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The Effect of Music Syntax Therapy on Speech Production in People with Aphasia

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The Effect of Music Syntax Therapy on Speech Production in People with Aphasia

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Abstract

Music is often thought to have medicinal or therapeutic properties across a wide variety of disciplines. The purpose of this study was to determine whether pairing linguistic phrases with the same structure, or syntax, of music affects the speech production of individuals with non-fluent aphasia. Prior to any intervention, four individuals with non-fluent aphasia were assessed to determine mean length of utterance and syntactic complexity in everyday (formulaic) phrases and less-frequently used (non-formulaic) phrases. They were also given a pre-test designed to measure their understanding of music syntax. They then received three one-hour sessions of linguistic syntax therapy and three one-hour sessions of linguistic syntax therapy paired with a music component to match the syntax. Both forms of therapy (linguistic syntax or linguistic + music syntax) consisted of the formulaic and non-formulaic phrases. The phrases were divided into varying levels of syntactic complexity. For the linguistic + music syntax condition, the phrases were all set to music with a chord progression that matched the linguistic syntax complexity of the phrase. All participants received both levels of treatment and were assessed after each to determine MLU and parts of speech. Order of treatment was counterbalanced. We found that MLU increased after both linguistic and music syntax training, but that music syntax training provided a larger benefit. The number of nouns and verbs increased across training as well, but neither linguistic nor syntactic training provided a larger benefit. These results indicate that music syntax therapy enhances MLU but does not target any specific parts of speech.

The Effect of Music Syntax Therapy on Speech Production in People with Aphasia

It has long been known that music affects people in extraordinary ways, and more recently, researchers have begun to examine how music impacts language production. Patel (2011) examined how a background in music may enhance the neural encoding of speech through the OPERA hypothesis. OPERA is an acronym that represents the five conditions necessary to achieve the language benefits that music may offer—overlap, precision, emotion, repetition, and attention. The two that seem to have the most impact on speech production are overlap and precision. Overlap means that some of the parts of the brain that process speech are also used in processing music. Precision pertains to the idea that music is more demanding of these brain networks than language. This hypothesis also suggests the idea that music and speech use the same qualities—pitch, timing, etc.—to portray a message. Because music and language have many overlapping characteristics, they can be broken into smaller components, including syntax, and studied to find similarities and differences or to find how one can influence the other.

Because music and language both incorporate syntactic components, researchers have looked to determine whether these forms of syntax have an overlapping location in the brain. Kunert, Willems, Casasanto, Patel, and Hagoort (2015) used fMRI to determine whether linguistic and music syntax utilize any of the same resources in the brain. They determined that Broca's area plays a significant role in linguistic syntactic processing as well as some musical syntactic processing. Because music is processed in both hemispheres of the brain, it is plausible that for individuals with preserved music comprehension post-stroke, that language use would be facilitated through this bi-hemispherical role of music.

Melodic Intonation Therapy (MIT) is one form of therapy in which both hemispheres of the brain become engaged, and it uses music to facilitate language across hemispheres. This form of therapy consists of singing and tapping of syllables. While it does not directly target syntax, it links the typically language-dominant left hemisphere with the right hemisphere. It has been proposed that for individuals with non-fluent aphasia post-stroke, there are two potential routes to restoring some language use. For individuals with little damage to the language areas of the left hemisphere, language recovery is divided between the left and right hemispheres. However, for individuals with significant damage, language recovery likely happens predominantly in the right hemisphere (Schlaug, Marchina, & Norton, 2008). By using music, MIT targets both the language-dominant left hemisphere and the music-dominant right hemisphere in order to facilitate language use. Consequently, in our study, we used a similar idea.

In people with agrammatic Broca's aphasia, musical syntactic processing, as well as linguistic syntactic processing, may be impaired (Patel, Iversen, Wassenaar, & Hagoort, 2008). As such, it makes sense to examine how training in musical syntax will impact the processing of linguistic syntax, which we examine in the current study. In this study, we define linguistic syntax as the structure of spoken sentences, and musical syntax will be defined as the hierarchical structure of pitch, scale, and chord progression in music.

Linguistic syntax is widely utilized in therapy for people with aphasia. Rather than pairing it with musical syntax training, however, many therapists choose to pair it with basic singing and rhythm, which may overlap only partially with a more specific musical syntax. In a case study conducted by Straube, Schulz, Geipel, Mentzel, and

Miltner (2008), the researchers examined whether song familiarity facilitated language production. Previously, people had noticed that individuals with aphasia had the ability to sing familiar songs even though they had difficulty speaking. This case study found that although the participant could sing the lyrics, he still could not speak them. Unfamiliar songs, lyrics, and melodies had no significant effect on speech production. Racette, Bard, and Peretz (2006) conducted a similar experiment with multiple participants and found some similar results. They did find, however, that when the participants sang or spoke at the same time as a model, they could reproduce more words while singing than while speaking. Other researchers have chosen to look at how speech output is influenced by lyrics and rhythm of music (Stahl, Henseler, Turner, Geyer, & Kotz, 2013). This study determined that some types of phrases receive more benefit from lyrics and rhythm and other phrases benefit more from the more typical types of therapy that do not utilize music.

One component of the standard therapy condition of the Stahl et al. (2013) study was reduced syntax therapy. This is a form of linguistic syntactic therapy that breaks language down into the most essential components in the beginning stages and adds increasingly complex parts as the levels increase (Springer, Huber, Schlenck, & Schlenck, 2000). Nearly all of the participants in this study saw substantial improvements in length of utterance production. Of the participants that were seen nearly one year after treatment, all had either the same or increased utterance length as seen immediately after the treatment. The Stahl et al. (2013) study found some benefits in phrases while utilizing a standard therapy which included the reduced syntax therapy outlined in the

Springer et al. study. As such, it seems necessary to determine the influence of this therapy when coupled with music syntax therapy.

The current study originates largely from the Stahl et al. study and the Springer et al. study. Stahl et al. utilized reduced syntax therapy (REST) as a component of linguistic therapy. REST as outlined by Springer et al. (2000) includes five levels of increasing difficulty. In the current study, we utilized the first two levels of this therapy. Level one consists of two-word utterances primarily in noun-verb pairs (e.g., “drinking coffee”). Level two includes two-to-three-word phrases consisting of a verb and a prepositional phrase (e.g. “driving to Chicago”). Stahl et al. (2013) studied the benefit of music on production of different types of phrases including formulaic (e.g., “How are you?”) and non-formulaic (e.g., “bright forest”). Because this study found improvements in different aspects of speech production in the participants in different linguistic and music conditions, we looked to determine whether combining syntax-specific parts of the conditions would improve overall speech production. Because the formulaic phrases do not correspond with a noun-verb or verb-prepositional phrase structure, they were assigned to the REST level that most matched their complexity (e.g., “good morning”=level one, “how are you”=level two).

Method

Participants

Participants in this study consisted of four members of the Butler Aphasia Community (BAC). Members of the BAC who have non-fluent aphasia with relatively preserved auditory comprehension were asked if they would be willing to participate in this study. All had been diagnosed with a form of non-fluent aphasia. The time of onset of their aphasia ranged from two to nine years. Three females and one male participated in this study, and they ranged in age from 35-58 years. Two of the participants had formal musical training. All but one of the participants had some college education, and two had college degrees. Table 1 displays demographic information of the four participants.

Stimuli

To establish a baseline of the participants' understanding of music syntax, a series of 50 chord sequences (Patel et al., 1998) was presented to the participants. They were asked to determine whether each sequence sounded correct or incorrect.

In addition, 60 phrases were designed to match the criteria for formulaic or non-formulaic phrases (Stahl et al., 2013) and the first three levels outlined in Reduced Syntax Therapy (REST) (Springer et al., 2000). Fifteen of the phrases were formulaic phrases (e.g., "How are you?"), and 45 were non-formulaic (e.g., "leaving for vacation"). Formulaic phrases consisted of things that might be said in everyday conversation, whereas the non-formulaic phrases were phrases that would not generally be used every day but that still could occur naturally in conversation. Of the total 60 phrases (including both formulaic and non-formulaic), 26 phrases were level 1 of REST, 18 were level 2, and 16 were level 3. For non-formulaic phrases, level 1 of REST consisted of a verb and noun. Level 2 contained a noun and a 2-3 word prepositional phrase. Level 3 used a noun, verb, and object. Table 2 shows examples of formulaic and non-formulaic phrases for each level of REST.

All of the level 1 and 2 phrases were also recorded into a musical structure that matched the linguistic structure. As the linguistic syntax became increasingly complex, the music syntax also become more complex by adding additional musical chords (e.g., level 1 = G major + C major; level 2 = F major + G major + C major).

Procedure

Music syntax pre-test

To assess the participants' understanding of music syntax, they were asked to determine whether chord sequences presented to them sounded musically correct or incorrect (Patel et al., 2008).

Linguistic syntax pre- and post-tests

A baseline measure of expressive language was assessed by presenting the level two and three non-formulaic phrases and all three levels of formulaic phrases to the participants. We chose to test the participants with level three phrases instead of level one in which they were trained because the two types of phrases are highly similar. Whereas level one consists of verb-object phrases, level three consists of subject-verb-object phrases, so the phrases were identical except for the addition of a subject (e.g., level 1= "drinking coffee", level 3="man drinking coffee"). We showed them pictures in sets of 15 and gave a 2-to-3-word description for each image. The participants were then asked to describe them in a similar way that we had done, but we informed them that they only needed to follow the format we had modelled, not the specific words. Performance on the pre- and post-tests was measured based on mean length of utterance and different components of speech including nouns, verbs, function words (articles, prepositions) and other (adverbs, adjectives).

Music and linguistic training

The participants were then assigned to one of two conditions. The first group (participants M1 and M3) received 3 sessions of training with the musical phrases. They were asked to sing along with us and the recording. After the three sessions, their expressive language abilities were assessed in the same manner as the pre-test. They then received three sessions of training with spoken phrases followed by the same post-test. The second group (participants L1 and L2) received the sessions of spoken phrases prior to the sessions of music phrases, each followed by the post-test. The participants only received training on the first two levels of reduced syntax therapy—two sessions of level one and one session of level two. For all sessions, we used both formulaic and non-formulaic phrases.

Results

We discarded the results of the music syntax pretest, because the measure we used did not accurately reflect the participants' understanding of music syntax. Pitch production accuracy and musical behaviors during the music training conditions confirmed our decision.

Mean length of utterance

The first thing we examined in this study was the change in mean length of utterance (MLU) across the three different types of phrases and the two training conditions. Figure 1 provides information about the MLU in each condition for the two participants who received the music syntax training first, followed by linguistic-only training (M1 and M3). Figure 2 shows the MLUs for the two participants that received linguistic training first, followed by music training (L1 and L2).

As shown by Figure 1, M3 had an improvement in MLU across all three phrase types after music syntax training (change in formulaic phrases = 0.2, level 2 non-formulaic phrases = 0.34, level 3 non-formulaic phrases = 0.93). However, M1 only improved slightly on formulaic phrases (0.19) and decreased in level 2 non-formulaic phrases (-1.97) and level 3 non-formulaic phrases (-0.33).

For participant M3, performance continued to improve slightly after linguistic training in formulaic phrases (change from post-music training to post-linguistic training = 0.07). In level 2 and level 3 non-formulaic phrases, her MLU declined as compared to after music training (level 2:Δ -0.34; level 3: Δ -0.73), but either remained the same or improved relative to her pre-test MLU (change from pre-test to post linguistic training: level 2 = 0.0, level 3 = 0.2). Participant M1 was less consistent in her changes. After linguistic training, for formulaic phrases, her MLU was worse than after music training (Δ-0.06), but better than before any training (Δ0.13). For level 2 non-formulaic phrases, her MLU increased relative to the post-music test (Δ0.57), but decreased relative to her pre-test score (Δ-1.4). For level 3 non-formulaic phrases her MLU increased relative to both prior to training (Δ0.27) and after music training (Δ0.6).

Participants L1 and L2 improved after all trainings with the exception of L1 in level 3 non-formulaic phrases. Her MLU remained the same after linguistic training and after music training. After linguistic syntax training, the MLU of participant L1 increased by 0.63 morphemes in formulaic phrases, 1.6 morphemes in level 2 non-formulaic phrases, and 1.27 morphemes in level 3 non-formulaic phrases. The results for L2 were similar. His MLU increased by 0.16 morphemes, 0.81 morphemes, and 0.67 morphemes in formulaic phrases, level 2 non-formulaic phrases and level 3 non-formulaic phrases, respectively.

After music syntax training, performance of both participants continued to improve. For participant L1, formulaic, level 2 non-formulaic, and level 3 formulaic phrases experienced a change of 0.47, 0.53, and 0.0 morphemes respectively. L2 experienced changes of 0.07, 0.06, and 0.33 morphemes across the three categories. From the pre-test to the second post-test, L1 experienced an improvement of 1.1 morphemes for formulaic phrases, 2.13 for level 2 non-formulaic phrases, and 1.27 for level 3 non-formulaic phrases. L2 improved by 0.23, 0.87, and 1.0 morphemes in formulaic, level 2 non-formulaic, and level 3 non-formulaic phrases respectively.

Parts of speech

Figures 3-6 show the changes across types of words (nouns, verbs, etc.) across the training sessions. Because nouns and verbs were the primary words used in training, we focused more on these parts of speech. Across all participants, there was an improvement in the average number of nouns and verbs used per utterance with some inconsistent exceptions. From pre-test to final post-test only the following parts of speech decreased: M1 level 3 nouns, M3 level 2 verbs, L1 level 3 nouns, and L1 formulaic nouns. The remainder either improved or remained the same from pre-test to final post-test.

Discussion

The current study examined the effects of linguistic syntax training and music syntax training on individuals with non-fluent aphasia. We hypothesized that adding music syntax training would improve mean length of utterance (MLU) more than only linguistic syntax training. This hypothesis seems to be supported by the data collected for the participants. We also investigated whether different types of phrases (formulaic, non-formulaic) experienced different benefits based on the type of training the participants completed. Based on previous research, we also hypothesized that the music condition would provide better results for formulaic phrases, and that linguistic training would improve MLU of non-formulaic phrases (Stahl et al., 2013).

Our first hypothesis that music syntax training benefits individuals with non-fluent aphasia more than linguistic syntax training was supported by this study. With the exception of one participant (M1), performance improved more after music syntax training than after linguistic training. For L1 and L2, performance continued to improve after music training despite large gains after linguistic training. For M3, MLU decreased after linguistic training in both non-formulaic conditions after a large increase in MLU after music training. These results suggest that adding music syntax training provides a benefit above and beyond that of only linguistic syntax training.

M1 had results that were not consistent with any of the other participants. We believe that during the pre-test, she was trying to use as many words as she could rather than modeling the examples given to her. For example, in the level 2 non-formulaic phrases condition, the target phrase would be “drinking coffee,” and she consistently added phrases such as “the guy/girl is” before each target phrase. During both of the post-tests, she no longer added this additional phrase so she could better match the target, and we believe that this could account for much of the decrease in MLU after music syntax training.

A second observation we made is that there is no noticeable pattern of benefit across the formulaic and non-formulaic phrases. Stahl et al. (2013) found a difference in improvement in the different types of phrases after different types of training, but our data did not reveal this same pattern, so our hypothesis was not supported by this experiment. One potential reason that this may have occurred is that our non-formulaic phrases were slightly different from that of the previous study. In both studies, formulaic phrases consisted of things that might be used in everyday conversation ("How are you?"). However, in Stahl et al. (2013), non-formulaic phrases were syntactically correct but unlikely to be used in conversation (more likely to be seen in poetry; e.g,. "bright forest"). In our study, these phrases were again syntactically correct, but they may be used in conversation. For example, our non-formulaic phrases consisted of things such as "singing in the shower," and "eating soup".

Although the average number of nouns and verbs increased overall for most participants for each level, the increase was inconsistent in both amount of increase and after which training the increase occurred. Some participants had larger increases while others remained the same or saw little improvement. Some also had decreases after one form of training while having increases after another. The total average number of different words also increased over time for nearly all participants. As with the MLU, the total for M1 decreased, but this could be because of the additions of the phrases previously mentioned.

There are some limitations to this study that must be considered. The first potential flaw with the design is that because the same phrases were used in all training and testing sessions, the participants may have had practice effects which could have resulted in an increase in scores that would not have occurred without the repetition. However, this does not seem probable because some MLUs decreased despite additional practice. Another potential limitation is that training in the music syntax and linguistic syntax conditions was short. The participants only had practice in each of these conditions for three weeks followed by a week of testing. Between the two different types of training, they also had a four-week break, but scores from the previous training session were still used as the baseline for the new training session. Longer periods of training could potentially have affected the amount of change from pre-testing to the post-tests. Participant L1 missed one session of the music syntax training, so her results could be slightly off as compared to the rest of the participants. Lastly, because we only had four participants, we treated this study as a series of studies rather than averaging scores. This limits the generalizability of this data, so we would need to replicate it with many more participants.

This replication could be a potential follow-up study. This would be able to determine whether these results could apply to other individuals with non-fluent aphasia. Having a more diverse group of participants would also enhance this study. These participants were all recruited from the Butler Aphasia Community, and they all have a history of participating in other studies. Consequently, they may not be representative of the larger population of individuals with aphasia. Another potential follow-up study would be to examine whether parts of language other than syntax experience the same benefits from music structure that this study found.

The results found by this study indicate that music syntax training combined with linguistic syntax training increase MLU more than linguistic syntax training alone. However, the parts of speech in which the improvements occur vary from participant to participant with no noticeable pattern. The participants also seemed to find the music training more enjoyable. Music has been found to affect people in extraordinary ways, and it also has the ability to make therapy more enjoyable while still providing a benefit.

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Table 1

Demographic Information of Participants

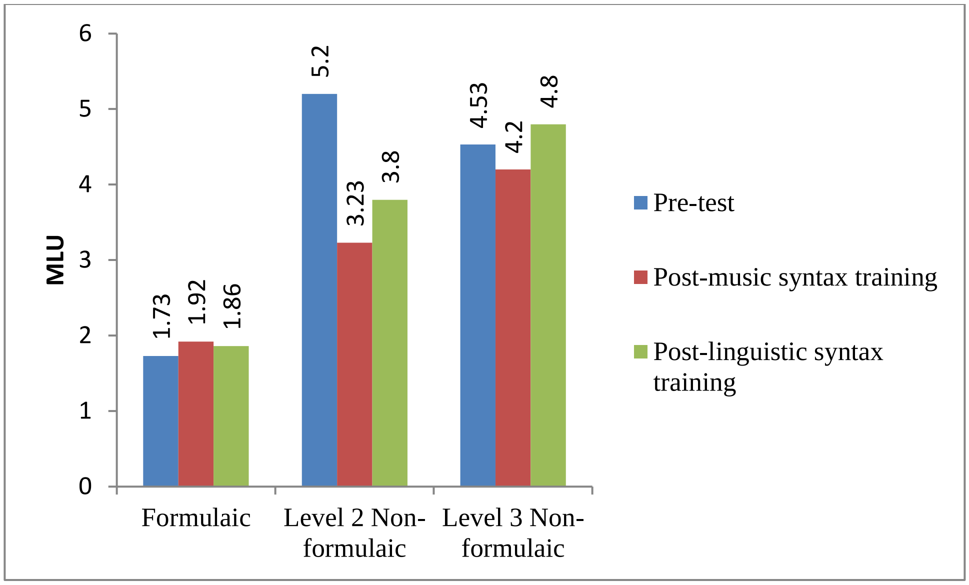
Participant	Gender	Age	Onset of aphasia	Music background	Education
M1	Female	58	7 years	3 years of piano	High school graduate
M3	Female	50	9 years	trumpet and piano	College graduate
L1	Female	54	6 years	none	Some college
L2	Male	35	2.5 years	4 years singing and guitar, 2 years piano	College graduate

Table 2

Examples of stimuli

REST level	Formulaic phrases	Non-formulaic phrase
REST level 1	I’m hungry, Thank you	Feeding dog, Doing laundry
REST level 2	How are you?, See you later	Going to Chicago, Walking on the beach
REST level 3	Did you sleep well?	Woman working hard, Mom cleaning kitchen

1a.



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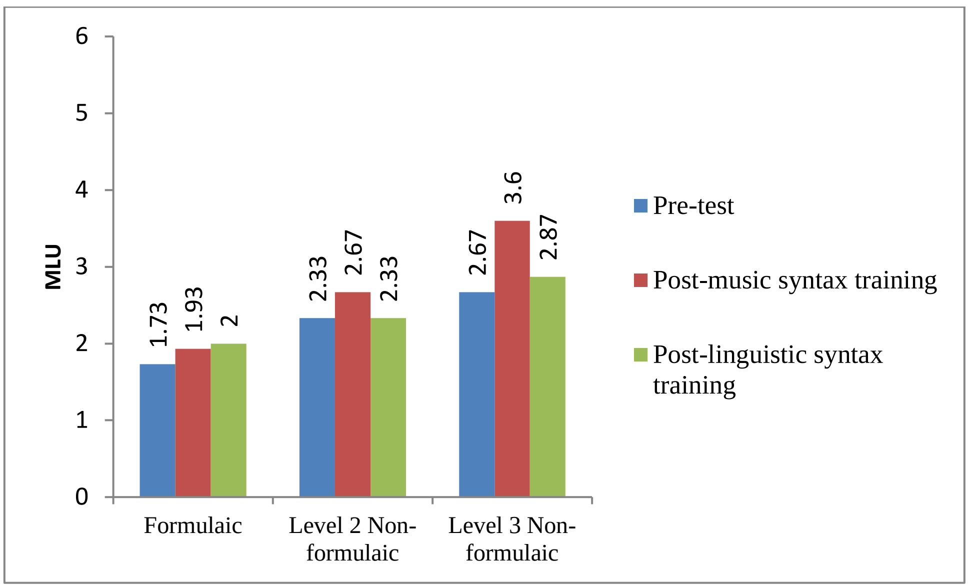
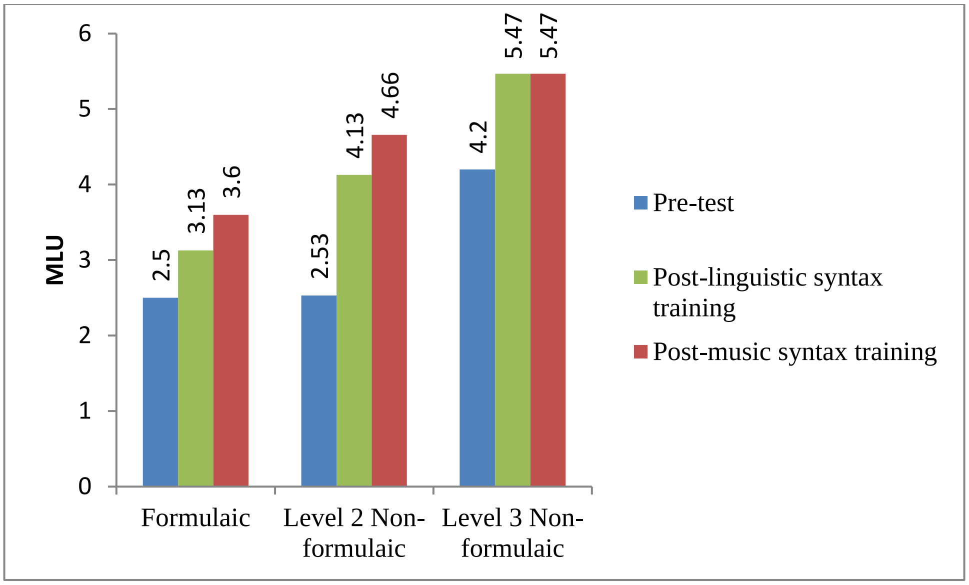


Figure 1: Change in MLU for participants M1 and M3. *Both charts in Figure 2 display the Mean Length of Utterance (MLU) for formulaic, level 2 non-formulaic, and level 3 non-formulaic phrases before any training, after music syntax training, and after linguistic synax training. Figure 2a displays the data for participant M1, and Figure 2b displays the data for participant M3.*



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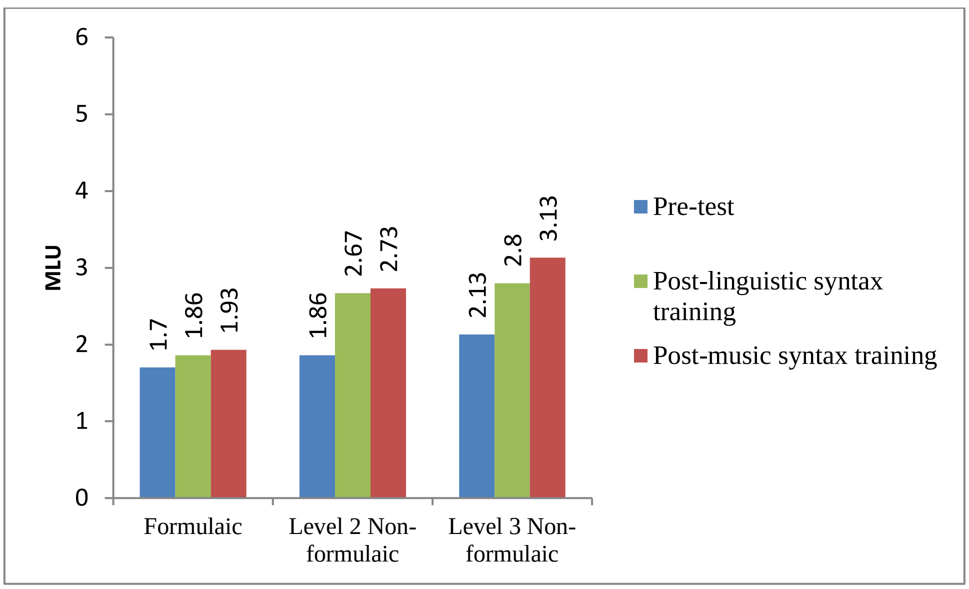
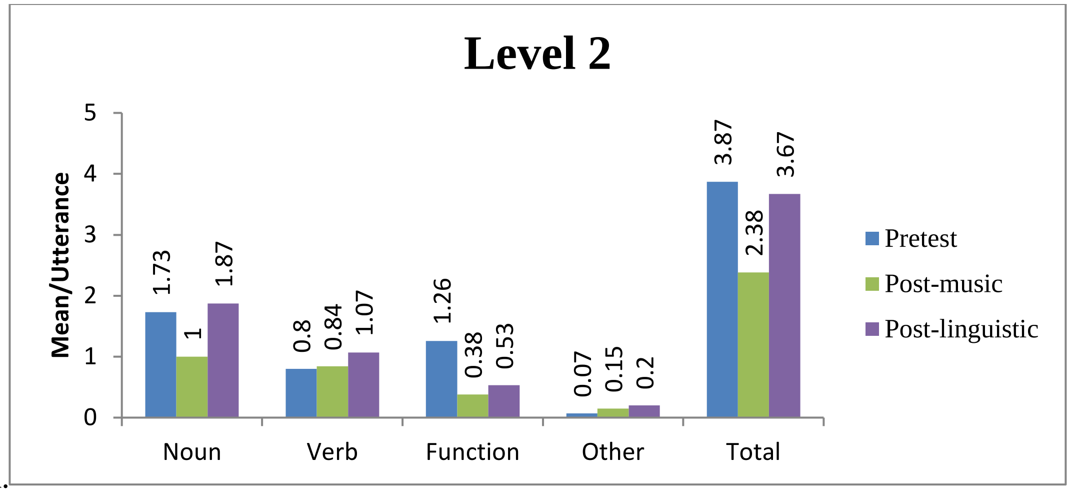


2b.

Figure 2: Change in MLU for participants L1 and L2. *Both charts in Figure 3 display the Mean Length of Utterance (MLU) for formulaic, level 2 non-formulaic, and level 3 non-formulaic phrases before any training, after linguistic syntax training, and after musicc synax training. Figure 3a displays the data for participant L1, and Figure 3b displays the data for participant L2.*



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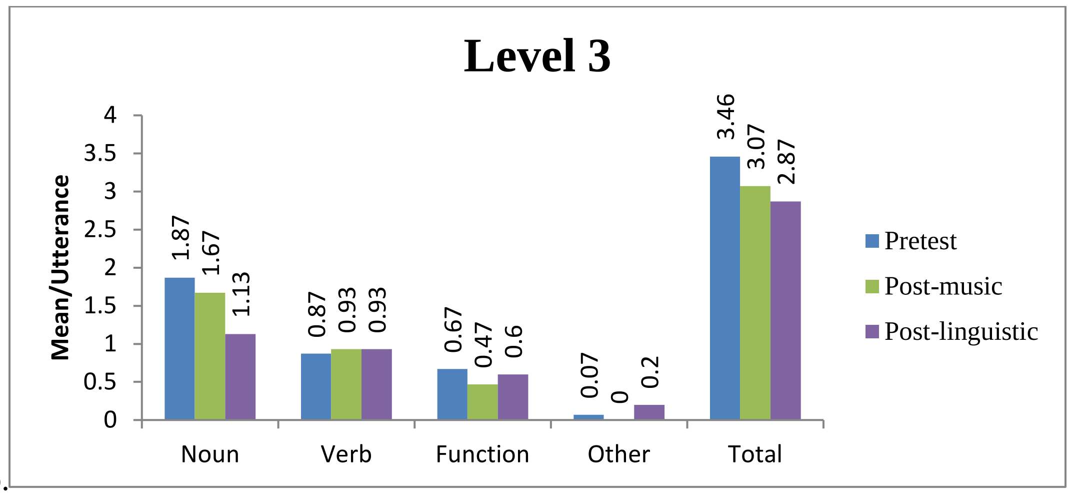

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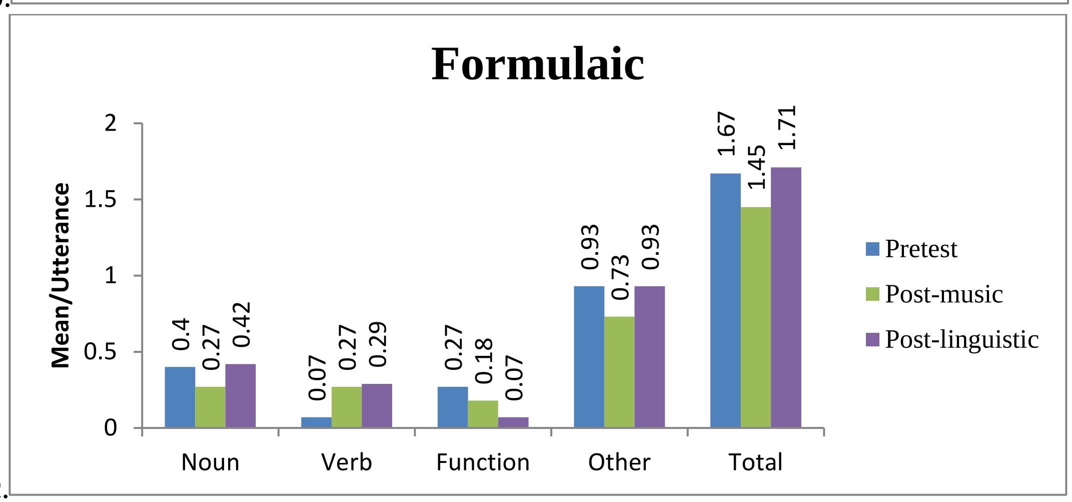
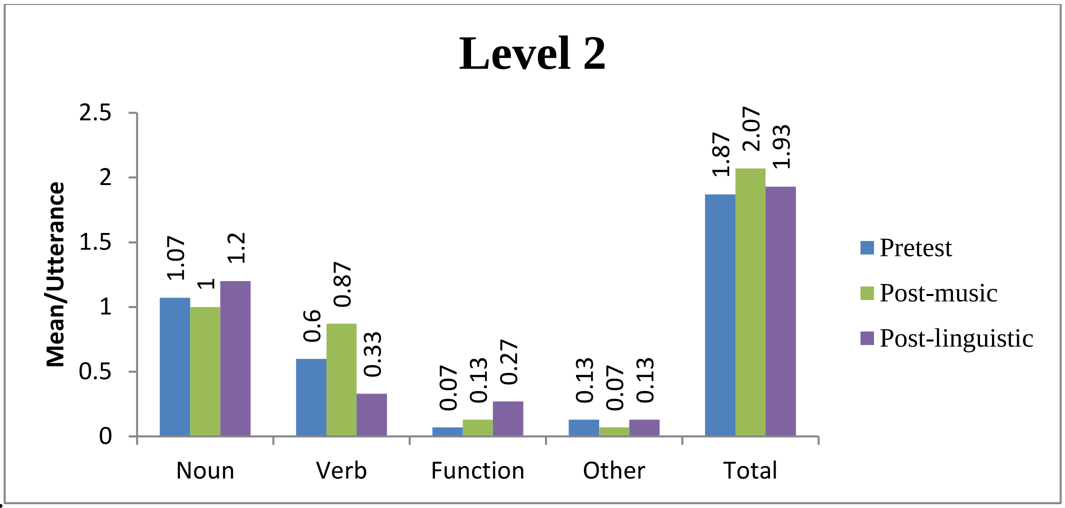


3c.

Figure 3: Change in parts of speech for participant M1. *Figure 3 shows the changes in the parts of speech prior to training and after each type of training for participant M1. 3a shows the change across training in level 2 non-formulaic phrases, 3b shows the changes for level 3 non-formulaic phrases, and 3c shows the changes for all levels of formulaic phrases.*



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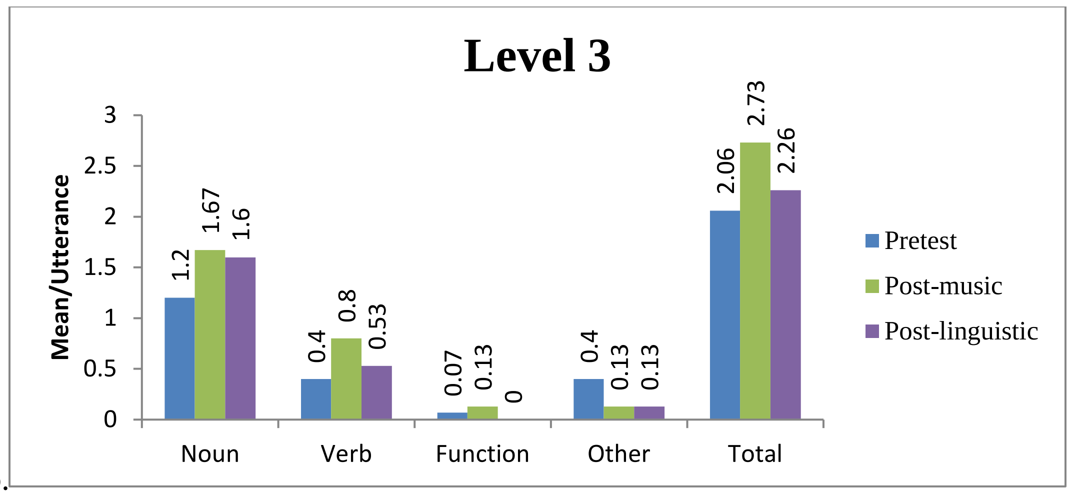

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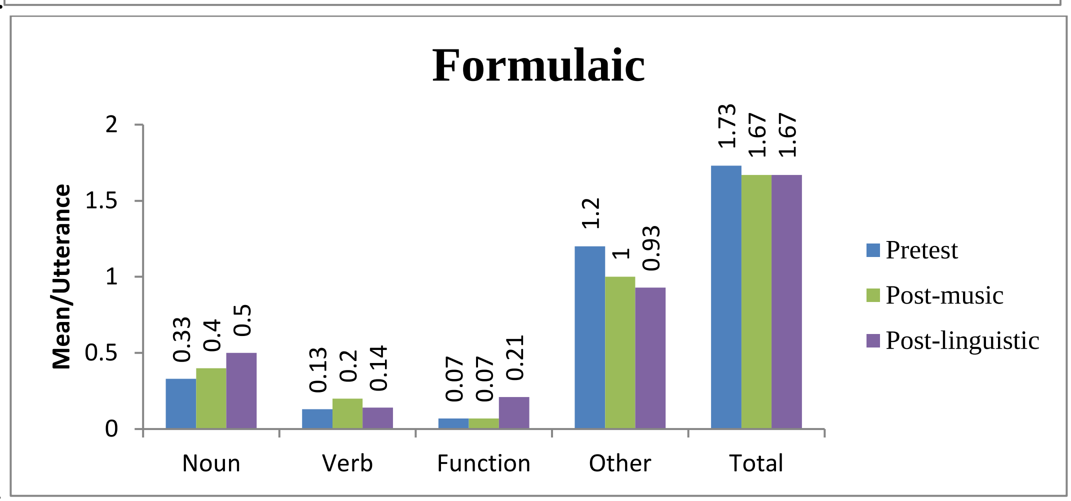
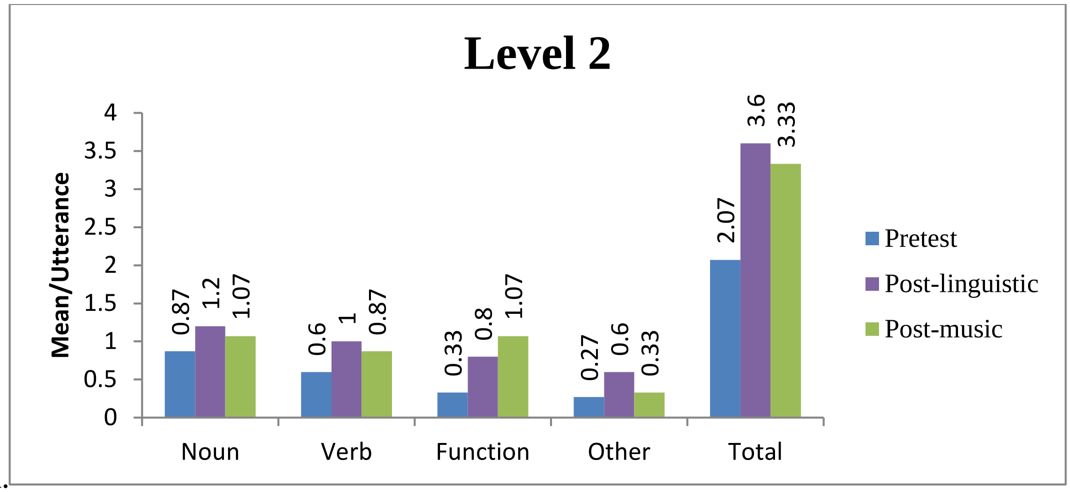


4c.

Figure 4: Change in parts of speech for participant M3. *Figure 4 shows the changes in the parts of speech prior to training and after each type of training for participant M3. Figure 4a shows the change across training in level 2 non-formulaic phrases, 4b shows the changes for level 3 non-formulaic phrases, and 4c shows the changes for all levels of formulaic phrases.*



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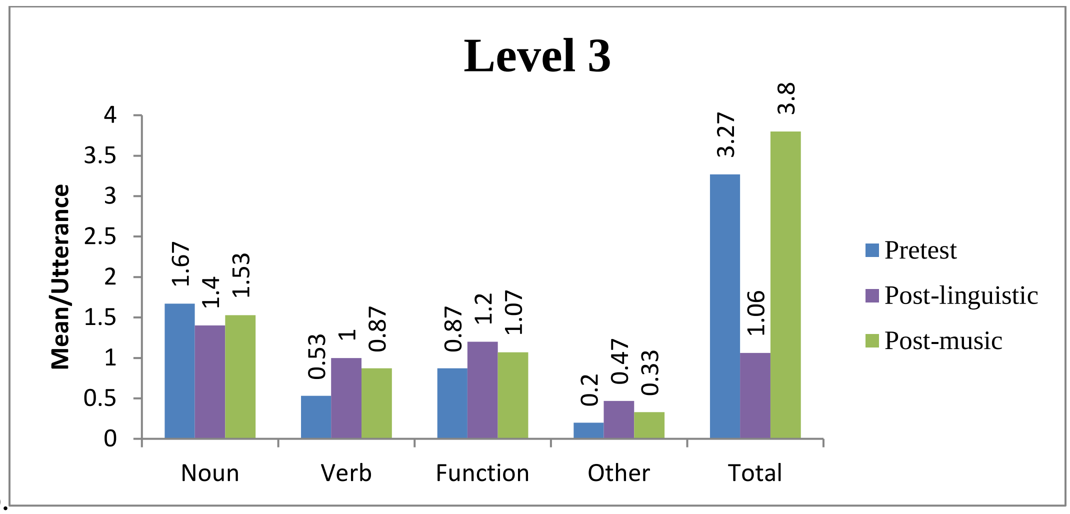

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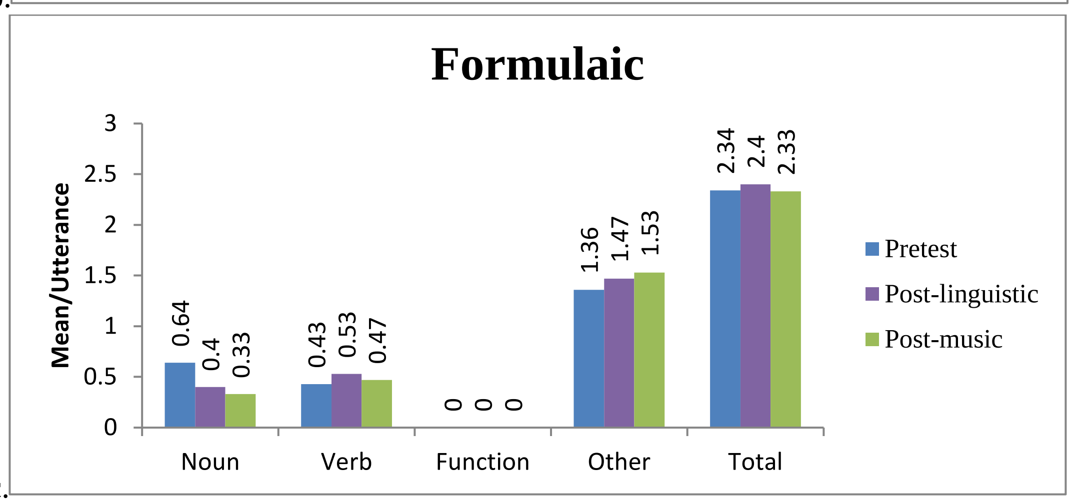
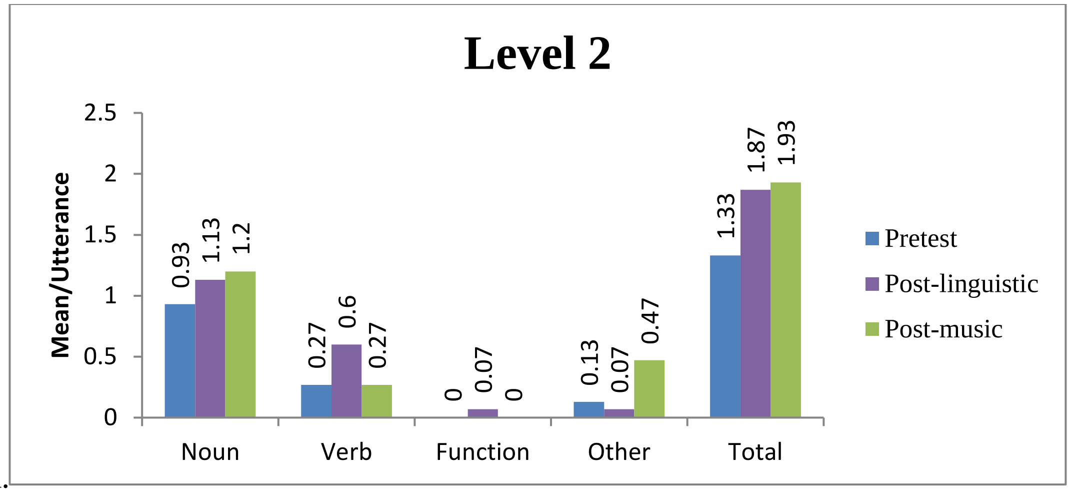


5c.

Figure 5: Change in parts of speech for participant L1. *Figure 5 shows the changes in the parts of speech prior to training and after each type of training for participant L1. Figure 5a shows the change across training in level 2 non-formulaic phrases, 5b shows the changes for level 3 non-formulaic phrases, and 5c shows the changes for all levels of formulaic phrases.*



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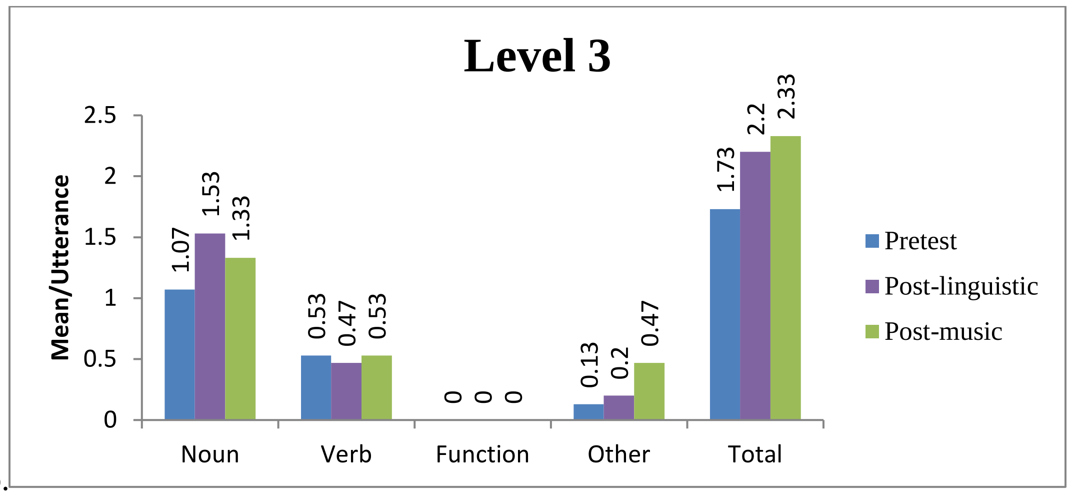
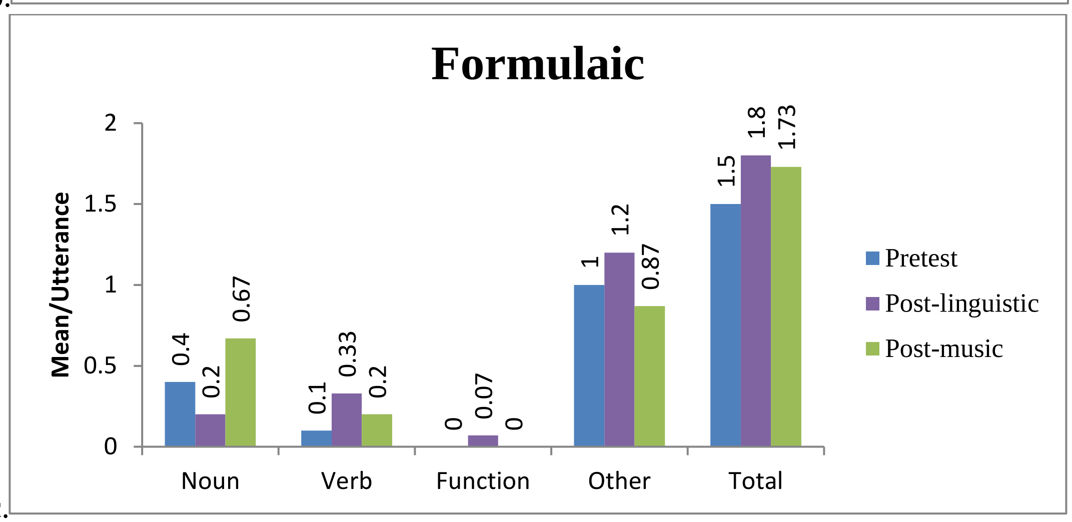


6b.



6c.

Figure 6: Change in parts of speech for participant L2. *Figure 6 shows the changes in the parts of speech prior to training and after each type of training for participant L2. 6a shows the change across training in level 2 non-formulaic phrases, 6b shows the changes for level 3 non-formulaic phrases, and 6c shows the changes for all levels of formulaic phrases.*