parents and teachers who do not speak Arabic, thus simply attaining the phonology, sound-symbol association, and Qur'anic recitation rules (*tajweed*) of the language, then advancing to memorization of the text, or 2) from teachers or parents who do speak Modern Standard and/or colloquial Arabic, either as second language learners or native speakers, and can therefore familiarize themselves with the meaning of the text as they read and memorize it. Children who fall in the first category may take Arabic language classes when they are older, to study the Qur'an in depth and learn about the historical and religious significance of the text they committed to memory and/or want to commit to memory, in addition to learning semantics, grammar, and how to speak Arabic.

The process of Qur'anic memorization usually begins in early childhood and continues well into adulthood, as consistent review of memorized material is encouraged. Over time, students often gain an understanding of the vocabulary they encounter, as well as the general meaning and historical significance of at least a few passages. However, it is not clear to what extent students acquire the Arabic language (i.e., lexically, syntactically) unless they take language classes, or if memorization is able to make one sensitive to grammatical categories.

The acquisition of the Arabic language through the Qur'an is different from the use of other Arabic texts, such as newspapers or classical poetry. Most notably, learners of the Qur'an are usually Muslim, and thus have non-secular motivations, intentions, and incentives to learn the Qur'an. The incentives in particular can thus stimulate further exposure to the language. In addition, readers and memorizers of the Qur'an often

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the six unique cantillation melodies of the Ashkenazic tradition, which are each devoted to a specific context.

interact with the text daily for extended periods of time, especially if they are in classes for memorization. Some Qur'an memorization (*hifzh*) programs, for example, last from 9 am to 3 pm, Monday through Friday. Beginner students of Arabic, let alone non-beginner students, rarely dedicate themselves to such intensive interaction with non-religious Arabic texts. Finally, many of the memorized verses are recited during the five daily prayers.

As with the general process of memorization, Qur'anic memorization varies among individuals, but usually involves a few key components. A student begins by reading a verse in Arabic, and then repeats it to himself aloud several times until he is able to recite the verse without looking at the text. This is done with each subsequent verse in a pre-determined section, and then the whole section is repeated until it can be recited correctly in full. Review of memorized Qur'an involves the student reciting passages from memory with the Qur'an nearby, usually at the hands of a teacher or peer who is following along to identify and correct mistakes (Gent, 2011). Many students also review by playing a recording of the Qur'an (Gent, 2011), which could further aid learning. As mentioned previously, Saffran and colleagues (1997) found that children and adults can passively learn parts of a language by hearing it. Supposedly, even if a student who is memorizing the Qur'an is not actively reviewing previously memorized portions with the text in front of him, he will still be able to passively acquire at least part of the text by listening to recordings of the Arabic recitation, which are presented as continuous streams and exist in a diverse abundance. It should thus be noted that memorization of the Qur'an involves two modalities--phonology and orthography--which are both, arguably, equally important.

Notably, second language learners have been found to benefit from the use of subtitles or closed-captions in foreign films, another bimodal form of exposure involving both phonology and orthography. Stewart and Pertusa (2004) found slightly higher vocabulary recognition abilities in their intermediate-level Spanish conversation students (ages unknown) who watched a Spanish film with Spanish closed-captioning (n=53) than in those who watched the same film with English subtitles (n=42). Furthermore, in post-experimental task surveys, the students in the closed-captioning group expressed that the extra feedback facilitated their language learning, but the others did not feel that English subtitles hindered learning, as these helped them pay more attention to the Spanish audio (Steward & Pertusa, 2004). Additionally, from their experiments on the effects of phonological or phonological and orthographic input on implicit and explicit memory, Bird and Williams (2002) found that spoken words are better processed with both sound and text. Grammar, however, has been proven more difficult to acquire through subtitles in foreign films than vocabulary (Lommel, Laenen & d'Ydewalle, 2006). Lommel and colleagues did not observe an acquisition of grammar rules (e.g., present and past tense verb endings) when they presented participants with an Esperanto film with Dutch subtitles and then gave them a post-test.

Considering the above populations, memorizers of the Qur'an who are not native[7] Arabic speakers often fall into two general categories:

1) Memorizers without classroom: non-Arabic speakers from non-Arabic speaking families, reading and memorizing the Qur'an having never taken lessons of the Arabic language (receiving distributional cues of Arabic grammar through memorization but no explicit knowledge or semantic cues through class).

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[7] It is assumed that native speakers of Arabic understand the Qur'an as they read and memorize.

2) Memorizers with classroom: those from non-Arabic speaking families learning to recite and memorize the Qur'an while taking Arabic language classes (i.e., learning to write and speak at a public or private institution, receiving semantic cues of Arabic grammar from class as well as distributional cues from memorization).

In an effort to explore the acquisition of Arabic grammar in a formal classroom setting and to see if these same aspects can be acquired through ambient exposure to Arabic without formal language training, the current study compared the above two groups with a third and fourth group:

3) Non-memorizers with classroom: those who have no experience with the Qur'an but are learning Arabic as a second language, thus receiving semantic cues of Arabic grammar through classroom exposure, but no distributional cues through memorization.

4) Naïve listeners (non-memorizers without classroom): those who have no experience with Arabic or the Qur'an, and thus receive no distributional or semantic cues of Arabic grammar.

Memorizers without classroom share similarities with the infants and adults in previously conducted AGL studies. All three groups lack formal experience with the target language, and receive distributional cues of the language but not semantic cues. Memorizers without classroom learn to read the Qur'an from their guardians or Qur'an-specific teachers, and practice it on a regular basis, with no prior knowledge or priming. Thus, they start afresh, as do infants. However, memorizers are critically different from the AGL participants in that they have been exposed to distributional cues of a natural

language for several months or even years, whereas AGL participants are familiarized with an artificial language for a few minutes.

1.4 Arabic Syntax

This section provides a brief introduction to Arabic syntax as a background for the current study.

Today, three forms of Arabic exist: Classical Arabic (CA; also known as Qur'anic Arabic, as it is preserved in the Qur'an), Modern Standard Arabic (MSA), and various colloquial dialects (e.g., Egyptian colloquial) (Bin Muqbil, 2006). This study focuses on CA and MSA. Syntax in CA and MSA are largely similar and mutually intelligible, as MSA evolved from CA (Bin Muqbil, 2006). Colloquial dialects also follow the same word order, although in a less governed form. In Arabic, each word is made of a three-consonant (or, rarely, two- or four-consonant) root (*jadhr*) that contains its basic meaning, and it also takes one of many patterns (*wazn*; pl. *awzaan;* for the singular form, plural form, verbs, and verbal nouns) that determine the word's grammatical category (Al-Tonsi, Al- Batal, & Brustad, 2004). Long vowels (e.g., alif), and the consonants *ta*, *seen*, *meem*, and *noon* are usually part of the word's *wazn* as infixes. In verbs, which can follow one of ten possible patterns, the root (*jadhr*) is usually the 3rd-person past tense form, and prefixes and/or suffixes determine part of speech and grammatical mood.

In general, Arabic follows a VSO (verb, subject, object) structure, but this is variable, since words often contain case endings. There are two types of sentences in Arabic, the sentence that begins with a noun (*aljumlah alismiya;* e.g., *Alwaladun taweelun*-The boy is tall) and the sentence that begins with a verb (*aljumlah alfa'liyah;* e.g., *yajlis alwalad fi alkursi*-The boy is sitting in the chair) (Al-Tonsi, Al- Batal, &

Brustad, 2004). The first example shows that adjectives in Arabic occur after the nouns they describe, and they must agree in gender, number, case, and state. In addition, pronouns attach directly to verbs (e.g., object, abbreviated subject) or nouns (e.g., possessive), auxiliary verbs occur before main verbs, and unabbreviated subject pronouns are usually only used for emphasis in verb sentences (e.g., *Huwa yajlis*-He, he is sitting vs. *yajlis*-He is sitting).

The current study focuses on the effects of Qur'anic memorization on non-Arabic speakers' ability to detect the distributional cues of past tense verbs attached to abbreviated subject pronouns and nouns attached to possessive pronouns. As they are learned in an introductory class, Arabic has three types of personal pronouns, subject, object, and possessive (Al-Tonsi, Al- Batal, & Brustad, 2004). There is some overlap across sets, however, there are many that do not exist in other languages (e.g., dual forms, masculine and feminine for both second and third person), and some of them will not be included in this study (e.g., pronouns in the form of a prefix and suffix, rather than one or the other).

2. Current Study

The purpose of the current study was to explore the effect of ambient exposure to Classical Arabic, in the form of Qur'anic memorization, on statistical learning and the acquisition of select Arabic grammatical categories: possessive pronouns, subject pronouns, nouns, and past-tense verbs. Furthermore, we wanted to investigate how this ambient exposure compared to formal language classes in Arabic. Given this question, there were two possible hypotheses. One possibility was ambient exposure to Arabic (of

the kind experienced by our memorizers without classroom group) would provide the relevant input to extract grammatical categories. The second possibility was ambient exposure would not be enough, and learning requires additional support through mapping to semantics (word learning from classroom instruction as exhibited by the classroom groups) and social communication. Finally, we were interested more generally in how non-linguistic (e.g., current age) and linguistic (e.g., proficiency level) variables would facilitate or interfere with statistical learning of Arabic grammar.

2.1 Participants

The current experiment varied two independent variables, and represented the cells of a 2x2 between-subjects design (see Table 1). The first factor considered the main effect of at least one semester[8] of formal Qur'anic memorization[9] and compared the abilities of those who memorize the Qur'an, and thus receive distributional cues of Arabic grammar, with those who do not memorize, on grammatical category learning. The second factor, classroom experience, compared the effect of at least one semester of formal Arabic language class[10], and the reception of semantic cues from class, with a lack of classes on the ability to learn grammatical categories.

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[8] One semester ~3.5 months; students in an Arabic class had been enrolled for at least 4.5 months at the time of the study (were in their second semester).

[9] Students in Qur'anic memorization classes are more advanced than those in other Qur'anic study classes, and the pre-requisites to this level of study are the skills required to read and recite the Qur'an properly. Those in memorization classes have thus been studying (i.e., exposed to) the text for a longer period of time. Thus, participants in classes for purely reading and reciting the Qur'an were not included in this study. The Term "[Qur'anic] memorizers," used throughout this study, should be read to assume reading and recitation, as well as memorization.

[10] As pronouns are introduced in the introductory level of Arabic (e.g., at UMD, "ARAB104")

Table 1. Subject Criteria

	Currently in memorization class?	Extent of memorization experience	Currently in Arabic class?	Extent of Arabic language class experience	Type of cues received
Memorizers[11] with Classroom	Yes	1+ semesters	Yes	1+ semesters	Distributional, semantic
Memorizers without Classroom	Yes	1+ semesters	No	None	Distributional
Non-memorizers with Classroom	No	None	Yes	1+ semesters	Semantic
Naïve Listeners (control group)	No	None	No	None	None

Participants were adolescents and young adults aged 12 to 32 years. The wide

age range of participants in this study allowed us to focus on the acquisition of

grammatical categories by adolescents and young adults, yet accounted for the meta-

linguistic processes that are necessary for the grammaticality judgment task. All

participants were students at the time of the study, with the exception of two participants

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[11] Students in Qur'an memorization (*hifzh*) programs attend class for a range of hours, depending on the specific program. In addition, students spend time practicing and reviewing what they have already memorized. A typical full-time *hifzh* student spends a variable amount of time in a full time program (e.g., four months to over six years; Gent, 2011), and memorizes the entire Qur'an. Students in part-time programs spend varied amounts of time memorizing the entire Qur'an. The amount of Qur'an memorized in a given amount of time varies highly according to devotion to the task, amount of time spent for memorization, the student's age, and other factors (e.g., whether they are studying the translation and historical context concurrently). See Gent, 2011 for an account of a part-time British *hifzh* school.
All Qur'anic memorizers were from non-Arabic speaking families, and colloquial dialects of Arabic were not incorporated into this study. Instead, a focus remained on Classical Arabic (Qur'anic Arabic) and Modern Standard Arabic (which is what is taught in an Arabic L2 classroom), and participants familiar with Arabic were informed that the Arabic Learning Task related to formal Arabic, not a colloquial dialect.

who graduated with their Masters degrees within the past year. Participants were recruited from the University of Maryland (UMD)'s general campus body, UMD's Muslim Students Association, and UMD's Arabic language department[12], as well as from *hifzh* classes at local Sunday schools and Islamic centers[13]. There were ten participants in each of the four conditions, except for memorizers with classroom, which had 13 participants due to questionable formality of Arabic language or Qur'an memorization class enrollment for three participants.

2.2 Materials

2.2.1 Arabic Learning Task

The main component of the study was the Arabic Learning Task. Stimuli for the familiarization language and grammaticality judgment task were recorded in a lab setting by a female native speaker of Arabic and then pre-loaded onto a laptop computer and presented through headphones. Although the words used for the Arabic Learning Task were taken from the Qur'an, which is usually recited melodically according to a certain set of rules, the current stimuli were recorded with less exaggerated prosody in an effort to minimize any possibly influence of presentation on language learning. Participants were randomly assigned to a condition that defined the familiarization language and grammaticality judgment task versions they would be presented with. There were two

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[12] Some of these students were in the Arabic Flagship Program, which involves meeting with a language partner for two hours per week in addition to class.

[13] Al-Nur Academy at Prince George's Muslim Association (Lanham, MD), Al-Huda School (Dar us-Salaam; College Park, MD), Muslim Community Center (Silver Spring, MD), and First Hijrah Masjid (Washington, D.C.)

possible familiarization languages (version 1 or 2) [14], which were assembled from the set of grammatical categories described below.

Noun and verb classes make for appropriate stimuli because they are present in all languages, and they co-occur (i.e., are adjacent to each other) often, making distributional cues apparent. Stimuli for the current experiment consisted of a familiarization language, as well as a test language presented through a grammaticality judgment task designed to test the participants' abilities to extract knowledge of grammatical categories. The four grammatical categories of interest were:

1) **Category A:** subject pronoun (abbreviated versions)

2) **Category B:** verb (past tense)

3) **Category C:** possessive pronoun

4) **Category D:** noun

These categories were chosen because they appear often in the Qur'an. The verbs and nouns, and their definitions, used to comprise the sentences were low-frequency words found in the Qur'an via the Qur'an Corpus (Dukes, 2011), which were separated from other words in the Qur'anic context for use in this study. Low frequency verbs and nouns, minor specialized vocabulary, were specifically selected for the Arabic Learning Task in an effort to ensure that no participant groups were too familiar with their translations and keep the familiarization phase as close as possible to natural, first language learning. Four native speakers of Arabic and three Arabic non-speakers were

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[14] For counterbalancing purposes. Both recordings accounted for all possible grammatical combinations of the stimuli. Since the grammaticality judgment task had to present both familiar grammatical phrases (phrases from the familiarization language that also occurred in the Sentence Task) and novel grammatical phrases (which occurred only in the Phrase Task), participants who listened to version 1 of the familiarization language received phrases from version 2 as their novel phrases, and vice versa.

informally asked to translate the verbs and nouns. The native speakers of Arabic were able to translate each verb and noun, or provide a close approximation of its meaning according to the word's root. The Arabic non-speakers, some of whom had been studying the Qur'an since childhood, did not know the meanings of the words. This gave us an idea of how novel the content words would be for our participants; pronouns were not screened as they are taught in introductory Arabic language courses.

Pronouns were selected using process of elimination, according to their syllable counts, mutual exclusivity across pronoun categories (i.e., the same pronoun form could not be used to indicate both possession and a subject, which would only be distinguishable according to context[15]), and if they were grammatical according to rules of Classical and Modern Standard Arabic when combined with a noun or verb. The invisible third person masculine pronouns were avoided. Each verb and noun was bi-syllabic, and each isolated pronoun was monosyllabic, in order to cue participants to category membership and facilitate language learning for them. The words and grammatical categories used to assemble the stimuli for this study can be seen in Table 2 below.

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[15] As is the case with the pronoun "-*na*" which can mean both "we" and "our."

Table 2. Words Used to Assemble Stimuli

Word Tokens	Grammatical Categories			
	A (abbreviated subject pronouns for past tense verbs)	B (past tense verbs)	C (possessive pronouns)	D (nouns)
1	*--tu*, I تُ--	*baTash--*, seized بَطَشْ-	*--ki,* your (f.) كِ--	*ma'waa--*, abode مَأْوَى--
2	*--tum*, you (pl.) تُمْ--	*farar--*, fled فَرَرْ--	*--ha*, her/its هَا--	*baqla--*, herbs بَقْلَ--
3	--	*awey--*, retired أَوَيْ-	--	*jidh'a--*, tree trunk جِذْعَ --
4	--	*kanaz--*, hoarded كَنَزْ--	--	*dalwa--*, bucket دَلْوَ--

Using a modified version of Thompson and Newport's (2007) procedure, the grammatical categories were analyzed to calculate their translational probabilities, or the probability of each occurring next to each other, and their respective grammaticality according to Arabic syntax. Each word was identified using a letter and number, as indicated in Table 2 (e.g., "*ma'waa*" is D_1). It was then determined that the grammatical combinations (transitional probability of 1) of the above categories were: BA or DC, which were both used as stimuli. All the possible ungrammatical combinations (transitional probability of 0) were BD, DB, AB, CD, BC, DA, CA, AC, AA, BB, CC, and DD. The AD and CB combinations were also technically ungrammatical but were ignored as ungrammatical possibilities for the Arabic Learning Task because they spanned a phrase boundary in Arabic if presented in a fluent stream of sentences, such as in our familiarization language. Additionally, the BD, DB, CA, and AC combinations, which attached a noun with a verb or possessive pronoun with subject pronoun, were not used for the Arabic Learning Task due to the chance that participants would quickly detect ungrammaticality, especially based on the unusually high and unusually low syllable counts of the combinations, respectively. Thus, eight ungrammatical

possibilities remained to construct the ungrammatical stimuli for this study: AB, CD, AA, BB, CC, DD, BC, and DA.

2.2.2 Supplementary Materials

Supplemental information about our participants was collected through two memory tasks to match participants on memory skills and ensure that cognitive abilities were adequate for participation in the study. Surveys regarding language background were also administered. The first memory task was the Digit Span subtest (Verbal Forward and Verbal Backward) from the Clinical Evaluation of Language Fundamentals-4 (CELF-4), and the second was the nonverbal Design Memory subtest from the Cognitive Linguistic Quick Test (CLQT). All participants were administered the same Design Memory task from the CLQT, which was normed on 18 to 89-year-olds. However, there were two verbal digit span tasks administered according to the participant's age. Participants aged 12-16 years were given the CELF-4 Digit Span task normed for 5 to 16-year-olds, and all other participants were given the CELF-4 Digit Span task for 17 to 21-year-olds.

The surveys, which were the same for all participants, included a post-test that assessed participants' knowledge of the parts of speech and translations of the individual words in the familiarization phase and grammaticality judgment task (see Appendix A). In addition, participants completed the Bilingual Language Profile: English-Arabic (Birdsong, Gertken, & Amengual, 2012), and an informal supplemental survey inquiring about experience with Qur'anic memorization (see Appendix B).

2.3 Procedures

The general procedure for this study followed that of an artificial language task (e.g., Thompson & Newport, 2007). Participants were tested individually, in pairs, or in small groups in a university lab setting, an Islamic community center, or in their homes. Session length ranged from 40 minutes to 1 hour, and during some sessions, background noise from rooms close to the testing room was noticeable to the researcher but did not appear to bother participants. Participants were first informed of the layout of the session (i.e., complete memory tasks, listen to familiarization language, complete grammaticality judgment task, then answer surveys), and written consent was obtained from each adult participant before beginning the study. For children under 18 years, written parental consent and the child's assent were obtained. The study was conducted in English, and all participants were either native speakers of English or were proficient in English.

Figure 1. Method Outline
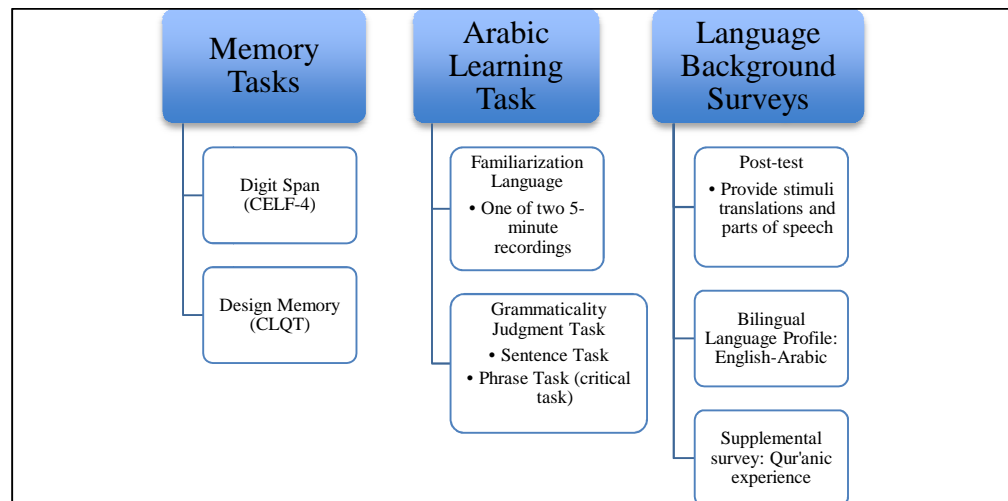
2.3.1 Memory Tasks

The memory tasks were the first component of a testing session, and the verbal measure (i.e., CELF-4 Digit Span) was administered before the nonverbal measure (i.e.,

CLQT Design Memory). The primary researcher calculated the raw scores for these tasks as the participant listened to the familiarization language.

2.3.2 Arabic Learning Task

Two versions of the familiarization language were recorded, each comprised of 8 sentences following the BA DC pattern (a past tense verb attached to an abbreviated subject pronoun and possessive pronoun attached to a noun, e.g., *baTashtu baqlaha*), with as little space between individual words as possible. The sentences were then copied, randomized, and looped to fill a 5-minute recording. This recording exposed participants to which grammatical categories could occur together, and when compared to the test language in the grammaticality judgment task, reflected that the number of legal combinations is less than the number of illegal combinations. The familiarization language was initially 20 minutes long, the same length of familiarization that Thompson and Newport used (2007). However, during pilot testing, we found that participants were able to learn the patterns of the simple test language fairly quickly and still perform with high accuracy on the grammaticality judgment task. After surveying pilot participants, the familiarization language was shortened to 5 minutes.

After listening to the familiarization language, participants were administered the grammaticality judgment task, a two-alternative forced-choice test which mimicked Thompson and Newport's (2007) judgment task. The task involved two parts, the Sentence Task, which tested participants on their ability to recognize a grammatical phrase heard in the familiarization language and choose it over a novel ungrammatical phrase, and the Phrase Task, which forced participants to make a grammaticality judgment between two novel phrases using the rules they acquired from the

familiarization language. The grammaticality judgment task consisted of 48 questions

total, each presenting a grammatical phrase and an ungrammatical phrase.

Figure 2. Grammaticality Judgment Task
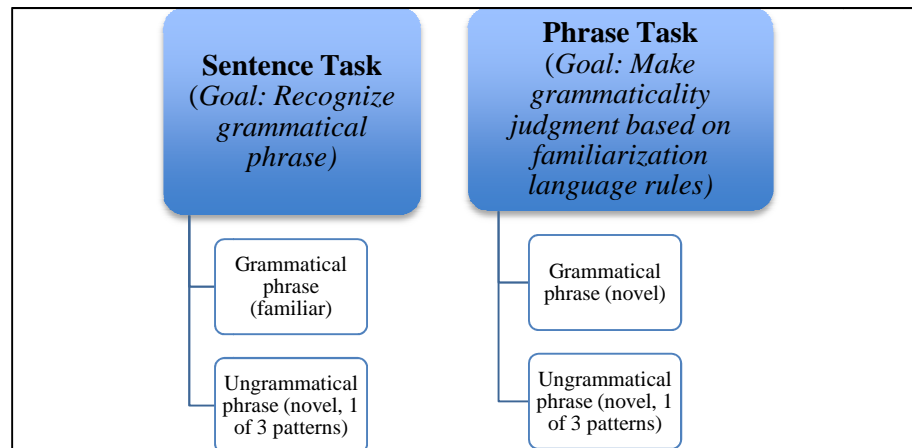
Instructions for the task appeared on the participant's computer screen before the

test items were presented.   For both the Sentence Task questions and Phrase Task

questions, participants had to press the space bar to hear Phrase 1, and then again to hear

Phrase 2, and were then presented with the question "Which one is grammatical? Phrase

1 or Phrase 2?" Participants then had to press "z" to say Phrase 1 was grammatical, or

"/" if Phrase 2 was grammatical, before pressing the space bar to proceed to the next test

item. The Sentence Task was presented first, followed by the Phrase Task. However, the

phrases in each task question were randomized across trials so that grammatical phrases

occurred first in half of the trials and second in the other half, to ensure that participants

could not predict grammaticality independent of the ungrammatical phrase.

In the Sentence Task, the grammatical phrase presented was one of the 16 phrases

heard during the familiarization language (e.g., "*kanaztum*"-B_4A_2, "*dalwaha*"-D_4C_2)

while the ungrammatical phrase was novel. In the Phrase task, both grammatical and

ungrammatical phrases were novel. Critically, novel grammatical phrases were ones that

included the words heard in the familiarization language *and* the syntax rules of its phrases, but they were not the same exact combinations of words heard before. For example, instead of presenting the phrases "*kanaztum*" (B_4A_2) and "*dalwaha*" (D_4C_2) heard in the familiarization language and the Sentence Task, the Phrase Task presented "*kanaztu*" (B_4A_1) and "*dalwaki*" (D_4C_1). Here the pronouns used in these two phrases were combined with different verbs and nouns in the familiarization language.

In both the Sentence Task and Phrase Task, the ungrammatical phrase followed one of three patterns, or types of ungrammaticality (8 phrases presented per pattern per task). These patterns were categorized from the group of eight possible ungrammatical combinations of stimuli mentioned above:

1) Reversal: a reversal of the words in the grammatical phrase, following the pattern AB or CD (e.g., "*tumkanaz*"-A_2B_4), which tested the participants' ability to recognize the incorrect order of the words in the phrase (i.e., pronoun before the verb or noun, as opposed to after).

2) Repetition: a combination of two words from the same grammatical category, following the pattern AA, BB, CC, or DD (e.g., "*kiha*"-C_1C_2). This pattern tested the participants' ability to realize that words in the same phrase must be from different categories.

3) Replacement: an incorrect combination of a noun attached to subject pronoun, or verb attached to possessive pronoun, following the pattern BC or DA (e.g., "*dalwatum*"-D_4A_2, "*kanazha*"- B_4C_2). This pattern was the most critical, as it tested participants' ability to detect the type of pronoun attached to a verb or noun, and not just its placement. Thus, it checked if participants formed

definitive categories for the words they were exposed to, and if they could use transitional probability to formulate a grammatical rule for how the words combine.

Participants continued the grammaticality judgment task until they received notification for a break (i.e., "Whew, time for a break!"), which was built into the task at a random point between test items. After participants answered the last test item, they received a prompt to await further instructions from the researcher.

2.3.3 Language Background Surveys

After completing the grammaticality judgment task, participants were presented with the three surveys (i.e., post-test, BLP: English-Arabic, and supplemental survey on GoogleDocs forms). These surveys were also presented on a laptop computer.

The researcher then reviewed the survey submissions to ensure that all responses were recorded, and briefed participants on the experiment and answered any questions they had about the study. Participants were informed of their memory task raw scores if they asked about them, but were not given any information regarding accuracy on the grammaticality judgment task. Finally, participants were paid at a rate of $10/hour as compensation for their participation, unless they did not want to accept payment (3 participants). Notably, if participants were being tested in a pair or small group, one participant was presented with the familiarization language and grammaticality judgment task first, while the other participant was administered the memory tasks. Participants who did not start their session with the memory tasks were administered these after the completion of the surveys.

3. Results

The results from the current experiment will be conducted in three steps. First, we will introduce 2x2 ANOVA group-level analyses on non-linguistic and linguistic demographic variables. Since our groups were quite heterogeneous, these analyses will account for any significant differences between participant groups. Next, we will introduce 2x2 ANOVA group-level analyses for the grammaticality judgment task. These analyses will allow us to answer our two critical questions. First, are adolescent and young adult non-Arabic speakers, who memorize the Qur'an, able to abstract Arabic grammatical category knowledge? Second if so, is this knowledge comparable to that of students taking Arabic language classes? These analyses will inform us about the advantages or disadvantages that distributional or semantic cues may provide for grammar learning. Finally, we will discuss Pearson correlations run for individual difference analyses, to see if any non-linguistic (e.g., age) or linguistic (e.g., proficiency level) participant characteristics affected accuracy on the grammaticality judgment task.

Due to the relatively small sample size, all reported p-values will adopt a $p < .05$ one-tailed threshold, unless otherwise noted. This threshold is appropriate for the current study because of the a priori predictions about the direction of the critical effects.

3.1 Participant Characteristics

The variables analyzed for each participant and condition were non-linguistic (i.e., current age, gender, and Verbal Total digit span task raw score from CELF-4, out of a possible score of 30) and linguistic (i.e., age of first exposure to Arabic, number of hours of exposure to Arabic per week, total correct translations of stimuli from the post-test, total correct parts of speech identified on the post-test, and self-rating of proficiency

in Arabic on a scale from 0 to 6). Table 3 below summarizes the participants according to each condition and all variables analyzed[16].

The first group-level analysis was conducted through 2x2 ANOVAs, which examined whether each participant condition was significantly different from the others according to the above non-linguistic and linguistic demographic variables. Our between-subjects independent variables were the memorizers (non-memorizers vs. memorizers) and classroom learners (without classroom vs. with classroom).

Non-linguistic effects were analyzed first. On measures of age, memorizers were significantly younger than non-memorizers, leading to a significant main effect of memorization ($F(1, 39)=54.98$, $p<.001$). Memorizers with classroom experience were also younger than naïve listeners and non-memorizers with classroom experience, leading to a significant interaction between memorization and classroom experience ($F(1, 39)= 8.60$, $p=.003$). No significant effects were found for gender (all p's$>.16$), or digit span raw scores (all p's$>.06$).

Next, linguistic effects were analyzed. These analyses revealed that relative to the non-memorizers, memorizers were exposed to Arabic much earlier ($F(1,39)=201.39$, $p<.001$), correctly identified more parts of speech of stimuli on the post-test ($F(1, 39)=4.28$, $p=.02$), and judged themselves to be more proficient ($F(1, 39)=14.42$, $p<.001$), all leading to significant main effects of memorization. Analyses also revealed that relative to their non-classroom counterparts, classroom learners were exposed to Arabic earlier ($F(1,39)=8.91$, $p=.003$), received more exposure to the language ($F(1, 39)=6.25$, $p=.01$), were unsurprisingly able to correctly translate more stimuli on the post-test ($F(1,$

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[16] Non-standardized (raw) digit span scores were analyzed instead of standardized scores, as our participants' age range (i.e., 12-32 years) exceeded the range that the CELF-4 was normed on (i.e., 5-21 years).

39)=19.85, *p*<.001), identified more parts of speech (F(1, 39)=11.17, *p*=.001), and gave themselves higher proficiency ratings (F(1, 39)=88.04, *p*<.001), leading to significant effects of classroom experience. Finally, memorizers with classroom experience were exposed to Arabic earlier than naïve listeners and non-memorizers with classroom experience, leading to a significant interaction between memorization and classroom experience (F(1, 39)=11.09, *p*=.001). Memorizers with classroom also correctly identified more parts of speech on the post-test than their non-classroom counterparts and naïve listeners, indicating an interaction between memorization and classroom experience (F(1, 39)=3.41, *p*=.04).

Table 3. Summary of Participants By Condition

	Current Age (years)[a,c]	Gender	Digit Span (Verbal Total raw score /30)	Age of First Exposure (years)[a, b, c]	Exposure to Arabic (hours/week)[b]	Total Correct Translations on Post-Test (/12)[b]	Total Correct Parts Of Speech on Post-Test (/12)[a, b, c]	Proficiency Self Rating (0 to 6)[a,b]
Memorizers with Classroom	M=16.38[c] SD=3.40 range: 12-22	8 M 5 F	M=17.15 SD=3.29 range: 14-23	M=7.54[c] SD=3.82 range: 4-18	M=8.69 SD=17.24 range: 1-65	M=2.08 SD=3.17 range: 0-10	M=3.15[c] SD=3.16 range: 0-11	M=3.44 SD=0.83 range: 2.25-4.5
Memorizers without Classroom	M=14.90[a] SD=2.56 range: 12-21	4 M 6 F	M=17.90 SD=3.73 range: 13-23	M=7.20[a] SD=3.16 range: 4-13	M=3.40 SD=7.47 range: 0-24	M=0.10 SD=0.32 range: 0-1	M=1.80[a] SD=2.57 range: 0-7	M=1.28[a] SD=1.02 range: 0-2.75
Non-Memorizers with Classroom	M=20.50 SD=1.65 range: 18-24	3 M 7 F	M=20.10 SD=3.96 range: 14-28	M=18.20[b] SD=0.92 range: 17-19	M=22.10[b] SD=30.49 range: 3-84	M=3.40[b] SD=1.58 range: 0-5	M=6.70[b] SD=2.91 range: 1-10	M=2.75[b] SD=1.13 range: 1-4
Naïve Listeners	M=24.40 SD=3.75 range: 21-32	4 M 6 F	M=18.80 SD=5.01 range: 13-27	M=24.40 SD=3.75 range: 21-32	M=0 SD=0 range: 0	M=0.10 SD=0.32 range: 0-1	M=2.00 SD=3.06 range: 0-9	M=0 SD=0 range: 0

NOTE: [a]=main effect of memorization, [b]=main effect of classroom experience, [c]=interaction between memorization and classroom experience

3.2 Group-level Analyses

Primary analyses targeted the effect of classroom experience and memorization on accuracy on the Arabic Learning Task according to each block and ungrammaticality type. The first group-level analysis focused on performance in the Sentence Task. It considered memorizers (non-memorizers vs. memorizers) and classroom learners (without classroom vs. with classroom) as between-subjects independent variables, and accuracy on the Sentence Task as the dependent variable. It was expected that everyone would exhibit above-chance accuracy on the Sentence Task, since it tested the recognition of grammatical phrases from the familiarization language, which was presented immediately before the judgment task.

The Phrase Task, however, was the critical task, as it tested participants' ability to apply the syntax rules they learned from the completely grammatical familiarization language to identify a grammatical phrase from two novel choices. Group-level analysis for the Phrase Task considered the same independent variables as above, and Phrase Task accuracy as the dependent variable. With regards to the Phrase Task, we tested two main hypotheses. If ambient exposure to Arabic is enough to learn grammatical categories, then the memorizers without classroom group's ability to distinguish between grammatical and ungrammatical strings should be as good as those who have explicit classroom teaching (the memorizers with classroom and non-memorizers with classroom groups). If, however, ambient exposure to Arabic is not enough to learn grammatical categories, then memorizers without classroom's ability to distinguish between grammatical and ungrammatical strings in the Phrase Task should be worse than those who have explicit classroom teaching.

In addition to separating analyses into Sentence and Phrase Task blocks, group level-analyses were separated by ungrammaticality type. These comparisons revealed differences in accuracy on the grammaticality judgment task depending on the three possible ungrammaticality patterns used to form the ungrammatical phrase (i.e., Reversal, Repetition, Replacement).

3.2.1 Sentence Task

Overall accuracy for all participant groups and ungrammatical item type for the Sentence Task was 87.31%, which was fairly high and unsurprising, considering this first part of the grammaticality judgment task presented grammatical phrases that had been heard in the familiarization language.

Mean accuracies for each participant group and ungrammaticality type can be seen in Figures 3-5 below. Notably, our naïve listeners--who were also the oldest participants and first exposed to Arabic outside of the critical period--did very well on the task overall. They were able to recognize phrases from the familiarization language without having any prior experience with Arabic or the Qur'an. Additionally, we found that accuracy on Reversal items (all p's$\geq$.10) and Repetitions (all p's$>$.20) were similar across all participant groups. This suggests that no participant group had an advantage or disadvantage while answering these questions during the Sentence Task.

We also found that all participants were less accurate on questions involving Replacement ungrammaticality. Recall that these were phrases that required participants to know the relationships of grammatical categories, specifically that a possessive pronoun goes with a noun and a subject pronoun goes with a verb. Critically, in these trials, memorizers were more accurate than non-memorizers (84% vs. 74%), leading to a

significant main effect of memorization (F(1, 39)=3.24, p=.04). We found that memorizers without classroom experience actually performed with the best mean accuracy on Replacement items (85%). These findings are consistent with our hypothesis that ambient exposure to Arabic is enough to abstract grammatical category information. However, we did not find a main effect of classroom experience (p>.18) or an interaction between memorization and classroom experience (p>.25). This indicates that ambient exposure is sufficient for acquiring grammatical category information, but classroom exposure does not provide an advantage on this type of task.

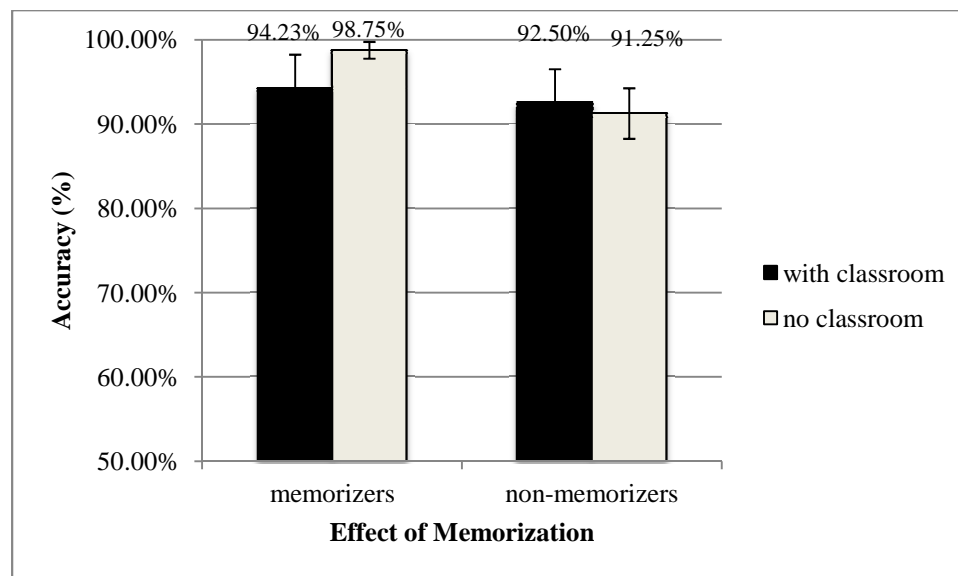Figure 3. Mean Accuracy on Sentence Task Reversal Items by Condition

Figure 4. Mean Accuracy on Sentence Task Repetition Items by Condition

Figure 5. Mean Accuracy on Sentence Task Replacement Items by Condition
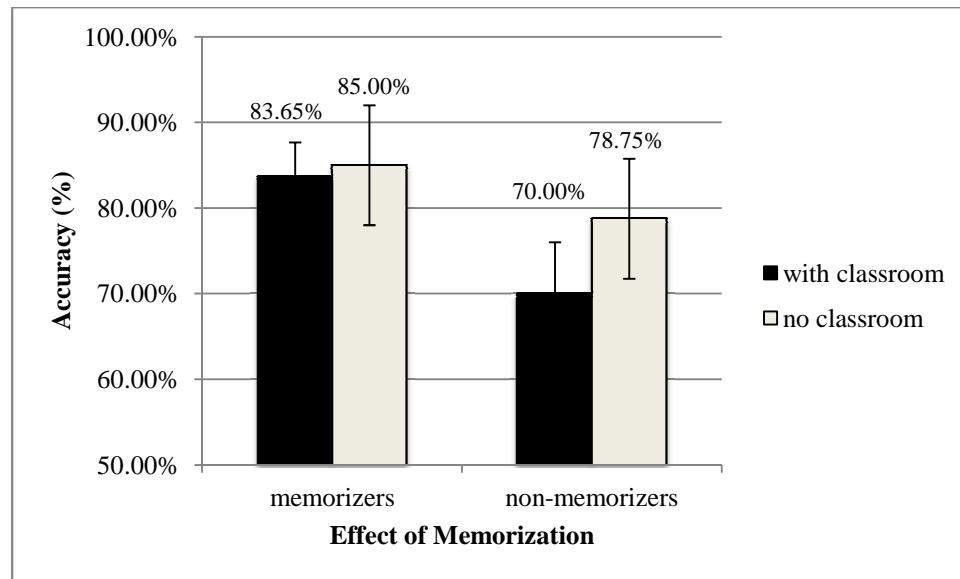
3.2.2 Phrase Task

Overall accuracy for the critical Phrase Task was 84.79%, which was also high, but was appropriately lower than the mean accuracy displayed on the Sentence Task. This is unsurprising since all Phrase Task items were novel and never heard during the familiarization phase. Thus, accurate judgments required sensitivity to the transitional

probability of category items. Mean accuracies for each condition and ungrammaticality type in the Phrase Task can be seen in Figures 6-8 below. Again, we found that naïve listeners did very well. However, their performance on this part suggests that even they learned grammar rules from the familiarization language without having any prior experience with Arabic or the Qur'an. Additionally, as observed for the Sentence Task, accuracy on items in the Phrase Task with Reversals (all *p*'s>.08) and Repetitions (all *p*'s>.29) were similar across all participant groups. This suggests again that no particular participant group had an advantage or disadvantage while answering these questions.

Again, all participants were less accurate on questions involving Replacement ungrammaticality, and in these trials, memorizers were more accurate than non-memorizers (80% vs. 68%), leading to a significant main effect of memorization (F(1, 39)=3.88, *p*=.03). In fact, the memorizers without classroom experience had the best mean accuracy on Replacement ungrammaticality items (83.75%). Ambient exposure to Arabic, then, is sufficient for abstracting grammatical category information. However, we did not find a main effect of classroom exposure (*p*>.18), or interaction between classroom exposure and memorization (*p*>.49), indicating classroom exposure to Arabic is not advantageous for this type of task.

Figure 6. Mean Accuracy on Phrase Task Reversal Items by Condition

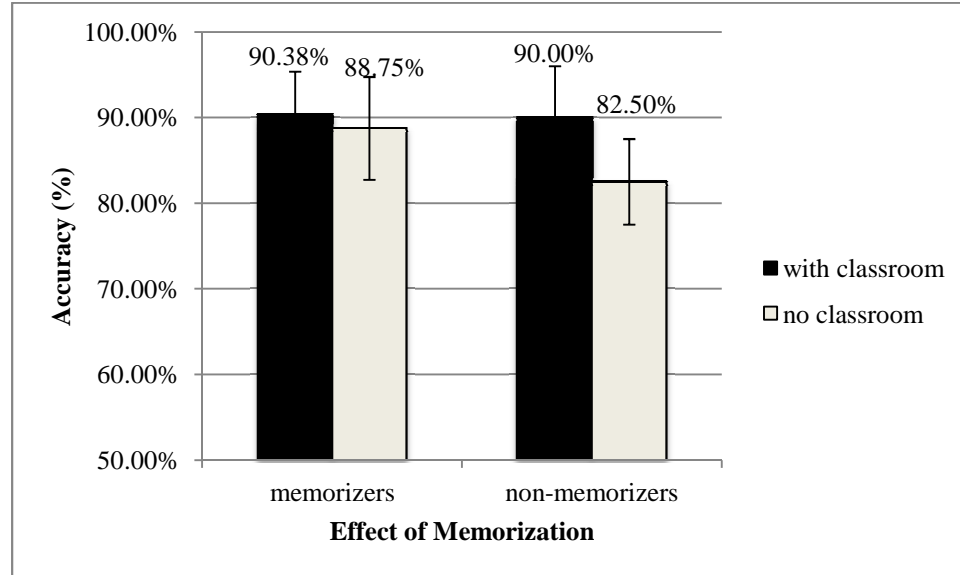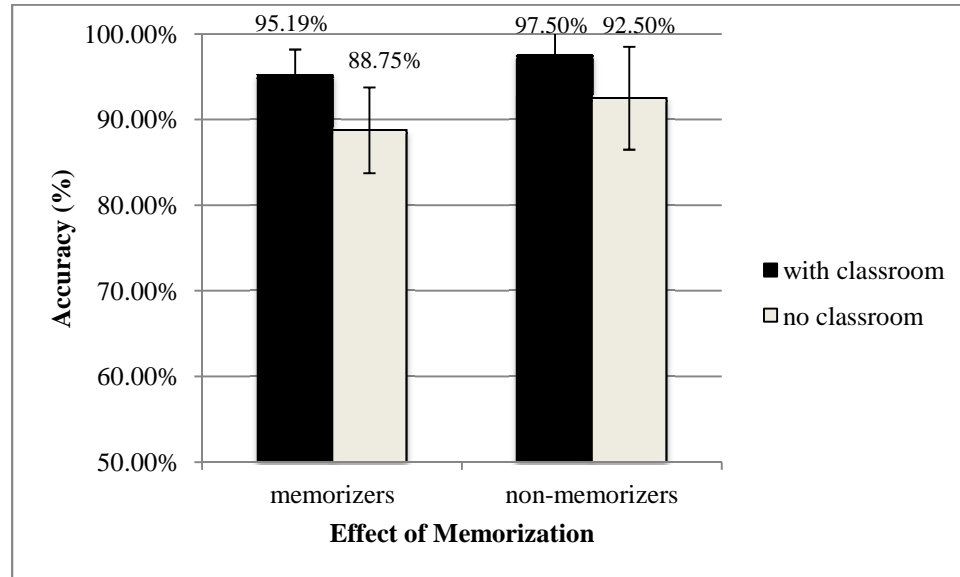Figure 7. Mean Accuracy on Phrase Task Repetition Items by Condition
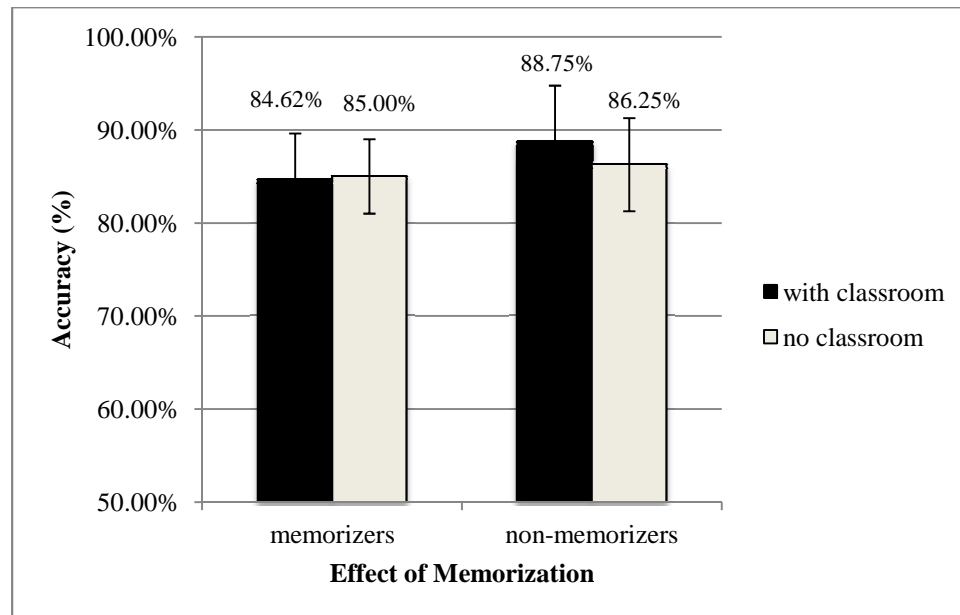
Figure 8. Mean Accuracy on Phrase Task Replacement Items by Condition
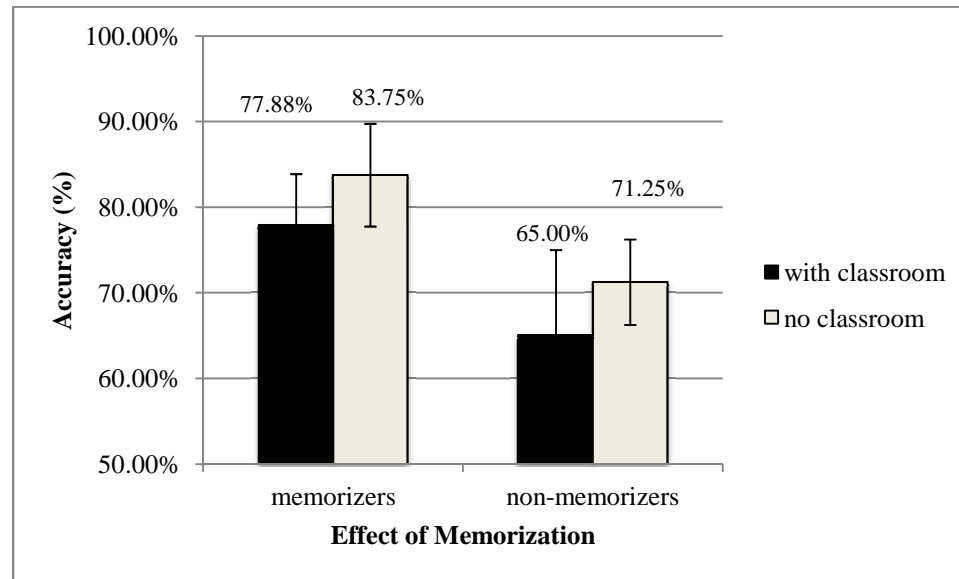
3.3 Individual Differences Analyses

Next, Pearson correlations were conducted. We investigated accuracy on items featuring grammatical items against ungrammatical items using Replacement ungrammaticality. These questions required knowledge of grammatical relations and proved to be the most challenging based on earlier analyses. They were most indicative of grammar learning because they verified if participants had formed categories for the words they were exposed to, and if they used transitional probability to formulate a grammatical rule. We correlated accuracy in these trials with non-linguistic participant characteristics (i.e., current age, gender, and verbal digit span raw scores) and linguistic participant characteristics (i.e., age of first exposure to Arabic, number of hours of exposure to Arabic per week, number of correct translations and parts of speech reported on the post-test, and self-rated proficiency). Our goal was to identify which variables, if any, affected the statistical learning of grammatical category information.

Table 4. *p-* and *r* values of Non-linguistic Variables in Sentence Task

	Age		Gender		Digit Span	
	r	*p*	*r*	*p*	*r*	*p*
Gender	**-.15**	.17				
Digit Span	**.18**	.13	**-.07**	.34		
Accuracy	**-.21**	.09	**-.03**	.42	**-.11**	.25

NOTE: *=significant at .05 level, ** = significant at .01 level

Table 5. *p-* and *r* values of Non-linguistic Variables in Phrase Task

	Age		Gender		Digit Span	
	r	*p*	*r*	*p*	*r*	*p*
Gender	**-.15**	.17				
Digit Span	**.18**	.13	**-.07**	.34		
Accuracy	**-.08**	.31	**-.07**	.33	**-.02**	.46

NOTE: *=significant at .05 level, ** = significant at .01 level

Analyses of non-linguistic measures found no significant effects between accuracy on the test items involving Replacement ungrammaticality on the Sentence Task and Phrase Task and current age (all *p*'s>.09), gender (all *p*'s>.33), or digit span raw scores (all *p*'s>.25). This means that participants' current age, gender, and verbal digit span memory abilities did not impact their performance on the grammaticality judgment task or their ability to acquire grammatical categories.

Table 6. *p-* and *r* values of Linguistic Variables in Sentence Task

	Age Exposed		Hours Arabic		Total Correct Trans.		Total Correct POS		Self-Rated Prof.	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Hours Arabic	**.10**	.26								
Total Correct Trans.	**.07**	.32	**.60**	<.001**						
Total Correct POS	**.11**	.24	**.43**	.002**	**.71**	<.001**				
Self-Rated Prof.	**-.47**	.001**	**.32**	.02*	**.46**	.001**	**.38**	.01**		
Accuracy	**-.28**	.03*	**-.26**	.05*	**-.02**	.46	**.05**	.37	**.08**	.32

NOTE: *=significant at .05 level, ** = significant at .01 level

Table 7. *p-* and *r* values of Linguistic Variables in Phrase Task

	Age Exposed		Hours Arabic		Total Correct Trans.		Total Correct POS		Self-Rated Prof.	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Hours Arabic	**.10**	.26								
Total Correct Trans.	**.07**	.32	**.60**	<.001**						
Total Correct POS	**.11**	.24	**.43**	.002**	**.71**	<.001**				
Self-Rated Prof.	**-.47**	.001**	**.32**	.02*	**.46**	.001**	**.38**	.01**		
Accuracy	**-.22**	.08	**-.29**	.03*	**.11**	.25	**-.01**	.48	**.10**	.27

NOTE: *=significant at .05 level, ** = significant at .01 level

In contrast, correlations were found between our linguistic variables and accuracy on the Replacement items of the judgment task. These can be observed in Tables 5 and 6 below. These analyses yielded three patterns of interest. First, accuracy was correlated with age of first exposure to Arabic in the Sentence Task ($r(43) = -.28$, $p=.03$). This indicates that the younger our participants were when they were first exposed to Arabic (i.e., memorizers) the more accurate their performance was on Replacement items on the Sentence Task. We observed the same pattern for accuracy on the critical Phrase Task, but this effect did not reach significance ($r(43)=-.22$, $p=.08$), probably due to our small sample size. The participants who were first exposed to Arabic more recently were those in the non-memorizers with classroom and naïve listener groups, and these participants were less accurate on the Replacement items of the Sentence Task.

Second, hours of exposure to Arabic per week was negatively correlated with accuracy on the Sentence Task ($r(43)=-.26$, $p=.05$) and Phrase Task ($r(43)=-.29$, $p=.03$). The longer participants were exposed to Arabic per week, the less accurate they were when presented with Replacement items on the grammaticality judgment task. This corresponded to the classroom learners, who were typically exposed to the most Arabic on a weekly basis, suggesting possible interference from the information they are learning about the Arabic language in class. The explicit presentation of grammatical rules in the classroom setting may be hindering their ability to implicitly acquire these rules in the Arabic Learning Task. This hypothesis is strengthened by the analyses we ran on reaction time. Our participants with classroom exposure exhibited longer mean reaction times than our non-classroom groups, particularly on Repetition items of the

Sentence Task (F(1, 39)=3.29, *p*=.04)[17]. Longer reaction times may have been exhibited

because classroom participants were trying to match their knowledge from class with the

requirements of the Arabic Learning Task.

Finally, it is interesting to note that accuracy on the critical Replacement items

was not correlated with self-rating of proficiency (all *p*'s>.27). One possibility is that

participants were not very good at providing subjective ratings of their own proficiency.

However, correlations between this rating and other objective measures suggest

otherwise. For both the Sentence Task and Phrase Task, self-rating of proficiency was

correlated with age of first exposure (*r*(43)=-.47, *p*=.001), hours of exposure to Arabic

per week (*r*(43)=.32, *p*=.02), total correct translations on the post-test (*r*(43)=.46,

p=.001), and total correct parts of speech on the post-test (*r*(43)=.38, *p*=.01). These

analyses suggest that self-ratings of proficiency were valid. Critically, its lack of a

relationship to accuracy on the grammaticality judgment task suggests that explicit

knowledge of a language may be less helpful in acquiring the implicit rules of

grammatical relationships.

4. Discussion

This study examined the effect of ambient exposure to Arabic through Qur'anic

memorization versus classroom exposure and explicit Arabic language learning on the

ability to acquire rules of Arabic grammatical categories. In the critical trials, we

examined accuracy in judging novel Replacement ungrammaticality items of the Phrase

Task. These trials required participants to identify a grammatical phrase based on rules

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[17] There were no significant effects of classroom exposure on reaction time for Reversal items (all *p*'s>.26) or Replacement items (all *p*'s>.08) of the Sentence Task, or on Reversal (all *p*'s>.17), Repetition (all *p*'s>.19), or Replacement (all *p*'s>.09*)* items of the Phrase Task.

that followed the transitional probabilities of items in the familiarization language. We found that while all groups achieved high levels of accuracy, memorizers achieved higher accuracy on the task than non-memorizers. This suggests that implicit, distributional information is sufficient for learning grammatical categories, and the statistical learning approach is validated. Most importantly, this distributional information was not acquired during the brief Arabic Learning Task alone, as was observed with the naïve listeners. Rather, it was collected over several years of Qur'anic memorization experience, and amounted to more knowledge than that exhibited by naïve listeners. Qur'anic memorization thus provides significant amounts of distributional cues to Arabic grammar, which aid the implicit acquisition of grammar rules.

In contrast, we found that classroom experience and the reception of explicit, semantic information of Arabic grammar do not provide an advantage for grammatical judgment accuracy. This suggests that explicit information may not be required in order for language learners to acquire grammatical categories. Our classroom learners provided the most accurate translations of the stimuli on the post-test[18], proving that they are receiving at least some semantic information in class. However, this information does not appear to aid their ability to formulate grammatical rules in the current study. In fact, we found that our participants with classroom experience exhibited longer reaction times, despite receiving the most exposure to Arabic per week. This implies that explicit language instruction in a classroom may be one possible cause of interference with the ability to acquire distributional information of grammatical categories.

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[18] All Arabic-experienced groups exhibited knowledge of parts of speech of the stimuli to some extent.

Altogether, these findings support our hypothesis, that ambient exposure from Qur'anic memorization is enough to abstract knowledge of grammatical categories, and semantic representations are not required from Arabic language classes. In the remainder of this section, we will discuss the broader implications of these findings in greater detail, as well as its present limitations, and possible avenues for further research.

4.1 Evidence for Statistical Learning

Thompson and Newport (2007) reported that adult learners of an artificial grammar calculated transitional probabilities and used those statistics to make new, grammatical phrases with the same words. They did this all in the absence of semantic information, having been exposed to an artificial grammar for 20 minutes each day for five days. Findings of the current study extend these results, and demonstrate that statistical learning can take place over several years as well as several minutes. We found that our memorizers without classroom experience achieved higher accuracy on the Arabic Learning Task than non-memorizers and naïve listeners. They were able to use distributional cues from several years of Qur'an memorization experience to acquire Arabic grammar rules without receiving semantic information.

Moreover, these findings highlight the effects of training grammar through rote memorization, the mechanism used to learn the Qur'an. This has implications for education in second language learning. Traditionally, teaching methods have involved a combination of grammar/translation methods, which involve using the first language to teach the second, or direct methods, which prohibit the use of the first language and emphasize submersion (Snow, 1998). Direct methods such as the audiolingual method (ALM; Snow, 1998) have sought to teach students grammar through memorized oral

drills, with the purpose of practicing particular constructions until they can be used in a spontaneous context. Our findings suggest that there are advantages to memorizing a language without mapping it to semantics.

We also found remarkable evidence for statistical learning that occurs over several minutes. Our naïve listeners exhibited above-chance accuracy on the grammaticality judgment task, thus demonstrating significant knowledge of grammatical categories after just five minutes of exposure to the language. Critically, by using Arabic in our study, we were able to apply Thompson and Newport's findings to a real language in a unique first-language context, through adolescents and young adults learning Arabic as a second language.

4.2 Suggested Evidence for Critical Periods

The current findings are also relevant to existing literature about a critical, or sensitive, period of language learning. This hypothesis says that normal language acquisition must occur as early as possible during childhood, before puberty, and after this period has passed, language acquisition is more difficult (Lenneberg, 1967). Reports exist of children like Genie, who was kept isolated from the ages of 2 to 13 with very limited interaction, and had no language when she was rescued or no expressive grammar even after extensive speech and language therapy. These cases have been used in support of the critical period of language acquisition (Berko-Gleason & Bernstein Ratner, 1998; Newport, 2002).

As Newport (2002) mentions, studying healthy individuals allows us to observe the normal language acquisition process without worrying about the physical or mental health of participants. Such studies have produced strongly favorable results in terms of

first and second language proficiency (Johnson & Newport, 1989) and its relationship to age of first exposure. These studies have also proven that although there are exceptions, the later the age of first exposure to a language is, the less proficient the learner will be (Newport, 2002). Johnson and Newport found this to be true with their 46 native Chinese or Korean speakers who immigrated to the United States at the ages of 3-39 years, and learned English as a second language.

In our study, the memorizers were the youngest participants, the youngest of whom were 12 years old. However, the memorizers without classroom experience were all first exposed to Arabic within the critical period of language learning, between the ages of 4 and 13 years. Our non-memorizers were first exposed to Arabic much later, through classes at their university (non-memorizers with classroom), or through the present study (naïve listeners). We found that the earlier participants were first exposed to Arabic, the more accurate they were on the critical Replacement items in our Sentence Task. That is, our memorizers were most adept at distinguishing a familiar grammatical phrase from a verb or noun attached to the wrong type of pronoun. We observed the same pattern emerging for the critical Phrase Task, however due to our small sample size, this effect did not reach significance.

4.3 Possible Limitations of the Current Study

There were several limitations to the current study. First, the sample size was relatively small. All conditions consisted of only 10-13 participants per group. While this sample size was sufficient to find that memorizers did better on the grammaticality judgment task than non-memorizers, it is possible that more significant effects may have been found with a larger population. Additionally, participants may not have been

matched for age, gender, or linguistic background as well as they could have been. It is possible that with a larger recruitment pool, equal numbers of age-matched male and female participants who have all been enrolled in Qur'an memorization and/or Arabic language classes for 1 to 10 years, or neither, could have been included in the study.

Another limitation is that some environments surrounding the testing room (e.g., other classes in a Sunday school) were noisy and may have distracted participants. Ideally, all participants would have been tested in pairs or small groups, with the help of a second researcher, in the same university lab setting. Finally, aspects of the non-Arabic Learning Task materials limited the results of the study. Although we surveyed participants about how many hours of exposure to Arabic they were currently receiving per week, we did not account for cumulative hours of exposure per week (i.e., average number of hours of exposure [per week] each year that they have been exposed to Arabic). Learning is cumulative, and this analysis would help uncover the amount and frequency of ambient and/or classroom exposure to Arabic that is required in order to acquire grammatical category information.

Finally, the standardized verbal digit span and nonverbal memory tests used were not matched for the ages of this study's participants. The CLQT was normed on adults aged 18 through 89 years, and the CELF-4 was normed on children and young adults aged 5 through 21 years. As our participants were aged 12 to 32 years and their ages did not match the normed ages, the CLQT and CELF-4 subtests administered were interpreted according to raw scores. This might have decreased the sensitivity of our non-linguistic measures even though the Verbal Total raw score means across participant groups were similar.

4.4 Future Research

Related future research should attempt to address the limitations of the current study. Conducting this study in a consistent, quiet testing environment with stricter material guidelines and a much larger sample size may result in more significant findings. In addition, with a larger sample size, participants in each condition can be separated by additional demographic considerations that were not analyzed in the current study, such as number of languages spoken and race or ethnicity. These factors may help isolate interactions relating to the effects of linguistic exposure in the environment on the ability to acquire distributional cues from the Qur'an, such as being monolingual, bilingual, or monolingual, or being a heritage speaker of a language that has Arabic (or Semitic) roots (e.g., Urdu). Future research would also benefit from including analysis of cumulative exposure to Arabic, and incorporating memory measures normed on the same ages as those of the participants being studied.

Another consideration would be to include native speakers of Arabic in this study to test the integrity of the stimuli on a larger scale, apart from the minimal pilot testing conducted for the current study, and investigate the possible effects of knowledge of colloquial Arabic dialects on the acquisition of distributional information from Qur'anic memorization and Classical Arabic. Furthermore, this study can be conducted with different stimuli, such as various forms of the Replacement ungrammaticality type, and a more complex familiarization language, as our participants demonstrated high accuracy on the grammaticality judgment task.

Finally, future research could include analysis of participants who have taken Arabic language classes or Qur'an memorization classes in the past, but are no longer

enrolled in either class. Analysis of accuracy by these participants compared to current memorization and Arabic language students could help uncover how much subconscious skill is retained over time, and further the investigation of the extent of innate abilities to use distributional cues for abstracting grammatical category information. We found large numbers of individuals in these populations while recruiting for the current study, and including former students in a future study may also facilitate age and gender matching across conditions.

Appendix A. Post-Test (Post-Arabic Learning Task Questionnaire)

Listening to Language: Post-Test

Thank you for your participation in this study! Here's a brief questionnaire to find out if you understood any of the words you heard during the task. Please translate the following words, and indicate their parts of speech, if you know them. Or, write "N/A" if you do not know the translation.

Keep in mind that the words below are usually attached to other words (indicated by "--").

* Required

Subject Number *
(To be filled out by experimenter)

[   ]

batash (--بَطَشن) *

Please type the translation and part of speech, or "N/A" below

[   ]

farar (--فَرَر) *

Please type the translation and part of speech, or "N/A" below

[   ]

awey (--أَوَي) *

Please type the translation and part of speech, or "N/A" below

[   ]

kanaz (--كَنَز) *

Please type the translation and part of speech, or "N/A" below

[   ]

ma'waa (--مَأوى) *

Please type the translation and part of speech, or "N/A" below

* (بَقَلَ--) baqla--

Please type the translation and part of speech, or "N/A" below

[   ]

* (جِذُعَ--) jidh'a--

Please type the translation and part of speech, or "N/A" below

[   ]

* (دَلُوَ--) dalwa--

Please type the translation and part of speech, or "N/A" below

[   ]

* (ك--) --ki

Please type the translation and part of speech, or "N/A" below

[   ]

* (ها--) --ha

Please type the translation and part of speech, or "N/A" below

[   ]

* (تُ--) --tu

Please type the translation and part of speech, or "N/A" below

[   ]

* (تُمُ--) --tum

Please type the translation and part of speech, or "N/A" below

[   ]

(Submit)
Never submit passwords through Google Forms.

Appendix B. Supplemental Survey to Bilingual Language Profile

Listening to Language

Participant Language Survey: Supplement to English-Arabic BLP
* Required

Name of Participant *

[   ]

Participant's date of birth and age *
If under 18, name of legal guardian

[   ]

Are you a student? *
If yes, please write name of institution below in the "other" box

☐ No

☐ Yes

☐ Other: [   ]

What is your native (first) language? *

[   ]

Is Arabic spoken at home? *

☐ No

☐ Yes

Approximately how many hours of Arabic do you hear per week? *

[   ]

Do you speak any other languages? If so, please list all with years of experience. *

Example: Mandarin (10 years), French (5 years)

Can you read the languages mentioned above? *

Example: "N/A" or "Mandarin-no; French-yes"

Can you write in the languages mentioned above? *

Example: "N/A" or "Mandarin-no; French-yes"

Are there any other languages you use on a daily basis, in any mode (e.g., reading, writing, speaking)? *

Are you currently enrolled in any language classes? *

If yes, indicate the language in the "other" box

☐ No

☐ Yes, see below

☐ Other:

Do you know how to read the Qur'an? *
If so, please elaborate below.

☐ No

☐ Yes

If you replied "yes" to the above question, how did you learn to read the Qur'an? *
From:

☐ Parent(s)

☐ Formal class

☐ Private native Arabic-speaking tutor

☐ Private non-native Arabic speaking tutor

☐ N/A

Age of learning to read the Qur'an *
Example: "N/A" or "6 years old"

[   ]

Have you memorized any portion of the Qur'an in a memorization (hifzh) class? If so, for how many years have you been enrolled? *
Example: Dar Us-Salaam, 2 years

☐ No

☐ N/A

☐ Yes, institution and length of time below

☐ Other: [   ]

Is your memorization class part of a full-time or part-time program? *

☑ Full-time

☐ Part-time

☐ N/A

Approximately how many hours do you spend memorizing and/or reviewing the Qur'an per day? *

[   ]

Do you plan to memorize the entire Qur'an? *

☐ No, that is not a goal of mine at this time

☐ Yes

Do you learn any aspects of the Arabic language (e.g., grammar, vocabulary) in your hifzh program? *

If so, please indicate which aspects in the "other" box

☐ No

☐ N/A

☑ Yes

☐ Other: [   ]

Are you currently taking/have you taken formal Arabic language classes while you are/were in your hifzh program? *

If so, please indicate name of institution and length of study in "other" box

☐ No

☐ N/A

☐ Yes, at _____ for _____ years

☐ Other: [   ]

Please rate your understanding of Arabic grammatical categories (e.g., nouns, verbs, possessive pronouns, subject pronouns) on a scale from 1 (no understanding) to 7 (very deep understanding). *

　　　　　1　2　3　4　5　6　7

No understanding ○ ○ ○ ○ ○ ○ ○ Very deep understanding

(Submit)

Never submit passwords through Google Forms.

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