ABSTRACT

AN INVESTIGATION INTO HOW NATIVE SPANISH SPEAKERS WHO LEARNED ENGLISH AS A SECOND LANGUAGE UNDERSTAND THE GIST OF COMPLEX MEDICAL TEXTS IN ENGLISH

by Josselyn Elizabeth Marroquín

Little research has focused on native Spanish speakers who speak English as a Second Language (ESL) regarding how to write medical information to promote gist comprehension. In this study, 181 ESL Hispanic/Latine/a/o native Spanish speakers were recruited from across the United States. An "authentic" article in English about universal flu vaccines was taken from the web, analyzed with Coh-Metrix, and further analyzed using Gist Inference Scores (GIS), a measure of how likely people are to understand a text's bottom-line meaning. The article was revised to obtain a higher GIS. Participants were randomly assigned to the original low GIS article, the improved high GIS version of the article, or a control article. Then, participants were asked questions about the flu vaccines using 7-point Likert scale questions to assess gist comprehension, and multiple-choice questions to assess verbatim knowledge conveyed in both the low GIS and high GIS articles about universal flu vaccines. In order to test differences in a person's health literacy, participants also filled out a health literacy questionnaire.
Results found that there were no significant differences between the groups for gist comprehension and verbatim knowledge multiple-choice questions. Groups did not differ in health literacy and did not predict other outcomes.

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Dedication

I dedicate this to my family, as I am breaking generational barriers by being the first in my family to graduate with a master's degree. Their love and support has got me to where I am now. I also dedicate this to those who relate to the perspectives, experiences, and stories presented in this thesis.

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Chapter 1: An Investigation into How Native Spanish Speakers Who Learned English as a Second Language Understand the Gist of Complex Medical Texts in English

The United States is full of multilingual and non-English speaking people, but documents and important information are often presented only in English. Not having resources that are in a person's native language can be challenging, especially when making medical decisions and among those with low health literacy (Berkman et al., 2010). The scenario presented here happens to many people who are navigating the healthcare system and are socially vulnerable, such as those who learned English as a Second Language (ESL) (i.e., non-native English speakers), people from minoritized communities, and immigrants (Wagner, 2019; Hernández-Rivera, Gullifer, & Titone, 2022). For example, Hispanic/Latine/a/o, and particularly Hispanic/Latine/a/o immigrants, generally have low health literacy (Soto Mas et al., 2015). Medical context is often complex to understand and can be more difficult when there are language barriers, limited health literacy, and mistrust of the healthcare system (Lipman, Kalra, & Kirkpatrick, 2015). Language access is essential yet often overlooked. Due to medical paperwork being verbatim-based and hard to comprehend, gist-based versions of medical paperwork need to be available to help people understand the bottom line meaning (i.e., gist) of complex medical contexts. Doing so can help readers understand information better and more accurately.

Health Literacy and Language Barriers

Health literacy is a person's competency to read, understand, speak, and apply medical information in a way that helps them make medical decisions (Squiers et al., 2012). In other words, health literacy is a navigation tool within the healthcare system, whether used when people visit their healthcare provider(s) or obtain medical information online or through the phone. Hernández-Rivera et al. (2022) explain that health literacy can be defined through socioecological and psycholinguistic approaches. A socioecological approach focuses on the person's interactions with themselves, their relationships, their community, and the overall societal environment (Nutbeam, 2008; McCloskey et al., 2015). Having a socioecological approach makes a person view health literacy as something past the individual level and look at how patients are accessing and attaining healthcare and resources (McCormack et al., 2017; Kósa et al., 2022). On the other side, a psycholinguistic approach focuses on the processing of language, specifically cognitive and linguistic skills (Grosjean et al., 2013).

Yip (2012) explains that multilingual people have a harder time than monolingual people in achieving health literacy. A socioecological approach explains that language experiences and barriers need to be addressed at a policy level because the individual and their environments shape policy and culture (Segalowitz & Kehayia, 2011; Bronfenbrenner, 1979; Oishi, 2014). Doing so can reduce the long history of structural and systematic inequalities between people who have low health literacy and those with high health literacy (Brutzman et al., 2022). How people interact with language depends on their cognitive skills, experiences, and environments. Language discordance happens when the healthcare provider and the patient do not share the same language. Hsieh (2017) found that language discordance happens when the patient and the healthcare provider do not speak the same language, which leads to miscommunication, less satisfaction in medical help, and minimizes a provider-patient relationship resulting in healthcare providers relying on translators (Hsueh et al., 2019). On the other side, language-concordance is when a healthcare provider speaks the patient's choice of language proficiently, which leads to higher satisfaction rates in healthcare outcomes and builds a relationship between the healthcare provider and the patient (Molina & Kasper, 2019; Cano-Ibáñez et al., 2021).

When looking at health literacy and factors that improve comprehension, it is also important to look at the psycholinguistic factors that affect multilingual people. Knowing more than one language often leads to cross-language activation, which is when bilingual individuals read the text in one language, and the information is also activated in the other language (Villameriel et al., 2022). These activations often occur when words are similar in meaning in two different languages, known as cognates and homographs (Hernández-Rivera et al., 2022). For example, some English and Spanish words are cognate with one another, such as no; funeral; hospital; medicine (i.e., medicina in Spanish); and horrible, while homograph words can look and sound similar in both languages, but differ in meaning (Hernández-Rivera et al., 2022; Gullifer & Titone, 2019; Friesen et al., 2019).

Another aspect of psycholinguistics is that multilingual people often use their first language (L1) to process and read text, which impacts their second language (L2) comprehension (Whitford & Titone, 2017). Words in L1 and L2 differ in emotions and experiences, especially among people whose L1 culture differs from their L2, such as with the foreign language effect in which decision-making and reasoning are affected by a person's mental, emotional, and cognitive state (Hernández-Rivera et al., 2022; Caldwell-Harris, 2015; Pavlenko, 2008; Driver,

2020). Lastly, how L2 learners encode, store, and retrieve information affects their discourse comprehension (McNamara & Magliano, 2009). All this is to say that acquiring health literacy is not always an easy task. Educators, healthcare professionals, and patients should know that being multilingual and having health literacy are affected by personal and societal factors.

Evidence suggests that having health literacy helps people make medical decisions for themselves, their families, and their communities because it increases understanding of the factors that should play a role in their decision (McQueen et al., 2007). Sometimes these decisions are made when people self-diagnose themselves using online medical information or media messages, known as media literacy (Manganello, 2008). Understanding health literacy is essential to a clear understanding between the patient and the healthcare provider, which increases the patient's awareness and knowledge of their diagnoses (Kickbusch & Maag, 2008). When health professionals lack an understanding of the needs their patients have, such as having someone translate information for the patient or finding someone that speaks their native language, communication can be difficult and impaired (Rojas-Guyler et al., 2013), which stems from cultural competence (Stubbe, 2020; Kleinman & Benson, 2006) and structural competence (Neff et al., 2020; Metzl & Hansen, 2014). If the healthcare provider does not speak the first language of the patient and the patient has low health literacy, it can lead to different scenarios. The first is that any information presented to the patient can be misinterpreted due to gestures or phrases, the second is misinformed, and the third is that the relationship between the patient and the healthcare provider is challenged due to language barriers (Allen et al., 2020).

People who are not proficient in English (particularly non-native English speakers) may experience language barriers in addition to lacking health literacy. Mann et al. (2019) found in their study that over 71% of the patients with diabetes from New York were unable to properly assess a Nutrition Facts label with 20% being unable to read and write and 30% having minimal education. As Berkman et al. (2010) explains, health literacy and numeracy skills should be taught in a clear manner that makes information easy to comprehend and matches a person's literacy level. In another study, Soto Mas et al. (2018) found that Spanish-speaking adults struggled in understanding cardiovascular disease (CVD) health interventions and conducted a study where participants placed in ESL courses had a focus on CVD literacy, which significantly improved their health literacy. When people navigate the healthcare system not knowing English, translation is necessary. However, translating information inaccurately can hinder a patient's

understanding of their health. Panayiotou et al. (2019) ran a study in which they evaluated iPad-compatible language applications to test how accurate their translations were for medical phrases and terms and found that the translation apps are useful for everyday conversation, especially for phrases in which a professional translator is not needed. However, for medical paperwork or diagnoses, Panayiotou et al. (2019) suggest healthcare facilities use professional translators over applications to communicate with their patients.

When there is a low health literacy and language barrier, patients can feel overwhelmed and unwelcome. Healthcare facilities should know the kind of people they are serving in the community to know the number of languages that are spoken other than English (US Census Bureau, 2015). Doing so will increase the resources available for specific populations and will give healthcare providers a perspective of who they are serving and helping. Flores (2005) explains that resources for translating information will also support a healthy relationship between the patient and the health profession, improve communication, outcomes of the appointments, and the patient's safety and satisfaction. Providing professional translators will be a great advantage for non-native English speakers because they will not have to worry about information being translated incorrectly or leaving out important information.

Health Disparities

Health literacy is associated with a person's economic, environmental, and societal factors (Sørensen et al., 2012). Moreover, having low health literacy leads to more frequent visits to the hospital, higher hospitalization, poor medical procedures, unnecessary payments, higher risks of disability and mortality, and a lack of self-autonomy (Baker et al., 2002; Berkman et al., 2011; Wolf et al., 2006; Paasche-Orlow & Wolf, 2007). Minoritized communities having low health literacy are disadvantaged not only as a result of language barriers but also socioeconomic factors and health disparities (Segalowitz & Kehayia, 2011). Health disparities are inequalities in health, healthcare, and healthcare outcomes, which are a result of systematic and structural inequalities that mostly affect people from minoritized groups and lead to mistrust from the patient and exclusions of patients in healthcare (National Conference of State Legislatures, 2021; Jaiswal & Halkitis, 2019). People from minoritized communities are often a target to health disparities based on their racial or ethnic group; gender; age; sexual orientation or gender identity; religion; traditions; socioeconomic status; mental health; cognitive and physical (dis)abilities; and geographic location (Ndugga & Artiga, 2021). These disparities are rooted in

racism, discrimination, and biases and are associated with a person's social, economic, and environmental factors (Braveman, 2014).

Health disparities are seen in different forms, such as in the environment people live in, their health outcomes, and the healthcare resources available to them. As a result, some populations are at a higher risk of health disparities than others due to systematic oppression in policies and resources and racial and discriminatory behaviors towards minoritized populations, which leads to poor medical decisions and poor health outcomes (Kelly, 2022). For example, migrants are often vulnerable to having low health literacy (Calvo, 2016; Beauchamp et al., 2015). Quenzel and Schaeffer (2016) conducted a cross-sectional study in Germany where they found that 71% of the people who identified as a migrant had difficulties understanding health related texts and in making medical decisions. Large populations with low health literacy in the United States are Hispanic/Latine/a/o immigrants and elders and they often face barriers with language, culture, resources, and legal factors (Becerra et al., 2017; Gracie et al., 2012; Becker Herbst et al., 2016). Simes and Jahn (2022) explain that expanding Medicaid (e.g., healthcare insurance program) across the US led to fewer police arrests, such as arrests related to drugs, and improved people's health care and outcomes because people finally got insurance coverage that they used to seek care and receive health solutions.

Studies have documented that language barriers and low health literacy lead to harmful and negative impacts on medical care and health care outcomes (Kirkman-Liff & Mondragón, 1991; Hu & Covell, 1986). Kim et al. (2011) found that Hispanic/Latine/a/o and Asian Americans that needed mental healthcare were at a high risk of not seeking mental health due to limited English proficiency (LEP). Ponce et al. (2006) conducted a study in which they examined the differences between LEP adults, adults proficient in English, and adults who spoke English only (EO), and found that LEP adults had worse access to healthcare, resources, and 52% of the LEP adults had poorer emotional health than EO adults. Flores (2006) explains that a Salvadorean mother came with her newborn child to a Boston, Massachusetts clinic where she explained that she migrated from El Salvador to the U.S. walking for months while being pregnant. When she got to Boston, she had the baby and felt depressed. Looking for places to medically help her was difficult because most of the healthcare facilities only spoke English. She was not able to get help until she spoke with someone who spoke Spanish and was finally able to get physical and mental healthcare and health insurance for herself and her child (Flores, 2006).

When people are forced to find resources on their own, it causes frustration and is a sign of struggles and barriers that should be addressed within healthcare to improve the communities' experiences navigating the healthcare system.

In total, only about 25% of hospitals in the United States have full-time interpreters, and when examined closely, there are only 3% of full-time interpreters in New Jersey hospitals, which is a ratio of one interpreter for 240,748 LEP patients (Flores et al., 2008). LEP patients are then left with using free clinics or community health centers that are free even if they provide limited services; they also go to these healthcare facilities because in most cases they do not ask patients for their legal status or health insurance (Kamimura et al., 2013; Okie, 2007). Finding doctors and healthcare providers that are similar to the patient in terms of race/ethnicity, sex, and other demographic backgrounds is important for many patients. When patients are unable to find the proper resources for themselves, they often stop calling on the phone or going in person to ask questions, or even find a clinic with an interpreter, or stop going to get healthcare (Flores, 2006). With language barriers also come cultural barriers in which patients seek doctors of their race or ethnic groups, especially when they can speak to them in their native language or dialect, as seen with Korean immigrants (Choi, 2013). There are also power differences between the doctor and patient in which a patient can feel inferior to the doctor due to their limited medical knowledge and having to speak with LEP (Jang, 2016).

When people do not have the proper resources within their communities to navigate the healthcare system, they are often left to find coping strategies on their own. Tanmoy Das et al. (2020) explain that during COVID-19, LEP patients faced barriers that often led to delayed healthcare, such as looking for an interpreter, finding a phone to use and being decontaminated, and speaking with masks on, which made the speaker's voice harder to hear. Patients were also unable to bring a relative with them in the room due to COVID-19 protocols, making it more difficult for them to have someone to help them translate their needs and symptoms and overall advocate for themselves (Shadmi et al., 2020). There are many instances in which family members or caregivers help translate medical documents and information for their loved ones and clients (Pirschel, 2019). Family members typically can be children/minors translating for their parents or an older adult in their life and adults who do their best to translate from their native language to English and back, academically known as a "language broker" (Orthy, 2022) Young children often become the language broker for their family at a very young age, which

usually happens when they begin learning English (Wang, 2016). The children are usually asked to read legal/medical paperwork, translate for their family members who do not speak English, and are the representatives for their family placing a big responsibility on them (Severn & Blanco, 2020). There have been many cases in which people without the requisite knowledge and language skills have had to act as interpreters, which has led to deaths, misdiagnoses, and inadequate services (Jacobs et al., 2018; Van Kempen, 2007; Wilson, 2013). For example, an 18-year-old Cuban boy went to the hospital because he felt "intoxicado" and the healthcare provider misinterpreted his words as "intoxicated," but the word he said meant "nauseated" in Spanish. After days of getting tested for drug abuse, they found damage from a ruptured brain aneurysm (i.e., bleeding into the brain), which ended with him being quadriplegic and filing a malpractice lawsuit, resulting in $71,000,000 in damages (Harsham, 1984; Ku & Flores, 2005).

DuBard and Gizice (2008) explain that Spanish-speaking Hispanics had worse health status and healthcare access than English-speaking Hispanics, which shows that even in the Hispanic population there are different turnouts if people do not speak English proficiently. Sometimes, there may not be language interpreters or technology in less common languages, which can lead to severe barriers and dangerous healthcare outcomes (Espinoza & Derrington, 2021; Shamsi et al., 2019). With modern technology growing each day, advanced technology such as Jeenie and Voyce are technologies that have live interpretation services, and healthcare providers and patients can choose from over 238 languages and dialects and can be used via Zoom and as a smartphone application (PR Newswire, 2022; Nexion Health, 2021). The University of California, San Francisco released MediBabble in 2011, which is an application used to translate medical information through voice recognition software that asks for medical history and translates medical instructions and languages (Irfan et al., 2018).

Providing patients with resources that take into account their language preference, their experiences, culture, and beliefs can lead to higher satisfaction and healthcare use among patients, such as with Chinese American patients (Hayakawa et al., 2021; Hornberger et al., 1996). Stanton et al. (2022; pg. 148) found that patients were much more satisfied with their healthcare when healthcare providers met their cultural needs and created a welcoming environment in which non-native English speakers were provided resources for them, thus creating what the researchers called a "patient-centered experience." Ensuring that patients feel welcomed, important, and heard will increase their use of healthcare facilities and will build a

trusting bond between the healthcare provider and the patient. Healthcare providers should be educated about a patient's background, experience, and needs while patients should be educated on health literacy and how to ensure maximum healthcare.

English as a Second Language

English as a Second Language (ESL) speakers are people who learned English as a second language, either when they are young or as adults (Krashen et al., 1979). Learning a second language usually happens after learning a first language, which is when someone can speak and understand their first language (Suryantani, 2018). Learning a language requires many cognitive skills and functions, such as explication and induction, memory, and motor skills; is associated with a person's social factors, such as their environments in and outside of their home; and is related to their motivation and attitudes (Gardner & Lambert, 1972; Cook, 2008; Steinberg et al., 2001). Preston (1989) explains that when children lack social acceptance, it can hinder their ability to acquire a second language and can lead to the child not wanting to associate with new peers and learn the new language. It is also important to note that if a child or adult has migrated to another country, there can be a culture shock that impacts their language learning and accommodations to a new culture and lifestyle (Brown, 2020).

As health literacy becomes more prevalent in making medical decisions, institutions and healthcare systems should implement resources to help people navigate medical information. There are new advances in the ESL curriculum that are supporting the education of health literacy to ESL learners and English Language Learners (ELL). Lum et al. (2018) state that ESL or English for Academic Purposes (EAP) students in higher education medical programs need to have a basic understanding of academic literacy and should be taught health literacy to learn their degree's dialect. Lewis (2021) found that ESL learners transitioning from high school to college need resources that will advance their English proficiency and their knowledge of U.S. cultures and customs to excel in higher education. LEP only adds more barriers to their higher education success in their courses, on-campus engagement, and overall learning.

Soto Mas et al. (2014) conducted a study with Hispanic college students and found that the participants had higher health literacy levels than the general Hispanic adult population. These findings reinforce the need to teach people health literacy in and outside of academia. Wong et al. (2021) explain that nurses who learn health literacy and interprofessional skills can help improve communication among nurses and patients when health literacy is incorporated into

their undergraduate nursing degrees. Squires (2017) also emphasizes the importance of having Internationally Educated Nurses who are educated in languages spoken in the countries they work, such as English and Spanish, which accounts for 62% of U.S. homes speaking Spanish. Edwards (2007) explains that ESL courses should also teach U.S. cultures and norms so ESL learners can have in-depth knowledge of culture and will help them learn how to apply concepts to real-world scenarios.

Teo et al. (2018) found that patients who are from a non-English speaking background had a limited understanding of their medications and diagnoses, which the researchers imply that interpreters and education on health literacy are essential. Teaching ESL learners more about health literacy in their ESL courses can help them actively use health literacy when they engage with medical information (Chervin et al., 2012). Soto Mas et al. (2013) explain that teaching health literacy in ESL curricula improves people's understanding of medical information, which they implemented in a 6-week course where 12 units of medical information were implemented with 84 ESL students. Researchers found that when the materials they learned were consistent with the medical documents and information they dealt with in the real world, it improved their understanding of medical information and paperwork (Soto Mas et al., 2013). Wagner (2019) also incorporated health literacy into ESL courses through active learning activities and incorporated their health goals as a motivation, which resulted in high satisfaction in learning health literacy.

When people take ESL courses, they are learning English words, phrases, and concepts, and adding a health literacy component not only educates but gives ESL learners a sense of autonomy for being able to use health literacy in the future. If ESL learners and the majority of the population can get educated in health literacy, it will increase their understanding of medical information. If information can be explained and presented in a simplified or gist-based manner, people will understand information better. For example, in Houston, Texas there are over 68,000 English language learners (ELL), according to the Houston Independent School District (2016), and the number of students from K-12 keeps increasing over the years, which requires attention from the district to provide adequate instructional support so the students can learn English to better adapt to their new environments. These are students who are considered "immigrant" children or teens, specifically from Central America (e.g., El Salvador, Honduras) that require additional support from their schools to help them adjust in the U.S. (Houston Independent

School District, 2016). These students may soon become adults that begin navigating the healthcare system on their own and may need support in understanding medical information in a language that makes sense to them with education on health literacy to make their own decisions.

As mentioned in McKee and Paasche-Orlow (2012), health literacy and people with LEP should be studied more, especially in an interdisciplinary way among researchers who solely study health literacy and researchers who solely study people with LEP. Doing so will improve people's interventions, resources, and understanding of the importance of taking into account cultural competence in healthcare to minimize health disparities and improve healthcare outcomes for people with LEP, whether the help is for minors or adults. If research can move forward in supporting the implementation of health literacy in academia, especially for people who face language barriers and medical professionals, interventions and resources can be created to help people when they navigate medical information whether online, at home, or in a healthcare facility.

The Complexity of Medical Texts

Texts vary in how complex they are to comprehend, and the more complex text is, the less likely people will understand the information. Rossetti and Van Waes (2022) explain that simplifying information for the layperson will increase the readability of a text, especially for those who learn a second language. Todd and Hoffman-Goetz (2010) conducted a study where Chinese immigrant women were tested for their understanding of colon cancer in their first or second language and found that 54.3% of the women understood basic colon cancer information, while 38.7% of women had health literacy comprehension. Being able to read and understand complex information is essential for making optimal decisions. Leroy et al. (2016) explain that online medical information is often written in difficult or technical words, phrases, and figures, which affects the reader's level of understanding. Reading medical information, whether online or on documents, requires a baseline of literacy and health literacy.

Crossley et al. (2012) explain that simplifying text comes from making the text more comprehensible, such as for those who learn second language acquisition. Learning a second language often comes in the form of simple information for learning acquisition (Hayes, 2004). Kim et al. (2018) found that multilingual L2 readers (e.g., a person's second language) read information faster when the text was presented in a simplified way, the same concept can be applied to L1 readers (e.g., a person's first language; Yamasaki & Prat, 2021). Simplifying text is

a job that requires an understanding of who the audience is, the context of the text, and what the implications of simplifying the text are; and recognizing the labor required to simplify text (Rosetti & Van Waes, 2022; Schriver, 2012). Children, teenagers, and young adults process information differently than older adults, which are more likely to use gist representations than children and teenagers. (Brainerd et al., 2018; Reyna & Rivers, 2008). Bol et al. (2016) explain that when health informational texts and figures are presented in a simplified manner, most people can understand them, they tested and found that older adult's paid attention to text more than illustrations and younger adults paid more attention to figures with text when simplified.

Fuzzy Trace Theory and Gist Inference Scores

Making judgments and medical decisions is often difficult to do when information is unclear (Peters et al., 2006). Having gist-based reasoning can improve a person's judgment and medical decision-making, which may ultimately improve a person's healthcare outcome (Blalock & Reyna, 2016). Reyna (2008) explains that in order to make proper medical decisions, information needs to be mentally represented in a gist-based form. Fuzzy Trace Theory (FTT) is a dual-process theory that explains how people rely more on gist-based mental representations with a bottom-line meaning of information (gist) rather than verbatim representations that are more detailed but also superficial (Reyna, 2008). Adults are more likely to use and remember gist-based information than verbatim-based information while children and adolescents rely more on verbatim-based information. The same can be said about experts who use gist-based representations and novices who use verbatim representations to make decisions (Reyna, 2012; Blalock & Reyna, 2016). As people transition into becoming adults and experts, they rely more on gist-based representations of information (Setton et al., 2014). In other words, people are more likely to understand the bottom-line meaning or gist of a text than they are to remember the verbatim or detailed information, whether the information is presented online or at a healthcare facility (Reyna & Brainerd, 1995).

Coh-Metrix is a discourse analysis technology that assesses the cohesion of a text and provides information on linguistic and psycholinguistic variables from single words to whole texts and also sentences and paragraphs (McNamara et al., 2014; Graesser et al., 2011). When specific texts are automatically analyzed with Coh-Metrix the computational tool provides data on over 106 linguistic and psycholinguistic variables (McNamara et al., 2014). One Coh-Metrix variable assesses readability for people who speak English as a second language (i.e., L2) in

which sentence syntax, word overlaps, and word frequency variables are analyzed at a word and sentence level with challenges in cohesion (McNamara et al., 2014; Guo et al., 2013). For example, Baba and Nitta (2010) conducted a study in which Japanese English as a Foreign Language student's L2 were asked to write 30 times within a year and used Coh-Metrix to analyze their texts; they found that the more students practiced their writing, the better they got in their L2 comprehension. McNamara and Magliano (2009) explain that text comprehension requires cracking down on word meanings and applying them to scenarios that will reinforce the connotations of the words.

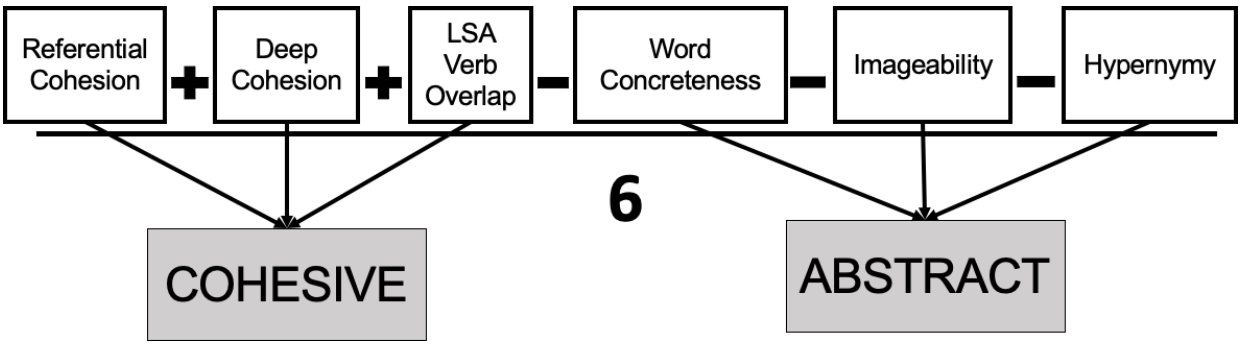
One way to make a text easier to read is to start by studying its readability and quality. Gist Inference Scores (GIS) are derived from six Coh-Metrix variables and are rooted in FTT that automatically assesses texts for the extent to which they will help readers form useful gist mental representation (Wolfe et al., 2019a; Wolfe et al., 2019b; Dandignac & Wolfe, 2020). When a text has a high GIS, the text focuses on the meaningful and bottom-line meaning of the text. GIS consists of six variables (see Figure 1) that focuses on the Coh-Metrix psycholinguistic variables referential cohesion; deep cohesion; LSA verb overlap; word concreteness; imageability; and hypernymy nouns and verbs (Dandignac & Wolfe, 2020). GIS is used to evaluate the likelihood that readers will understand the gist of the text by combining Coh-Metrix variables on the level of individual words, sentences, and paragraphs (Wolfe et al., 2019a; see also McNamara et al., 2014).

The GIS formula consists of six linguistic and psycholinguistic variables that have been converted to z scores to put them on a common footing (Wolfe et al., 2019a), with three positively weighted and three negatively weighted (see Figure 1). On the positive side, referential cohesion focuses on the ideas and phrases that are repeated throughout a text and should be high in cohesiveness to increase gist representation (McNamara et al., 2014). A text that is consistently about the same set of ideas is more coherent than one that flits from one topic to another. Deep cohesion focuses on how sentences are related to each other (e.g., with words such as however, also, moreover). Having a deep cohesion improves the way that words flow with one another and connect a sentence (McNamara et al., 2014). Latent Semantic Analysis or LSA verb overlap is about how related verbs are to each other in the text. LSA should be high on cohesiveness to understand the semantic overlap of words in sentences and paragraphs (McNamara et al., 2014). On the negative side, word concreteness is focused on the verbatim

information in a text (McNamara et al., 2014). The purpose of GIS is to assess a text's gist representation, which requires word concreteness to be less abstract. Imageability is focused on the extent to which words evoke an image. The variable should be low on abstractness since it can be hard to create a clear and universal image of some words (McNamara et al., 2014). Lastly, hypernymy focuses on how nouns and verbs subordinate in a hierarchy, which should be low to better understand the gist of the information, instead of the specifics of information (Wolfe et al., 2019a; McNamara et al., 2014). As seen in Figure 1, referential cohesion, deep cohesion, and LSA verb overlap are cohesive while word concreteness, imageability, and hypernymy are abstract, which limits people's understanding of a text.

Figure 1. GIS formula combining Coh-Metrix Variables (as Z Scores).

An illustration of the GIS formula consisting of six variables.



Applying FTT to revising online medical texts can increase GIS and the comprehension of complex materials, which can help online-based texts be more accessible to all people regardless of their reading comprehension or background knowledge (Dandignac and Wolfe, 2020). Researchers and educators can help improve people's understanding of medical text using GIS by improving comprehension of medical text and medical decision-making. As done by Marroquín (2022), revising online medical information systematically from authentic articles with a low GIS can improve the GIS score and understanding of a text. Improving people's understanding should be done by focusing more on increasing the use of the first three variables and focusing less on the last three variables of the GIS formula. Risky decisions in health care can also be minimized with graphic and verbal information that relies on a gist-based approach, making information more interpretable and understandable (Brust-Renck et al., 2013). Wolfe et al. (2019b) found that authentic online medical texts from the National Cancer Institute (NCI) were hard to understand. Wolfe et al. (2021) used Coh-Metrix with GIS to conduct a study in

which online texts from the NCI were used to test non-native English speakers' and native English speakers' understanding of breast cancer texts and found that high GIS texts did improve native English speakers, but their results were unclear for non-native English speakers, which may have been due to the fill in the blank methodology. Future research should focus on how non-native English speakers, specifically ESL learners understand medical information through a gist-based approach using FTT, Coh-Metrix, and GIS to evaluate their reading comprehension and health literacy.

Limitations of Prior Research and Gaps in the Literature

Current research on health literacy and ESL learners is limited in looking at the relationship between FTT, Coh-Metrix usage, and GIS. For example, Wolfe et al. (2021) conducted a study where non-native English speakers, primarily international undergraduate students from China and native English speakers were tested on a cloze task and found no evidence of gist information supporting non-native English speakers' understanding of online medical information. It is not clear whether the cloze procedure adequately assessed comprehension for ESL participants. There is also limited research on how the field of health communication and health literacy support ESL learners (Ishikawa & Kiuchi, 2010). In addition, there is limited research on how psychology researchers can improve ESL learners' understanding of medical information with a qualitative and quantitative approach. Although research can show how effective ESL learners are with health literacy, it is important to also focus on specific people, such as those who are native Spanish speakers, and to understand their perspectives and experiences on how they navigate the healthcare system as ESL speakers through conversation.

Marroquín (2022) conducted a study in the Fall of 2021 in which an authentic article about universal flu vaccines was used to test people's understanding of medical information by randomly assigning participants to the original low GIS text (GIS score: -0.08), a high GIS version of the text that I re-wrote (GIS score: 0.48), or a control text about photosynthesis. A one-way ANOVA revealed that there was a statistically significant difference between the groups for the Likert scale questions, ($F(2,191) = 13.66$, $p = .001$). Those in the high GIS ($M = 5.258$, $SD = .457$) and low GIS groups ($M = 5.041$, $SD = .296$) did about the same in the verbatim 7-point Likert scale questions versus the control group ($M = 4.905$, $SD = .383$). Results from a one-way ANOVA revealed that there was a statistically significant difference between the

groups for the multiple-choice questions, ($F(2,191) = 14.05$, $p = .001$). Native English-speaking participants randomly assigned to the high GIS text understood medical information significantly better ($M = .606$, $SD = .108$) than those in the low GIS text group ($M = .612$, $SD = .137$) and the control group ($M = .512$, $SD = .128$) for the gist multiple-choice questions (Marroquín, 2022). To learn more about cultural differences, I decided to replicate the Fall 2021 study as a pilot test in Spring 2022 with ESL speakers. Unfortunately, multiple limitations pose barriers to collecting research about ESL speakers. One of the limitations was that the study was conducted at Miami University, which is a predominantly White institution with a lack of variation among students' backgrounds. Participants were collected through the Miami University psychology subject pool with others being recruited from the Miami community by reaching out to different clubs, organizations, and programs that were toward ESL speakers or of multicultural backgrounds. A total of 66 participants participated in the study and only 13 of those were ESL speakers. As a result, the pilot study ended, and the findings were inconclusive.

The Current Study

The current study is an improved version of Marroquín (2022), and the pilot study done in Spring 2022 with ESL participants. The study aimed to understand and improve ESL speakers' comprehension of complex health texts for those who have high and low health literacy. Medical information is often difficult to understand and is even harder to comprehend when there are barriers, such as language comprehension, little to no health literacy, and environmental, systematic, and social factors. The study aimed to understand how medical information could be converted into an easier version to read by the layperson where participants completed a survey about universal flu vaccines and answered questions about the article and assessed their health literacy.

The study recruited participants that identified as Latine/a/o/Hispanic students who were ESL speakers to see whether a verbatim-based (i.e., low GIS; GIS score: -0.128) authentic text from the web or a revised gist-based (i.e., high GIS; GIS score: 0.519) article on universal flu vaccines helps readers understand the information better. The "authentic" article text "A Universal Influenza Vaccine: How Close Are We?" is from the American Society for Microbiology by Angel Corona (2020) that is often visited by the public for medical information and educational purposes. This "authentic" text was chosen due to the complexity of the topic and the fact that the original version had a low GIS. I retrieved it in September 2021 and created

a revised higher GIS gist-based version of the article and hypothesized that it would be easier to read by a layperson than a verbatim-based article. Participants were people for whom English is a Second Language and they were randomly assigned to read the original low GIS text, the revised high GIS text, or a control text about photosynthesis. The dependent variables are 7-point Likert scale statement questions about the gist information and multiple-choice questions about verbatim information covering content in both the original and revised texts about universal flu vaccines.

The study asked whether gist information can help improve ESL speakers' comprehension by revising complex authentic medical texts to have a high GIS. Hypothesize 1 is that participants who get the gist-based article would perform better on the 7-point Likert scale and multiple-choice questions than those randomly assigned to read the original version (i.e., low GIS) and the control condition texts. Hypothesis 2 is that participants who are randomly assigned to the gist-based article will understand the article's complex materials better because the content is easier and more accessible to learn.

The second research question was whether ESL learners understand the medical information and perform well in the statement and multiple-choice questions regardless of their level of health literacy. Hypothesis 1 was that ESL learners who have a high health literacy would do better than those who have a low health literacy regardless of the condition. Hypothesis 2 was that ESL learners who get the high GIS text will perform better than those in the low GIS or control conditions regardless of their level of health literacy.

Chapter 2: Understanding Universal Flu Vaccines

Methods

Participants

Participants included undergraduate and graduate students from around the United States who learned ESL. Inclusion criteria consisted of participants being 18 years old or older or having parental consent, being a native Spanish speaker, having learned ESL, identifying as Latine/a/o, Hispanic or an ethnic-specific group from Latin America, and being an undergraduate or graduate student. Exclusion criteria consisted of participants that were not 18 years old or older or had parental consent, were not a native Spanish speaker, did not learn English as a second language, did not identify as Latine/a/o, Hispanic or an ethnic-specific group from Latin America, and were not an undergraduate or graduate student. Figure 2 shows that people were excluded based on not meeting these criteria in addition to not giving consent or dropping out of the survey at the beginning of the study, leading to missing data.

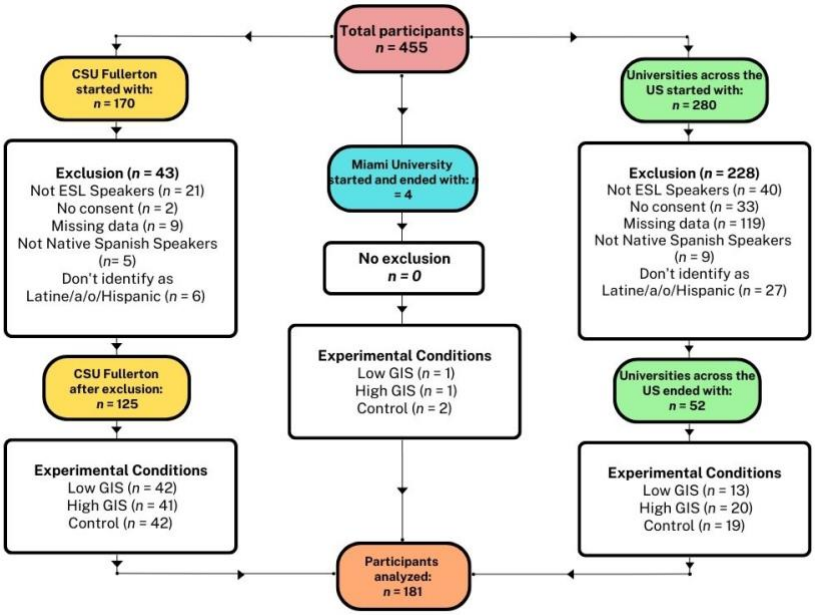
A total of 455 participants participated in the survey across the United States and after exclusions, data from a total of 181 participants were analyzed (see Figure 2). A total of 168 participants came from California State University, Fullerton who were recruited to participate for course credit and after excluding those that did not meet the criteria, a total of 125 participants were analyzed. A total of 4 participants came from Miami University who were recruited to participate for course credit and since all completed the survey and met the inclusion criteria, all of the participants were analyzed. Lastly, a total of 280 participants were recruited using a flyer (see Appendix A) and sharing the survey via email or direct messages to universities, sites, and social media platforms for college students across the US (see Appendix B) with the chance of four participants being selected to win a $50 gift card and after excluding those that did not meet the criteria, a total of 52 participants were analyzed.

Of the 181 participants, 80.1% identified as a woman, ages ranged from 18 to 40 (M_{age} = 21.40 years), 100% identified as Latine/a/o, Hispanic, or an ethnic-specific group from Latin America, and 80.11% identified their race/ethnicity as Latine/a/o (Central and/or South) American. A total of 36.46% were first-year college students, 4.4% were international students, 82.87% identified as a first-generation college student with 45.30% rating their ability to read English as excellent. A total of 26% participants learned English at the age of 5 with 64.64% taking an ESL course in their lifetime. At the beginning of the survey all participants were asked

if they learned ESL with 100% identifying as ESL speakers; however, when asked again during the demographic questions, a total of 95.03% participants identified as learning ESL, which may be due to the rest learning English and Spanish simultaneously.

Figure 2. A breakdown of recruitment.

There is no evidence for unequal dropout rate by experimental condition.



Materials

Participants were asked to be a part of a quantitative between-subjects design survey created in Qualtrics. Participants were first asked if they were ESL speakers to exclude those who did not meet the first criteria (see Appendix C), then participants had to consent or not consent to the study (see Appendix D). Then, each participant was assigned to read either a low GIS text (Corona, 2020) or a high GIS text about universal flu vaccines, or a control text about photosynthesis (see Appendix E). The revised or high GIS article focused less on specific terminologies and focused more on the overall meaning of the information, which does not require the reader to know exact details. The original and revised article was submitted to CohMetrix.com and after getting the data, the data was submitted to the GIS calculator, which gave a score for each of the texts. Each of the texts were written to fit into a three page length for the sake of the survey taking place online. Thus, the original or low GIS text originally scored -0.78 and when it got adjusted to fit into three pages, the GIS changed to -0.12. The revised article was +0.48 and after fitting adjusting it to fit into a three page length, the GIS changed to +0.51. Each change that was done to the texts were recorded, resulting in the original being finalized on version five and the

revised text being finalized on version four. Using Coh-Metrix and GIS it is important to consider that not only should the researcher focus on the GIS being higher for the revised text but also in making sure that the article is much more understandable than the original text.

After, all of the participants answered the same 7-point Likert scale questions, a total of 30 questions (see Figure 3; see Appendix F), which measured the gist information presented in the article and multiple-choice questions, a total of 13 questions (see Figure 4; see Appendix G), which measured the verbatim information presented in the article. Participants were asked to answer 16 questions that assessed their performance on health literacy from Chew et al., (2004) followed by demographic questions (see Appendices H and I). After being debriefed (see Appendix J), the participants that did the survey for course credit got to the end of the survey where they were asked if they were interested in participating in a 30-minute interview with me to talk about their experiences navigate the healthcare system as ESL speakers for 1/2 research credit. The rest of the participants got the option to sign up for a raffle to be randomly picked for a $50 gift card for completing the survey.

Figure 3. Assessing gist comprehension with a Likert scale.
Agree/disagree statement question example.

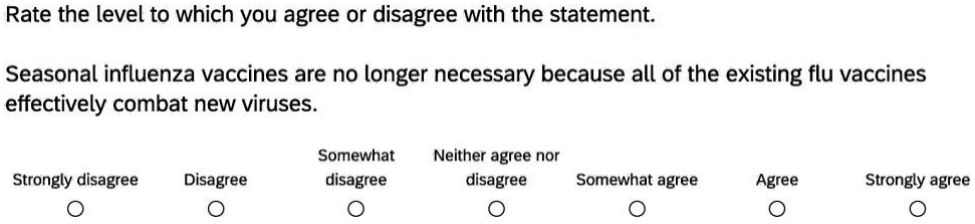
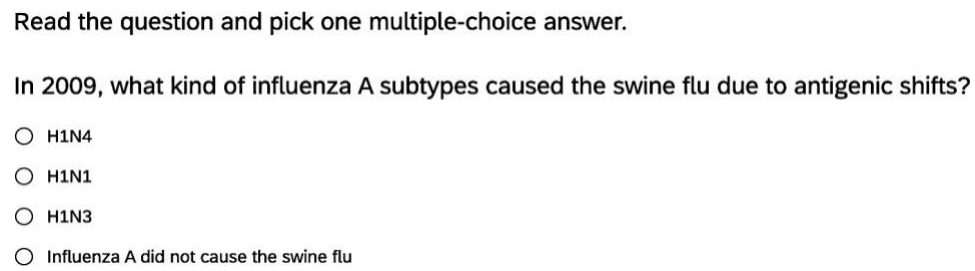


Figure 4. Assessing verbatim recognition with multiple-choice items.

Multiple-choice question example.



Procedure

All of the participants were asked to complete the study online, except four participants from Miami University who did the survey in a controlled lab environment. Participants were

randomly assigned to read a version of the universal flu vaccine article that is either low or high on GIS or the control (photosynthesis) article. Then, they were asked to complete the questions for the Likert scales and multiple-choice questions. Participants were also assessed on their health literacy using Chew et al., (2004) questions. Lastly, participants were asked to complete demographic questions. At the end of the survey, all participants were asked to voluntarily sign up on a separate Qualtrics survey to a raffle where four participants were randomly selected to win a $50 gift card.

Results

To examine research Question 1 Hypothesis 1 about whether gist comprehension can be improved for ESL learners by revising complex authentic medical texts to have higher GIS, a one-way ANOVA was conducted to compare the three different conditions based on their scores in the 7-point Likert scale statement questions and the multiple-choice questions. A one-way ANOVA revealed that there are no statistically significant differences between the original condition (M = 4.830, SD = .530), the high GIS condition (M = 4.887, SD = .494), and the control condition (M = 4.765, SD = .374) for the Likert scale questions, ($F(2,180) = 1.065$, p = .347 (see Figure 5; see Table 1). ESL learners did not do better on the gist comprehension task using the 7-point Likert scale statement questions. Tukey's HSD Test for multiple comparisons found that there was no statistically significant difference in mean understanding scores for the Likert scale questions between the original condition and the high GIS condition, (p = .782, 95% C.I. = [-.262, .146]), and the original condition and the control condition, (p = .734, 95% C.I. = [-.138, .268]).

Figure 5. 7-point Likert scale gist questions.

Results of the 7-point Likert scale statement questions.

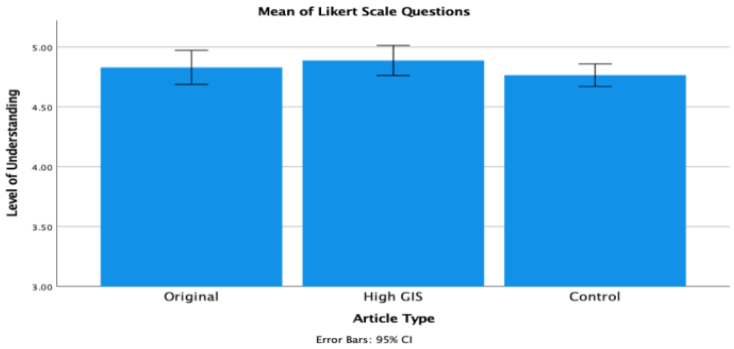


Table 1

Means and standard deviations for each condition in the 7-point Likert scale gist statement questions.

Condition	*M*	*SD*
Original	4.830	.530
High GIS	4.887	.494
Control	4.765	.374

To examine research Question 1 Hypothesis 2 about whether gist comprehension can be improved for ESL learners by revising complex authentic medical texts to have higher GIS a For the multiple-choice questions, a one-way ANOVA revealed that there is no statistically significant difference between the original condition (*M* = .502, *SD* = .176), the high GIS condition (*M* = .465, *SD* = .171), and the control condition (*M* = .509, *SD* = .147), (*F*(2,180) = 1.272, *p* = .283 (see Figure 6; see Table 2). ESL learners did not score similarly in the high and low GIS text conditions and were not better at both than the ESL learners in the control condition on the verbatim multiple-choice questions. Tukey's HSD Test for multiple comparisons found that there was no statistically significant difference in mean understanding scores for the multiple-choice questions between the original condition and the high GIS condition, (*p* = .436, 95% C.I. = [-.034, .109]), and the original condition and the control condition, (*p* = .976, 95% C.I. = [-.078, .065]). These results indicate that regardless of what article the participants got, it did not improve their understanding based on the 7-point Likert scale questions and the multiple-choice questions.

Figure 6. Multiple-choice verbatim questions.

Results of the multiple-choice questions.

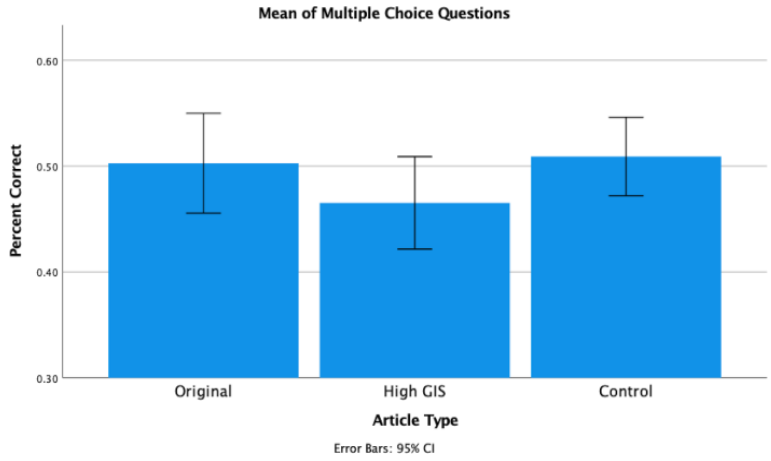


Table 2

Percent correct for each condition on the multiple-choice verbatim questions.

Condition	*M*	*SD*
Original	.502	.176
High GIS	.465	.171
Control	.509	.147

To examine research Question 2 Hypothesis 1 about whether ESL learners understand the medical information and perform well in the statement questions and the multiple-choice questions regardless of their level of health literacy an independent samples T-test was conducted to compare participants 7-point Likert scale statement questions doing a median split at the median 3.19, where high is identified as a 1 and low is identified as a 2. There was not a significant difference in the high (M = 4.831, SD = .457) and low (M = 4.823, SD = .481) health literacy for the 7-point Likert scale statement questions (see Table 3); $t(179) = .121$, $p = .904$. ESL learners that had a high health literacy did not do better than those that had a low health literacy within the high GIIS text condition, the low GIS text condition, and the control condition.

To examine research Question 2 Hypothesis 2 about whether ESL learners understand the medical information and perform well in the statement questions and the multiple-choice questions regardless of their level of health literacy, an independent samples T-test was conducted to compare participants multiple-choice questions doing a median split of 3.19, where high is identified as a 1 and low is identified as a 2. There was not a significant difference in the high (M = .507, SD = .170) and low (M = .478, SD = .160) health literacy (see Table 4); $t(179) = 1.193$, $p = .235$. ESL learners who got the high GIS text did not perform better than those in the low GIS text or control condition, regardless of their level of health literacy. These results indicate that health literacy does not have an effect on people's results for the 7-point Likert scale questions and the multiple-choice questions.

Table 3

Means and standard deviations for health literacy in the 7-point Likert scale statement questions.

Level	*M*	*SD*
High	4.831	.457
Low	4.823	.481

Table 4

Means and standard deviations for health literacy in the multiple-choice questions.

Level	*M*	*SD*
High	.507	.170
Low	.478	.160

Post-hoc Comparisons to Data from Marroquín (2022)

When comparing the results from Marroquín (2022), findings were not consistent with this study. As discussed in the introduction, a one-way ANOVA revealed that there was a statistically significant difference between the groups for the Likert scale questions, (F(2,191) = 13.66, p = .001) for Marroquín (2022). However, when compared to this study's results, similar results were not consistent (see Table 3). In Marroquín (2022), a one-way ANOVA revealed that there was a statistically significant difference between the groups for the multiple-choice questions, (F(2,191) = 14.05, p = .001). However, when compared to this study's results, similar results were not consistent (see Table 4). Further interpretation will be provided in the discussion section.

Table 5

Mean gist comprehension rating by experimental condition in the 7-point Likert scale statement questions for Study 1 vs Study 1 in 2022.

7-point Likert Scale Questions					
Current Study			**Study 1 (Marroquín, 2022)**		
Condition	*M*	*SD*	Condition	*M*	*SD*

Original	4.830	.530	Original	5.041	.296
High GIS	4.887	.494	High GIS	5.258	.457
Control	4.765	.374	Control	4.905	.383

Table 6

Percent correct verbatim comprehension by experimental condition in the multiple-choice questions for Study 1 vs Study 1 in 2022.

	Multiple-choice Questions				
	Current Study		**Study 1 (Marroquín, 2022)**		
Condition	*M*	*SD*	Condition	*M*	*SD*
Original	.502	.176	Original	.612	.137
High GIS	.465	.171	High GIS	.606	.108
Control	.509	.147	Control	.512	.128

Chapter 3: Discussion

Medical information in English is often written in to promote verbatim representations, making information harder to understand and less accessible to everyone, especially Latine/a/o non-native English speakers and ESL speakers ("Language Barriers Contribute to Health Care Disparities for Latinos in the United States of America," 2002). Low to no health literacy and not being native English speakers makes navigating the healthcare system difficult, which leads to improper healthcare outcomes that should be addressed by creating the proper resources for people (McKee & Paasche-Orlow, 2012). Creating proper and better health resources will increase patient satisfaction, health, healthcare, and healthcare outcomes, such as having translators, making information easier for people to understand, and healthcare professionals that are culturally competent (Pandey et al., 2021). The purpose of this study was to understand how medical information can be written into an easier version for people to understand the information, specifically with native Spanish speakers who are ESL learners. Hypothesis 1 was that the high GIS condition would perform better than the original condition and the control condition for the 7-point Likert scale statement questions and the multiple-choice questions. Hypothesis 2 was that participants randomly assigned to the high GIS article would understand the content better than those reading the original article and the control article, since the high GIS article was written to increase gist comprehension.

The results were not consistent with previous research, specifically Marroquín (2022) in which participants who got the high GIS condition performed better than the original condition and control condition on both the 7-point Likert scale statement questions and the multiple-choice questions (see Table 5 and 6). As seen in Table 5, the means for the 7-point Likert scale statement questions were much lower than those in Marroquín (2022) and the standard deviations were higher. One possible explanation for the differences between studies is that participants started with less knowledge of universal vaccines. However, the control condition means are about the same across the studies with the Marroquín (2022) with the current participants doing slightly better with the two texts. Thus, there is no evidence that the ESL participants started with less knowledge or gist comprehension of universal flu vaccines. Another possible explanation of the differences is that GIS is only helpful for native English speakers. However, the finding that participants in the current study also did worse with the original low GIS version does not support this interpretation. One explanation is that participants completed

the Marroquín (2022) study in a lab controlled environment while participants for this study completed the study in their own environment and may have not read any of the texts as carefully. Table 6 shows similar findings in which this study had lower means and higher standard deviations than the study in Marroquín (2020). Specifically, the control conditions were relatively similar across the studies. However, the ESL participants did not benefit from the texts altogether, which may have been due to limitations that will be discussed in the next chapter.

Participants were asked about their health literacy in order to find whether ESL learners understood medical information and performed well in both the statement and multiple-choice questions. I hypothesized that 1) ESL learners with a high health literacy would do better than those with a low health literacy regardless of the condition and 2) ESL learners who got the high GIS text would perform better than those in the low GIS or control conditions regardless of their level of health literacy. Health literacy did not define the participants' understanding of the materials they read and the questions they had to answer. My predictions were not supported for this study, which may be due to participants not fully reading the article or skimming through the article, being distracted in their environment(s), or completing the study for a compensation.

The study examined how replicating the study from Marroquín (2022) would have similar results with ESL speakers. Previous research has shown that medical information that is written in gist helps people understand medical information better than when written in verbatim (Wolfe et al., 2021). However, no research about gist information has been done with native Spanish ESL speakers. Although this study did not find statistical significance, it opens a window for future research to focus on ESL speakers and better understanding how medical information can be written and explained in ways that are understandable to non-native English speakers.

Limitations and Future Research

In the study, there were many limitations. For one, recruiting participants for the study required sharing the survey with people across the US by sharing the survey with personal connections, such as faculty, staff, and students, and on social media platforms. Since Miami University has a very limited population of native Spanish speakers that are ESL speakers, I had to recruit across the US. I also reached out to my undergraduate advisor at CSU Fullerton to recruit participants. After collecting data, a total of 455 participants completed the study, and after exclusions, only 181 participants were analyzed. Second, due to the study being online,

with the exception of the four participants recruited through Miami University, there was a big dropout rate, leading to missing and incomplete data. Third, over 80% of the participants identified as woman, which does not generalize the results to all genders. Fourth, the participants were all college students, which does not generalize to populations that speak minimal to no English in the US, those with minimum to no (college) education, and to minors. Fifth, a seriousness question check could have been asked at the beginning of the survey to identify whether participants were serious about the study to improve data quality (Reips, 2021). For example, the participants could be asked if they are serious about participating, whether they are checking out the study, if they are doing the study only for the sake of compensation (e.g., money, course credit), or to support the research/literature with the option of picking more than one option.

Future research should focus on recruiting participants across the US outside of college participants to better understand how other people from society interact with medical information. Another is that future research should include listening to personal experiences and stories of ESL speakers navigating the healthcare system through a qualitative approach to better understand their situations, barriers, and the kind of resources that would adequately help ESL speakers. This gap in the literature would benefit ESL speakers when navigating the healthcare system by providing the proper resources they may need, which would increase patient-center care, minimize misdiagnoses, deaths, and improve patient's satisfaction, health, and overall healthcare experience. Lastly, future research and efforts should focus on the importance of healthcare providers speaking the same language as their patients and learning about having cultural competency to better connect with their patients (Ali & Watson, 2017).

Conclusions

The results of this study add to the literature on how medical information should be improved. Although the results were not statistically significant with ESL speakers, previous research has shown that making medical information in gist does improve people's understanding of medical information (Marroquín, 2022). Further research should investigate ways to improve ESL speakers understanding of medical information in gist with a bigger number of participants and in a lab controlled environment. With more effective resources, non-native English speakers, such as native Spanish speakers and those who are also ESL speakers

could better navigate the healthcare system and have a patient-centered relationship with their healthcare providers.

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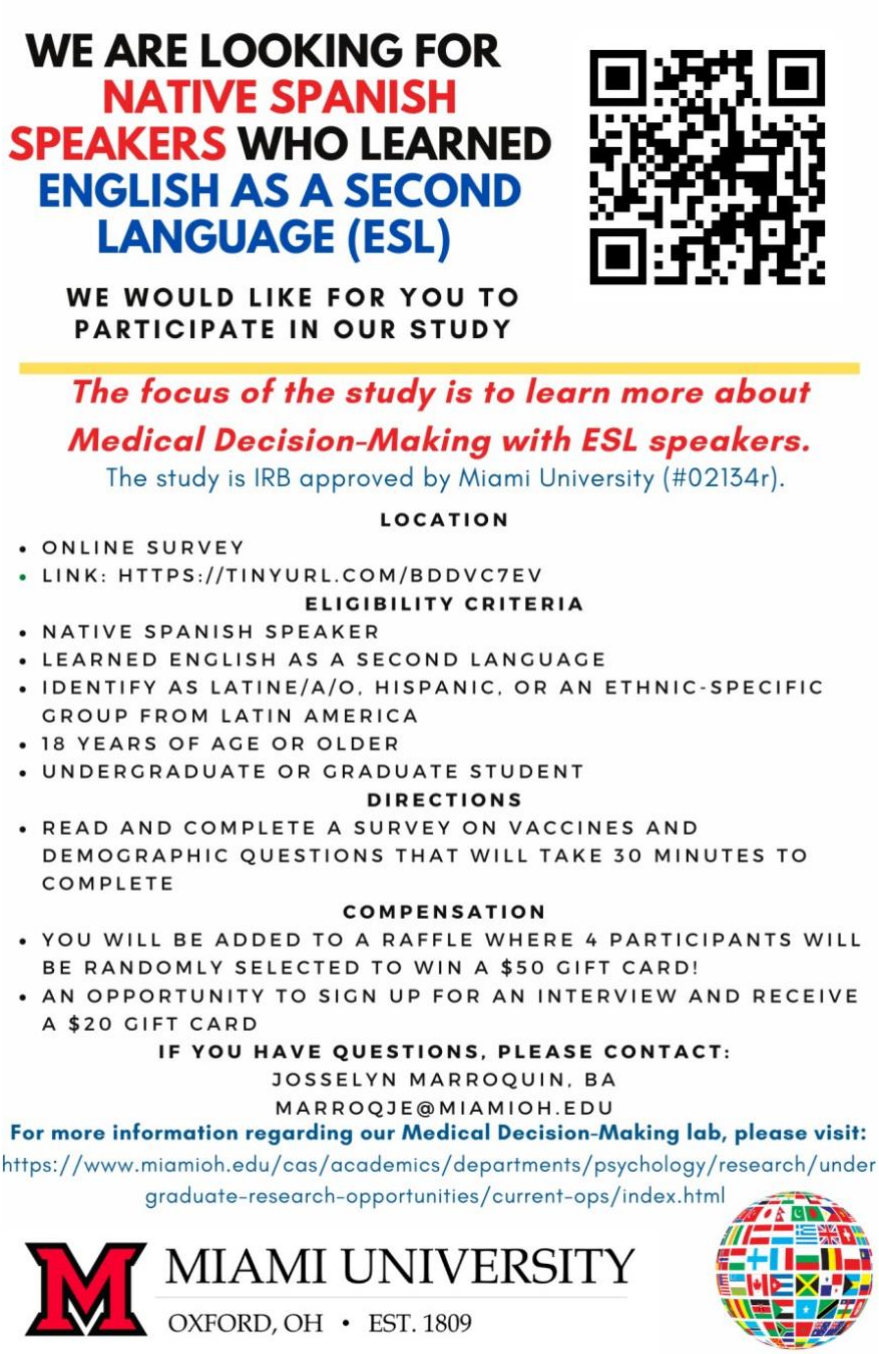
Appendices

Appendix A
Flyer

Below is the flyer for the study. The flyer provided the information to complete the online survey and was used to share on different platforms (e.g., social media, LinkedIn, and email).



Appendix B
Survey Sites
Below is the list of the universities, faculty, and sites where I shared the survey.

- California State University, Fullerton
    - Dr. David Gerkens; psychology subject pool
    - Titan Dreamers Resource Center
    - Psychology Department Student Association
    - Dr. Patricia Literte; McNair Scholars Program at CSUF
    - University Honors
- Miami University
    - Dr. Brooke Spangler-Cropenbaker
    - Dr. Christopher Wolfe
- University of Texas at San Antonio
    - Dr. Claudia Garcia-Louis
- Texas A&M University
    - Dr. Cinthya Salazar
- University of California, San Diego
    - Dr. John Wixted
- LinkedIn
- Instagram
- Twitter
- Facebook
- Research Requests

Appendix C
ESL Criteria

At the beginning of the survey, students were asked the following question. Doing so ensured those who do not fit the study's ESL criteria were excluded from the study.

1. Did you learn English as a Second Language?
    a. Yes
        i. BRANCH: Proceeds to the survey
    b. No
        i. BRANCH: Sent to the end of the survey.

Appendix D
Consent Forms
The online consent form was shown at the beginning of the survey for the psychology subject pool at CSU Fullerton.

You are invited to participate in a research study. This study aims to understand how well people understand an article. For each statement question, you will rate whether you agree or disagree with the statement, and for the multiple-choice, choose the best-fit answer. We will also ask demographic questions at the end of the study. The entire survey will take approximately fifteen to thirty minutes.

Your participation in the study is voluntary. Your responses provided today will not be associated with your identity. Your answers will be password protected on a server. Nevertheless, there is always a remote possibility that an unauthorized party could obtain your provided answers despite these safeguards. You are free to decline to answer any question that makes you uncomfortable. You need to know that you will not be judged in any way as an individual during this experiment. The data for this study are being collected anonymously. Neither the researcher(s) nor anyone else will be able to link data to you. The information for this study will be kept for a minimum of three years after the research is completed. Data will be privately stored and password protected on Google Drives and Qualtrics. IP addresses will not be collected for any of the surveys. The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous. Furthermore, your name will not be connected to the data collected during your session. The risks associated with participating in this research study do not exceed those experienced daily, such as mild discomfort related to thinking about or expressing personal opinions. Participating in this research study can provide more insight into psychological research.

This study has been approved by California State University-Fullerton's Research Ethics and Integrity (IRB), protocol number HSR-22-23-332 ESL Speakers. If you have questions about this study or the information in this form, please contact the researcher Dr. David Gerkens through email dgerkens@fullerton.edu or phone number 657-278-2553 or Josselyn Marroquin through email jossmarroquin@csu.fullerton.edu or phone number 657-278-3514.

You will receive 0.5 hours of research credit for your psychology course for completing this experiment. Participation in this experiment is voluntary. If you feel uncomfortable at any time during this experiment for any reason you may choose not to participate. Declining to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled.

If you have questions about your rights as a research participant or would like to report a concern or complaint about this study, please contact CSUF's Institutional Review Board at (657) 278-7719 or e-mail irb@fullerton.edu.

The online consent form was shown at the beginning of the survey for the psychology subject pool at Miami University.

You are invited to participate in a research study. This study aims to understand how well people understand an article. For each statement question, you will rate whether you agree or disagree with the statement, and for the multiple-choice, choose the best-fit answer. We will also ask demographic questions at the end of the study. The entire survey will take approximately fifteen to thirty minutes.

Your participation in the study is voluntary. Your responses provided today will not be associated with your identity. Your answers will be password protected on a server. Nevertheless, there is always a remote possibility that an unauthorized party could obtain your provided answers despite these safeguards. You are free to decline to answer any question that makes you uncomfortable. You need to know that you will not be judged in any way as an individual during this experiment. The data for this study are being collected anonymously. Neither the researcher(s) nor anyone else will be able to link data to you. The information for this study will be kept for a minimum of three years after the research is completed. Data will be privately stored and password protected on Google Drives and Qualtrics. IP addresses will not be collected for any of the surveys. The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous. Furthermore, your name will not be connected to the data collected during your session. The risks associated with participating in this research study do not exceed those experienced daily, such as mild discomfort related to thinking about or expressing personal opinions. Participating in this research study can provide more insight into psychological research.

This study has been approved by Miami University's Research Ethics and Integrity (IRB), protocol number #02134r ESL Speakers. If you have any questions about the experiment, feel free to contact Josselyn Marroquin via email at marroqje@miamioh.edu or Dr. Christopher Wolfe at wolfecr@miamioh.edu.

You will receive 1 hour of research credit for your PSY 112 course for completing this experiment. Participation in this experiment is voluntary. If you feel uncomfortable at any time during this experiment for any reason you may choose not to participate. Declining to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled.

If you have any questions regarding your rights as a research participant in this, or any other research conducted at Miami, please contact Miami's Research Ethics and Integrity Office (MREI) at 102 Roudebush Hall, Miami University, Oxford, Ohio 45056, telephone at 513-529-3600, e-mail at humansubjects@MiamiOH.edu.

The online consent form was shown at the beginning of the survey for students completing the survey across the US.

You are invited to participate in a research study. This study aims to understand how well people understand an article. For each statement question, you will rate whether you agree or disagree with the statement, and for the multiple-choice, choose the best-fit answer. We will also ask demographic questions at the end of the study. The entire survey will take approximately fifteen to thirty minutes.

Your participation in the study is voluntary. Your responses provided today will not be associated with your identity. Your answers will be password protected on a server. Nevertheless, there is always a remote possibility that an unauthorized party could obtain your provided answers despite these safeguards. You are free to decline to answer any question that makes you uncomfortable. You need to know that you will not be judged in any way as an individual during this experiment. The data for this study are being collected anonymously. Neither the researcher(s) nor anyone else will be able to link data to you. The information for this study will be kept for a minimum of three years after the research is completed. Data will be privately stored and password protected on Google Drives and Qualtrics. IP addresses will not be collected for any of the surveys. The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous. Furthermore, your name will not be connected to the data collected during your session. The risks associated with participating in this research study do not exceed those experienced daily, such as mild discomfort related to thinking about or expressing personal opinions. Participating in this research study can provide more insight into psychological research.

This study has been approved by Miami University's Research Ethics and Integrity (IRB), protocol number #02134r ESL Speakers. If you have any questions about the experiment, feel free to contact Josselyn Marroquin via email at marroqje@miamioh.edu or Dr. Christopher Wolfe at wolfecr@miamioh.edu.

The survey will send you to another survey where you can add your name and email address so that you will be added to a raffle where four participants will be randomly selected to win a $50 gift card for participation in the survey. Participation in this experiment is voluntary. If you feel uncomfortable at any time during this experiment for any reason you may choose not to participate. Declining to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled.

If you have any questions regarding your rights as a research participant in this, or any other research conducted at Miami, please contact Miami's Research Ethics and Integrity Office (MREI) at 102 Roudebush Hall, Miami University, Oxford, Ohio 45056, telephone at 513-529-3600, e-mail at humansubjects@MiamiOH.edu.

Appendix E
Articles
Participants were randomly assigned one of the three articles below:

Article 1. Original Low GIS Version.
Seasonal influenza vaccinations currently provide narrow protection against select strains of the virus. There are now several 'universal' flu vaccine candidates, using a variety of technologies, in Phase 2 and Phase 3 clinical trials that aim to provide broader and longer-lasting influenza protection. There are 2 main reasons why we need seasonal influenza vaccinations: 1. Strains Of Influenza Change Annually and 2. Flu Vaccine Efficacy Is Narrow And Short Lived.

The flu is primarily caused by the influenza A virus (IAV), and it can be caused by the influenza B virus (IBV). Both are enveloped RNA viruses, with IAV having several different strains. A study that analyzed patient data from Glasgow, United Kingdom from 2003 to 2013 found the prevalence of IAV and IBV to be 30% and 15% in those with respiratory illness. Both influenza virus membranes contain proteins known as hemagglutinin (HA) and neuraminidase (NA), important for entry and release (respectively) of the virus from infected cells. Other structural components of the virus, such as the RNA-binding matrix protein M1, the nucleoprotein (NP) that coats the viral RNA or the ion channel M2 protein, can be recognized by our immune systems.

We need yearly flu vaccinations due to changes in the sequence of the HA protein. Random mutations in IAV make the globular head of HA highly variable over time. This process is known as antigenic drift. Antibodies that recognize a previous strain will no longer protect against the new variant. Another mechanism of evasion by the virus is known as antigenic shift, or recombination. Recombination of 2 different strains of viruses in the same infected host can yield a completely new HA that has never been seen by our immune system. Such antigenic shifts have caused pandemic strains of influenza, such as the 2009 H1N1 outbreak. New seasonal vaccinations must be developed to provide protection against strains predicted to be common in the upcoming flu season.

The other reason annual flu vaccination is necessary is since the antibody response to current flu vaccines is quite fleeting. A systemic review and meta-analysis of various influenza vaccination studies found that vaccine effectiveness waned 180 days post vaccination compared to 15-90 days post vaccination, suggesting a fading immune response within 6 months of vaccination. Due to both variation in the virus and a temporary immune response, most influenza vaccinations have short-lived efficacy and narrow protection. The stalk, which is the domain of HA that anchors the globular head to the membrane of the virus, is relatively similar across IAV strains. This means that despite the vast number of different IAV strains, the stalk remains conserved. Conserved regions for viruses typically correspond to a preserved enzymatic activity, such as a polymerase, protease, structural features that cannot be easily changed without deleterious effects. This is why the HA stalk is a target for universal vaccine candidates. Recent research has highlighted the need to consider childhood and previous exposure to influenza and the ability to generate anti-stalk antibodies. The response of an individual to generating protective anti-stalk antibodies may be dependent on the influenza subtype that they were exposed to as a child.

One strategy to target the stalk involves a recombinant HA protein that lacks the globular head and contains only the stalk domain. The second strategy for a universal vaccine uses reverse genetics to make viruses expressing recombinant, chimeric HA proteins. These constructs typically have the same stalk (the H1 clade of widely circulating IAV strains) fused with the globular head of non-human IAV strains. Sequential vaccine doses against these chimeric HAs that share the same stalk aim to generate stalk-specific antibodies that provide universal protection against IAV. This approach suffers from the possibility that vaccine-generated stalk-specific antibodies may target regions inaccessible during an actual infection.

One advantage of the chimeric HA approach is that it has the potential to protect against novel pandemic IAV strains. If a pandemic strain ever expressed that same HA, vaccinated people would be protected from lethal infection. GlaxoSmithKline (GSK) started clinical trials of 2 different chimeric HA-based vaccines, one of which is a collaborative vaccine between GSK, Icahn School of Medicine at Mount Sinai and Duke University. This candidate completed Phase I trials in May 2020, though its fate is unknown, as it isn't listed in GSK's development pipeline. Nanoflu utilizes a quadrivalent approach, with recombinant HA from 4 IAV strains that have been predicted to circulate during the 2019-2020 season. Nanoflu successfully demonstrated efficacy in its clinical trials, demonstrating non-inferiority against the current seasonal vaccine (which is a major hurdle for Food and Drug Administration (FDA) approval), as well as generating comparable hemagglutination assay inhibition (HAI) against the 4 influenza strains.

Vaxart, Inc. is currently in Phase 2 clinical trials utilizing an adenovirus vector-based vaccine expressing the HA protein of H1N1. While it may lack strictness, a universal flu vaccine candidate, the VXA-A.1 vaccine is a proof-of-concept for the use of an oral tablet-based vaccine versus the standard intramuscular injection. Recently published data from the clinical trials suggests that the vaccine was well-tolerated and provided protection against homologous H1N1. Altimmune has generated a nasal spray-administered vaccine composed of a replication-deficient adenovirus vector expressing an H1N1 HA. NasoVax completed Phase 2a clinical trials in 2019, revealing robust antibody protection against H1N1, as well as detectable increases in mucosal antibodies, suggesting induction of mucosal immunity. There is some trepidation about nasal sprays as influenza vaccine delivery systems, with evidence pointing to reduced efficacy with FluMist, an approved nasal influenza vaccine.

Another promising candidate is a quadrivalent HA virus-like particle (VLP) vaccine from Medicago, Inc. This candidate is currently a proof-of-concept vaccine for the plant-based VLP technology, which uses plants to manufacture recombinant virus-like particles. These particles can be engineered to express HA proteins from influenza/spike (S) protein from coronaviruses, such as SARS-CoV-2. While many IAV researchers still believe that stalk-specific antibodies will ultimately be the most protective strategy, using this chimeric approach allows the immune system to develop antibodies against the non-human HA globular heads. Whether these will actually confer protection against novel IAV strains remains to be seen. Unlike most of the vaccines listed, FLU-v was designed to promote cellular (T-cell) immune responses over humoral (antibody) immunity, and demonstrated successful protection against intranasal challenge with H1N1. OVX836 induced CD4 and CD8 T-cell NP-specific responses in mice during preclinical studies, and similar results are expected from the clinical trials. Another vaccine candidate that is in Phase 2 is MVA-NP+M1, sponsored by Vaccitech.

One preclinical animal study utilized an H1N1 HA stem trimer that was stabilized and formulated into capsid-like particles. They were able to show protection in mice against heterologous challenge with a different strain of IAV 28 days post vaccination. Protection against homologous H1N1 was observed 34 weeks post vaccination. The monoglycosylated chimeric HA produced stem-specific antibodies in mice. When challenged with a panel of IAV strains, they found broad protection against the tested IAV strains.

While many of the above strategies protect against a variety of IAV strains and some even target IBV, researchers don't yet know how protective these vaccines will be in people. Dosage effects of the chimeric HA vaccines differ in mouse model experiments compared to preliminary results from human trials. Mouse models can never fully capture the immunological history of people who experience both bouts of flu and receive influenza vaccinations. Human trials are critical to test vaccine performance in people. There is a concern regarding the length of protection conferred by a universal vaccine. Most seasonal influenza vaccinations only provide a short-term period of efficacy. While influenza continues to strike every year, promising work on broadly effective vaccines may ultimately break our never-ending cycle of annual influenza vaccinations.

Article 2: Revised High GIS Version.

There are flu vaccines that protect against the different types of flu. With the advancement of technology, there are now universal flu vaccines, which can attack different strains of the flu. These results are shown in clinical trials where scientists study new tests and treatments to evaluate the vaccine's effects on human health outcomes. Even though there has been an advancement in the development of universal vaccines for the flu, more work needs to be done to improve vaccines.

There are two reasons why seasonal influenza vaccines are necessary. First, the flu changes yearly and causes severe and sudden respiratory infections that attack the nose, throat, and lungs. Second, vaccines cannot protect the body from the new strains of the flu because they are new viruses to the body. In order to understand how the flu works, it is essential to know that the flu is caused by viruses influenza A and influenza B which break down the strains in proteins. These viruses have proteins that allow the entry and exit of the viruses from infected cells.

Moreover, our immune system fights off infections depending on which kind of infection it is, with antibodies that are proteins made by the immune system. However, due to the continuous changes in the proteins, flu vaccines need to be changed yearly. For example, when a person has a strain of Influenza A, they develop antibodies specific for that strain, and where there are random mutations of the flu, protein changes over time, which is known as antigenic drift. On the other hand, the antibodies that once recognized the previous strain can no longer protect against the new strain due to recombination, which is called antigenic shift. In other words, the recombination of two different strains in the same human leads to new proteins that the immune system does not recognize. For example, in 2009, antigenic shifts caused the swine flu (H1N1) pandemic because of the changes in the flu strains that earlier vaccines could not fight. Therefore, flu vaccines should protect against new flu strains predicted to be a part of the upcoming flu season. For this reason, predicting the kinds of strains the next flu season will have will help predict the vaccines necessary to combat the flu successfully.

Another reason flu vaccines are necessary is that antibody reactions to the flu are short-term. For instance, a study found that the effectiveness of flu vaccines only lasts for six months compared to a few days after vaccination. Moreover, these results suggest that the immune system does not respond to the flu vaccines after six months of vaccination, so this means that they have short-term success in protecting against numerous strains of the flu. For this reason, it is important to study the constant change of the protein and the immune system's choice of toxic molecules.

The first approach to creating a universal vaccine is to reduce viruses. In short, suppose vaccines can help support the immune system against viruses found in proteins, which would cause less recombination and also more protection for all kinds of flu strains. The structure of proteins is similar across all Influenza. The stable regions of the viruses are due to protein activity, which is the reaction rate of a product working. These products are hard to change without damage. Therefore, the structure of the protein is a vital component to consider when creating a universal vaccine. Furthermore, studying previous exposure to the flu is necessary to know how to create antibodies. Consequently, it is essential to look at the kind of flu a person was exposed to when they were a child. So, in order to help this happen is to have a recombination of a protein because it would change the structure of the protein.

The second approach to creating a universal vaccine is to reverse the genetics of a recombination virus to a protein from different species, also known as chimeric. A chimeric vaccine is created in order to combine at least two fragments from two different sources. If-then, it would keep the original structure of the protein and protect it from a flu pandemic. Chimeric protein vaccines have antibodies that specifically aim at the protein to provide a universal vaccine treatment against the flu. Using the chimeric protein approach can protect against pandemic flu strains and can support the immune system to distinguish the kind of strain-specific antibodies needed. However, moving forward with this approach can lead to the vaccine choosing regions of the protein that have no virus. Nonetheless, looking at the different access points of the protein can help regulate where the vaccine goes to protect the antibodies and locate the virus efficiently. If a pandemic happened due to the new flu, people with the universal vaccine would be protected.

There are many pharmaceutical companies that are researching universal vaccines. One laboratory researched two different chimeric vaccines. Another laboratory did similar work where they conducted their research on older adults. They looked at the recombination of four different Influenza A strains from the flu season of 2019-2020, which had success. Moreover, other laboratories use vaccines with viruses of different illnesses in proteins. One laboratory designed an oral vaccine tablet, compared to an injection vaccine. Research showed that the vaccine had protection against the swine flu. In contrast, a laboratory created a nasal spray vaccine that has diverse immune protection against the swine flu and quickly detects mucosal antibodies interacting with mucosal immunity. Researchers advocate for antibodies to protect against the flu vaccines with specific structures. However, using the chimeric protein approach supports the immune system to form antibodies of another protein structure. There is still much work to be done to see whether these approaches work. Researchers have not targeted specific proteins because antibodies do not access this area. However, there is fear regarding the effectiveness of the first nasal spray as the flu vaccine.

Additionally, a vaccine was created by one of the laboratories with plant-based technology and another with a synthetic vaccine. The synthetic vaccine targets regions that are conserved in numerous flu strains from Influenza A and B and was created to use immune responses that attack infected cells over antibody immunity. Furthermore, a laboratory used t-cells in mice that combine proteins from Influenza A. For example, one of these studies utilized mice stems to turn into particles. In these mice, they demonstrated protection against different species with Influenza A strains a month after vaccination. Researchers also found protection against similar species eight months after vaccination. Another group used chimeric protein strains that produced antibodies in mice. However, they did find less protection against Influenza A strains already known in previous flu seasons.

Overall, companies are working to create a universal flu vaccine, but researchers are still researching how effective these vaccines are in people. For example, the dosage for vaccines in mice differs from that for humans. However, many humans have had previous flu strains, while mice do not. Consequently, human trials are much more important than animal trials. The main concern with a universal flu vaccine is the length of protection it will have against the flu. Also, most flu vaccines only last for a short period, and those in work also show similar results in short-term success. The research now is providing a way to replace old flu vaccines with more

effective vaccines to achieve a universal vaccine by constantly working on the different flu strain vaccines.

Article 3: Control Group Text.

Scientists are looking at how plants turn sunlight into sugars — a process known as photosynthesis — as a model for cleaner ways to produce energy for people and industry. Their research even suggests ways people can help plants photosynthesize more efficiently.

Photosynthesis comes as naturally to plants as breathing does to people. This process converts the simple ingredients of carbon dioxide, water and sunlight into energy. Photosynthesis allows plants to grow. In turn, we rely on photosynthesis as the foundation for our life on Earth.

Carina Baskett recalls the first time she learned about photosynthesis. She says, "I remember feeling like, this seems so magical." She's now a plant biologist at the Institute of Science and Technology Austria in Klosterneuburg. "It's just so amazing that plants are taking air, water and light — things we walk around in, all the time — and they're turning that into energy and food for the whole world."

Sunlight can trigger a reaction in green plants. Its energy splits the water molecules in leaves into hydrogen and oxygen atoms. The plant then uses that hydrogen to react with carbon dioxide, to form sugars — a type of food and fuel.

The sun's energy makes us feel warm when it hits our bare skin. But when sunlight touches the leaves of a plant it does more. It powers a chemical reaction that converts one type of energy into another. Those plant leaves contain plenty of water. That water is made of oxygen atoms bonded to hydrogen atoms. The sun's energy can excite electrons inside the water molecule enough that the bonds split. This triggers a reaction "that takes the oxygen away from the water. And that becomes the oxygen in the air that we all breathe," explains Baskett. Meanwhile, she notes, "Hydrogen from the water gets smushed together with the carbon dioxide [in air], and that makes sugar."

People and all other animals use this sugar — glucose — as an energy source from food. Plants become the food that our bodies can convert into energy. Essentially, photosynthesis is the reason we can exist, Baskett explains.

It's no mystery why photosynthesis fascinates her and other scientists. Many of them now want to know more about it, imitate it — even improve upon it.

The basics of photosynthesis are well-known. Chlorophyll, the green pigments in plants, use sunlight to make sugars. But there's still a lot to learn about how plants control the process and its efficiency. Enter Avihai Danon. He's a plant biologist at the Weizmann Institute of Science in Rehovot, Israel. He studies how plants regulate, or control, photosynthesis. In a paper published last year in iScience, his team described one such process. He describes it as plants "blinking."

Scientists at the University of Cambridge are working to create a type of solar fuel that's made from natural, rather than synthetic, chemicals. The catalyst they use comes from a plant.

"Too much light can actually burn the plant's cells," says Danon. He compares a plant exposed to too much light to a person playing with electricity. "If suddenly there is a rise in light level,

how do they handle it? Do they get burned?" Any gardener knows plant species are adapted to live in particular amounts of sunlight. But light conditions naturally change. Clouds travel across the sky, wind ruffles leaves and the sun's position moves throughout the day. To study how photosynthesis adjusts to these changes, Danon studied mustard plants in his lab under low light.

In one test, he increased the light's intensity every 10 minutes. This was to mimic the rising sun. As the light changed, Danon measured the plant's fluorescence (Fluor-ESS-ents). This is a form of light energy released by photosynthesis. Measuring the fluorescence helped Danon see how much photosynthesis occurred under different levels of light.

As the day brightened, Danon expected to see a steady increase in photosynthesis. Instead, the pattern resembled more of a flicker. Photosynthesis would slow way down, and then bump back up a little. Down, and then up. Again and again, little by little, it adjusted to the strengthening light. "It's taking a better-be-safe-than-sorry approach," Danon explains. The plant was anticipating the worst conditions, he says, before adjusting to the actual changes.

Danon couldn't help but draw a comparison to how human eyes respond to sudden, bright sunlight. When we step outside on a sunny day, our pupils constrict. That response protects our eyes from damage while making sure we still can see important things around us.

Plants can't move, so their "blinking" helps protect them from burning or bleaching when they are in bright sun. A plant's light gauges — you can think of them as antennae — register when light levels change. These antennae shrink, and in the process reduce photosynthesis. This shrinking also protects them from sudden changes that might damage the entire plant. Danon is inspired by what plants can do. "If plants have developed this type of very sophisticated response, and they are successful for hundreds of millions of years, maybe it can help us in our own engineering," he says.

Scientists have already begun copying, or mimicking, photosynthesis. Their artificial processes also use light to split oxygen and hydrogen — for energy. The dream is to eventually replace fossil fuels. If people could make energy from sun, air and water — as plants do — it would cut down on planet-warming releases of carbon dioxide. It also could create a huge new source of renewable energy.

Many researchers look to solar fuels — fuels made from sunlight — as "green" replacements for today's carbon-based fossil fuels. These include oil, gas and coal.

Solar fuels can take many forms. They might look like traditional carbon-based fuels, using carbon dioxide to "recycle" emissions from fossil fuels. Hydrogen and oxygen, the chemical products of photosynthesis, can power fuel cells that allow cars to run on electricity. Also, solar energy can convert sunlight into electricity that could be stored in batteries. No matter what form solar fuels take, the first step is splitting water into its elemental building blocks.

"Nature has this power," explains Julien Warnan. He's a chemist working with Erwin Reisner on solar fuels at the University of Cambridge in England. Nature has had a lot of time to figure out how to do this efficiently, he notes. When it comes to splitting up water's building blocks,

engineers are “a bit more limited,” he says. “Everyone is trying to develop different tools to do it.”

Researchers at the University of Cambridge in England engineered a semi-artificial form of photosynthesis in the lab. One of their setups, shown here, used light to split water into oxygen and hydrogen. That hydrogen can be used as a fuel to run vehicles, as a feedstock for industrial processes and more.

Last year in the journal Nature Energy, Warnan’s team described a new way to use sunlight to split water. The idea, Warnan explains, “is to take water and air and put that together in a box.” Then you add a catalyst. This is some material that can trigger chemicals to react. Later, he says, “You shine light on this box. And what comes out is fuel — like what you put in your car or a plane.”

Scientists around the world are experimenting with devices — think of them as artificial leaves. Like the processes in leaves, they split water into hydrogen and oxygen. Warnan’s team wasn’t the first to do it. But they did it with a different type of catalyst. It’s the same one that a plant uses to jump-start a chemical reaction.

They extract that catalyst from a plant, rather than creating it from chemicals in a lab. That means fewer harsh chemicals would go into making their solar fuel. But more work is needed before people can produce a solar fuel from water as easily as plants can.

“The great power of the plant is that it can always regenerate and replenish [the catalyst] if it breaks down,” says Warnan. “We cannot.” This type of solar fuel, therefore, “is still very expensive,” he points out.

Appendix F
Gist Comprehension Questions
Participants were asked to read the statements and agree or disagree with the statements. The instructions were listed once at the beginning of this section.

Please read the following statements. Rate how much you agree or disagree with each statement. One being "strongly disagree" and seven being "strongly agree":

1 2 3 4 5 6 7

1. The flu is caused by viruses that break down the strains in proteins.
2. Seasonal influenza vaccines are necessary because any existing flu vaccines cannot combat new viruses.
3. R(reversed score) The flu is caused by viruses that build up the strains in proteins.
4. R(reversed score) Seasonal influenza vaccines are no longer necessary because the flu has stabilized markedly.
5. R(reversed score) Seasonal influenza vaccines are no longer necessary because all of the existing flu vaccines effectively combat new viruses.
6. The immune system works by recognizing the structure of the virus.
7. Flu vaccines typically only last for six months.
8. The immune system is only able to fight off viruses within six months of getting a flu vaccine, which is why a universal flu vaccine is essential.
9. Vaccines are created to fit the specific structures of viruses to combat them.
10. We need a universal influenza vaccine for long-term protection against the flu.
11. According to researchers, even if a universal influenza vaccine was created the vaccination would have short-term effects.
12. If a specific influenza strain from a previous virus is used in a vaccine, it will not help combat the upcoming flu.
13. The human immune system creates specific antibodies that attack the flu.
14. A universal flu vaccine is hard to create because it would only last for a short-term period.
15. Oral-based influenza vaccines protect against the flu.
16. New flu vaccines are needed because old flu vaccines are short-term.
17. R(reversed score) Flu vaccines do not target influenza A and influenza B.
18. R(reversed score) Flu vaccines are harmful to the human body.
19. Proteins undergo recombinations of previous viruses to protect against the flu.
20. R(reversed score) Previous flu seasons have not led to the swine flu.
21. By predicting what kind of influenza strains will be present in the upcoming flu season, researchers can help predict a vaccine that attacks the upcoming influenza strains.
22. A universal vaccine would protect against new strains of influenza by having previous flu strains in the vaccine that protect against previous influenza strains.
23. The passage was easy to read.
24. Flu vaccines are not widely accepted.
25. I would recommend the reading to a friend/family member.
26. The reading helped me understand universal flu vaccines.

27. I understand the universal flu vaccine process.
28. I felt confident in universal flu vaccines.
29. I could never get a universal flu vaccine.
30. This passage was political.

Appendix G
Verbatim Multiple-Choice Questions
Participants were asked to read the questions and choose one answer from four multiple-choice answers. The answers in bold are the correct choice.

1. Why does the flu change yearly?
    1. **Due to antigenic drift and shift**
    2. Flu mutations
    3. Pharmaceutical drugs that alter human proteins
    4. The flu doesn't change
2. In 2009, what kind of influenza A subtypes caused the swine flu due to antigenic shifts?
    1. H1N4
    2. **H1N1**
    3. H1N3
    4. Influenza A did not cause the swine flu
3. Why do we need annual flu vaccines?
    1. **Due to changes in the proteins**
    2. Due to changes in the weather
    3. Due to changes in antibodies
    4. Due to changes in the immune system
4. It is important to know the kind of flu people were exposed to when they were
    1. An adolescent
    2. Sick
    3. **Children**
    4. Around sick people
5. To be protected from the flu, antibodies need to be produced through the
    1. **Recombination of the proteins**
    2. Recombination of the virus
    3. Recombination of the flu
    4. Recombination of the vaccine
6. How often does the flu change?
    1. Monthly
    2. **Yearly**
    3. Every 5 years
    4. Does not change
7. Flu vaccines are short-term because
    1. They only last six months after vaccination
    2. Antibodies no longer respond to the vaccine after eight months
    3. The immune system declines over time
    4. **Flu viruses change quickly**
8. Researchers used vaccines with t-cells on mice to test how influenza A virus
    a. Protects against influenza

b. Does not protect against influenza
c. Can only work on mice and not humans
d. Needs the influenza B virus to work

9. Antibodies reactions to the flu
a. Only last six-months
b. Only lasts a year
c. Only last nine-months
d. Only last seven-months

10. What option is the best approach to combating the flu?
a. Getting a flu vaccine
b. Getting a nasal-spray vaccine
c. Getting an oral-based vaccine
d. Getting natural immunity

11. Researchers tested chimeric protein vaccines on mice and found that
a. They quickly got sick and died
b. The vaccine provided short-term effects
c. The vaccine did nothing to the mice
d. There was less protection against influenza A

12. How many influenza A virus strains underwent recombination from the flu season 2019-2020 research?
a. 1
b. 2
c. 3
d. 4

13. The nasal-spray vaccine detects
a. Mucosal antibodies
b. Neutralizing antibodies
c. Variant antibodies
d. IgA antibodies

Appendix H Health Literacy Questions

Below are the questions that were used to assess health literacy, which are from Appendix 1 from Chew et al. (2004).

Appendix 1

All 16 Health Literacy Screening Questions

1. How often are appointment slips written in a way that is easy to read and understand?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
2. How often are medical forms written in a way that is easy to read and understand?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
3. How often are medication labels written in a way that is easy to read and understand?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
4. How often are patient educational materials written in a way that is easy to read and understand?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
5. How often are hospital or clinic signs difficult to understand?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
6. How often are appointment slips difficult to understand?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
7. How often are medical forms difficult to understand and fill out?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
8. How often are directions on medication bottles difficult to understand?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
9. How often do you have difficulty understand written information your health care provider (like a doctor, nurse, nurse practitioner) gives you?
   (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
10. How often do you have problems getting to your clinic appointments at the right time because of difficulty understanding written instructions?
    (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
11. How often do you have problems completing medical forms because of difficulty understanding the instructions?
    (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
12. How often do you have problems learning about your medical condition because of difficulty understanding written information?
    (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
13. How often are you unsure on how to take your medication(s) correctly because of problems understanding written instructions on the bottle label?
    (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never
14. How confident are you filling out medical forms by yourself?
    (1) Extremely (2) Quite a bit (3) Somewhat (4) A little bit (5) Not at all
15. How confident do you feel you are able to follow the instructions on the label of a medication bottle?
    (1) Extremely (2) Quite a bit (3) Somewhat (4) A little bit (5) Not at all
16. How often do you have someone (like a family member, friend, hospital/clinic worker, or caregiver) help you read hospital materials?
    (1) Always (2) Often (3) Sometimes (4) Occasionally (5) Never

Appendix I Demographic Questions

Participants were asked about their demographics using the following questions.

1. What is your current gender identity? *Note: cisgender = gender identity aligns with biological sex assigned at birth.
    1. Cisgender* Woman
    2. Cisgender* Man
    3. Gender Queer/Gender non-conforming/Gender Fluid
    4. Non-binary/agender
    5. Transgender Woman
    6. Transgender Man
    7. Prefer to self-describe/Not listed
        1. [self-describe]
    8. Prefer not to say
2. Age?
    1. [self-describe]
3. Which of the following best represents your racial heritage? Select all that apply.
    1. Black, African American
    2. Afro-Caribbean and/or Afro-Latine/a/o
    3. Latine/a/o (Central and/or South) American
    4. East Asian
    5. South Asian and/or Indian
    6. Southeast Asian
    7. Arab American, Middle Eastern, and/or North African
    8. Native American, American Indian, Native Alaskan, and/or Indigenous
    9. Native Hawaiian and/or Pacific Islander
    10. White
    11. European American, and/or European
    12. Not listed (What is your racial heritage?)
        1. [self-describe]
    13. Mixed ethnicity (Fill in your mixed ethnicity)
        1. [self-describe]
4. Do you identify as Latine/a/o, Hispanic, or an ethnic-specific group from Latin American?
    1. Yes (If yes, what is your ethnic heritage?)
        1. [self-describe]
    2. No
5. What is What is your grade level?
    1. First year/Freshman
    2. Second year/Sophomore
    3. Third year/Junior

4. Fourth year/Senior
5. Graduate student

6. Are you an international student?
    1. Yes (If yes, from what country?)
        1. [self-describe]
    2. No
7. Are you a first-generation college student?
    1. Yes
    2. No
8. Is English your first language (that you spoke growing up)?
    1. Yes
    2. No (If no, what is your first language?)
        1. [self-describe]
9. At what age did you learn English?
    1. [self-describe]
10. How do you rate your own ability to read English?
    1. Terrible
    2. Poor
    3. Average
    4. Good
    5. Excellent
11. Have you taken an English as a Second Language (ESL) course?
    1. Yes
    2. No
    3. I am currently taking an ESL course.

Appendix J
Debriefing
The online debriefing was presented at the end of the survey for the participants in the psychology subject pool at Miami University.

Thank you for your participation in this experiment. The goal of this study was to see how the article you read influenced your understanding of the article based on how you answered the multiple-choice and statement questions. Other participants got a different article than the one you read but received the same questions. By having various participants read additional articles and answer the same questions, we will compare results. Due to the study being ongoing, please do not discuss the specifics of the study with anyone. Your participation is greatly appreciated by the researchers involved.

If you have questions about this study, please contact Dr. Christopher Wolfe (Psychology Professor) at wolfecr@miamioh.edu or Josselyn Marroquin (Graduate Student) at marroqje@miamioh.edu. If you have any questions regarding your rights as a research participant in this or any other research conducted at Miami, please contact Miami's Research Ethics and Integrity Office (MREI) in 102 Roudebush Hall, Miami University, Oxford, Ohio 45056, telephone 513-529-3600, email humansubjects@MiamiOH.edu.

The online debriefing was presented at the end of the survey for the participants in the psychology subject pool at CSU Fullerton.

Thank you for your participation in this experiment. The goal of this study was to see how the article you read influenced your understanding of the article based on how you answered the multiple-choice and statement questions. Other participants got a different article than the one you read but received the same questions. By having various participants read additional articles and answer the same questions, we will compare results. Due to the study being ongoing, please do not discuss the specifics of the study with anyone. Your participation is greatly appreciated by the researchers involved.

If you have questions about this study or the information in this form, please contact the researcher Dr. David Gerkens through email dgerkens@fullerton.edu or phone number 657-278-2553 or Josselyn Marroquin through email jossmarroquin@csu.fullerton.edu or phone number 657-278-3514. If you have questions about your rights as a research participant or would like to report a concern or complaint about this study, please contact the Institutional Review Board at (657) 278-7719 or e-mail irb@fullerton.edu.

The online debriefing was presented at the end of the survey for the participants not in any psychology subject pool.

Thank you for your participation in this experiment. The goal of this study was to see how the article you read influenced your understanding of the article based on how you answered the multiple-choice and statement questions. Other participants got a different article than the one you read but received the same questions. By having various participants read additional articles and answer the same questions, we will compare results. Due to the study being ongoing, please

do not discuss the specifics of the study with anyone. Your participation is greatly appreciated by the researchers involved.

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