and a more dispersed tissue in stroma. However, the collagen fibers in the KO with fibroblast tumors are more organized around the individual tumor nodes.

TGF-β with BAPN treatment regulation on collagen fiber.

LOX is an enzyme that forms a strong bond between fibers, which is found in the fibroblast located in the stroma. Some studies have shown that LOX increases fibroblast cells and induce metastases [6]. In the results, the sample without TGF-β signaling and BAPN treatment tumors cause the collagen fibers to develop differently in the stroma.

There is more collagen fibers expression in tumors lacking TGF-β with no BAPN treatment. The collagens were organized around the epithelial cells.

LC3B protein expression is correlated with increased cell death in the KO – BAPN.

Several studies have determined that LOX is essential for hypoxia related cell death [11]. In the Western blot for protein LC3B (Figure 3), it illustrated that KO without BAPN treatment has a higher expression of LC3B.

Loss of TGF-β signaling and BAPN treatment regulates LYVE-1 expression.

One of the major microenvironment components is LYVE-1 expression, which occurs in the lymphatic vessels. The results determined that the treatment with BAPN in KO tumors significantly reduces the number of lymphatic vessels and LYVE-1 infiltration myeloid cells.

Future studies will focus on determining whether migration of cells in the chick embryo are fibroblast-like cells or epithelial cells, both of which are located in the stromal areas. It will also be important to understand the relationship between LOX and hypoxia and alterations in cell death for the KO tumors that have been treated with BAPN.

ACKNOWLEDGMENTS. I am grateful for Lauren Matise's and Michael Pickup's patience and lectures on the knowledge of cancer biology, the understanding of TGF-β, helping me to learn different experimental techniques, and their great contribution in creating an awesome experiment. I am also thankful for working in a kind, warm atmosphere created by all the members in Dr. Moses's lab. I also thank Dr. Angela Eeds at the School for Science and Math at Vanderbilt for her care and support. Finally, big thanks to Dr. Harold Moses for accepting me and allow me to work in his lab.

SUPPORTING INFORMATION.

Figure S1. Picrosirius Red Staining of TRBII KO mouse tumor sections

Figure S2. LYVE-1 immunohistochemistry conducted on TβRII KO tumor sections.

REFERENCES.

1. D. Mann. Health. Web. (2009).
2. B. Bierie, and H.L. Moses. Cell Cycle. **8**, 3319 (2009).
3. B. Bierie, and H.L. Moses. Nat Rev Cancer. **6**, 506 (2006).
4. B. Bierie, et al. Cancer Research. **6**, 1809 (2008).
5. P. Friedl, and D. Gilmour. Mol Cell Biol. **10**, 445 (2009).
6. S. L. Payne, M. J.C. Hendrix, D. A. Kirschmann. J Cell Biochem. **101**, 1338 (2007).
7. L.A. Matise, personal communication. (2009)
8. E. Forrester, et al. Can Res. **6**, 2296 (2005).
9. K. R. Levental, et al. Cell. **139**, 1590 (2009).
10. L.A. Matise, et al. Nat Cell Biol. 11, 1281 (2009).
11. J. T. Erler, et al. Nature. **4**, 1590 (2006).

Yi-ting Huang is a student at Overton High School and enrolled in the School for Science and Math at Vanderbilt.

Vowel Representation in the Spelling of Kindergarten Children

Chandelor G. Simon, Krystal L. Werfel, C. Melanie Schuele

KEYWORDS. Hearing, speech, child, vowel

BRIEF. A study interpreting the results of kindergarten children's spelling of vowel sounds in words.

ABSTRACT. The purpose of this study was to analyze vowel representation in the spelling of monosyllabic words by kindergarten children. Fifty-seven kindergarten children from two different schools participated in the study. The children were typically developing, had no prior history of speech or language therapy, and spoke English primarily. Children who natively spoke another language were excluded for the validity of the research. The children were asked to spell seventy-four monosyllabic words with consonant blends in the second semester of their kindergarten year. Responses were analyzed for the ability to spell vowel sounds correctly and logical representation of vowels to describe differential accuracy across vowel types (Frontal vowels, High vowels, Back low vowels, Mid vowels, etc.). Children demonstrated differential success, depending on the phonetic properties of vowels, including tongue height and position. These findings support an order for the way our brain learns vowels; some vowels are easier to learn than others, whether it is because there are few ways to spell or it sounds like the letter by which it is represented. Specifically, low and frontal vowels are the easiest for children to logically represent, whereas high and back vowels are more difficult for children to interpret.

INTRODUCTION.

Speech is a spectacular phenomenon that occurs in nature. As individuals with a well-structured communication system, not only can we communicate messages to each other, but we can create new messages that have never been said before, and continue endlessly to develop new words in our lexicons.

All words are made up of consonants phonemes (speech sounds) surrounding vowel phonemes. Thus, it can be said vowels are individual speech sounds that serve as the nucleus of syllables. Vowel phonemes are produced through lack of obstruction to outgoing breath. That is, vowels are 'open' sounds, rather than the generally 'closed' sounds of consonants.

Consonants are created through breath obstruction created by articulators (tongue, teeth, et cetera). This build-up of air makes it much easier to identify consonant sounds in spoken language than vowel sounds because there are visual cues and sounds that come from one mouth position. Unlike consonants, vowels' sole form of identification is through changes in position of the tongue and rounding of the lips. This makes all vowel sounds more closely related in sound than consonant speech sounds. In terms of tongue position, vowels can be recognized as front, central, or back and high, mid, or low (see Figure 1) [1].

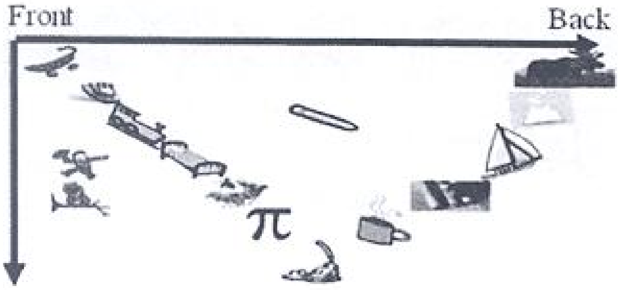

Figure 1. Shows the position of the tongue (whether Frontal/ Back, High or Low) when each of the vowel sounds in the following words is spoken (words listed left to right, high to low) Pea, Boy, Owl, Mitt, Train, Bed, Bat, Pi, Pencil, Mop, Mug, Chalk, Boat, Book, Moose).

Commonly, vowels are referred to as 'short' or 'long'. These terms are inappropriate as what separates these two categories of vowels is not the length of the sound, but the level of tension in the voice. Tense vowels require more muscle tension, and in education are referred to as long vowels, while the term lax is used to describe short vowels, or vowels that do not require as much muscle tension. You can note this difference by placing your middle and pointer fingers beneath your jaw and making the sounds 'ee' and 'ah'. You should feel your muscles expanding more on 'ee' and any other tense vowel phoneme. In spelling, certain rules can be used to determine if vowels are either tense or lax. For example, in *vowel-consonant-e* (cake), the first vowel is tense. In *vowel-c-k* (duck), the vowel is lax. These rules also lead to multiple spellings of the same sound [2].

In terms of spelling, vowel graphemes, or written representation of phonemes, have greater variance than consonant graphemes do (Table S2 S1) [1]. Mostly, this is because vowels rely on the consonants around them to determine their spelling. This makes the spelling of vowels much more difficult than that of consonant; because consistency in rules is what children rely on to, these multiple spellings of vowels can lead to extra trouble for young children who are just being introduced to written language and cause discouragement. Thus, the hypothesis for the experiment was if the vowel has more multiple spellings and/or does not give a visual signal as to what the vowel is, then it will be more difficult for the child to represent correctly/logically.

MATERIALS AND METHODS.

This study is an analysis of data from an extant database; fifty-seven kindergarten children with no history of speech-language therapy were requested for testing. Age was seventy-two months, with a standard deviation of four months. Participants were native English speakers, and were not members of a household in which multiple languages were spoken (this was done to ensure consistency in the data).

Participants were asked to spell seventy-four monosyllabic words with different vowel sounds over an eighteen week period. This measure was performed three times at six-week intervals during the second semester of their kindergarten year. Monosyllabic words were analyzed to observe how children spelled to observe the child's logical representation of vowel phonemes in the words These words included those listed in Table S2.

Words with dipthongs, 'R' and 'L' colored vowels, and nasalized vowels were excluded from the study. Dipthongs are vowel sounds that become other vowel sounds as they are spoken. This would include the vowel sound at the end of '*boy*' and the vowel sound at the end of '*brown*'. 'R' and 'L' colored vowels are vowels that change in frequency because they are followed or preceded by the letters 'R' or 'L'. This category would include words such as '*north*', '*worthy*', *and* '*bottle*'. Nasalized vowels include words such as hand and camp that change the pronunciation of the vowel because they are sounded partially through the nose, thus sounding different from other vowels [3].

RESULTS.

The purpose of the experiment was to determine if kindergarten-aged children are differentially successful with vowel representation based on phonetic properties of vowels. This study used measurement of tongue position and tongue height to measure how children vary in success with vowel representation. Vowels were classified as long or tense for the 'A', 'E', 'I', 'O', and 'U' phonemes. Figure 2 shows the percentage of times that the vowel sound was either logically represented or spelled correctly.

Children were more likely to logically represent different vowel sounds that to spell them correctly (see Figure 3). There is an apparent difference most present in tense vowels. Tense vowels sound like the names of the letters by which they are represented; however, in most cases that is not how they are spelled due to the wide variety of conventional spellings of tense vowels. This could be the reasoning behind the extreme difference in the representation and conventional spelling of tense vowels.

Kindergarten children were more likely to logically represent tense vowels as opposed to lax vowels. Again, this may be due to tense vowels sounding like the name of the letter that represents them. Furthermore, the relationship between /e/ (as in the word *day*) and name of the letter 'a' is much more noticeable than the relationship between /ae/ (as said in the word *bat*) and the letter name 'a'.

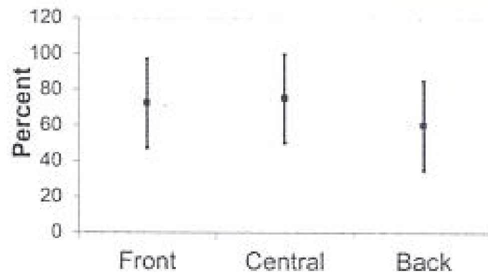

Figure 2. The percentage of time that the vowel sounds were represented correctly in each of the tongue height positions. Children were more likely to logically represent front vowels (M = 72.27, SD = 26.39) than back vowels (M = 60.07, SD = 24.83,) and more likely to logically represent central vowels (M = 75.06, SD = 25.29) than back vowels (p = .00, d = .48)

Kindergarten children were differentially successful with vowel representation based on position of the tongue. It was more likely that the child would correctly represent a front or central vowel as opposed to a back vowel. Because front and central vowels are produced closer to the front of the mouth, children can more readily use visual feedback to determine the vowel.

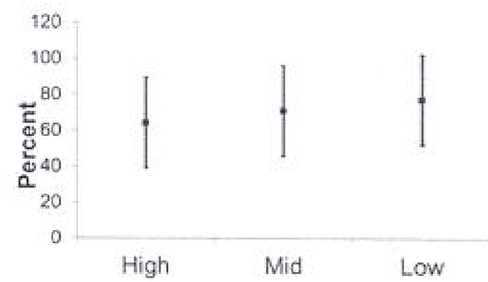

Figure 3. Supports that children were more likely to logically represent vowels (M = 77.10, SD = 21.60) than mid vowels (M = 77.96, SD = 25.56, p = .00, d = .26) and high vowels (M = 64.08, SD = 25.58, p = .00, d = .55, and are more likely to logically represent mid vowels (M = 70.96, SD = 25.56) than high vowels (M = 64.08, SD = 25.58, p = .001, d = .27).

The data shows that kindergarten children's level of success with vowel representation also relied on tongue height. The most likely vowels to be logically represented were low vowels, and the least likely were high vowels. The fact that low vowels require the most movement from rest and therefore children can more readily use articulatory feedback to determine the vowel may be why they distribute a higher percent represented correctly with lower vowels.

DISCUSSION.

This study showed several significant results that led to four major conclusions. It can be concluded that kindergarten children are significantly more likely to represent a vowel in a logical form than to spell the vowel in the manner it is represented in the word. In addition, kindergarten children are more likely to logically represent tense vowels than lax vowels, which accounts for the tremendous difference in Figure S2.

This is all likely due to the fact that tense vowels have a wider variety of conventional spelling for each vowel phoneme as opposed to lax vowels, thus increasing their chance of correctly representing the vowel (consult Chart S1). Also, tense vowels tend to sound like the name of the letter by which they are represented. For example, the tense or "long" vowel sound in the word *'pail'* sounds nearly if not identical to the sound used to describe the first letter of the English alphabet (A). However, lax or "short" vowels such as the lax sound in *'father'* do not very much sound like the letter 'A'.

Our results suggest that kindergarten children are differentially successful in the representation of vowels based on the tongue position. Front vowels were more likely to be logically represented than central vowels, and central vowels were more likely to be represented than back vowels.

We have determined this is likely because front and central (more prominently, front) vowels – like the vowel sound in *train* or the vowel sound in *mitt* - are produced closer to the front of the mouth and are easier to see. Thus, children can more readily use visual feedback to determine which vowel it is.

Kindergarten children are also differentially successful with vowel representation based on tongue height. The vowels most likely to be logically represented were low vowels; mid vowels were the next likely to be logically represented. The final class measured, high vowels, were the least likely to be represented logically. Rest position is the position your mouth is in when your mouth is shut and your teeth are not clenched. Low vowels (like the vowel sound in *map*) require a lot of movement from rest position compared to high vowels, such as *book*.

This shows us that kindergarten children are differentially successful with the representation of vowels based on their phonetic properties. The data shows that tense vowels are more likely to be logically represented than lax vowels, probably due to their sounding like the letter they represent. In addition, tongue height and tongue position are also important to understanding vowel representation. The lower a vowel is, and/or the closer it is to the front of the mouth, the easier it is to determine what the vowel is.

ACKNOWLEDGMENTS. Thank you to Krystal Werfel, Dr. Melanie Schuele, staff and faculty of the Bill Wilkerson Research Center for their time and cookies, and Dr. Jonathan Creamer and staff and students of The School for Science and Math at Vanderbilt,.

SUPPORTING INFORMATION.

Figure S1. Shows percentage of percent of both tense and lax vowels logically represented.

Table S1. Demonstrates the multiple spellings of the tense 'A' grapheme.

Figure S2. Shows the percentage of times that the vowel sound was either logically represented or spelled correctly.

REFERENCES.

1. R. Treiman; *Beginning To Spell.* (Oxford University Press 200 Madison Avenue, New York, New York 10016 1993)
2. P. Ladefoged; *A Course in Phonetics.* (Thomson Learning Boston, Massachusetts 4th ed. 2001)
3. P. Ladefoged; *Vowels and consonants: an introduction to the sounds of languages.* (Blackwell, Maiden, Massachusetts, 2001)

Chandelor Simon is a student at Nashville School of the Arts and enrolled in the School for Science and Math at Vanderbilt.

The Effects of Tachykinin on Olfactory Reception in *Periplaneta americana*

Rita E. Pfeiffer, Terry L. Page

KEYWORDS. Tachykinin, tachykinin-related peptide, olfaction, electroantennogram, *Periplaneta americana*

BRIEF. A neuropeptide found in invertebrates, the tachykinin-related peptide, caused an overall decrease in olfactory sensitivity for the American cockroach.

ABSTRACT. Neurotransmitters are responsible for sending information throughout the nervous system, yet some of their behavioral functions in organisms are unknown. One specific neurotransmitter, tachykinin, is a part of a common family of neurotransmitters, whose behavioral functions in invertebrates are unknown. In a recent study, the invertebrate form of tachykinin, the tachykinin-related peptide (TKRP), was shown to reduce sensitivity in odor perception in the fruit fly. To better understand their function, 15 variants of tachykinin were tested in American cockroaches to determine its effects on odor sensitivity. It required an electroantennogram, which measures the initial odor response from the cockroach. Injecting a small amount of the neurotransmitter into the head of the cockroach and observing the responses to periodical odor pulses in the following hour determined the effect of a variant. Many variants caused the odor sensory sensitivity to decrease, suggesting that TKRP plays a role in regulating odor sensitivity in the cockroach. Additionally, the cockroaches' responses to TKRP were affected by the time of day, signaling an influence of their biological clocks.

INTRODUCTION.

Proteins perform a wide variety of functions, and some types of proteins are neurotransmitters that are responsible for sending information throughout the body's entire nervous system. This type of protein is called a neuropeptide. Neuropeptides, the most chemically diverse and numerous of the neurotransmitters, are not well understood in invertebrates, especially concerning their roles in their central nervous systems [1]. To better understand this opaque field, we researched the neuropeptide family of tachykinins as they relate to invertebrate behavior. By better understanding the functionality of this specific type of neurotransmitter, the scientific community can gain more understanding of the brain, central nervous system, and peptide interactions, and also the functionality of neuropeptides and the behavioral roles they play.

Tachykinins comprise the largest family of neuropeptides, which has been conserved through evolution [1]. A subgroup of tachykinins commonly found in invertebrates, the tachykinin-related peptides (TKRP) are structurally related to the mammalian tachykinins, specifically substance P and neurokinins A and B [1, 2, 3]. While some progress in knowledge has been made in understanding tachykinin, tachykinin's neural function in invertebrates is largely unknown,