

AN EVALUATION OF BARRIERS TO EFFECTIVE COMMUNICATIONS AND  
LEARNING FOR INFORMATION RELATED TO  
ENVIRONMENT, HEALTH AND SAFETY

A Dissertation

by

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## ABSTRACT

Environment, Health & Safety (EHS) procedures and training are used by global industries to mitigate risks and are often provided in a lingua franca. This research, investigated strategies for overcoming language barriers associated with procedure performance, hazard comprehension, and training effectiveness. Written procedures were tested using SecondLife® to explore effects of native language on procedural performance and safety statement adherence. Additionally, non-linguistic (NAPO) and English language (ENG) versions of EHS training were compared for effectiveness with native English language participants (L1), non-native English language participants (L2), and non-English language participants (L0).

First, 54 participants completed procedures under time pressure and were scored according to performance and hazard comprehension. Analysis showed differences between L1 & L2 performance (specifically L2 Females), although no meaningful language fluency or hazard comprehension differences were observed. Results suggest the lower performance of L2 was not due to English proficiency, but rather time pressure. Implications of lingua franca procedures are not fully understood particularly regarding gender.

Second, 102 L1 & L2 US employees completed either the NAPO or ENG training and were assessed on their reaction to and comprehension of the training (sensory modality was also measured). Results show that ENG was more effective and preferred by both language groups. These results may be due to the workers' English proficiency and the number of channels of communication provided by the training medium.

Third, 78 L0 Brazilian and Chinese employees completed trainings and were assessed identically to the 2<sup>nd</sup> study. Results showed NAPO training was more effective and preferred by

both groups likely because ENG L0 trainees had no channels for processing the information versus NAPO's single channel of information. Interestingly, ENG Brazilians outperformed Chinese counterparts—possibly due to the commonalities of Romance languages (Portuguese) and English. Conversely, NAPO Chinese outperformed NAPO Brazilians, perhaps due to the logographic nature of the Chinese language. Though participants preferring kinesthetic learning had lower preference ratings than others, they did not prefer one training over another and their modality preference had no effect on performance.

This research provides important implications regarding the use of single language procedures and training in multi-lingual workforces.

## DEDICATION

Dedicated to:

My mother, Keiko, from whom I learned “Ganbatte!” (頑張つて) which translated from Japanese, means “Try your best!” Who instilled in me that no matter the outcome, the effort is what matters most.

My father, Bill, from whom I learned “Where there’s a will, there’s a way” and that through hard work, perseverance and dedication anything is possible.

My brother, John, whose unconditional loyalty and friendship I have always relied.

My children, Mallory, Maya, and Jake, whose patience, support, and understanding have softened the guilt I carry from missing some of their special moments. They are always in my thoughts and ever present in my heart.

My wife, Marcie, the greatest partner I could have ever hoped, whose love, devotion, and encouragement have carried me through life’s adversities and with whom I am dedicated to share a lifetime of happiness.

Gig ‘em!

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## NOMENCLATURE

A	Auditory
ANOVA	Factorial Analyses of Variance
BR	Rio de Janeiro, Brazil
CN	Guangzhou, China
CNC	Computer Numerical Control Lathe
EHS	Environment, Health and Safety
ENG	Lingual GHS Training (English)
EU-OSHA	European Union Agency for Safety and Health at Work
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
HCS	Hazard Comprehension Scores
HF	Human factors
IRB	Texas A&M University's Institutional Review Board
K	Kinesthetic/Tactile
L1	Native English language participants
L2	Non-native English language participants
L0	Non-English language participants
LMS	Learning Management System
LOTO	Lockout/Tagout
M	Multi-Modal of Multiple Sensory Modality Preferences
NAPO	Non-lingual GHS Training

OHC	Overall Hazard Comprehension
OPP	Overall Procedure Performance
OSHA	United States Occupational Safety & Health Administration
PPS	Procedure Performance Scores
RMANOVA	Mixed repeated measure analysis of variance
SDS	Safety data sheets
SL	SecondLife®
SMP	Sensory Modality Preference
TOEFL	Test of English as a Foreign Language proficiency measure
TSS	Training Satisfaction Score
UNECE	United Nations Economic Commission for Europe
US DOL	U.S. Department of Labor
V	Visual
VAK	Visual-Auditory-Kinesthetic/Tactile
WBT	Web-based training
$\Delta T$	Performance Difference from Pre-Test to Post-Test

## DEFINITIONS

**Cross-linguistic Transfer Theory** - Proposes that individuals use the linguistic knowledge of a language with which they are proficient to leverage the learning of another language.

**Dual-Coding Theory** - Postulates that there are two separate channels (auditory and visual) for processing information.

**Kirkpatrick's Four-Level Training Evaluation Model** – A four-Level model to evaluate training comprised of: (1) reaction, (2) learning, (3) behavior, and (4) results.

**Richard Mayer's Cognitive Theory of Multimedia Learning** - Postulates that individuals are only capable of processing a finite amount of information, per channel (auditory or visual), at any given moment, and that comprehension of information is achieved through the creation of mental representations.

**Visual-Auditory-Kinesthetic/Tactile (VAK) Learning Style Model** - Postulates that individuals have preferred or dominant tendencies toward either visual, auditory and/or kinesthetic/tactile learning style(s).

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## INTRODUCTION

### **Purpose**

The purpose of this research was to investigate strategies for overcoming the challenges associated with multiple language workplaces/organizations and Environmental, Health, and Safety (EHS) communications (*e.g.*, written operating procedure performance, hazard warning comprehension, and training effectiveness). The first study in the series analyzed language barriers associated with procedure performance and comprehension of hazard warning statements/symbols. The second and third studies investigated the efficacy of non-lingual web-based safety learning to bridge language, geographical, resource, literacy, cultural, and/or generational gaps. The results of the studies provide public health and EHS professionals' insight into occupational language barriers and the potential use of hazard warning statements and non-lingual training as convenient, economical, and effective tools for promoting safe behavior around the world by overcoming language, literacy, and cultural barriers.

### **Background**

Highly publicized EHS disasters, such as the Bhopal Union Carbide methyl isocyanate release, the Deepwater Horizon drilling rig explosion, the Texas City BP (British Petroleum) refinery explosion, and the West Texas Fertilizer Plant explosion are reminders of the hazards associated with many industrial, chemical, and other high risk processes (Jones, 2015; Laboureur, Han, Harding, Pineda, Pittman, Rosas, Jiang & Mannan, 2016; Dahle, Dybvig, Ersdal, Gulbrandsen, Hanson & Tharaldsen, 2012). The potential for harm to human health and the environment necessitates the highest levels of management being actively involved in EHS management (United States, 2011). In fact, studies have shown that where senior leadership play

a pivotal role in supporting EHS, incident rates are lower (Fruhen, Mearns, Flin & Kirwan, 2014). Leadership can promote robust risk management practices through the implementation of standardized procedures and training that help workers to identify hazards, effectively perform tasks, and to safely complete their jobs (Steege, Boiano, & Sweeney, 2014; Amalberti, Vincent, Auroy & Maurice, 2006). Consequently, globally, organizations are spending considerable time, money, and technical resources delivering EHS documentation and training to an increasingly diverse workforce. As businesses seek greater workforce diversity, barriers related to geography, culture, language, literacy, disability, and age are adversely impacting communication, safety, and thus EHS documentation and training efficacy (Rana, 2013). Of particular concern to providing effective EHS documentation and training are the challenges related to language and literacy (Paul, 2013; Lindhout, Swuste, Teunissen & Ale, 2012; Arcury, Estrada & Quandt, 2010) given that ineffective EHS documentation and training can result in the failure of workers to protect human health and the environment (Cheng & Wu, 2013; Lindhout, Swuste, Teunissen & Ale, 2012).

Standard operating procedures are one method of supporting safe work and are typically composed of written steps that instruct people regarding how to complete a task (Peres, Quddus, Kannan, Ahmed, Ritchey, Johnson, & Mannan, 2016; Peres, Mannan, Quddus, 2016). As such, these procedures are a communications tool that should be easily understood, well written, and use terms or languages that are common to users within that industry. Comprehension of this common terminology and language has been found essential for workers if they are to correctly follow the procedures (Wold & Laumann, 2015). The development of effective procedures that are comprehended by a wide group of workers can be complicated for high-risk industries that operate worldwide with international crews coming from various nationalities and cultures. As a

result, companies use many strategies to deal with multi-language workplaces/workforces.

Although not all are necessarily explored in the current series of studies, the following is a list of a few of the other common types of interventions practiced within industry:

- **Lingua Franca:** Mandating the use of or only hiring employees that are proficient in a common language.
- **Interpreting:** Using bilingual professionals or colleagues to interpret information.
- **Translating:** Having materials translated into multiple languages.
- **Grouping (Patron):** Minimizing language barriers by organizing workers into groups of common language speakers/nationalities that are guided by a bilingual leader.
- **Language Education:** Providing learning opportunities for employees to learn an official language as a second language.
- **Visual Aids:** Using pictures to communicate.

Paul (2013) did a summary of major issues regarding training for international companies. They report that interpreting and translating have long been used in businesses and provides a means to effectively communicating to linguistically heterogeneous groups, however, it can be costly and time-consuming (Paul, 2013). Grouping is effective for small or tight-knit work groups but has limitations as groups grow larger. Additionally, with all three of the interventions mentioned above, communication effectiveness relies on an interpreter and in the case of grouping, lies almost exclusively on a bilingual leaders' interpretation and/or interpersonal conflicts. Language education is a good long-term solution, but takes time, money, and effort on the part of the student to be successful (Paul, 2013).

An extremely concerning intervention is a common practice in industry to provide safety material, including procedures in a lingua franca or common language, which is often the language most prevalently spoken in the country in which the employees are located. In many cases, this practice ignores the fact that employees may not be proficient in the chosen lingua franca leaving them vulnerable to not understanding, misunderstanding or missing critical written and spoken communications. This communications gap is especially troubling in EHS where the consequences can be fatal or disastrous. Predominantly, most multinational companies use English as their lingua franca (Melitz, 2016). Ostensibly to establish common terminology, many companies mandate some level of English proficiency and have their procedures written exclusively in English. However, in practice, this may be more of a cost savings effort as there are few documented studies regarding the difficulties this may pose to non-native English readers—even though these difficulties may seem obvious on the face of it. Due to the critical nature of EHS communications, a failure of any of these intervention methods to sufficiently inform, could result in a compromise to safety leading to losses, injuries or death. As such, there is a need to understand how performance and comprehension with procedure and training programs might differ for those who are working with English as their native language (L1) versus those working with it as their non-native language (L2) or that are non-English language users (L0) altogether.

Previous research has identified differences between those reading in their native language (L1) and those who adopt and read in additional languages later in life (L2, L3, etc.). Rai, Loschky, and Harris found that for L1 people, reading in their native language is a highly automated skill with low cognitive demand (2015). Additional findings relate time stress and working memory to the experiences of L1 and L2 readers. For instance, the higher people's

reading ability, the more likely they will have high working memory span in terms of processing and storage capacity (Rai, Loshky, Harris, Peck & Cook, 2015). So, for L1 readers, lower-level language processes such as lexical access and parsing are considered to consume fewer cognitive resources than in L2 readers (Morishima, 2013; Erçetin, 2015). This could have implications for L2 readers' performance in high stress environments as they would have fewer cognitive resources available. Although some studies have concluded that mild stress levels can result in improved comprehension rates and increased reader mindfulness for L2 readers (Walczyk, Kelly, Meche & Braud, 1999), most studies have shown that high psychosocial stress creates anxiety with a negative effect on the accuracy of L2 readers more so than L1 readers (Rai et al., 2015). People can experience this type of stress when under time pressure to complete tasks and this type of situation occurs regularly in high-risk industrial settings.

In the U.S., global training expenditures are estimated to be anywhere between \$130 billion to \$307 billion and like standard operating procedures, EHS training comprehension is also a challenge in multilingual workplaces (Bersin, 2014; ASTD, 2012; Howard, 2014). Interventions to address barriers, such as, translating training materials can be costly and implementation of a lingua franca risks alienating or overlooking employees that do not grasp the lingua franca or comprehend it as a second language. The U.S. Department of Labor (US DOL) considers the remediation of language/literacy barriers resulting in safety and health documentation and training challenges of such critical importance to public health that they issued a memorandum to all of its Regional Administrators reiterating their policy that employers must instruct employees in a language or vocabulary that they can understand (Michaels, 2010). Additionally, the U.S. Occupational Safety & Health Administration (OSHA)

has established special programs and grants dedicated to funding and addressing EHS documentation/training and language/literacy barriers (USOSHA, 2017).

One strategy to overcoming these barriers may be using non-linguistic means of EHS training. The European Union Agency for Safety and Health at Work (EU-OSHA) has developed non-linguistic programs to address the bridging of language and safety content, such as NAPO. NAPO is the hero in a series of animated language-free films that EU-OSHA claims allows people of all backgrounds, cultures, and ages to understand featured safety topics (EU-OSHA, 2018). Globally, the UN has adopted the "Globally Harmonized System of Classification and Labelling of Chemicals (GHS)" that addresses classification of chemicals by types of hazard and proposes harmonized hazard communication elements, including labels or pictograms. These GHS pictograms are intended to provide information on physical hazards and toxicity from chemicals, to culturally and linguistically diverse populations, in order to enhance the protection of human health and the environment during their handling, transport, and use (UNECE, 2018). Given the increased global attention to non-linguistic means of communications, it is of vital importance to understand if non-linguistic EHS documentation and training might effectively deliver information and facilitate learning globally to a diverse workforce.

Though training and procedures are considered key to risk reduction, incident avoidance, and hazard communication, many companies and policymakers have neglected to consider whether, and if so how, training and procedures may need to differ in multilingual work settings. A recent study concluded that incorrect operating procedures contribute to foreign worker injuries and that "enhancing employers' responsibility to educate and manage foreign workers, ... translate teaching materials and ... establish a standard operating procedure ... can effectively

reduce occupational risks encountered by foreign workers and ensure their safety during working operations.” (Cheng & Wu, 2013). However, with the increasingly global workforce, methods for effectively following these recommendations is clearly difficult in work settings. For instance, a study conducted in the E.U. states the “...number of languages in work settings is slowly becoming so large that, in practice, a common language everyone can speak may no longer exist.” In fact, the researchers indicated that shop floors where employees are speaking 10 or more languages was “no longer exceptional”. As with the previous study, the research identified an “absence of specific risk-control measures in multilingual workplaces”, despite resulting damages and injuries (Lindhout et al., 2012). This clearly indicates the need for better risk-control methods for addressing multilingual workplaces.

Given that the impact of language barriers on effective communications is a well-recognized challenge in the modern workplace, many tactics have been employed to try and overcome these barriers. A detailed literature search indicated that while there is a plethora of research published about language barriers within the workplace (Deczkowska, 2017; Madera, Dawson & Neal, 2014; Piekkari, D. Welch & L. Welch, 2014; Blume & Board, 2013; Paul, 2013) and a fair number of studies regarding language barriers and occupational safety (Bust, Gibb, & Pink, 2008; Campbell, Duguay & Lecoindre, 2010; .De Jesus-Rivas, Conlon & Burns, 2016; Kalaroa, 2004; Lin, Migliaccio, Azari, Lee & De la Llata, 2012; Schulte, 2002; Starren, Hornikx & Luijters, 2013; van Rosse, de Bruijne, Suurmond, Essink-Bot & Wagner, 2016; Viveros-Guzmán & Gertler, 2015; Wallerstein, 1992; Wilkins, Chen & Jenkins, 2014), few have focused on the quantitative and qualitative efficacy of non-linguistic safety communications.

For instance, although studies exist regarding the effective use of *static* icons and symbols to overcome communication barriers (Patton, Griffin, Tellez, Petti & Scrimgeour, 2015;

Zender, 2006; Zender, 2014), these studies were unstructured, informal and focused on icon design rather than non-lingual training effectiveness. Furthermore, there were no published studies identified, examining the efficacy of non-lingual *animated* safety training to overcome communication barriers. It is easily conceivable that this type of training may be particularly relevant for employees with language, literacy, and hearing deficits and this potential benefit has not been previously explored empirically. Another group that may benefit from non-lingual, animated training are those of a younger generation as the attractiveness of visual aids or images to this group of workers who have come to rely on emoticons, Snapchat®, Instagram®, and Pinterest® as popular means of daily communication (Tapp, 2015; Barnes, Marateo & Ferris, 2007; Carlson, 2005). A potentially attractive feature of non-linguistic training could be for those who consider themselves “visual learners.” The idea of individual learning styles is widely accepted in educational practice (Coffield, Moseley, Hall, & Ecclestone, 2004) with the most common modalities being visual, auditory or kinesthetic/tactile. Advocates of sensory modality preferences believe that learning is enhanced for individuals when their preferred modality is incorporated into their training. Still others support the notion that learning preference differences exist between the generations (Cekada, 2012; Ivanova & Ivanova 2009; Deeken, Webb & Taffurelli, 2008). Regardless of the attractiveness of the relationship between content delivery and learning differences and the wide spread acceptance of sensory modality preferences by Educators, the academic evidence regarding the impact of learning styles on learning is equivocal at best with most research showing no evidence of an effect (Arbuthnott & Krätzig, 2015; Lodge et al., 2016). As with many educational settings, sensory modality preferences are also widely accepted by Industry/EHS Trainers, therefore to explore the relevance of modality for EHS content, it is necessary to measure employees’ performance as

well as assess their sensory modality preference to identify if these preferences are associated with simply preferences for the different types of training or actual performance differences.

In summary, due to globalization and cost reduction efforts, one of the common practices for global businesses is to provide employees worldwide with documentation and training in a common language or Lingua Franca. Further with the spatial and temporal convenience of delivering content electronically, shared cloud files and web-based training (WBT) have emerged as practical tools for efficiently delivering EHS content worldwide. Additionally, due to the cost and inconvenience of language translation, many EHS documents and most of the globally available EHS WBT content is limited to languages, such as English, Spanish, and French. However, little is known about the impact of these methods and policies for delivering EHS content and training. With native language EHS documentation and training often unavailable to vulnerable workforces, research is necessary on whether non-linguistic means of communication, such as symbols or animation, can provide convenient global access to EHS content while overcoming language, literacy, cultural, hearing, learning preference, and/or generational barriers.

### **Approach**

For Study 1, there was no experimental manipulation but instead participants from two different language groups (L1 and L2) were recruited and participated in a study where they performed procedures in a simulated warehouse. The procedures had hazard information presented in them using safety statements. Participants' performance on the procedures as well as their comprehension of the safety statements were assessed and compared to identify any effects of native language.

The second and third studies were designed to further explore the effects of native language and particularly focused on EHS training programs. In these studies, the type of training delivery system was experimentally manipulated—one delivery method consisted of traditional text based training presented in English; the other training employed the use of visual aids (videos, animation, slides, models, etc.) to present the EHS content to employees.

In Study 2, we compared the effectiveness of the non-lingual training versus English language training on a group of U.S. English language employees, both L1 and L2.

Complementary to the second, the third study compared the effectiveness of the non-lingual training versus English language training on groups of employees that were linguistically and culturally different from our second study. Participants in the third study were non-English language (L0) employees recruited from manufacturing facilities in Brazil and China. Though the outcome of this study may seem obvious (a low effectiveness of English training to non-English employees), the widespread use of lingua franca (including training materials) globally necessitated an understanding of training using English only to deliver effective EHS communications and learning.

### *Training Effectiveness*

For evaluating training effectiveness, one of the most widely used schemas is Kirkpatrick's Four-Level Model (Kirkpatrick, 1996). The four levels of the model include: (1) reaction, (2) learning, (3) behavior, and (4) results (see Table 1). The Reaction level, measures how a participant feels (interest, motivation, attention levels, etc.). The Learning level measures the increase in knowledge as a result of the training. The Behavior level attempts to measure whether the newly acquired skills or knowledge are utilized when the employee returns to work. The Results level is a measure of the overall business impact of the training where the impact

might be financial, incident reduction, improved morale, increased production, etc. (Smidt, Balandin, Sigafos & Reed, 2009). Although, Kirkpatrick's Model is comprised of four-levels, organizations can and often do pick and choose which of the levels they will use to evaluate training effectiveness (Ritzmann, Hagemann & Kluge, 2014). This model will be used in Studies 2 and 3 of the presented research and the levels used to measure effectiveness will be Reaction (using a Training Satisfaction Score: TSS) and Learning (using the difference in content test scores before and after the training as the measure of content learning:  $\Delta T$ ). The behavior and results levels are outside of the scope of this study and thus will not be assessed in this study.

No formal power analyses were done to determine necessary N for each study. However, the study was deemed to have sufficient power given that the sample size in each study (all > 50) is sufficient for the assumption of normality (needed for the ANOVA analyses performed).

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**Table 1.** Application of Kirkpatrick’s Four-Level Model for Study 2 & 3.

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Level & Evaluation Type	Description	Assessment Method
1-Reaction	This evaluation is how the participants felt about the training.	Training Satisfaction Score (TSS).
2-Learning	This evaluation considers how you can measure the increase in knowledge as a result of the training.	Pre-Event and Post-Event Tests.
3-Behavior	This evaluation is the extent to how the participants have applied and implemented their learning once back in their work place environment.	This could include observation and interview over time so that you can assess the changes taking place, the relevance of the changes, and how the changes are sustainable. <u>Not assessed in this study.</u>
4-Results	This evaluation is the effect or impact in the workplace of the new learning.	Impact measures are already in place within the workplace context, and the challenge is to relate the impact to the new learning being put in place. <u>Not assessed in this study.</u>

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### *Learning Styles*

Beginning in the 1920’s, Psychologists and Teaching Specialists such as Fernald, Gillingham, Keller, Orton, Montessori and Stillman began conceptualizing learning styles centered on sensory modality preferences. This early concept eventually led to the Visual-Auditory-Kinesthetic/Tactile (VAK) learning style model postulating that individuals have preferred or dominant tendencies toward either visual, auditory and/or kinesthetic/tactile learning style(s). VAK theory has had a prominent following within learning communities for decades and due to technological advances has more recently experienced a resurgence with the increase

of multimedia learning (Gholami & Bagheri, 2013). The three main sensory receivers of VAK include:

- Visual learners – Learn best through seeing and reading.
- Auditory learners – Learn best through listening and speaking.
- Kinesthetic/Tactile learners – Learn best through touching and doing.

This model is incorporated in the Sensory Modality Preference Inventory used in Studies 2 and 3 of the presented research to measure whether VAK learning styles effect TSS or  $\Delta T$ . The Sensory Modality Preference Inventory used in this study is based on Lynne O'Brien's Learning Channel Preference Questionnaire and was chosen because of its wide-spread use and relative simplicity (1985).

# STUDY 1: NATIVE LANGUAGE INFLUENCE ON PROCEDURE PERFORMANCE AND HAZARD COMPREHENSION<sup>1</sup>

## Overview

The key focus of this study was to explore the effects of native language with regards to workers' use of procedures. Specifically, procedure performance and hazard comprehension were assessed and participants from two different native languages groups were compared—Native English (L1) and Non-native English (L2) readers.

Question 1: Does native language (L1 or L2) influence procedure performance?

Question 2: Does native language (L1 or L2) influence hazard statement comprehension with procedures?

## Methods

### *Participants*

Fifty-four students (19 female) were recruited to participate from Texas A&M University College of Engineering (Mean age 23, SD = 3.5) and 17 (9 L2) of the participants had prior industrial experience. Engineering Students were deliberately targeted for this study because this sample population has a technical background similar to that of industrial workers in developing countries (e.g., Nigeria and India).

Three criteria were used to categorize participants as L1 or L2 readers; their primary language, nationality, and proportion of their life spent living in the United States (US). L1 readers were native English speakers whose primary language was English. Non-native English

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<sup>1</sup> Part of this chapter is reprinted with permission from Peres, S. C., Johnson, W. D., Thomas, S. E., & Ritchey, P., The Effects of Native Language and Gender on Procedure Performance, *Human Factors*, 61(1), Pages 32-42. Copyright © 2019, Human Factors and Ergonomics Society. DOI: 10.1177/0018720818793042.

readers (L2) were: 1) participants whose native language was not English; 2) who were born outside of the US; and 3) who had spent *more than half of their life living outside of the US* (e.g., if the participant was 23 and L2, he or she would have been in the US for less than 11.5 years). Of the 54 participants, 27 (10 female) were L1 including an English-reading Canadian living in the U.S. for 17 years and an English-reading Mexican National living in the U.S. for 22 years. The other 27 (9 female) were categorized as (L2) readers and hailed from sixteen different countries in Europe, Asia, and North & South America. All but 1 of the 27 participants categorized as non-native had lived outside the U.S. for more than 80% of their lives and the 27<sup>th</sup> non-native reader had been outside the US 67% of their life.

### *Testing Environment*

A virtual industrial environment was created within the online 3D virtual world Second Life® (SL). The SL environment was selected to provide a safe and controlled space within which the participants could interact. SL has been previously used in various medical, Human Factors (HF) and psychological research and training programs (Dalgarno & Lee, 2010; Boulos, Hetherington & Wheeler, 2007; Mennecke, Roche, Bray, Konsynski, Lester, Rowe & Townsend, 2007). In SL, much like a gaming environment, users move an avatar around the environment by using the arrow keys on the keyboard to accomplish specific goals. Although studies show gaming performance differences by gender, generation, and nationality, SL has a higher than average usage by women (~51%) and older than average age (~37 years old) of users (Pearce, Blackburn & Symborski, 2015; Martey & Consalvo, 2011; Seo, 2012), thus making it a suitable gaming environment for use in experiments. With regards to the fidelity (realism) of the simulation, we considered the three typical categories for supporting fidelity: environment (structure); equipment (function); and psychological (Marlow, Lacerenza, Reyes, & Salas, 2017).

For this research, we focused on creating a setting closely approximating the environment and equipment, specifically, an industrial warehouse environment with the tools, machinery and tasks closely approximating real-world equipment. This helped participants better identify the areas and items referenced within each procedural step—as step performance was of primary interest to this study. Although, risk consequence (psychological fidelity) was considered, a realistic portrayal of consequence would likely have resulted in a termination of the simulation (avatar injury/death or equipment destruction), which in turn would have prohibited the continuation of the remaining procedural steps. Therefore, the consequence was omitted to allow participants to complete as much of the procedure as the allotted time would allow (Marlow et al., 2017).

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**Table 2.** Listing of the Procedures by Station and Hazard Type.

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**Mechanical/Electrical Hazards**

Electrical 1 - Ventilation Fan Cleaning

Electrical 2 - Air Compressor Lockout/Tagout (LOTO)

Electrical 3 - Computer Numerical Control (CNC) Lathe Lockout/Tagout (LOTO)

**Gravity Hazards**

Gravity 1 - Refilling Dry Additive Stock

Gravity 2 - Moving Finished Product to a Train Car

Gravity 3 - Adding New Dry Additive to a Hopper

**Motion/Transportation Hazards**

Motion 1 - Forklift Operations

Motion 2 - Dock Lock Light System

Motion 3 – Mobile Crane Load Transfer

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**Table 2.** - continued

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**Pressure Hazards**

Pressure 1 - Forklift Propane Cylinder Change Out

Pressure 2 - Biomass Boiler Start-up

Pressure 3 - Wet Additive Mixing

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For this study, a warehouse environment with twelve unique stations was designed to closely match the tasks and hazards normally performed in this type of environment as well as the types of procedures participants would perform. The procedures contained one of four hazard types: 1) Mechanical/Electrical, 2) Gravity, 3) Motion/Transportation, and 4) Pressure. These hazard types were selected because they are commonly associated with workplace injuries and thus are important for workers to understand (U.S. Department of Labor, 2017). Three procedures were authored for each of the hazard types. Table 2 lists the 12 procedures and their hazard type.

*Written Procedures*

The written procedures were designed for the person to follow step-by-step while performing the task. The twelve procedures had a specific number of steps ranging from 6 to 15 with an average of 11.2 steps. Each procedure contained one warning statement with: a box around it, textual information about the warning (containing: the hazard, consequence of non-compliance, and preventative action), and warning symbols. Each step of the procedure was sequentially numbered with the warning step not numbered. Different warning symbols were used representing either the hazard, consequence of non-compliance, and/or preventative action for each of the hazard types (see Figure 1 for an example of the written procedures). The

procedures were assessed for readability yielding an average Flesch Reading Ease score of 74.0 (range 57.1 to 82.6; median 73.9) and an average Flesch-Kincaid Grade Level of 4.5 (range 3.6 to 6.1; median 4.4).

The study was originally focused on both the effectiveness of symbol designs and native language. The analyses showed no difference in participant performance or comprehension based on symbol design (i.e., inclusion of hazard, consequence of non-compliance, and/or preventative action) and are reported elsewhere (Tharpe, Thomas, & Peres, 2017). This result would seem to support a conclusion that the participants relied less on the visual guidance of the warning symbols and more on the warning text, increasing the importance of the language variable given they were presented with the symbol and the verbiage simultaneously.

**P-001b**  
**OPERATIONS PROCEDURE**  
Ventilation Fan Cleaning

1. Go to the “Back-up Venting Fan” and inspect by clicking on the fan.
2. Go to the “Motor Control” panel that controls both fans.
3. Power ON the “Back-up Venting Fan” using the lever.
4. Start the “Back-up Venting Fan” with the green button.
5. Visually check that the “Back-up Venting Fan” is running.
7. Stop the "Main Venting Fan" with the red button



Electrical shock hazard.  
Can cause serious bodily injury or death.  
Power off the equipment to prevent electrocution.

8. Open the valve for the “Back-up Venting Fan”.
9. Close the valve to the "Main Venting Fan".
10. Go to the “Main Venting Fan” and clean by clicking on the Fan.

**Figure 1.** Study 1: Example procedure—participants used this to support their performance through the tasks.

*Protocol*

This research complied with the American Psychological Association Code of Ethics and was approved by the Institutional Review Board at Texas A&M University. Informed consent was obtained from each participant. They were given a brief orientation consisting of a short introduction on how to move their virtual being (avatar), interacting with the simulated environment, and walking around the area to become acquainted with controlling their avatar.

The study proceeded only after the observer and participant felt comfortable that the participant could competently operate the Avatar.

Before each procedure, each participant was required to be oriented to the specific task by watching a video of a researcher completing each step of that specific procedure with the researcher always performing the safety behavior. This was done so participants would know how to interact with SL to perform the task and to illustrate the necessary steps for the tasks as well. However, this presented the possibility of a ceiling effect due to the potential demand effect of social desirability. To mitigate the likelihood of this effect, the researcher verbally noted that “not everyone does this step” to promote volitional procedure use (or disuse). Note that the performance of the safety step is not a variable of interest for this study, as these results are published elsewhere (Tharpe et al., 2017).

Participants were timed with a visible timer and instructed that completing the procedure within the allotted time was the priority. Because the tasks were not remarkably difficult, a time limitation of 2 minutes was used to create a significant time pressure, thereby increasing the stress level of the participant while performing each of the tasks. This decreased the likelihood of a ceiling effect for performance and mimics real world environments when there is limited time to perform a specific task (Praino, & Sharit, 2016).

Upon completion of each procedure’s orientation and setting of the timer, each participant began. At the end of each procedure, the participant would complete five questions designed to measure comprehension. Specifically, they were to describe:

1. The hazard
2. Potential consequences to either the user or the equipment
3. Actions necessary to avoid the hazard

4. The purpose of the procedure
5. If any part of the procedure was unclear

When the participants completed all the procedures, they had 20 minutes to complete an English proficiency measure (described below). The session ended with each participant completing a demographic survey capturing age, gender, education level, academic major, country of birth, years in the U.S., native language, ethnicity, and industrial experience.

### *Design*

Study 1 was a mixed factorial design with one within subject variable—comprehension question type (3: Hazard, Consequence of non-compliance, & Preventative Measure) and one between subject variable—native language (2: L1 & L2). There were three dependent variables—overall procedure performance, comprehension, and TOEFL scores.

### *Measures*

**Overall Procedure Performance (OPP).** This was the primary measure of interest and subjects were assigned a relative performance score of 0, 1, or 2 for each step of each procedure. If the step was done incorrectly, skipped, or not completed, a step score of 0 was assigned; if a step was completed correctly but with difficulty (i.e., hesitancy), 1 was assigned; and 2 was assigned if the step was completed correctly and without difficulty. Difficulty with a step was defined as: referring back to the procedure before performing the step or repeating a procedure step that had already been completed. These performance scores were averaged for each of the subject's procedures to compile mean OPP scores. It should be noted that within the OPP scores the safety step was not differentiated from any of the other procedure steps.

**TOEFL Scores.** To measure participants' English proficiency, each participant read a passage and answered 14 questions—both from reading preparatory materials for the Test of

English as a Foreign Language (TOEFL) (Peirce, 1992). The reading material was chosen instead of the entire exam because the time and financial costs of the actual TOEFL was beyond the scope of project. Further, because Hamp-Lyons' material was specifically designed to represent the TOEFL, it was thus designed to be a good representation of the reading section of the exam. Subjects' TOEFL scores were computed by calculating the percent correct on their responses to the 14 questions on the reading excerpt. Subjects were then grouped in one of two groups based on their TOEFL score with 0 assigned to those scoring an 88 or higher and a 1 for those scoring less than 88.

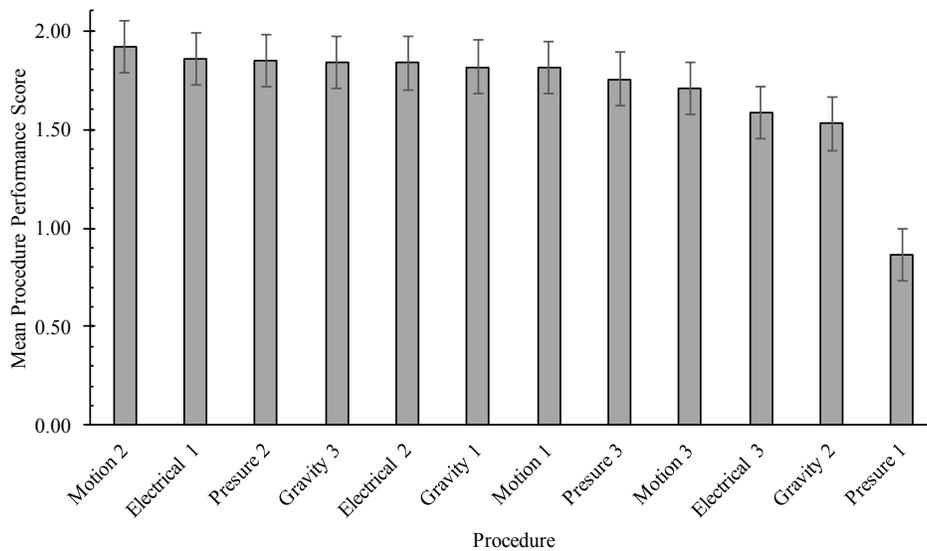
**Overall Hazard Comprehension (OHC).** To measure participants' comprehension of the procedures, participants were assigned a relative comprehension score of 0 (incorrect) or 1 (correct) for each question regarding the procedure's safety statement. Answers to the comprehension questions were evaluated as correct or incorrect based on key concepts or words that were present in the participants' answers for the hazard for each procedure by two different evaluators. The two evaluators compared their ratings and where there were discrepancies, discussed them until they reached an overall inter-rater reliability minimum of 90 percent agreement in the two-rater model. The comprehension scores for each question type (hazard, consequence or prevention) were summed for the OHC Scores.

**English Comprehension.** Two measures were used to identify the participants' comprehension of the English language (as it could be that the L2 readers were not as proficient in English as the L1 readers). Those measures were the TOEFL (reading comprehension only) and participants' overall hazard comprehension.

**Demographics.** Participant age, gender, and industry experience were collected with a demographic questionnaire.

## Analysis

To identify if native language (2 levels) had an effect on overall procedure performance, a mixed repeated measure analysis of variance (RMANOVA) was conducted using OPP as the dependent variable. To address the question of whether native language had an effect on hazard comprehension, a mixed repeated measure analysis of variance (RMANOVA) was conducted using OHC as the dependent variable. Further, analyses were done by gender and experience to determine if these variables had any effect on the dependent variables. All analyses were performed using IBM SPSS v.24 (IBM Corp., 2016).



**Figure 2.** Study 1: Mean Overall Procedure Performance (OPP) for each procedure. There were main effects for Procedure ( $F(11, 528) = 40.56, p < 0.001, \eta_p^2 = 0.458$ ). Error bars represent the 95% confidence interval.

## Results

Initial analyses were conducted on the mean performance scores for each of the procedures to confirm that they were all similar in level of difficulty. As seen in Figure 2, there were differences in performance by procedure ( $F(11, 528) = 40.56, p < 0.001, \eta_p^2 = 0.458$ ), with

a pairwise comparison indicating that the Pressure 1 procedure had significantly lower performance than all other procedures (all  $p$ 's < 0.001).

Further, the Gravity 2 procedure was significantly different from all procedures with lower performance ( $p$ 's < 0.04) than all procedures except Electrical 3, Motion 3, and Pressure 3. Finally, the Electrical 3 procedure was significantly different from all procedures with lower performance ( $p$ 's < 0.03) than all procedures except Gravity 2, Motion 1, Motion 3, and Pressure 3. To remove variability in the data that were due to the difficulty of the procedure itself (versus the effects of the IV), and to maintain balance within the design of the study, the procedure with the lowest performance from each hazard was removed from analysis (Pressure 1, Gravity 2, Electrical 3, & Motion 3).

*Overall Procedure Performance Data*

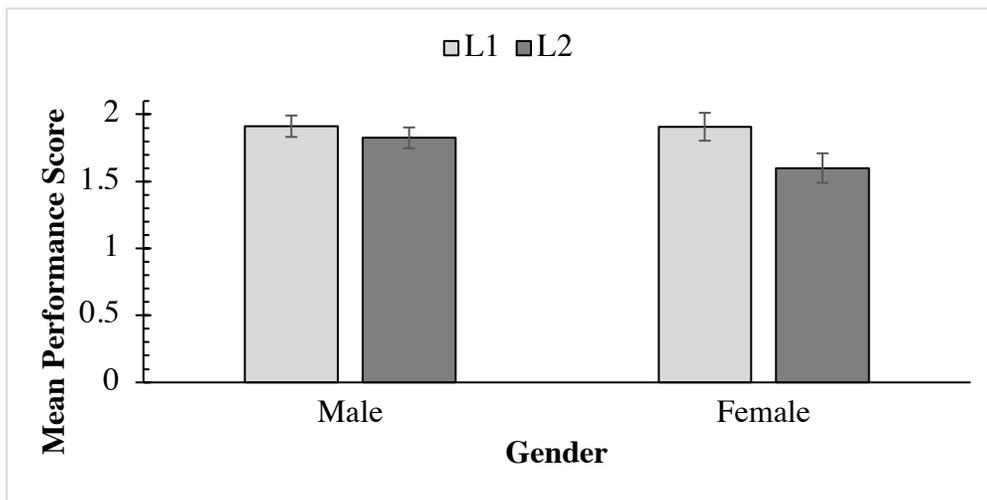
As seen in Table 3, the L2 subjects did not perform as well on the procedures as the L1 subjects and this difference was significant,  $F(1, 53) = 17.82, p < 0.001, \eta_p^2 = 0.263$ .

**Table 3.** Study 1: Descriptives for Overall Procedure Performance by Native Language

Language	Mean	SEM	95% Confidence Interval	
			Lower Bound	Upper Bound
L1	1.91	.035	1.845	1.985
L2	1.75	.034	1.685	1.820

Separate analyses were also conducted by Age, years of Experience, and Gender to identify any effects of these subject variables on performance. Age and years of Experience did not have any effect on OPP (all  $p$ 's > 0.550) or interaction with Language on OPP (all  $p$ 's >

0.250). As seen in Figure 3, there were effects of Gender. Specifically, the Female participants did not perform as well on the procedures as the Males,  $F(1, 53) = 5.96, p = 0.018, \eta_p^2 = 0.107$ , and there was an interaction between Gender and Language,  $F(1, 53) = 5.57, p = 0.022, \eta_p^2 = 0.100$  with pairwise comparison showing a significant difference between L1 and L2 readers for Females ( $p < 0.001$ ) but not for Males ( $p = 0.123$ ).



**Figure 3.** Study 1: Mean Overall Procedure Performance (OPP) Scores by Gender and Language. There was a main effect of Gender ( $F(1, 53) = 5.96, p = 0.018, \eta_p^2 = 0.107$ ) and an interaction between Gender and Language ( $F(1, 53) = 5.57, p = 0.022, \eta_p^2 = 0.100$ ). Error bars represent the 95% confidence interval.

### *English Comprehension*

Analysis showed no difference between L1 and L2 for TOEFL scores,  $F(1, 53) = 1.08, p = 0.310$  (see Table 4). Further, there were no main effects or interactions for Gender, Age, or Experience ( $p$ 's  $> 0.23$ ).

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**Table 4.** Study 1: Mean, Standard Error, and the 95% Confidence Intervals for the Participants' Scores on the TOEFL Response Questions by Language.

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Language	Mean	SEM	<u>95% Confidence Interval</u>	
			Lower Bound	Upper Bound
L1	88.05	2.80	82.27	93.82
L2	82.68	2.65	77.22	88.15

---

#### *Hazard Comprehension Data*

As seen in Table 5, the Mean OHC Scores were not significantly different for the L1 and L2 subjects ( $p = 0.19$ ). Separate analysis on comprehension for Age, Gender, and Experience in Industry showed that participants did not have significantly different comprehension scores based on these variables nor were there any interactions (all  $p$ 's  $> 0.39$ ).

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**Table 5.** Study 1: Mean Overall Hazard Comprehension (OHC) Scores by Native Language.

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Language	Mean	SEM	<u>95% Confidence Interval</u>	
			Lower Bound	Upper Bound
L1	1.506	0.096	1.313	1.699
L2	1.324	0.096	1.131	1.517

---

#### **Discussion**

The first study in this series of studies compared people's performance level with procedures based on whether they were L1 or L2 readers.

In regards to native languages influence on procedure performance, there was a difference between the L1 and L2 groups and the effect size was large based on Cohen's

standards (Cohen, 1988), with native language explaining 26% of the variability in performance. Surprisingly, the effect of native language interacted with Gender, as seen in Figure 3, with the L2 Females performing lower than the other three groups (L1 males and females and L2 males). No other demographic variables (*i.e.*, Age or Industry experience) were associated with differences in procedure performance levels.

Additional analysis showed an effect of native language (L1 or L2) on hazard statement comprehension with procedures. Certainly, the L2 Female group drove the large main effect of Language, however, given that there were differences for L2 Males (albeit not significant), the large effect size (0.263), and the practical significance of L2 readers having lower performance on procedures, we will first present an explanation for main effect and then discuss the interaction with Gender. Perhaps L2 participants, in particular L2 Females had lower English reading comprehension abilities and thus performed worse when using the written procedures to perform the tasks. If so, we would expect to see a similar pattern of results (Language and Gender interaction) for the TOEFL scores and for the Hazard Comprehension scores. However, this was not the case and there was no interaction between Gender and Language for TOEFL scores. Further, if L2 readers had an issue with procedure *comprehension*, we would expect to find differences in their scores on the content of the Hazard statements and there were none, nor an interaction. These combined results suggest that the performance differences found were not due to comprehension of English but to another factor. This difference may be associated with cultural differences due to risk-taking, response to authority, etc. between L1 and L2 participants. However, given that participants were from sixteen different countries (females from nine different countries), any cultural influence would be difficult to identify in this study.

Given that there was no difference for any groups in reading comprehension or procedure comprehension, it is possible that the effect of Language is due to the two-minute time limit on each procedure, *i.e.*, *time pressure* may have impacted L2 participants' performance. The notion of time pressure impacting performance is consistent with studies showing that severe time limitations, such as those imposed in this study, can negatively affect reading performance for L2 readers (Walczyk et al. 1999). There are two prevailing theories regarding reading fluency, the first at the word level and the second at the syntactic level (fluency in reading sentences and phrases). These theoretical views help to explain the possibility that the lower performance of L2 readers versus L1 readers are due a lower level of automaticity for word recognition speed and a lower automaticity-like effect related to syntactic processing skill (Klauda & Guthrie, 2008). Other studies have shown that L1 readers are more adept at using lower-level language processes such as lexical access and parsing to consume fewer cognitive resources than L2 readers (Morishima, 2013; Erçetin, 2015).

In process industry, such as chemical processing, refining, oil, and gas operations, *etc.*, there are many procedures that are regularly conducted with very tight timelines. Further, there are other situations where external conditions may induce time pressures where normally workers could perform procedures at their own pace. This study indicates that for those L2 workers, when time pressure is introduced, their performance may be impeded—particularly for female L2 workers.

With regard to the interaction between Language and Gender—with the L2 Females driving much of the differences between L1 and L2 readers—the procedure performance differences between Genders might be a result of the smaller female sample size, as of the 54 participants, only 19 were female, and of those only 9 were L2 females. Thus, there may have

been some unique characteristics of these 9 Females that are not representative of all females in this domain. Another possibility may be related to the spatial nature of the task as some studies have found that women tend to underperform men on spatial tasks (Maeda & Yoon, 2013; Mäntylä, 2013; Tascón, García-Moreno & Cimadevilla, 2017). If so, we would expect to find that both male groups would have outperformed both female groups. However, a detailed look at the data shows that the performance of both male groups and L1 females are not significantly different (although L2 was lower overall). Nevertheless, L2 females did perform significantly lower on performance than the other groups. The L2 female performance could be a result of cultural and gender-role conformity pressures influenced by a participant's country of origin (Reilly & Neumann, 2013) and although outside the scope of this study, this is certainly something that should be explored further. Another possibility for the performance differences might be attributed to gender differences in gaming experience with females typically having much less experience gaming (Seo, 2012). Although in the study protocol, there were specific attempts to minimize these types of differences (i.e., low level of complexity of the SL tasks, the avatar practice sessions, fidelity of the simulation environment/equipment to closely approximate reality, and the design of the performance evaluation criteria) and the results from this study cannot directly address this possibility. Additionally, because psychological fidelity (realistic portrayal of risks/consequences) was not present in the simulation, as they might be in real life, it is certainly possible that this could have somehow impacted overall procedure performance. Finally, the possibility of implicit biases resulting from the study design and/or the researchers cannot be discounted. Overall, the major limitations of the findings from this paper are that an explanation of the performance differences for the L2 females is uncertain. Therefore, while the design of the study and the results seem to rule out spatial ability and gaming experience

differences, cultural differences and effects of implicit bias cannot be accounted for with regard to the differences in procedure performance for the L2 females. Given that there are females working in this industry and that this number is increasing, this topic warrants further investigation (DePasquale & Geller, 1999; Helms Mills, 2005; Miller, 2004).

Due to the major predictor of performance with procedures being a subject variable that cannot be experimentally manipulated (*i.e.*, Gender), it is not possible to draw conclusions regarding causality for these findings. Further, because there are no results regarding L2's performance when using procedures for timed tasks in their native language, it is not possible to conclude that this would resolve the issue. Nevertheless, we submit that these findings suggest a need for future research regarding unexplored consequences of the current industry standard for having all English procedures—specifically for procedures that must be done with tight timelines—and studies to confirm the causal pathways for this. Further, the fact that there was no effect for language comprehension between L1 and L2 and there was one for procedure performance provides evidence that the differences between the L1 and L2 procedures performance is not due to the participants' English reading ability but something else (*i.e.*, introduction of time pressure).

## STUDY 2: COMPARISON OF TRAINING METHODOLOGY EFFECTIVENESS - U.S.

### **Overview**

The key focus of this investigation was the efficacy of a non-linguistic EHS training (NAPO) versus an English language version of the training (ENG) for L1 and L2 U.S. employees. Specifically, is non-linguistic training effective and does effectiveness differ by language or sensory modality preference?

Question 1: Does Training type (English or Non-Lingual) influence native language employees' (L1 or L2) comprehension of EHS training?

Question 2: Does Training type (English or Non-Lingual) influence native language employees' (L1 or L2) reaction to training?

Question 3: Does sensory modality preference influence training performance or reaction?

### **Methods**

#### *Participants*

Approximately 102 employees (25 female) were recruited to participate in this study from a Dover Fueling Solutions Manufacturing facility in Austin, Texas. 57 of the participants were L1 (13 Female) and 45 were L2 (12 Female). Employees from each Language group were randomly assigned to the non-linguistic training and the English language version of the training. 30 L1 (7 Female) and 24 L2 (6 Female) employees participated in the English version of the training (ENG), while 27 L1 (6 Female) and 21 L2 (6 Female) employees participated in the non-linguistic training (NAPO). Although the GHS training provided was required by both Dover and regulations, participation in this study was voluntary.

### *Testing Environment*

A brief non-linguistic EHS training animation was identified for use in this study. The chosen animation was part of the EU-OSHA NAPO series of safety training. Additionally, a full text and verbal English language version of the training was created. Both trainings were presented to participants electronically via an online delivery system, called a Learning Management System (LMS). An online LMS was preferred because they are commonly used in industry to deliver a variety of trainings and other EHS content (Bersin, 2014a). For this study, the LMS content was used to provide an efficient, convenient, and cost-effective means to deliver content to participants and the Pre-Test, Post-Test, Training Satisfaction Survey, and Sensory Modality Preference Inventory (SMPI, 2017) were completed using paper and pen.

The training topic for this study was the United Nations' Globally Harmonized System of Classification and Labeling of Chemicals (GHS). GHS defines and classifies the hazards of chemical products and communicates health and safety information on labels and safety data sheets. The goal of the GHS is to establish the same set of rules for classifying hazards, as well as having the same format and content for labels and safety data sheets (SDS) adopted and used around the world (CCOHS, 2018). Since its inception, GHS has been widely adopted globally by major countries as their primary means of chemical hazard communication. In fact, in many instances, such as with the United States, Brazil, and China (UNECE, 2018a). GHS has been incorporated into their regulatory standards. Additionally, at the time of this study GHS pictograms were a new training topic for the participants recruited. Although some participants may have had previous chemical safety training or experience, much of the GHS material presented in the HAPO And ENG trainings was unfamiliar. Consequently, the widespread, mandated use, global applicability and novelty of GHS made it a desirable topic for this study.

Participants were recruited from Dover Fueling Solutions Manufacturing and although the GHS training provided was required by both Dover and regulations, participation in this study was voluntary.

### *Training Presentations*

Two separate GHS training presentations were used in this Study. The first, a brief non-linguistic GHS training animation titled “NAPO in... Danger: Chemicals!” part of the NAPO series of safety training procured from an EU-OSHA website (EU-OSHA, 2018). Figure 4, shows a screenshot of the NAPO animated GHS Training. The second, was a written and spoken English language content GHS PowerPoint presentation developed by the researcher using GHS materials from the U.S. Occupational Safety & Health Administration (OSHA, 2016a-c) and compiled to closely match the EU-OSHA chemical safety NAPO training. The trainings were approximately 5 to 7 minutes in length covering the meaning of the 9 GHS pictograms and general chemical safety. Both trainings were reviewed by the respective manufacturing facilities’ EHS professionals to ensure that the content of each was equivalent.



**Figure 4.** Study 2 & 3: Screenshot of the NAPO Animated Non-Lingual GHS Training.<sup>1</sup>

<sup>1</sup> Reprinted with permission from “NAPO: Safety with a Smile” by Napo Consortium, 2019, Via Storia, Strasbourg, France. Copyright © 2019 by Via Storia.

### *Protocol*

Before beginning, each participant was provided a copy of the study information sheet form approved by Texas A&M University's institutional review board (IRB). The form was read by and to the participants. The form presented aspects of the study as well as the fact that participants could discontinue participation at any time (see Appendix A1). The participants were given an opportunity to review the form and to ask any questions. It was then emphasized that participation in the study was completely voluntary. Once satisfied, the participant acknowledged consent by completing the Pre-test, Training Satisfaction Survey, Post-test, and the Sensory Modality Preference Inventory. The trainings presented included content that is normally required annually outside of the research context and presented no more than minimal risk of harm to the participants.

The first task the participants completed was a brief pre-test to assess their subject knowledge before the training (see Appendix B). Upon completion of the pre-test they were randomly assigned to one of the training conditions and they completed that training, *i.e.*, the non-linguistic (NAPO) or linguistic (ENG) GHS. Following the training, the participant completed a post-test to assess their subject knowledge after the training (see Appendix B). Finally, the participant completed a brief TSS (see Appendix C), including a Sensory Modality Preference (SMP) Inventory (see Appendix D) to determine their learning preferences (Lodge, Hansen & Cottrell, 2016; SMPI, 2017).

### *Design*

Study 2 was a pre-test/post-test design with three between subject independent variables—Native Language (2: Native English-L1 and Secondary English-L2); Training Type (2: Non-Linguistic and Linguistic) and Modality Preference (Verbal, Auditory, Kinesthetic, and

Multi-modal). There were two dependent variables—Performance Difference from Pre-Test to Post-Test ( $\Delta T$ ) and Training Satisfaction Score (TSS). The L1 and L2 participants were randomly assigned to Training Type conditions, resulting in 48 participants completing the non-linguistic electronic training (27 L1 and 21 L2 employees) and 54 participants (30 L1 and 24 L2 employees) completing the English language version of the electronic training.

### *Measures*

Kirkpatrick's Four-Level Model was used in this study to evaluate training effectiveness (see Table 1) and specifically assessed employees' reactions to the training and how much they learned from the training (Williams & Nafukho, 2015; Ritzmann, Hagemann & Kluge, 2014; Smidt, Balandin, Sigafos & Reed, 2009; Hamtini, 2008; Galloway, 2005). Additionally, sensory modality preference was assessed to evaluate training effectiveness relative to visual, auditory or kinesthetic/tactile preferences.

**Reaction Level.** How participants felt about the training was assessed in this study with the use of a Training Satisfaction Survey (see Appendix C1). Aside from general demographic information, such as, gender, age, job category, and education level, the responses to the survey evaluated employee perceptions regarding training enjoyment, usefulness, difficulty, knowledge gain, interest, and employee training preferences (Ritzmann, 2014). A five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree") was used to quantify employee perceptions and preferences. The ENG and NAPO trainees completed the same 6 questions, however the ENG trainees completed 1 additional question for a total of 7 questions. The scores from each of the questions were averaged resulting in the Training Satisfaction Score (TSS). A TSS of 1 would be the minimum score that could be achieved indicating the least favorable impression of the training and a maximum score of 5 indicating the most favorable impression of

the training. An analysis of reliability resulted in an  $\alpha = .872$  for all 7 questions and an  $\alpha = .880$  for the 6 questions. Additional reliability analysis showed no significant difference in  $\alpha$  based on language proficiency.

**Learning Level.** Increase in knowledge as a result of the training, was assessed by calculating employees' improvement (post-test minus pre-test) on a 10-question test of the content for the training (see Appendix B). The tests were scored, on a 100-point scale with each question being worth 10 points. This primary measure of performance improvement is referred to as  $\Delta T$ .

**Sensory Modality Preference Inventory.** The sensory modality preference (SMP) was administered to the employees to assess their learning style preference—visual, auditory or kinesthetic/tactile (Lodge, Hansen & Cottrell, 2016). Visual (V) indicated a preference to learn by looking at image intense figures, graphics, diagrams and other visual means of communication and interaction. Auditory (A) indicated a preference for words and learning through listening or participating in discussion. Kinesthetic/Tactile (K) indicated a preference for “hands on” learning, a dislike to merely listening and a typical passivity to classroom settings. The assumption was that “V” learners would prefer the non-linguistic training the most and that “K” learners would prefer the non-linguistic training more so than “A” learners.

The Sensory Modality Preference Inventory (SMP: see Appendix D) was comprised of three sections with each section representing one of 3 modalities (visual, auditory, and kinesthetic/tactile). Each section had 10 questions that participants responded to using a Likert scale: 1) Seldom/Never, 2) Sometimes, and 3) Often. The score for each section was totaled with the highest scoring section being allocated as the sensory modality preference of the employee. Where multiple sections tied for highest modality preference the subject was

identified as having a Multi-modal (M) preference. The resulting scale for SMP was 1) V-Visual, 2) A-Auditory, 3) K-Kinesthetic, and 4) M-Multi-Modal.

### *Analysis*

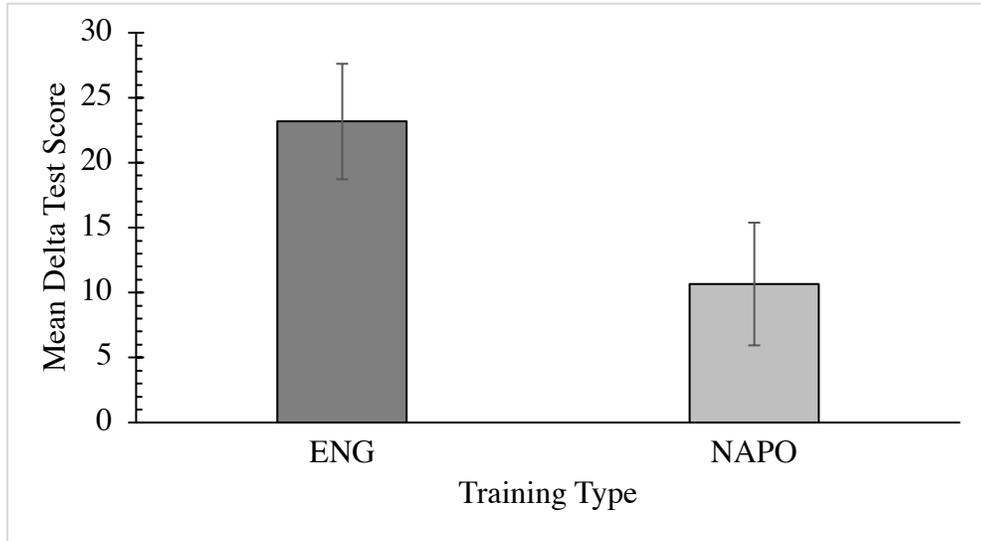
To evaluate performance ( $\Delta T$ ) and employee preferences (TSS), a 3 Way (Language—L1, L2; Modality—V, A, K, and M; Training—English, NAPO) Factorial Analyses of Variance (ANOVA) was conducted for both dependent variables. After these analyses were conducted possible effects of individual differences (i.e., Gender, Age, Job Function, and Education Level) were considered. All the learning and reaction data was analyzed using IBM SPSS v.24 (IBM Corp., 2016).

### **Results**

Initial analyses were conducted to evaluate if there were differences in knowledge gained ( $\Delta T$ ) and employee reaction (TSS) with the following results.

#### *Performance Difference from Pre-Test to Post-Test ( $\Delta T$ )*

For the  $\Delta T$ , positive scores indicate a knowledge gain, whereas negative scores indicate a knowledge loss. Figure 5 shows the average  $\Delta T$  score by training type.



**Figure 5.** Study 2: Comparison of Mean Test Score Deltas by Training Type. There were main effects for Test Score Deltas by Training Type ( $F(1, 101) = 14.64, p < 0.001, \eta_p^2 = 0.130$ ), but no effect of Language ( $p = 0.52$ ) or interaction ( $p = 0.64$ ). Error bars represent the 95% confidence interval.

As seen in Figure 5, there were significant differences in performance by training type ( $F(1, 101) = 14.64, p < 0.001, \eta_p^2 = 0.130$ ) with the employees performing the ENG training showing more improvement than those performing NAPO with approximately 13.0% of variability being explained by Training Type. However, there was no effect of Language ( $p = 0.52$ ) or interaction between Language and Training ( $p = 0.64$ ). Further there were no main effects or interactions on performance with Gender (*all p's* > 0.349).

The distribution of sensory modality preferences are show in Table 6 and when this variable was included in the analyses, there were no effects of Modality on performance ( $p = 0.984$ ), nor were there modality interactions with Language and Training (*all p's* > 0.132).

**Table 6.** Study 2: Distribution of Sensory Modality Preferences

Training Type	Sensory Modality Preference				TOTAL
	Visual	Auditory	Kinesthetic	Multi-Modal	
ENG	15	9	19	11	54
NAPO	13	8	18	9	48
Total	28	17	37	20	102

### *Training Satisfaction Score (TSS)*

Analysis showed there were no main effects or interactions for Training type, Language, Gender or Sensory Modality (all  $p$ 's > 0.077) on employees' satisfaction with their training sessions.

### **Discussion**

The second study in this series of studies compared U.S. employee's knowledge gain and reaction to lingual or non-lingual GHS training based on whether they were L1 or L2 employees.

In consideration of training types influence on native language employee's (L1 or L2) training performance and preferences revealed learning in all groups after participating in either trainings (ENG or NAPO). Remarkably, both L1 and L2 groups showed very similar gains in knowledge. However, a much higher increase in learning was observed in the ENG trainees versus the NAPO trainees, and the effect size was large based on Cohen's standards (Cohen, 1988), with training type explaining 13.0% of the variability in knowledge gain.

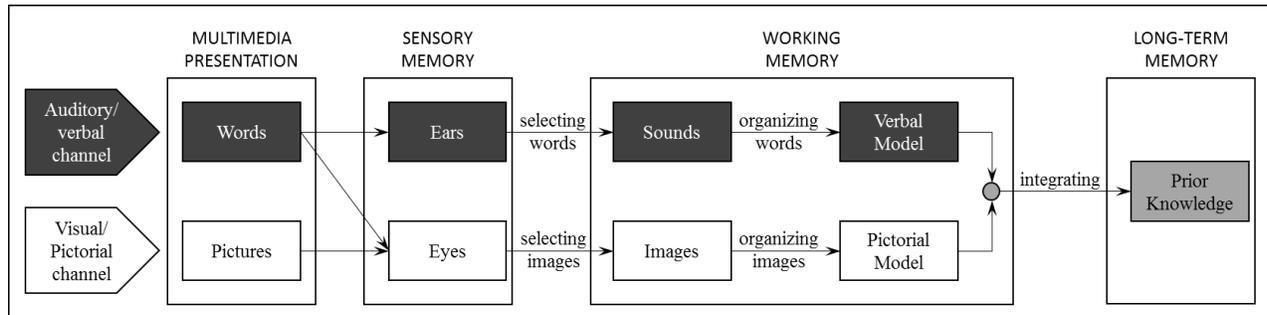
It was expected that the L2 employees would prefer the NAPO training since it did not rely on English. However, the English version of the training was more effective and preferred by the U.S. L2 employees as well as the L1 employees. Although, both L1 and L2 employees from both Training Types experienced increased knowledge gains at similar rates, the ENG trainees gained a higher level of learning than did the NAPO trainees. As discussed in Study 1,

perhaps the similar performance of L1 and L2 employees is because of the absence of time pressure for completing the tests. Additionally, this may be due to both L1 and L2 employees having an understanding of the English language, which allowed for a higher level of comprehension of the English written (visual) and spoken (auditory) material presented in the lingual version of the GHS training. Whereas the NAPO non-lingual training was dependent solely on personal interpretations (or misinterpretations) of the single media, visual, non-lingual animated material and symbols leading to a lower increase in knowledge gain. This is also consistent with Richard Mayer's Cognitive Theory of Multimedia Learning in that both groups were capable of using two separate channels (visual and auditory), allowing the learners to work with more information due to the spoken and written material of the ENG training being processed separately, as opposed to the single channel non-lingual animation (visual) of the NAPO training, see Figure 6 (Mayer & Moreno, 2003). Richard Mayer's Cognitive Theory of Multimedia Learning is comprised of three primary assumptions regarding learning with multimedia:

1. There are two separate channels (auditory and visual) for processing information, also known as the Dual-Coding theory;
2. Each channel has a limited capacity, similar to Sweller's notion of Cognitive Load;
3. Learning is an active process of filtering, selecting, organizing, and integrating information based upon prior knowledge.

All things considered, the theory postulates that people are only capable of processing a finite amount of information, per channel, at any given moment, and that comprehension of information is achieved through the creation of mental representations (Mayer, 2002).

Additionally, the subjectivity of interpretation needed to comprehend the NAPO training was likely less effective than the objective linguistic material presented in the ENG training.



**Figure 6.** Model of Mayer’s Cognitive Theory of Multimedia Learning.<sup>2</sup>

With regard to sensory modality preference influence on training performance or reaction, although each employee’s sensory modality preferences were identified, analysis showed they had no effect on employee reaction or knowledge gain in respect to training type. This is similar to the conclusions of Arbutnott & Krätzig and illustrates that people’s preferences for learning modalities is not predictive of their performance when using that learning modality (2015).

The results from this study suggest that for training paradigms, the workers’ native language did not impact their ability to learn from English training. However, for many companies, English-based training is used even for employees who do not normally speak any English at all. The assumption with this practice is that the presentation of any training material,

<sup>2</sup> Reprinted with permission from “Nine ways to reduce cognitive load in multimedia learning” by Richard E. Mayer, and Roxana Moreno, 2003, *Educational Psychologist*, 61(1), Pages 32-42. Copyright © 2003 by Taylor & Francis.

even if it is not given in the employee's primary language, is better than nothing. To identify any potential challenges with this assumption, it is necessary to examine any effects of training type on the performance, preferences and modality of those employees working in a company with English as the lingua franca but who do not speak any English.

## STUDY 3: COMPARISON OF TRAINING METHODOLOGY EFFECTIVENESS - BRAZIL AND CHINA

### **Overview**

While Study 2 investigated the efficacy of non-linguistic EHS training vs. an English language version with people who speak English (either Native or Non-Native), the key focus of this investigation was the efficacy of the two training versions for those who do not speak English (L0) and in two separate cultures/countries (China & Brazil). If the results of Study 2 are due to the ENG training being simply better than the NAPO then the expected result of Study 3 would be that the L0 participants of the ENG training would outperform the L0 participants of the NAPO training. Additionally, if Mayer's theory is correct regarding channels of communication, it would be expected in Study 3 that the L0 participants in the ENG training, with little to no channels to process information would not perform as well as the L0 participants of the NAPO training which have one or more channels of information to process. Therefore, the general question was whether non-linguistic training is effective and does effectiveness differ by the non-English language employees' location or sensory modality preference?

Question 1: Does Training type (English or Non-Lingual) influence non-English language employees (Brazil or China) training performance?

Question 2: Does Training type (English or Non-Lingual) influence non-English language employees (Brazil or China) reaction to training?

Question 3: Does sensory modality influence training performance or reaction?

## **Methods**

### *Participants*

Approximately 78 employees were recruited to participate in this study. 28 employees from a manufacturing facility in Guangzhou, China (CN), and 50 from a manufacturing facility in Rio de Janeiro, Brazil (BR). Employees from each facility were randomly assigned to the non-linguistic training and the English language version of the training. 24 Brazilian (2 Female) and 15 Chinese (1 Female) employees participated in the English version of the training (ENG), while 26 Brazilian (2 Female) and 13 Chinese (3 Female) employees participated in the non-linguistic training (NAPO). Although the GHS training provided was required by both Dover and regulations, participation in this study was voluntary.

### *Testing Environment*

The brief non-linguistic (NAPO) animation and English language (ENG) GHS training presentations, and the online LMS from the previous study were used for this study. The information sheet, tests, and surveys were translated into simplified Chinese and Brazilian Portuguese as these were the dominate languages for the workers in these facilities. The documents were translated by Donnelley Language Solutions (see Appendix G) and verified by the EHS Managers of the Brazilian and Chinese Manufacturing facilities, respectively. Both trainings were presented to employees from the same LMS used in Study 2. However, employees were gathered into conference rooms with the trainings presented via a projector. Translated versions of the documents were presented to employees, as location appropriate, specifically, Simplified Chinese to Guangzhou employees and Brazilian Portuguese to Rio employees.

### *Training Presentations*

The same two, ENG and NAPO, GHS training presentations used in this Study 2 were used identically in Study 3.

### *Protocol*

Before beginning, each employee was provided an appropriately translated copy of the study information sheet form approved by Texas A&M University's institutional review board (IRB). The form was read by and to the employees in their native language. The form presented aspects of the study as well as the fact that employees could discontinue participation at any time (see Appendix A2 & A3). The employees were given an opportunity to review the form and to ask any questions. It was then emphasized that participation in the study was completely voluntary. Once satisfied the employee acknowledged consent by completing the Pre-test, TSS, Post-test, and the Sensory Modality Preference Inventory. As with Study 2, approval was granted for a waiver of documentation of Informed Consent.

The first task the employees were given was a brief, appropriately translated, pre-test to assess their subject knowledge before the training (see Appendix B1 & B2). Upon completion of the pre-test they were randomly assigned to one of the GHS training methods—either NAPO or ENG—training programs and then completed that program. Following the presentation, the employee completed a translated post-test to assess their subject knowledge after the training (see Appendix B1 & B2). Finally, the employee completed a brief translated TSS (see Appendix C), including a translated Sensory Modality Preference (SMP) Inventory (see Appendix D1 & D2) to determine whether their learning preference was Visual, Auditory, Kinesthetic/Tactile or Multi-modal.

### *Design*

The design of Study 3 was exactly the same as Study 2 with the exception being that the participants differed based on location (Brazil or China—all L0) versus (L1 and L2). The design of the study was a pre-test/post-test design with three between subject independent variables—Location (2: Brazil and China); Training Type (2: NAPO and ENG); and Modality Preference (Verbal, Auditory, Kinesthetic, and Combination). There were two dependent variables—Performance Difference from Pre-Test to Post-Test ( $\Delta T$ ) and Training Satisfaction Score (TSS). The Brazil (BR) and China (CN) employees were randomly assigned to Training Type conditions, resulting in 39 employees completing the NAPO training (24 BR and 15 CN employees) and 39 employees (26 BR and 13 CN employees) completing the English language version of the GHS training.

### *Measures*

The measures were similar to Study 2; however, the employees were Brazilian and Chinese non-English speakers (L0). As with Study 2, Kirkpatrick's Four-Level Model was partially used in this study to evaluate training effectiveness (see Table 1). The scope included the assessment of employee learning, reactions to the training, and sensory modality preference.

**Reaction Level.** The Kirkpatrick reaction level was assessed in this study using the Study 2 TSS that had been translated into simplified Chinese and Portuguese (see Appendix C2 & C3). An analysis of reliability resulted in an  $\alpha = .861$  for all 7 questions and an  $\alpha = .800$  for the 6 questions. Additional reliability analysis showed no significant difference in  $\alpha$  based on location.

**Learning Level.** The Kirkpatrick learning level was assessed with the use of the Study 2 pre-test and post-test translated into simplified Chinese and Portuguese (see Appendix B1 & B2). The tests were graded identically to Study 2 and, like Study 2 is referred to as  $\Delta T$ .

**Sensory Modality Preference Inventory.** The sensory modality preference was measured using the Study 2 Sensory Modality Preference Inventory translated into simplified Chinese and Portuguese (see Appendix D1 & D2). The resulting scale for SMP was 1) V-Visual, 2) A-Auditory, 3) K-Kinesthetic, and 4) M-Multi-Modal.

### *Analysis*

To evaluate knowledge gained or performance ( $\Delta T$ ) and employee reaction or preferences (TSS), a 3 Way (Location—BR, CN; Modality—V, A, K, and M; Training—English, NAPO) Factorial Analyses of Variance (ANOVA) was conducted for each dependent variable. After these analyses were conducted possible effects of individual differences (i.e., Gender, Age, Job Function, and Education Level) were considered. All the learning and reaction data was analyzed using IBM SPSS v.24 (IBM Corp., 2016).

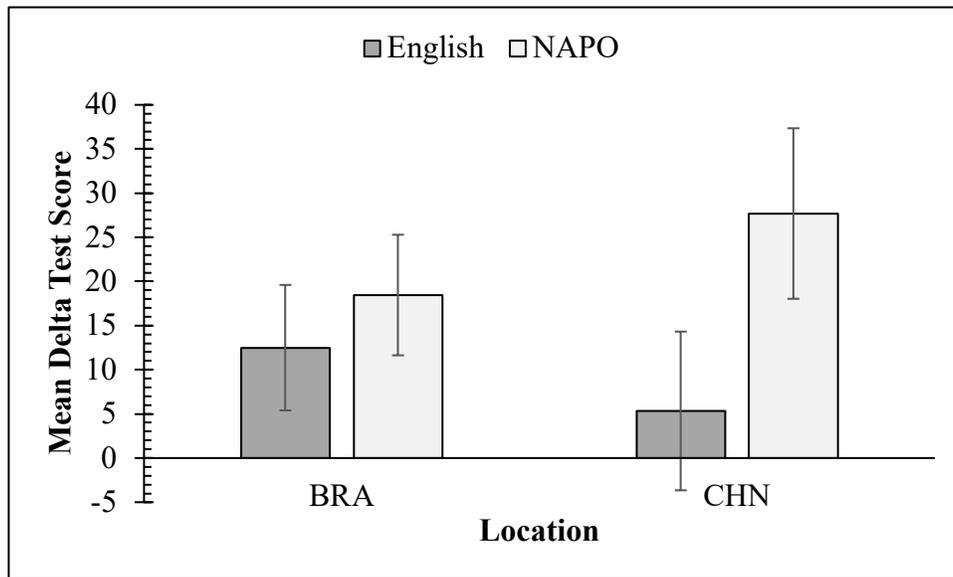
### **Results**

Initial analyses were conducted to evaluate if there were training performance differences in knowledge gain ( $\Delta T$ ) and employee reaction (TSS) with the following results.

#### *Performance Difference from Pre-Test to Post-Test ( $\Delta T$ )*

Figure 7 shows the average  $\Delta T$  score by Location group and training type and as seen in this figure there were significant differences in performance by training type ( $F(1, 77) = 11.74, p = 0.001, \eta_p^2 = 0.137$ ) with the employees performing the NAPO training showing more improvement than those performing ENG with approximately 13.7% of variability being explained by Training Type. There was also an interaction between Location and Training ( $F(1,$

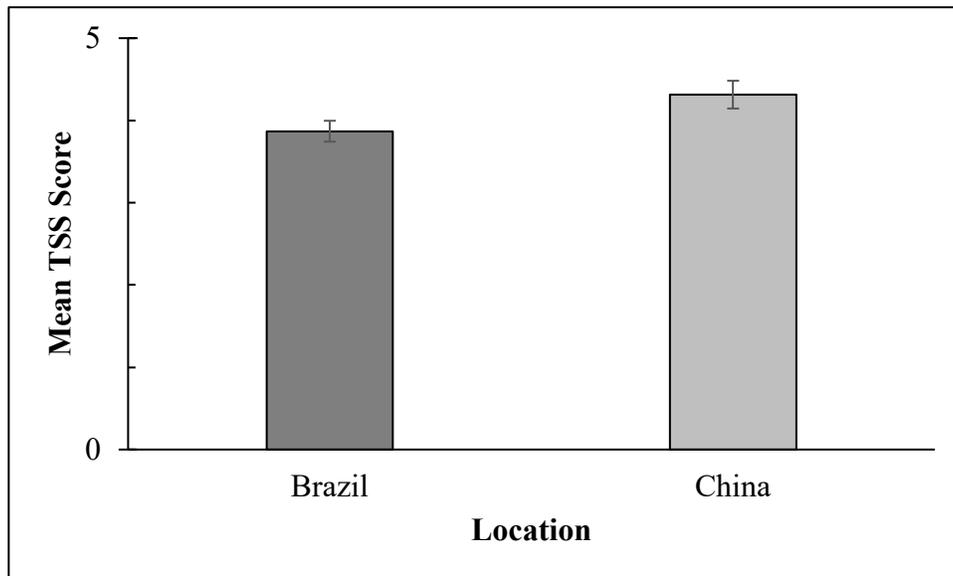
77) = 3.94,  $p = 0.051$ ,  $\eta_p^2 = 0.051$ ). Aside from the significant effects in  $\Delta T$  by Training Type, separate analyses were also conducted by Gender and Modality to identify any effects of these subject variables on performance. There were no main effects of Location, Gender or Modality on  $\Delta T$  all  $p$ 's > 0.213).



**Figure 7.** Study 3: Comparison of Mean Test Score Deltas by Training Type and Location (Brazil and China). There were main effects for Test Score Deltas by Training Type ( $F(1, 77) = 11.74, p = 0.001, \eta_p^2 = 0.137$ ), and interaction between Location and Training Type ( $F(1, 77) = 3.94, p = 0.051, \eta_p^2 = 0.051$ ), but no effect of Location ( $p = 0.80$ ). Error bars represent the 95% confidence interval.

Training Type	Sensory Modality Preference				Total
	Visual	Auditory	Kinesthetic	Multi-Modal	
ENG	5	21	9	4	39
NAPO	4	20	9	6	39
Total	9	41	18	10	78

The distribution of sensory modality preferences are show in Table 7 and ANOVAs that included this variable found no effects of Modality on performance ( $p = 0.885$ ), nor were there modality interactions with Location ( $p = 0.503$ ) and/or Training ( $p = 0.320$ ).



**Figure 8.** Study 3: Mean TSS Score per Location. There were main effects for TSS Score by Location ( $F(1, 77) = 17.70, p < 0.001, \eta_p^2 = 0.193$ ) and Sensory Modality ( $F(3, 77) = 4.85, p = 0.004, \eta_p^2 = 0.187$ ), but no effect or interactions for Training Type and Gender (*all p's* > 0.131). Error bars represent the 95% confidence interval.

#### *Training Satisfaction Score (TSS)*

Analysis showed an effect of Location for TSS scores,  $F(1, 77) = 17.70, p < 0.001, \eta_p^2 = 0.193$  with Chinese employees rating the trainings more favorably than Brazilians (see Figure 8). Although there were no main effects or interactions for Training Type and Gender (*all p's* > 0.131), there was an effect of Sensory Modality,  $F(3, 77) = 4.85, p = 0.004, \eta_p^2 = 0.187$ . Table 8 indicates that employees with kinesthetic learning preferences rated the training less favorably than other employees.

**Table 8.** Study 3: Descriptives for TSS Reactions by Sensory Modality

Modality Type	Mean	SEM	95% Confidence Interval	
			Lower Bound	Upper Bound
Visual	4.17	0.343	3.830	4.515
Multi-Modal	4.17	0.278	3.895	4.450
Auditory	4.19	0.136	4.058	4.330
Kinesthetic	3.76	0.199	3.561	3.959

In this sample, L0 employee's training performance and preferences show the training type effect size was significant at  $p = 0.001$  with approximately 13.7% of  $\Delta T$  variability being explained by Training Type. The interaction of Training type and Location was also significant at  $\sim 0.051$ , explaining 5.1% of the variability in knowledge gain. Moreover, there was an effect of Location,  $F(1, 77) = 14.98, p = 0.000, \eta_p^2 = 0.192$  and Sensory Modality,  $F(3, 77) = 4.85, p = 0.004, \eta_p^2 = 0.187$  explaining 19.3% and 18.7% of the variability in employee reaction (TSS), respectively.

### Discussion

The third and final study in this series of studies compared non-English language employees' knowledge gain and reaction to lingual or non-lingual GHS training based on whether they were Brazilian or Chinese employees.

Similar to Study 2, Figure 7 strongly supports our observations that there was increased learning in all groups after having participated in either of the trainings. However these findings also clearly indicate that for L0 workers, the non-linguistic NAPO was more effective than the English training. Further, for the workers in the ENG training group, the Brazilian trainees

showed a greater degree of knowledge gain than did their Chinese counterparts, while, within the NAPO training group the Chinese showed a greater increase in learning than the Brazilians.

The English version of the training appeared to be less effective than the non-lingual NAPO training for both Brazilian and Chinese non-English (L0) employees. A lack of understanding of the English language, by the L0 trainees, likely made comprehension of the English written and spoken material extremely problematic resulting in a lower improvement in test performance,  $\Delta T$ , than the increases observed in the performance improvement of NAPO trainees. In consideration of the Cognitive Theory of Multimedia Learning and working memory, the ENG training provided the L0 employees no channels (visual nor auditory), whereas the NAPO training allowed for a solitary channel permitting the NAPO learners to work with more information than the ENG trainees (Mayer & Moreno, 2003).

Although performance improvements were observed for both Brazilian and Chinese employees of the NAPO training, the Brazilians did significantly better on the English version of the training than did the Chinese. The reverse was observed with the NAPO employees where the Chinese performed significantly better. The higher level of performance on the ENG training by the Brazilians over the Chinese may be due to differences in writing systems influencing English-word recognition (Li & Suen, 2015). This would almost certainly place the non-English Chinese trainees at an immediate disadvantage with reading and writing English to learners from Romance language backgrounds that are similar to English in structure and alphabet (e.g., Brazilian Portuguese). Furthermore, the larger dissimilarities between English and the phonetics of Chinese versus other Romance languages, again places Chinese learners at a disadvantage to verbal comprehension of English (Baker, 2016). This is also consistent with the Cross-linguistic Transfer Theory, which proposes that individuals use the linguistic knowledge of a language

with which they are proficient to leverage the learning of another language. Correspondingly, the larger improvement in the Test scores of the Chinese NAPO trainees could be attributed to the logographic nature of the Chinese language lending itself to animations and symbols (Li, & Suen, 2015).

On average, the Chinese employees rated the trainings more favorably than did the Brazilians. Perhaps this is reflective of Brazilians being more outspoken and comfortable with dissent in favor of individualism, as opposed to their Chinese counterparts who have a tendency to avoid confrontation or dissent in favor of promoting harmony. The Chinese culture places a high value on balance, harmony, and order, with group interests coming before the individual (collectivism), believing that to succeed it is important not to upset the harmony of the group. This indirect communication style that the Chinese have, suggests that a lack of positive feedback would constitute an outright rejection. Thus, these participants may have rated the trainings positively in order for their group to be perceived as favorable to the authority or group. They may also have wanted the researcher or authority to preserve face. In China, this is a value concept known as “guanxi (relationship) and mianzi (face)” (Ardichvili, Jondle, Kowske, Cornachione, Li, & Thakadipuram, 2012; Buckley, Clegg, & Tan, 2010). In fact, guanxi and mianzi were observed during the study, whereby Chinese participants were reluctant to take the pre-test before having the training, fearing a poor test performance would cause a loss of face. Conversely, Brazilians favor “jeitinho”, a value that allows each person to be seen as individuals or equal human beings free from social inequalities (Torres, Alfinito, Galvão, & Tse, 2015). Brazilians have a very direct communication style, whereby feedback is direct and frank and thus they may have been more comfortable giving negative feedback about the trainings. Though the materials were anonymous, these deeply rooted values cannot necessarily be discounted.

Employees who identified with kinesthetic learning preferences viewed the trainings less favorably than other employees. However, as identified in the  $\Delta T$  scores, this difference in modality preference did not translate into an effect of modality on performance. Therefore, although employees preferring kinesthetic learning may not have preferred the trainings, their modality preference did not appear to have an effect on performance.

## SUMMARY AND CONCLUSION

In today's global economy, businesses are dealing more frequently with multinational and multicultural workforces resulting in multilingual complexities. A common strategy for handling these challenges has been to provide procedures and trainings in a lingua franca. Globally, one of the most commonly adopted lingua franca is English. Therefore, the findings of these studies have important implications regarding the impacts of having a common language for procedures and trainings for workers whose native language is not the common language of English.

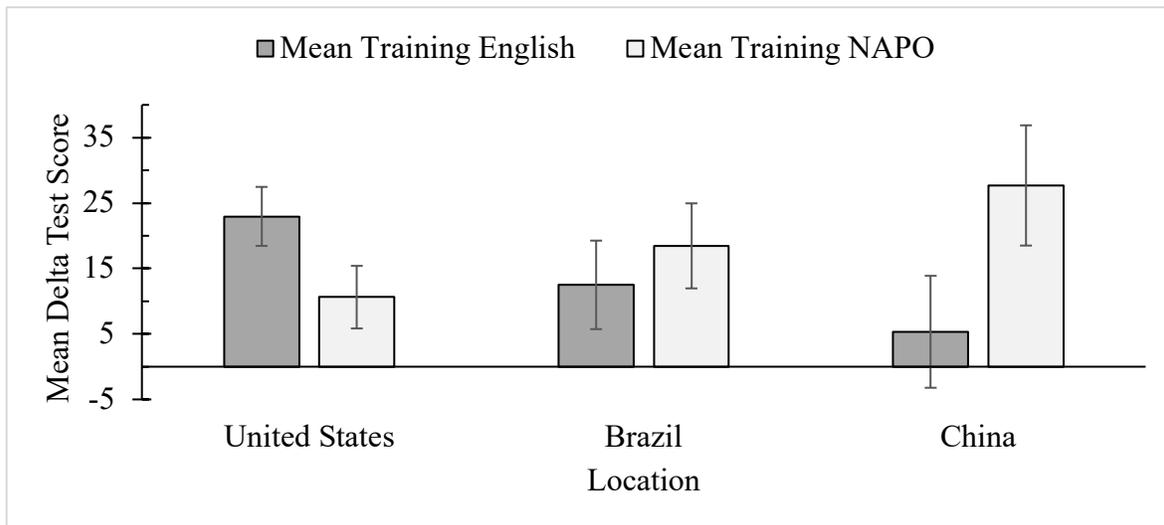
Study 1 adds to our understanding of procedure performance differences between L1 and L2 participants under times of high stress or time pressure. These considerations should prompt us to take a further look at potential unintended consequences of having procedures only available to employees in their non-native language. These results are particularly relevant given current findings that workers report they are more likely to use procedures for tasks they do infrequently and with which they are less familiar (Williams, Sasangohar, Peres, Smith, & Mannan, 2017). For these situations, workers need to be clearly reminded of how to do the work. Further, this is especially troubling when considering procedures used during times of crisis or emergencies. Additionally, gender implications were encountered in the study that are not fully understood. The findings led to a need to further explore beyond procedures to other types of critical/urgent communications, documents, and trainings that are delivered in non-native languages.

To build on the previous study, Study 2 was designed to add to our understanding of training performance (learning & reaction) between L1 and L2 employees by English language

versus non-lingual training types. Although both training types demonstrated knowledge gain, training presented in a language for which the employee comprehends was preferred and clearly more effective. These considerations should prompt us to focus on providing training to employees in a language that is understood by the employee. Though, multimedia (auditory, visual, and/or tactile) training is clearly preferred if presented in the employees native or secondary language, non-lingual training may be an effective means to providing learning to employees that have no mastery or comprehension of the lingua franca. Moreover, though English language training was clearly more effective, non-lingual training did show performance improvement. Again this is particularly interesting given the multinational/multilingual nature of global business and as an alternative to training that is often provided to global employees in a lingua franca, a choice that is especially attractive when considering the need for providing training to L1, L2 and L0 employees. Therefore, Study 3 of this research compared the efficacy of English language versus non-lingual training types and non-English language (L0) employees.

Study 3 was designed to add to our understanding of training performance (learning & reaction) of non-English language employees (Brazil and China) by English language versus non-lingual training types. Although both training types demonstrated knowledge gain, training presented in a non-lingual media was preferred and clearly more effective. These considerations should further prompt us to take a closer look at the potential for the unintended consequences of having training only available to employees in their non-native language. Again, this is especially worrying when considering that training is often provided to global employees in a lingua franca, such as English. This is strongly evident in Table 7, where amongst employees of the English version of the training, Brazilians had a larger improvement in  $\Delta T$  than the Chinese employees. On the other hand, for employees of the NAPO version of the training, the Chinese

had a larger improvement in Test scores between Pre & Post Tests than the Brazilian employees. Regardless, overall a larger improvement in knowledge was observed by employees of the non-lingual (NAPO) version of the training versus the English language (ENG) version trainees.



**Figure 9.** Combined result of Study 2 and 3: Mean Delta Test Score per Location. There were interactions between Training Type and Location ( $F(2, 179) = 13.56, p < 0.001, \eta_p^2 = 0.135$ ). Error bars represent the 95% confidence interval.

Comprehensively, examining the combined results of Studies 2 and 3 (see Figure 9), we see a very interesting pattern demonstrating the highest level of performance improvement on the English language training by the English language employees, followed in performance by the Brazilians and then Chinese. This could be explained by the Cross-linguistic Transfer Theory whereby Portuguese has more commonalities to English than Chinese. Conversely, the higher level of training performance improvement by the Chinese employees on the non-lingual training may be attributable to the logographic nature of Chinese.

Though the methodologies and analyses of these studies were sound there were several limitations that must be considered. This study was limited to one manufacturing company and

one topic (GHS) and therefore the results may not be indicative of other companies, industries or topics. Additionally, there were significantly fewer female versus male participants in any of the studies nor as many Chinese participants as Brazilians, L1 Americans, or L2 Americans. Unfortunately the effects of gender found in Study 1, could not be adequately explored in Study 2 and Study 3 because the low distribution of females in both the Brazilian and Chinese manufacturing sites. Specific measures used in Study 2 and Study 3 were not validated for cultural sensitivity. Variations could have existed due to the differences in training format between Study 2 and Study 3, in that the trainings were conducted in groups versus individually delivered via LMS. Also as mentioned previously in Study 1, the possibility of implicit biases resulting from study design and/or the researchers cannot be discounted from any of the studies. Finally, limitations may also have included the potential for cultural and gender biases, spatial ability and computer gaming experience differences, the level of complexity of the simulation/training, psychological fidelity of the simulation environment to closely approximate reality/risks, and the design of the performance evaluation criteria.

To conclude, these studies build upon one another to provide scientific insight into the effects of language proficiency on EHS communications (documentation and training) by assessing participants' written operating procedure performance and hazard warning statement/symbol comprehension, and the efficacy of non-linguistic safety training to bridge language, geographical, resource, literacy, and cultural gaps thereby expanding our academic understanding. This research assessed theoretical expectations concerning the relative effectiveness of different types of EHS documentation and training aimed at modifying performance, comprehension and knowledge on groups of L1, L2 and L0 participants. Our results are consistent with Mayer's Cognitive Theory of Multimedia Learning and the Cross-

linguistic Transfer Theory in that the totality of our findings clearly demonstrate that documentation/training provided in a language that is understood by the receiver is effective and preferred and that non-lingual materials may be an effective alternative given the absence of translated materials. In regards to the Visual-Auditory-Kinesthetic/Tactile (VAK) Learning Style Model our findings showed no evidence that supports the notion that modality preferences effect knowledge gain or reaction to training. Although this study was comprehensive and exhaustive, further study is still warranted to better understand training effectiveness related to different modes & media of delivery, culture & gender, industry & topic and modality preferences.

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## APPENDIX A

### STUDY 1 CONSENT FORM

#### CONSENT FORM

##### **Project Title: Procedure Designs for Hazard Communications**

You are invited to take part in a research study being conducted by S. Camille Peres Ph.D., a researcher from the Texas A&M Health Science Center and funded by The Center for Operator Performance. The information in this form is provided to help you decide whether or not to take part. If you decide you do not want to participate, there will be no penalty to you, and you will not lose any benefits you normally would have.

##### **Why Is This Study Being Done?**

The purpose of this study is to assess how procedure design affects people's abilities to complete tasks when using written procedures.

##### **Why Am I Being Asked To Be In This Study?**

You are being asked to be in this study because you fulfill the following inclusion/exclusion criteria:

1. You are at least 18 years old.
2. You are currently enrolled in the College of Engineering

##### **How Many People Will Be Asked To Be In This Study?**

50 people (participants) will be invited to participate in this study.

##### **What Are the Alternatives to being in this study?**

None, the alternative to being in the study is not to participate. Participation is completely voluntary.

##### **What Will I Be Asked To Do In This Study?**

You will be asked to complete a series of short computer-based tasks in a simulated environment by using written procedures (i.e., instructions). Your participation in this study will last up to 2 hours during one visit.

##### **Are There Any Risks To Me?**

The things that you will be doing involve no greater risk than you would come across in everyday life. The overall physical work required for this experiment is

not significantly more than for common computer tasks.

**Will There Be Any Costs To Me?**

Aside from your time, there are no costs for taking part in the study.

**Will I Be Paid To Be In This Study?**

You will receive \$20 USD as compensation for your time.

**Will Information From This Study Be Kept Private?**

The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only Dr. Camille Peres, Juan Carlos Batarse, William Johnson, and Paul Ritchey will have access to the records.

Information about you will be stored in a locked file cabinet and computer files stored on a protected drive.

Information about you and related to this study will be kept confidential to the extent permitted or required by law. People who have access to your information include the Principal Investigator and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the Texas A&M University Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly.

**Who may I Contact for More Information?**

You may contact the Principal Investigator, S. Camille Peres, Ph.D. to tell her about a concern or complaint about this research at 979-436-9326 or [peres@sph.tamhsc.edu](mailto:peres@sph.tamhsc.edu).

For questions about your rights as a research participant; or if you have questions, complaints, or concerns about the research, you may call the Texas A&M University Human Subjects Protection Program office at (979) 458-4067 or [irb@tamu.edu](mailto:irb@tamu.edu).

**What if I Change My Mind About Participating?**

This research is voluntary and you have the choice whether or not to be in this research study. You may decide to not begin or to stop participating at any time. If you choose not to be in this study or stop being in the study, there will be no effect on your student status, medical care, employment, evaluation, and relationship with Texas A&M University or the Texas A&M Health Science Center.

## STATEMENT OF CONSENT

I agree to be in this study and know that I am not giving up any legal rights by signing this form. The procedures, risks, and benefits have been explained to me, and my questions have been answered. I know that new information about this research study will be provided to me as it becomes available and that the researcher will tell me if I must be removed from the study. I can ask more questions if I want. A copy of this entire consent form will be given to me.

\_\_\_\_\_  
Participant's Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed Name

### INVESTIGATOR'S AFFIDAVIT:

Either I have or my agent has carefully explained to the participant the nature of the above project. I hereby certify that to the best of my knowledge the person who signed this consent form was informed of the nature, demands, benefits, and risks involved in his/her participation.

\_\_\_\_\_  
Signature of Presenter

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed Name

## APPENDIX B

### STUDY 2 PRE-TEST & POST-TEST (ENGLISH)

Dover Fueling Solutions has partnered with researchers at Texas A&M University to study attitudes, beliefs and behaviors associated with non-linguistic online EHS Training. Using both pre- and post-tests, we aim to specifically improve our understanding of the effectiveness of non-linguistic web-based safety training. This test, consisting of 10 questions in total, is expected to take you no more than 10 minutes to complete. Your responses will be kept confidential. Thank you in advance for your valuable time.

#### Choose the correct pictogram for each description:

- \_\_\_ 1. Acute Toxicity: The adverse effects of a substance that result either from a single exposure or from multiple exposures in a short space of time. May be Fatal or Toxic.



- \_\_\_ 2. Health Hazard: Substance may be a carcinogen, can damage eyes, lungs, or other target organs; can also can be a sensitizer, mutagen, or be a respiratory sensitizer.



- \_\_\_ 3. Corrosion: Causes Skin Corrosion or Burns, can cause eye damage. Corrosive to metals.



- \_\_\_ 4. Gasses Under Pressure: This can include compressed gasses or liquefied gasses. Gas released may be very cold. Gas container may explode if heated.



\_\_\_ 5. Explosives: Explosive articles, and substances as well as mixtures and articles that are manufactured to produce a practical explosive or pyrotechnic effect.



\_\_\_ 6. Flammables: Flammable gasses, liquids, or aerosols; self reactive or pyrophoric material; self-heating substances and mixtures, organic peroxides.



\_\_\_ 7. Irritant: Harmful to the skin or eyes, a skin sensitizer or respiratory irritant, may experience narcotic effects.



\_\_\_ 8. Aquatic Toxicity: The effects of manufactured chemicals and natural materials and activities on aquatic organisms.



### True or False

\_\_\_ 9. If you transfer chemicals from a large container into a smaller container, to use at a workstation, you must put a label on the small container to identify the chemical.

\_\_\_ 10. Instead of disposing of harmful chemicals into a river or stream, you should flush them down a toilet or wash them down a sink.

**Study 2 Pre-Test & Post-Test (English)**

**ANSWERS**

1. C 2. A 3. B 4. D 5. A 6. C 7. C 8. D 9. True 10. False.

APPENDIX B1

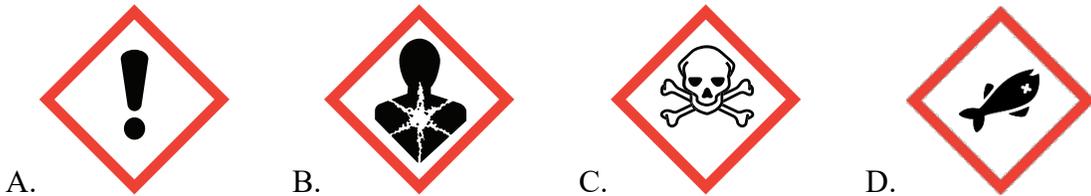
STUDY 3 PRE-TEST & POST-TEST (CHINESE - SIMPLIFIED)

第3项研究(3)的先期测试及后期测试

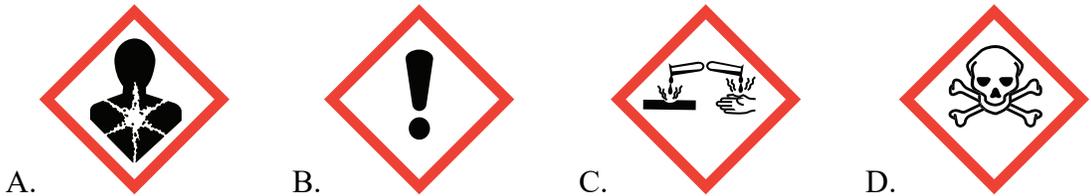
Dover Fueling Solutions 已与德州农工大学的研究者合作研究对非语言在线 EHS 培训有关的态度、观念及行为。我们计划通过先期测试及后期测试提高我们对基于网络的非语言性安全培训的成效的了解。该测试共有10个问题，预期10分钟即可完成。您的回答将予以保密。首先感谢您投入宝贵的时间。

为以下每个描述选择正确的象形图：

1. 急性中毒：源自单次接触或短时间内的多次接触某种物质的负面效应。可能致命或有毒。



2. 健康危害：相关物质可以是致癌物质，可能会损伤眼睛、肺部或其他靶器官；还可能是过敏物、突变原或者致呼吸道过敏之物质。



3. 腐蚀：导致皮肤腐蚀或烧伤，可能会导致眼睛损伤。腐蚀金属。



4. 承压气体：可包括高压气体或液化气体。释放的气体温度可能极低。如果加热，气体容器可能会爆炸。



5. 爆炸物：爆炸性物品和物质以及制造的那些用于产生实际爆炸或爆破效果的混合物品。



6. 易燃物：易燃气体、液体或气溶胶；自反应或自燃物质；自热物质及混合物、有机过氧化物。



7. 刺激物：对皮肤或眼睛有害，皮肤致敏物或呼吸道刺激物，可能具有麻醉效果。



8. 水生生物毒性：人造化学品和天然材料及活动对水生生物的影响。



## 正确或错误

9. 如果要将化学品从大容器转移到小容器，以在工作台使用，必须在小容器上贴上标签，以识别该化学品。
10. 不应该将有害化学品倒入河流或小溪内，而应倒入厕所或冲下下水道。

**Study 2 Pre-Test & Post-Test (Chinese - Simplified)**

答案

1.C 2.A 3.B 4.D 5.A 6.C 7.C 8.D 9.正确 10.错误

APPENDIX B2

STUDY 3 PRE-TEST & POST-TEST (PORTUGUESE)

**Estudo nº3 - Teste preliminar e teste posterior**

A Dover Fueling Solutions firmou uma parceria com pesquisadores da Texas A&M University para estudar atitudes, opiniões e comportamentos associados à Qualificação on-line não linguística em EHS. Através de testes preliminares e posteriores, pretendemos obter uma melhor compreensão sobre a eficácia da qualificação on-line não linguística em segurança. Este teste contém 10 perguntas e sua duração estimada é de 10 minutos. O teor das suas respostas será confidencial. Desde já, agradecemos pelo tempo dedicado.

**Escolha o pictograma correto para cada descrição:**

1. Toxicidade aguda: Efeitos adversos decorrentes de exposição única ou de múltiplas exposições a uma substância durante um curto período. Pode ser fatal ou tóxica.



2. Risco à saúde: A substância pode ser cancerígena ou causar danos aos olhos, pulmões ou outros órgãos; também pode ser sensibilizante ou mutagênica ou provocar sensibilização respiratória.



3. Corrosão: Causa corrosão ou queimaduras na pele ou pode causar danos aos olhos. Corrói metais.



4. Gases sob pressão: Podem ser gases comprimidos ou liquefeitos. A temperatura do gás liberado pode ser muito baixa. Os recipientes com gás podem explodir quando aquecidos.



5. Explosivos: Artigos e substâncias explosivas e misturas e artigos fabricados para produzir efeitos explosivos ou pirotécnicos.



6. Inflamáveis: Gases, líquidos ou aerossóis inflamáveis; material autorreativo ou pirofórico; misturas e substâncias suscetíveis a autoaquecimento e peróxidos orgânicos.



7. Irritante: Causa danos à pele ou aos olhos, sensibilização da pele, irritação respiratória e, possivelmente, efeitos narcóticos.



8. Toxicidade aquática: Efeitos de produtos químicos manufacturados e materiais e atividades naturais sobre organismos aquáticos.



### **Verdadeiro ou falso**

- 9.** Ao transferir um produto químico de um recipiente maior para outro menor a fim de utilizá-lo numa estação de trabalho, é necessário colocar um rótulo no recipiente menor para identificá-lo.
  
- 10.** Em vez de descartar produtos químicos nocivos em rios ou córregos, jogue-os no vaso sanitário e dê a descarga ou os despeje no ralo de uma pia.

**Study 2 Pre-Test & Post-Test (Portuguese)**

**RESPOSTAS**

1. C 2. A 3. B 4. D 5. A 6. C 7. C 8. D 9. Verdadeiro 10. Falso.

## APPENDIX C

### STUDY 1 POST-SURVEY (ENGLISH)

Please answer the following questions:

1. What is your age?
2. What is your gender?
3. What is the highest level of education you have completed?
4. Are you currently enrolled as a student? If so please list your year and major:
5. Were you born in a country other than the United States? If so please list name of country.
6. If you were not born in the United States how long have you been residing in the United States?
7. Have you ever lived outside of the United States? If so please list the countries you lived in and the number of years you've lived in those countries.
8. What is your native language?
9. If English was not your first language when did you begin learning English?
10. Do you speak any languages other than English?
11. What ethnicity do you identify as (please select all that apply)
  - African American/Black
  - American Indian/Alaska Native
  - Asian
  - Native Hawaiian/Other Pacific Islander
  - White/Caucasian
  - Other: (please specify)
12. Have you ever worked in an industrial setting (like a chemical plant or other type of processing plant?) If you have, how many years did you work and what type of work did you do?
13. Have you ever used procedures in an industrial setting before?

## APPENDIX C1

### STUDY 2 POST-SURVEY (ENGLISH)

Dover Fueling Solutions has partnered with researchers at Texas A&M University to study attitudes, beliefs and behaviors associated with non-linguistic online EHS Training. Using this survey, we aim to specifically improve our understanding of the effectiveness of non-linguistic web-based safety training. This survey, consisting of 10 questions in total, is expected to take you no more than 10 minutes to complete. Your responses will be kept confidential. Thank you in advance for your valuable time.

**Question 1** Please indicate your gender.

- Male
- Female

**Question 2** Please select the category that includes your age.

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 or older

**Question 3** Please select the category that includes your job.

- Administrative
- Production/Service
- Engineering/Technical
- Manager/Supervisor
- Executive/Director
- Other

**Question 4** Please select the category that includes your education level.

- Less than High School
- High School
- Some College
- Associates
- Bachelors
- Graduate Degree

**Please choose the answer that is best associated with your perceptions and attitudes towards the non-linguistic web-based safety training.**

**Question 5** Overall I liked the training?

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

**Question 6** I find the training useful for my job and safety?

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

**Question 7** The content was understandable?

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

**Question 8** I feel that I have learned something new from this training?

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

**Question 9** I found the content interesting?

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

**Question 10** I prefer this type of training over traditional classroom training?

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

**Question 11** I prefer this type of training over training that includes spoken language?

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

## APPENDIX C2

### STUDY 3 POST-SURVEY (CHINESE - SIMPLIFIED)

#### 第3项研究 (3) 后期调查

Dover Fueling Solutions 已与德州农工大学的研究者合作研究对非语言在线 EHS 培训有关的态度、观念及行为。我们计划通过该调查提高我们对基于网络的非语言性安全培训的成效的了解。该调查共有10个问题，预期10分钟即可完成。您的回答将予以保密。首先感谢您投入宝贵的时间。

**问题 1** 请指出您的性别

- 男
- 女

**问题 2** 请选择您的年龄所在的类别。

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 岁或以上

**问题 3** 请选择您的工作所在的类别。

- 行政
- 生产/服务
- 工程/技术
- 经理/主管
- 高管/董事
- 其他

**问题 4** 请选择您的学历所在的类别。

- 高中以下
- 高中
- 上过一些大学课程
- 副学士
- 学士
- 研究生

请选择最符合您对基于网络的非语言性安全培训的看法和态度的回答。

问题 5 我对培训的总体看法？

1	2	3	4	5
完全不同意	不同意	未决定	同意	完全同意

问题 6 我觉得培训对我的工作和安全有用？

1	2	3	4	5
完全不同意	不同意	未决定	同意	完全同意

问题 7 内容可理解？

1	2	3	4	5
完全不同意	不同意	未决定	同意	完全同意

问题 8 我认为我从培训中学到新东西？

1	2	3	4	5
完全不同意	不同意	未决定	同意	完全同意

问题 9 我觉得内容很有趣？

1	2	3	4	5
完全不同意	不同意	未决定	同意	完全同意

问题 10 我更喜欢这类培训而不是传统的教室培训？

1	2	3	4	5
完全不同意	不同意	未决定	同意	完全同意

问题 11 我更喜欢这类培训而不是那些包含用口语宣讲的培训？

15. 1	2	3	4	5
完全不同意	不同意	未决定	同意	完全同意

## APPENDIX C3

### STUDY 3 POST-SURVEY (PORTUGUESE)

#### Estudo nº 3 - Questionário posterior

A Dover Fueling Solutions firmou uma parceria com pesquisadores da Texas A&M University para estudar atitudes, opiniões e comportamentos associados à Qualificação on-line não linguística em EHS. Por meio deste questionário, pretendemos obter uma melhor compreensão sobre a eficácia da qualificação on-line não linguística em segurança. Este questionário contém 10 perguntas e sua duração estimada é de 10 minutos. O teor das suas respostas será confidencial. Desde já, agradecemos pelo tempo dedicado.

**Pergunta 1** Informe o seu gênero.

- Masculino
- Feminino

**Pergunta 2** Selecione a sua faixa etária.

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 ou mais

**Pergunta 3** Selecione a sua categoria profissional.

- Administrativa
- Produção/serviços
- Engenharia/técnica
- Gerente/supervisor
- Executivo/diretor
- Outra

**Pergunta 4** Selecione a sua escolaridade.

- Ensino médio incompleto
- Ensino médio
- Ensino superior incompleto
- Curso técnico
- Ensino superior completo
- Pós-graduação

**Selecione a resposta que melhor corresponde à sua percepção e atitude com relação à qualificação on-line não linguística em segurança.**

**Pergunta 5** Em termos gerais, a qualificação atendeu às minhas expectativas?

1	2	3	4	5
Discordo totalmente	Discordo	Não sei	Concordo	Concordo totalmente

**Pergunta 6** Achei a qualificação útil para o meu trabalho e minha segurança?

1	2	3	4	5
Discordo totalmente	Discordo	Não sei	Concordo	Concordo totalmente

**Pergunta 7** O conteúdo foi administrado de modo compreensível?

1	2	3	4	5
Discordo totalmente	Discordo	Não sei	Concordo	Concordo totalmente

**Pergunta 8** Aprendi algo novo na qualificação?

1	2	3	4	5
Discordo totalmente	Discordo	Não sei	Concordo	Concordo totalmente

**Pergunta 9** Achei o conteúdo interessante?

1	2	3	4	5
Discordo totalmente	Discordo	Não sei	Concordo	Concordo totalmente

**Pergunta 10** Prefiro esse tipo de qualificação a cursos convencionais em sala de aula?

1	2	3	4	5
Discordo totalmente	Discordo	Não sei	Concordo	Concordo totalmente

**Pergunta 11** Prefiro esse tipo de qualificação a cursos com exposição verbal?

17. 1	2	3	4	5
Discordo totalmente	Discordo	Não sei	Concordo	Concordo totalmente

## APPENDIX D

### STUDY 2 SENSORY MODALITY PREFERENCE INVENTORY (ENGLISH)

Read the statements below and select the appropriate response as it applies to you.

#### **VISUAL MODALITY**

**Question 1** I remember information better if I write it down.

- Often
- Sometimes
- Seldom/Never

**Question 2** Looking at the person helps keep me focused.

- Often
- Sometimes
- Seldom/Never

**Question 3** I need a quiet place to get my work done.

- Often
- Sometimes
- Seldom/Never

**Question 4** When I take a test, I can see the textbook page in my head.

- Often
- Sometimes
- Seldom/Never

**Question 5** I need to write down directions, not just take them verbally.

- Often
- Sometimes
- Seldom/Never

**Question 6** Music or background noise distracts my attention from the task at hand.

- Often
- Sometimes
- Seldom/Never

**Question 7** I don't always get the meaning of a joke.

- Often
- Sometimes
- Seldom/Never

**Question 8** I doodle and draw pictures on the margins of my paper.

- Often
- Sometimes
- Seldom/Never

**Question 9** have trouble following lectures.

- Often
- Sometimes
- Seldom/Never

**Question 10** I react very strongly to colors.

- Often
- Sometimes
- Seldom/Never

### **AUDITORY MODALITY**

**Question 1** My papers and notebooks always seem messy.

- Often
- Sometimes
- Seldom/Never

**Question 2** When I read, I need to use my index finger to track my place on the line.

- Often
- Sometimes
- Seldom/Never

**Question 3** I do not follow written directions well.

- Often
- Sometimes
- Seldom/Never

**Question 4** If I hear something, I will remember it.

- Often
- Sometimes
- Seldom/Never

**Question 5** Writing for me has always been difficult.

- Often
- Sometimes
- Seldom/Never

**Question 6** I often misread words from the text (i.e., “them” for “then”).

- Often
- Sometimes
- Seldom/Never

**Question 7** I would rather listen and learn than read and learn.

- Often
- Sometimes
- Seldom/Never

**Question 8** I'm not very good at interpreting an individual's body language.

- Often
- Sometimes
- Seldom/Never

**Question 9** Pages with small print or poor quality copies are difficult for me to read.

- Often
- Sometimes
- Seldom/Never

**Question 10** My eyes tire quickly, even though my vision check-up is always fine.

- Often
- Sometimes
- Seldom/Never

### **KINESTHETIC/TACTILE MODALITY**

**Question 1** I start a project before reading the directions.

- Often
- Sometimes
- Seldom/Never

**Question 2** I hate to sit at a desk for long periods of time.

- Often
- Sometimes
- Seldom/Never

**Question 3** I prefer first to see something done and then to do it myself.

- Often
- Sometimes
- Seldom/Never

**Question 4** I use the trial and error approach to problem solving.

- Often
- Sometimes
- Seldom/Never

**Question 5** I like to read my book while riding an exercise bike.

- Often
- Sometimes
- Seldom/Never

**Question 6** I take frequent study breaks.

- Often
- Sometimes
- Seldom/Never

**Question 7** I have a difficult time giving step-by-step directions.

Often

Sometimes

Seldom/Never

**Question 8** I enjoy sports and do well at several different types of sports.

Often

Sometimes

Seldom/Never

**Question 9** I use my hands when describing things.

Often

Sometimes

Seldom/Never

**Question 10** I have to rewrite or type my class notes to reinforce the material.

Often

Sometimes

Seldom/Never

**SCORING SHEET:** Tabulate as follows: Often = 3; Sometimes = 2; Seldom/Never = 1.

Total the score for each section.

VISUAL MODALITY SCORE = \_\_\_\_\_

AUDITORY MODALITY SCORE = \_\_\_\_\_

KINESTHETIC/TACTILE MODALITY SCORE = \_\_\_\_\_

A score of 21 points or more in a modality indicates a strength in that area. The highest of the 3 scores indicates the most efficient method of information intake. The second highest score indicates the modality, which boosts the primary strength. For example, a score of 23 in the visual modality indicates a strong visual learner. Such a learner benefits from the text, charts, graphs, etc. If the second highest score is auditory, then the individual would benefit from auditory tapes, lectures, etc. If you are strong kinesthetically, then taking notes and rewriting class notes will reinforce information.

## APPENDIX D1

### STUDY 3 SENSORY MODALITY PREFERENCE INVENTORY (CHINESE - SIMPLIFIED)

#### 第 3 项研究 (3) 感觉形态兴趣量表

请阅读以下说法，并选择适用于您的适当回答。

#### 视觉模式

**问题 1** 如果我写下来，我可以更好地记忆信息。

- 经常
- 有时
- 很少/从不

**问题 2** 看着对方可以帮助我集中注意力。

- 经常
- 有时
- 很少/从不

**问题 3** 我需要安静的地方完成工作。

- 经常
- 有时
- 很少/从不

**问题 4** 当我考试时，我可以在脑海中浮现教科书的相应页面。

- 经常
- 有时
- 很少/从不

**问题 5** 我需要写下指示，而不仅仅是口头接受。

- 经常
- 有时
- 很少/从不

**问题 6** 音乐或背景噪音会分散我在处理手头任务时的注意力。

- 经常
- 有时
- 很少/从不

**问题 7** 我并不总是能够明白笑话的意思。

- 经常
- 有时
- 很少/从不

**问题 8** 我在页边涂鸦绘画。

- 经常
- 有时
- 很少/从不

**问题 9** 上课听讲有困难。

- 经常
- 有时
- 很少/从不

**问题 10** 我对颜色反应非常强烈。

- 经常
- 有时
- 很少/从不

### 听觉模式

**问题 1** 我的文件和笔记本总是显得很凌乱。

- 经常
- 有时
- 很少/从不

**问题 2** 在我阅读时，我需要用食指指着每一行阅读。

- 经常
- 有时
- 很少/从不

**问题 3** 我不能很好地遵循书面指示。

- 经常
- 有时
- 很少/从不

**问题 4** 如果我听到什么东西，我会记住。

- 经常
- 有时
- 很少/从不

**问题 5** 写作对我来说一直是个难题。

- 经常
- 有时
- 很少/从不

**问题 6** 我经常看错课文里的词语（如，将“them”看成“then”）。

- 经常
- 有时
- 很少/从不

**问题 7** 我更愿意听讲学习，而不是阅读学习。

- 经常
- 有时
- 很少/从不

**问题 8** 我不是很擅长解读个人的肢体语言。

- 经常
- 有时
- 很少/从不

**问题 9** 对我来说，字体较小的书页或质量较差的复印件比较难阅读。

- 经常
- 有时
- 很少/从不

**问题 10** 我的眼睛会很快疲劳，虽然我的视力检查结果一直很好。

- 经常
- 有时
- 很少/从不

### 动觉/触觉模式

**问题 1** 我在读取指示前就开展一个项目。

- 经常
- 有时
- 很少/从不

**问题 2** 我讨厌长时间坐在办公桌旁。

- 经常
- 有时
- 很少/从不

**问题 3** 我更愿意首先看到某项工作怎样完成，然后我自己再做。

- 经常
- 有时
- 很少/从不

**问题 4** 我用反复试验方法（试错法）来解决问题。

- 经常
- 有时
- 很少/从不

**问题 5** 我喜欢在踩健身车时读书。

- 经常
- 有时
- 很少/从不

**问题 6** 我在学习中频繁休息。

- 经常
- 有时
- 很少/从不

**问题 7** 我对提供具体的一步一步的指示方面有困难。

- 经常
- 有时
- 很少/从不

**问题 8** 我喜欢运动，擅长多项不同的运动。

- 经常
- 有时
- 很少/从不

**问题 9** 我在描述事物时会使用双手。

- 经常
- 有时
- 很少/从不

**问题 10** 我必须重写或输入我的课堂笔记，以强化该学习资料。

- 经常
- 有时
- 很少/从不

## APPENDIX D2

### STUDY 3 SENSORY MODALITY PREFERENCE INVENTORY (PORTUGUESE)

#### Estudo nº 3 - Avaliação de preferências de modalidades sensoriais

Leia as afirmações abaixo e selecione a resposta aplicável ao seu caso.

#### **MODALIDADE VISUAL**

**Pergunta 1** Lembro melhor quando anoto as informações.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 2** Fico mais concentrado quando vejo a pessoa que está falando.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 3** Preciso de um lugar silencioso para trabalhar.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 4** Quando faço um teste, imagino a página do livro correspondente.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 5** Preciso anotar as orientações que recebo e não apenas ouvi-las.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 6** Música ou ruído de fundo me distraem da tarefa que estou executando.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 7** Nem sempre entendo as piadas que ouço.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 8** Costumo rabiscar e desenhar figuras nas margens dos papéis.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 9** Tenho dificuldades para acompanhar palestras.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 10** Tenho fortes reações a cores.

- Frequentemente
- Às vezes
- Raramente/nunca

### **MODALIDADE AUDITIVA**

**Pergunta 1** Meus papéis e cadernos sempre estão desorganizados.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 2** Quando leio, acompanho com o indicador a linha de leitura.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 3** Não consigo interpretar muito bem orientações escritas.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 4** Costumo lembrar do que ouço.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 5** Sempre tive dificuldades para escrever.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 6** Costumo trocar palavras quando leio textos (por exemplo, "ideia" e "ideal").

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 7** Aprendo melhor ouvindo do que lendo.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 8** Não consigo interpretar muito bem a linguagem corporal das pessoas.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 9** Tenho dificuldades para ler páginas com letras muito pequenas e cópias de má qualidade.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 10** Embora não tenha problemas oftalmológicos, fico com a vista cansada muito rápido.

- Frequentemente
- Às vezes
- Raramente/nunca

## **MODALIDADE TÁTIL/CINESTÉSICA**

**Pergunta 1** Início um projeto antes de ler as orientações.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 2** Odeio passar muito tempo sentado.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 3** Prefiro ver antes para só depois fazer algo por conta própria.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 4** Para resolver problemas, utilizo a abordagem de tentativa e erro.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 5** Gosto de ler livros enquanto me exercito numa bicicleta ergométrica.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 6** Faço pausas frequentes quando estudo.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 7** Tenho dificuldades para dar orientações detalhadas em etapas para outras pessoas.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 8** Gosto de praticar e tenho um bom desempenho em diversos tipos de esportes.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 9** Costumo gesticular quando descrevo algo.

- Frequentemente
- Às vezes
- Raramente/nunca

**Pergunta 10** Tenho que reescrever ou digitar minhas anotações para aproveitar melhor o material.

- Frequentemente
- Às vezes
- Raramente/nunca

## APPENDIX E

### STUDY 1 RECRUITMENT EMAIL AND INFORMATION SHEET (ENGLISH)

Howdy!

Students enrolled in the College of Engineering are needed for a study that involves performing tasks in a simulated environment while using procedures (i.e., instructions). For this study, 25 international students as well as 25 national students will be recruited.

Participants will complete a short series of computer-based tasks and complete a set of surveys. Participants will attend one session lasting no longer than 2 hours and will be compensated \$20 for their time.

If interested, you must be 18 or older to participate and be currently enrolled in the College of Engineering. The research session will take place at the School of Public Health.

If you're interested in participating or would like more information, please contact our research team at [peres@sph.tamhsc.edu](mailto:peres@sph.tamhsc.edu) and please include if you are an international student or national student.

Principal Investigator information:

S. Camille Peres, Ph.D.

Assistant Professor

Department of Environmental and Occupational Health

School of Public Health

Texas A&M Health Science Center

[peres@tam.u.edu](mailto:peres@tam.u.edu)

979-436-9326

## **Study 1 Information Sheet**

### **Project Title: Procedure Designs for Hazard Communications**

#### **Introduction**

The purpose of this document is to provide you information that may affect your decision as to whether or not you want to participate in this research study.

If you agree, you will be asked to participate in a research study examining factors associated with the use of written procedures. The purpose of this study is to assess how procedure design affects people's abilities to complete tasks when using written procedures. You have been selected to be a possible participant because you are a Texas A&M University engineering student over the age of 18.

#### **What will I be asked to do?**

If you decide to participate in this study, you will be complete a series of short computer-based tasks in a simulated environment by using written procedures (i.e., instructions). Your participation in this study will last up to 2 hours during one visit. No identifiable information about you related to this study will be shared.

#### **What are the risks involved in this study?**

The risks associated with this study are minimal, and are not greater risk than you would come across in everyday life. The overall physical work required for this experiment is not significantly more than for common computer tasks.

**What are the possible benefits of this study?**

You will receive \$20 USD as compensation for your time participating in this study.

Additionally, the information from this study will help with understanding how procedure design might be improved to enhance people's abilities to complete critical tasks.

**Do I have to participate?**

No, you do not have to be in this research study. There is no penalty for choosing not to participate, and you can withdraw from the research study without any penalty if you change your mind later.

**Who will know about my participation in this research study?**

This study is confidential and the records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only Texas A&M Researchers Dr. Camille Peres, Juan Carlos Batarse, William Johnson, and Paul Ritchey will have access to the records.

**Whom do I contact with questions about the research?**

If you have questions regarding this study, you may contact William Johnson at 817-932-4956 or [wjohns01@tamu.edu](mailto:wjohns01@tamu.edu) or Dr. Camille Peres 979-436-9326 or [peres@sph.tamhsc.edu](mailto:peres@sph.tamhsc.edu).

**Whom do I contact about my rights as a research participant?**

This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or

questions regarding your rights as a research participant, you can contact these offices at 979-458-4067 or [irb@tamu.edu](mailto:irb@tamu.edu).

### **Consent**

Please be sure you have read the above information, asked questions and received answers to your satisfaction. By acknowledging the online consent form, you consent to participate in this study.

## APPENDIX E1

### STUDY 2 INFORMATION SHEET (ENGLISH)

#### **Project Title: Efficacy of Non-linguistic EHS training**

##### **Introduction**

The purpose of this document is to provide you information that may affect your decision as to whether or not you want to participate in this research study.

If you agree, you will be asked to participate in a research study examining factors associated with the use of a non-linguistic web-based safety training. The purpose of this study is to assess the effectiveness of non-linguistic web-based safety training. You have been selected to be a possible participant because you have access to the non-linguistic web-based safety training via a Learning Management System and English is your primary language.

##### **What will I be asked to do?**

If you decide to participate in this study, you will be asked to log onto an online learning management system, acknowledge consent, complete a 10 question pre-test, review a 6½ minute video, complete a 10 question post-test and complete a brief survey. The entire process should take less than 1 hour. No identifiable information about you related to this study will be shared.

##### **What are the risks involved in this study?**

The risks associated with this study are minimal, and are not greater risk than you would come across in everyday life. The overall physical work required for this experiment is not significantly more than for common computer tasks.

**What are the possible benefits of this study?**

You will receive no direct benefit from participating in this study; however, information from this study will help with understanding how non-linguistic web-based EHS training might be used to promote EHS to benefit global employees.

**Do I have to participate?**

No, you do not have to be in this research study. There is no penalty for choosing not to participate, and you can withdraw from the research study without any penalty if you change your mind later.

**Who will know about my participation in this research study?**

This study is confidential and the records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only Texas A&M Researchers only Dr. Camille Peres and William Johnson will have access to the records.

**Whom do I contact with questions about the research?**

If you have questions regarding this study, you may contact William Johnson at 817-932-4956 or [wjohns01@tamu.edu](mailto:wjohns01@tamu.edu) or Dr. Camille Peres 979-436-9326 or [peres@sph.tamhsc.edu](mailto:peres@sph.tamhsc.edu).

**Whom do I contact about my rights as a research participant?**

This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, you can contact these offices at 979-458-4067 or [irb@tamu.edu](mailto:irb@tamu.edu).

**Consent**

Please be sure you have read the above information, asked questions and received answers to your satisfaction. By acknowledging the online consent form, you consent to participate in this study.

## APPENDIX E2

### STUDY 3 INFORMATION SHEET (CHINESE - SIMPLIFIED)

#### 第3项研究 (3) 信息表

项目名称：非语言性EHS培训的成效

#### 简介

本文件旨在向您提供可能会影响您是否参与决定此研究的信息。

如果您同意，您将获邀参与旨在研究与基于网络的非语言性安全培训的使用有关的因素的研究。本研究的目的是评估基于网络的非语言安全培训的成效。您已获选为可能的参与者，因为您可以通过学习管理系统访问基于网络的非语言性安全培训，且英语并非您的主要语言。

#### 我需要做什么？

如果您决定参与本研究，您将需要登录在线学习管理系统，确认内容，完成包含10个问题的先期测试，观看6½分钟的视频，完成10个问题的后期测试，然后完成简单的调查。整个过程需时应该不超过1小时。我们不会透露与本研究有关的您的可识别信息。

### **该研究涉及的风险？**

本研究涉及的风险极低，不会超过您在日常生活会遇到的风险水平。本次实验所需的具体活动不会超过普通电脑任务所需的程度。

### **该研究的可能益处？**

您参与本研究不会获得任何直接好处。但是，本研究的信息有助于了解基于网络的非语言性EHS培训可如何用于促进EHS，从而令公司全球的员工受惠。

### **我是否必须参与？**

否，我们并不强制您参与本研究。选择不参与并不会有任何惩罚。如果您后来改变主意，您可退出研究，而不会面临任何惩罚。

### **谁会知道我参与该研究？**

本研究将予以保密，研究记录亦将保密。任何和此研究相关的您的特征信息不会放入可能发表的任何类型的报告中。研究记录将以安全的方式存储，只有德州农工研究人员（Camille Peres博士和William Johnson）可以访问这些记录。

### **如果我有关于研究的问题，应该联系谁？**

如果您有关于本研究的问题，您可以致电 817-932-4956或发送电邮至[wjohns01@tamu.edu](mailto:wjohns01@tamu.edu) 联络 William Johnson，或者致电 979-436-9326或发送电邮至[peres@sph.tamhsc.edu](mailto:peres@sph.tamhsc.edu) 联络 Camille Peres。

**关于我作为研究参与者的权利，我应该联系谁？**

本研究已经德州农工大学的人类受试者保护计划及/或机构审核委员会审核。对于本研究相关的问题，或若您有关于作为本研究参与者的权利的疑问，您可以致电 979-458-4067或发送电邮至[irb@tamu.edu](mailto:irb@tamu.edu) 联络这些机构。

## **承诺**

请务必阅读上述信息，询问问题及得到令您满意的答复。通过确认在线同意书，即表示您同意参与本研究。

## APPENDIX E3

### STUDY 3 INFORMATION SHEET (PORTUGUESE)

#### **ESTUDO N° 3 - Ficha de Informações**

##### **Título do projeto: Eficácia da qualificação não linguística em EHS**

##### **Introdução**

O objetivo deste documento é oferecer informações que orientem a sua decisão de participar ou não do presente estudo.

Caso concorde, iremos convidá-lo a participar de um estudo que busca avaliar os fatores associados ao oferecimento de qualificação on-line não linguística em segurança. O presente estudo busca avaliar a eficácia da qualificação on-line não linguística em segurança. Você foi selecionado como possível participante por dispor de acesso à qualificação on-line não linguística em segurança por meio do Sistema de gestão de aprendizado da e em razão do inglês não ser o seu idioma nativo.

##### **O que terei que fazer no estudo?**

Caso confirme, sua participação consistirá em acessar um sistema de gestão de aprendizado on-line, confirmar sua participação, realizar um teste preliminar com 10 perguntas, assistir a um vídeo com duração de 6 minutos e meio, realizar um teste posterior com 10 perguntas e responder a um breve questionário. Todo o processo tem duração estimada de menos de 1 hora. Suas informações pessoais relacionadas ao presente estudo não serão compartilhadas.

**Quais são os riscos associados ao estudo?**

Os riscos associados à sua participação no estudo são equivalentes aos de qualquer atividade cotidiana, ou seja, mínimos. O desgaste físico associado ao presente estudo não é mais expressivo do que o relacionado a tarefas básicas de computação.

**Quais são os possíveis benefícios do estudo?**

Nenhum benefício direto será obtido com a sua participação no estudo. Contudo, as informações decorrentes do estudo auxiliarão na compreensão do modo como a qualificação on-line não linguística em EHS poderá ser utilizada para trazer benefícios relacionados a EHS para funcionários do mundo inteiro.

**É obrigatório participar do estudo?**

Não, não é obrigatório participar do presente estudo. Caso opte por não participar, não haverá sanções e, a qualquer momento, será possível interromper a sua participação no estudo sem incorrer em sanções caso mude de ideia posteriormente.

**Quem terá conhecimento da minha participação no estudo?**

O presente estudo é confidencial e os registros correspondentes serão mantidos em sigilo. Nenhum relatório publicado incluirá dados que identifiquem a sua participação no presente estudo. Os registros da pesquisa serão armazenados de forma segura e apenas os pesquisadores Dr<sup>a</sup>. S. Camille Peres e William Johnson poderão acessá-los.

### **Quem devo contatar para encaminhar dúvidas sobre a pesquisa?**

Em caso de dúvidas sobre o presente estudo, entre em contato com William Johnson no número 817-932-4956 ou pelo e-mail [wjohnso1@tamu.edu](mailto:wjohnso1@tamu.edu) ou com a Dr<sup>a</sup>. Camille Peres no número 979-436-9326 ou pelo e-mail [peres@sph.tamhsc.edu](mailto:peres@sph.tamhsc.edu).

### **A quem devo encaminhar dúvidas sobre meus direitos como participante da pesquisa?**

O presente estudo foi analisado pelo Programa de proteção a seres humanos em pesquisas e/ou pelo Conselho de avaliação institucional da Texas A&M University. Em caso de dúvidas e reclamações sobre a pesquisa ou sobre seus direitos como participante da pesquisa, entre em contato com esses órgãos no telefone 979-458-4067 ou pelo e-mail [irb@tamu.edu](mailto:irb@tamu.edu).

### **Consentimento**

Leia as informações acima e encaminhe suas dúvidas até obter todas as respostas necessárias. Ao assinar o formulário de consentimento on-line, você confirma sua participação no presente estudo.

APPENDIX F

STUDY 1 TOEFL READING TEST

**Reading Section**

**Directions:** These sample questions in the Reading section measure your ability to understand academic passages in English. You will read one passage and answer questions about it. In a real test, you would have 20 minutes to read the passage and answer the questions. Candidates with disabilities may request a time extension.

**Meteorite Impact and Dinosaur Extinction**

There is increasing evidence that the impacts of meteorites have had important effects on Earth, particularly in the field of biological evolution. Such impacts continue to pose a natural hazard to life on Earth. Twice in the twentieth century, large meteorite objects are known to have collided with Earth.

5

If an impact is large enough, it can disturb the environment of the entire Earth and cause an ecological catastrophe. The best-documented such impact took place 65 million years ago at the end of the Cretaceous period of geological history. This break in Earth's history is marked by a mass extinction, when as many as half the species on the planet became extinct. While there are a dozen or more mass extinctions in the geological record, the Cretaceous mass extinction has always intrigued paleontologists because it marks the end of the age of the dinosaurs. For tens of millions of years, those great creatures had flourished. Then, suddenly, they disappeared.

10

The body that impacted Earth at the end of the Cretaceous period was a meteorite with a mass of more than a trillion tons and a diameter of at least 10 kilometers. Scientists first identified this impact in 1980 from the worldwide layer of sediment deposited from the dust cloud that enveloped the planet after the impact. This sediment layer is enriched in the rare metal iridium and other elements that are relatively abundant in a meteorite but very rare in the crust of Earth. Even diluted by the terrestrial material excavated from the crater, this component of meteorites is easily identified. By 1990 geologists had located the impact site itself in the Yucatán region of Mexico. The crater, now deeply buried in sediment, was originally about 200 kilometers in diameter.

20

This impact released an enormous amount of energy, excavating a crater about twice as large as the lunar crater Tycho. The explosion lifted about 100 trillion tons of dust into the atmosphere, as can be determined by measuring the thickness of the sediment layer formed when this dust settled to the surface. Such a quantity of material would have

25

30 blocked the sunlight completely from reaching the surface, plunging Earth into a period  
of cold and darkness that lasted at least several months. The explosion is also calculated  
to have produced vast quantities of nitric acid and melted rock that sprayed out over  
much of Earth, starting widespread fires that must have consumed most terrestrial forests  
and grassland. Presumably, those environmental disasters could have been responsible for  
the mass extinction, including the death of the dinosaurs.

35

Several other mass extinctions in the geological record have been tentatively identified  
with large impacts, but none is so dramatic as the Cretaceous event. But even without  
such specific documentation, it is clear that impacts of this size do occur and that their  
results can be catastrophic. What is a catastrophe for one group of living things, however,  
40 may create opportunities for another group. Following each mass extinction, there is a  
sudden evolutionary burst as new species develop to fill the ecological niches opened by  
the event.

Impacts by meteorites represent one mechanism that could cause global catastrophes and  
45 seriously influence the evolution of life all over the planet. According to some estimates,  
the majority of all extinctions of species may be due to such impacts. Such a perspective  
fundamentally changes our view of biological evolution. The standard criterion for the  
survival of a species is its success in competing with other species and adapting to slowly  
changing environments. Yet an equally important criterion is the ability of a species to  
50 survive random global ecological catastrophes due to impacts.

Earth is a target in a cosmic shooting gallery, subject to random violent events that were  
 unsuspected a few decades ago. In 1991 the United States Congress asked NASA to  
investigate the hazard posed today by large impacts on Earth. The group conducting the  
55 study concluded from a detailed analysis that impacts from meteorites can indeed be  
hazardous. Although there is always some risk that a large impact could occur, careful  
study shows that this risk is quite small.

1. The word “pose” on line 2 is closest in meaning to
  - a. Claim
  - b. model
  - c. assume
  - d. present

2. In paragraph 2, why does the author include the information that dinosaurs had flourished for tens of millions of years and then suddenly disappeared?
  - a. To support the claim that the mass extinction at the end of the Cretaceous is the best-documented of the dozen or so mass extinctions in the geological record
  - b. To explain why as many as half of the species on Earth at the time are believed to have become extinct at the end of the Cretaceous
  - c. To explain why paleontologists have always been intrigued by the mass extinction at the end of the Cretaceous
  - d. To provide evidence that an impact can be large enough to disturb the environment of the entire planet and cause an ecological disaster
  
3. Which of the following can be inferred from paragraph 3 about the location of the meteorite impact in Mexico?
  - a. The location of the impact site in Mexico was kept secret by geologists from 1980 to 1990.
  - b. It was a well-known fact that the impact had occurred in the Yucatán region.
  - c. Geologists knew that there had been an impact before they knew where it had occurred.
  - d. The Yucatán region was chosen by geologists as the most probable impact site because of its climate.
  
4. According to paragraph 3, how did scientists determine that a large meteorite had impacted Earth?
  - a. They discovered a large crater in the Yucatán region of Mexico.
  - b. They found a unique layer of sediment worldwide.
  - c. They were alerted by archaeologists who had been excavating in the Yucatán region.
  - d. They located a meteorite with a mass of over a trillion tons.
  
5. The word “excavating” on line 25 is closest in meaning to
  - a. digging out
  - b. extending
  - c. destroying
  - d. covering up
  
6. The word “consumed” on line 32 is closest in meaning to
  - a. Changed
  - b. Exposed
  - c. Destroyed
  - d. Covered

7. According to paragraph 4, all of the following statements are true of the impact at the end of the Cretaceous period EXCEPT:
- A large amount of dust blocked sunlight from Earth.
  - Earth became cold and dark for several months.
  - New elements were formed in Earth's crust.
  - Large quantities of nitric acid were produced.
8. The phrase "tentatively identified" on line 36 is closest in meaning to
- identified after careful study
  - identified without certainty
  - occasionally identified
  - easily identified
9. The word "perspective" on line 46 is closest in meaning to
- sense of values
  - point of view
  - calculation
  - complication
10. Paragraph 6 supports which of the following statements about the factors that are essential for the survival of a species?
- The most important factor for the survival of a species is its ability to compete and adapt to gradual changes in its environment.
  - The ability of a species to compete and adapt to a gradually changing environment is not the only ability that is essential for survival.
  - Since most extinctions of species are due to major meteorite impacts, the ability to survive such impacts is the most important factor for the survival of a species.
  - The factors that are most important for the survival of a species vary significantly from one species to another.
11. Which of the sentences below best expresses the essential information in the following sentence?

**Earth is a target in a cosmic shooting gallery, subject to random violent events that were unsuspected a few decades ago.**

Incorrect choices change the meaning in important ways or leave out essential information.

- Until recently, nobody realized that Earth is exposed to unpredictable violent impacts from space.
  - In the last few decades, the risk of a random violent impact from space has increased.
  - Since most violent events on Earth occur randomly, nobody can predict when or where they will happen.
  - A few decades ago, Earth became the target of random violent events originating in outer space.
12. According to the passage, who conducted investigations about the current dangers posed by large meteorite impacts on Earth?
- Paleontologists

- b. Geologists
- c. The United States Congress
- d. NASA

13. Look at the four letters (A, B, C, and D) that indicate where the following sentence could be added to the passage in paragraph 6.

**This is the criterion emphasized by Darwin’s theory of evolution by natural selection.**

Where would the sentence best fit?

Impacts by meteorites represent one mechanism that could cause global catastrophes and seriously influence the evolution of life all over the planet. **(A)** According to some estimates, the majority of all extinctions of species may be due to such impacts. **(B)** Such a perspective fundamentally changes our view of biological evolution. **(C)** The standard criterion for the survival of a species is its success in competing with other species and adapting to slowly changing environments. **(D)** Yet an equally important criterion is the ability of a species to survive random global ecological catastrophes due to impacts.

Choose the place where the sentence fits best.

- a. Option A
- b. Option B
- c. Option C
- d. Option D

14. An introductory sentence for a brief summary of the passage is provided below. Complete the summary by selecting the THREE answer choices that express the most important ideas in the passage. Some sentences do not belong in the summary because they express ideas that are not presented in the passage or are minor ideas in the passage. **This question is worth 2 points.**

Write your answer choices in the spaces where they belong. You can write in the number of the answer choice or the whole sentence.

**Scientists have linked the mass extinction at the end of the Cretaceous with a meteorite impact on Earth.**

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**Answer choices**

- (1) Scientists had believed for centuries that meteorite activity influenced evolution on Earth.
- (2) The site of the large meteorite impact at the end of the Cretaceous period was identified in 1990.
- (3) There have also been large meteorite impacts on the surface of the Moon, leaving craters like Tycho.
- (4) An iridium-enriched sediment layer and a large impact crater in the Yucatán provide evidence that a large meteorite struck Earth about 65 million years ago.
- (5) Large meteorite impacts, such as one at the end of the Cretaceous period, can seriously affect climate, ecological niches, plants, and animals.
- (6) Meteorite impacts can be advantageous for some species, which thrive, and disastrous for other species, which become extinct.

Key to Reading Section:

1. d
2. c
3. c
4. b
5. a
6. c
7. c
8. b
9. b
10. b
11. a
12. d
13. d
14. 4,5,6

APPENDIX G

CERTIFICATION OF ACCURACY FOR TRANSLATIONS

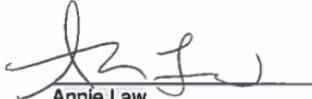


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**Certificate of Accuracy**

This is to certify that the attached translation, 001-WDJ\_Proposal\_20171018-translate.docx, originally written in English is, to the best of our knowledge and belief, a complete and accurate translation into Brazilian Portuguese and Simplified Chinese.

Dated: November 7, 2017

  
Annie Law  
Production Lead  
Donnelley Language Solutions