Reducing Beginning Welders' Anxiety by Integrating Virtual Reality Simulations

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Abstract

This study examined the use of virtual reality to reduce the anxiety of individuals in a welding training program. Byrd and Anderson (2012) posited that with the need for welders finding a more efficient way of training has become a necessity. With the multiple safety concerns related to the welding profession numerous triggers of anxiety are present. This study utilized the VRTEX® 360 virtual reality welding simulator to examine if virtual reality could reduce anxiety in welders. Several training programs were utilized that integrated the virtual reality welding simulator. Researchers recorded anxiety related measures by utilizing a BioHarness® data logger system. Live readings were recorded via the BioHarness® and a laptop. The measures that were collected related to anxiety included heart rate, respiration rate, body temperature, and pulse. Participants were also video recorded during the completion of test welds to help aid in identifying triggers of anxiety during the welding process. It can be concluded that all participants experienced anxiety during the completion of test welds and it affected the ability to produce a passing weldment. This implies that if industry can reduce the amount of anxiety trainees would experience it may lead to a higher percentage of welding certifications.

Introduction

Anxiety is a tense and unsettling anticipation of threatening event which has a negative effect on a person, yet the cause is unknown (Rachman, 2004). Anxiety and fear are closely related due to the fact of that both feelings have a negative effect on a person, which has led to the two words being used interchangeably (Barlow, 1988; Goodwin, 1986; Rachman, 2004). Distinctions between the two can be made in order to understand how each feeling affects a person. Rachman (2004) stated that distinctions could be made between the causes, duration, and maintenance of fear and anxiety. Fear is described as a reaction to a specific, perceived danger, and identifiable threat (Rachman, 2004). Reactions to fear are usually intense and recedes after the danger is removed (Rachman, 2004). On the other hand, anxiety is described as a heightened vigilance than an emergency reaction, which causes an uneasy tension where the cause is not readily identifiable (Rachman, 2004). Anxiety can be experienced at any given time or place.

Several types of anxiety are known that a person can suffer from but this study will looked at social anxiety and social phobia because of the social nature of a learning environment. The terms social phobia and social anxiety are used interchangeably and are associated with social anxiety disorder (Barlow, 1988; Rachman, 2004). The critical feature of social anxiety is an intense and a persistent fear of social or performance situations (Barlow, 1988; Goodwin, 1986; Rachman, 2004). The manifestation of anxiety symptoms can take many forms because the anxiety is experienced in social situations (Barlow, 1988; Goodwin, 1986; Rachman, 2004). The innate fear of possible scrutiny because they might behave in a manner that is embarrassing, unacceptable, or perform ineptly occurs within people that suffer from social anxiety (Rachman, 2004).

The individuals that suffer from social phobia contain a predisposition to feel anxious in social situations (Rachman, 2004). Rachman (2004) stated that cognitive theorists have three beliefs about people that suffer from social anxiety: 1) perfectionist standards for social performance; 2) false beliefs about social evaluation; and 3) negative views about the self. Another difference is a more direct focus especially on internal feelings and their significance, including if the emotional state that a person is in is visible to others (Rachman, 2004).

A person suffering from social anxiety may misinterpret the emotional reactions of others as an indication that others are criticizing them making the individual think they are the center of attention (Rachman, 2004). During the interpretation of others emotions, a person would respond to a threat as if the people can see that they are inept or inadequate within the social situation (Rachman, 2004). If the person interprets the emotional reaction as benign, a friendly or accepting feeling will occur and anxiety will subside (Rachman, 2004). If the reaction is interpreted as harmful, the person would get the feeling that they may be shunned or rejected (Rachman, 2004). If an individual experiencing social anxiety interprets a reaction as negative it may lead them to escape, avoid, cope, or block that social interaction from happening again (Rachman, 2004).

Although symptoms of anxiety are mostly negative; however, in a workplace positive results can be seen from anxiety and stress (Stein & Hollander, 2003). Anxiety and stress in some degree is always present in the workplace and can be beneficial source of motivation (Stein & Hollander, 2003). The concept of anxiety and stress in the workplace and learning how to manage them are widely accepted, but there are people who believe that they are the victim of anxiety and stress (Stein & Hollander, 2003).

Having employees that suffer from anxiety and stress can have detrimental to the rest of an organization (Pflanz & Heidel, 2003). Poor job performance, job dissatisfaction, absenteeism, and interpersonal conflict can be exhibited by workers that suffer from stress and anxiety (Pflanz & Heidel, 2003). Psychiatric illnesses have been shown to affect at least 48% of Americans during their lifetime (Pflanz & Heidel, 2003). Across the U.S., approximately 30% of the population has deals with anxiety related illnesses annually (Pflanz & Heidel, 2003). Pflanz and Heidel (2003) found that anxiety related disorders cost industries approximately $4 billion per year, which 88 percent is attributable to decreased productivity. One such workplace that could be affected by anxiety disorders is a welding training program.

In a welding environment, anxiety may be triggered by many different things. A majority of the triggers that may lead to anxiety stem from the safety issues related to welding. Some of the safety related issues include electrical shock, compressed gases, air contamination, fire, explosion, and arc radiation (Cary & Helzer, 2005; Jeffus, 2012). Electrical shock is a concern because of the amount of volts being used while welding. Voltage range between 115 to 460 volts for most alternating current (AC) sources, but fatalities can occur with equipment using less than 80 volts (Jeffus, 2012). The welding arc emits ultra-violet (UV) rays also known as arc radiation is harmful (Cary & Helzer, 2005; Jeffus, 2012). The UV rays emitted can cause flash burn to unprotected eyes and severe sunburns to exposed skin while welding (Cary & Helzer, 2005; Jeffus, 2012).

Air contamination comes in two forms through the process of welding, particulate matter and gases (Cary & Helzer, 2005). The smoke or fumes rising from the welding operation are identified as air contamination (Cary & Helzer, 2005). The hazard is created by the metal being welded, chemical composition of the flux, and the length of time a welder is exposed to the fumes (Cary & Helzer, 2005). Welding in an area not suitable for welding and the fact that sparks can travel up to 40 feet contacting flammable substances can cause fire and explosions (Cary & Helzer, 2005; Jeffus, 2012). Safety concerns with compressed gases revolve around the gas cylinders used to provide the shielding gas for various welding operations (Cary & Helzer, 2005; Jeffus, 2012). Inadvertently breaking off the tank valve allowing the cylinder to act as a rocket the major concern with gas cylinders is (Cary & Helzer, 2005).

With all the different types of safety issues related to the welding occupation it is clear that those individuals that are beginning welders may exhibit more anxiety related symptoms. Ursano, Fullerton, Wiesaeth, and Raphael (2007) postulated that inexperienced disaster volunteers may be at a higher risk for acute effects of psychological discomforts than experienced personnel. Understanding that inexperienced individuals may exhibit more symptoms of anxiety it is imperative to examine methods of reducing anxiety within a training programs. Reducing an individual's anxiety level may lead to increase levels of performance (Pflanz & Heidel, 2003).

One suggested method that may lead to reduced anxiety in beginning welders is the integration of virtual reality simulations (Byrd & Anderson, 2012). Kunkler (2006) stated that the utilization of simulations provides a safe realistic computer-based environment for individuals to practice. Virtual reality environments can be used to train workers to acquire the basic skills necessary to perform the tasks required for a job in a technical field (Manca, 2013). The utilization of virtual reality simulations allows trainees to learn basic skills within a safer environment (Lucas, Thabet, & Worlikar, 2007). One study found that full and partial virtual reality integration into a welding training program was appropriate, depending on the level of task difficulty (Stone, McLaurin, Zhong, & Watts, 2013). Would the introduction of virtual reality into a welding training program lead to the reduction of anxiety exhibited by inexperienced individuals?

Theoretical Framework

The guiding framework of this study is the model of anxiety by Rachman (2004). Rachman (2004) describes anxiety as a process and not a categorical event that does or does not happen. Anxiety as described by Rachman (2004) is a feeling that is created through several cognitive realizations. The susceptibility of a person to experience anxiety is termed vulnerability (Rachman, 2004). The degree of vulnerability varies from person to person (Rachman, 2004). Temperamental vulnerabilities are not controlled by one's mind and are experiential and biological in nature (Rachman, 2004). Cognitive vulnerabilities are shaped from personal experiences and present beliefs, which are controlled by one's mind (Rachman, 2004). One's susceptibility to anxiety is put to the test once they enter a new or unfamiliar environment. A person predisposed to anxiety becomes hypervigilant upon entering an environment (Rachman, 2004). Hypervigilance be seen when a person begins global scanning, where a person has rapid eye movement throughout the visual field (Rachman, 2004). When global scanning, a person will first broaden their attention to detect any threats, and if a threat is found the person's attention will narrow as the threat is being processed (Rachman, 2004). Hypervigilance is usually not found once a person overcomes their anxiety disorder (Rachman, 2004).

Focused attention refers to people who found a threat, the person focuses all of their attention solely on the threat and appears inattentive to everything else around them (Rachman, 2004). Perceptual enhancement or distortion relates to people who have extreme cases of anxiety (Rachman, 2004) An example is once an individual leaves a familiar place are they fixated on globally scanning for threats to the point it is all that they do (Rachman, 2004). When a person enters an environment and detects a threat but decides to find a place of safety to avoid the threat is referred to as behavioral inhibition (Rachman, 2004). The information gathered from global scanning and focusing one's attention on a threat is utilized to determine if the threat is benign or harmful (Rachman, 2004). Rachman (2004) posited that misinterpretations have two dimensions where the probability or the seriousness of an event occurring is exaggerated.

Rachman (2004) stated that if a threat were found to be benign no anxiety would occur. If a threat is found to be harmful a person will attempt to reduce the effects of their anxiety (Rachman, 2004). There are four common ways a person can reduce the effects of anxiety has on themselves, which include escape, avoid, cope, and block (Rachman, 2004). Once a person experiences anxiety, the individual will try to reduce the effect by escaping as quickly as possible (Rachman, 2004). If this occurs at the same place, several times the same person will begin to avoid the place (Rachman, 2004). To cope with not being able to go to the place an individual might ask someone else to go there for them or accompany them (Rachman, 2004).

Purpose and Objectives

The purpose of this study was to examine the effect of virtual reality on anxiety in participants in a welding training program. In addition, the study sought to describe the effect anxiety susceptibility has on participants visual inspection pass/fail rating on test welds. This study also intended to describe the relationship between the time participants experienced anxiety while completing the test welds and the visual inspection pass/fail rating. The insight gained relating to how anxiety affects beginning welders can benefit welding training programs as well as any educational setting that teaches welding based skills such as an agricultural education program. The following objectives were identified to address the purposes of this study.

1. Describe the average welding program trainee in terms of susceptibility to anxiety.
2. Examine the pass/fail rating of visual inspection of test welds performed by participants.
3. Determine if a relationship exists between participants' susceptibility to anxiety and the visual inspection pass/fail rating.
4. Examine the number of instances participants exhibited anxiety in terms of ECG heart rate spikes.
5. Determine if a relationship exists between participant's anxiety to the visual inspection pass/fail rating.
6. Identify the triggers of anxiety experienced by participants during the completion of test welds.

Methods

This study is a small portion of a larger study that utilized a virtual reality integrated welding school and real-world welding school. The welding schools were constructed at the agricultural

mechanics laboratory located on the Iowa State University Farm. The real-world welding school was overseen by a certified welding instructor (CWI) during this study. The virtual reality school was overseen by the researchers. The materials stocked for the real-world welding school included welding jackets, gloves, slag hammers, wire brushes, auto-darkening welding helmets, Miniflex® Portable weld fume control units, and Power Wave® C300 multi-purpose welders. The consumable material used included 3/8 inch thick coupons (groove weldments), 1/2 inch thick coupons (Tee weldments), and Excalibur® 7018 electrodes conditioned in an electrode oven. =

The virtual reality welding school was overseen by the researchers. The researchers were extensively trained to how to use the VRTEX® 360 Virtual Reality Arc Welding Trainer. The virtual reality welding school was equipped with three VRTEX® 360 Virtual Reality Arc Welding Trainers with shielded metal arc welding (SMAW) stingers, helmet, and plastic coupons. This trainer was chosen because it was the highest fidelity virtual reality simulator currently available. This virtual reality simulator allows users to be fully immersed in a 3D virtual reality welding environment. For the virtual training, users wore a welding helmet with integrated stereoscopic virtual reality screens and used dynamic visual feedback, in the form of visual overlays, for known welding variables.

Participants

Before any training took place, participants were given an informed consent form. There were 20 male participants and 3 female participants randomly assigned to either the integrated training (15 participants) or the VR training (eight participants). The number of participants was initially limited to have a student to CWI ratio that was representative to a real-world welding training program, which generally do not exceed 12 students at a time. Participants fell into two groups of experience. The first group had little to no practical experience in SMAW prior to the beginning of the study. The second group had practical experience in SMAW, but did not hold any welding certifications. The amount of experience of the participants was not known until after participants were grouped in order to create a true random sampling. Participants chose to complete either a one or two week welding training program. The one week training program taught the participants how to SMAW the 2F (horizontal fillet weld) and 1G (flat groove weld) welds. The two week training program additionally taught the 3F (vertical fillet weld) and 3G (vertical groove weld) welds.

The experimental groups that participants were randomly assigned into included: 100% virtual reality training; 75% virtual reality and 25% real-world training; and 50% virtual reality and 50% real-world training. The participants received safety training before entering into the welding environment. Within the VR training room, participants received instruction from the researchers on how to use the VRTEX® 360 Virtual Reality Arc Welding Trainers. In the virtual reality training, participants worked in groups of three or four per VRTEX® 360. In the real-world training, participants had individual welding booths, but could work together if they wanted. While in the real-world welding training portion the participants received instruction from the CWI on how to use the Power Wave® C300 multi-purpose welders. The schedule for the weld training program was as follows: Monday through Thursday was practice time and Friday was test day. The only exception to this schedule was the 100% virtual reality group. The 100% virtual reality group received real-world training on Thursday afternoon to acclimate to real-world welding so that participants could perform the test welds on Friday.

In order to assess anxiety levels participants filled out the Zung (1971) self-rated anxiety scale (SAS) and electrocardiogram (EKG or ECG) readings were taken. The Zung (1971) SAS was used to measure the participants' susceptibility to anxiety. The Zung (1971) SAS is a survey instrument that utilized 20 statements that dealt with how an individual might feel when anxious. The participants rated each statement on a summated rated scale of none or a little of the time, some of the time, good part of the time, or most of the time (Zung, 1971). The responses given were then converted into a point system between one through four. The points were then added together giving an overall raw score. The raw score was then converted into an anxiety index. The anxiety index ranges from 25 to 100. Zung (1971) recommended the following scale to interpret the anxiety index: 25 - 45 = normal range; 45 – 59 = minimal to moderate anxiety; 60 – 74 = marked to severe anxiety; and 75 - 100 = extreme anxiety. This interpretation was used to describe participants' susceptibility to anxiety.

The ECG measurements collected included blood pressure, respiration rate, temperature, and pulse rate. Heart rate was utilized because prior research has linked heart rate to anxiety (Shinba, Kariya, Matsui, Ozawa, Matsuda, & Yamamoto, 2008). To obtain these measures participants wore a BioHarness® data logger system. The BioHarness® is a chest strap that has two sensors and a removable transmitter/logger built in. Data was streamed live to a laptop computer and logged onto the built in transmitter/logger. To accurately identify periods of anxiety a basal reading was taken for all participants while standing at rest. The basal reading was taken in a standing position because the real-world welding stations used required the participants to stand while welding. The basal reading was compared to the ECG measurements to identify moments of anxiety, specifically utilizing an individual's heart rate. The participants were also recorded as they welded their certification plates via a closed-circuit camera system. The recordings of the participants' test welds were utilized to help identify the cause(s) of anxiety when present.

The data were analyzed using Microsoft Excel 2010 and Predictive Analytics SoftWare (PASW) Statistics 18 software package. Descriptive statistics were calculated to identify frequencies for pass/fail rates and dexterity percentile rankings. A bivariate correlation was calculated to examine the relationship between participants' susceptibility to anxiety and visual pass/fail rates. With a numerical variable and a dichotomous variable utilizing the bivariate correlation calculation is needed to evaluate the relationship between the variables (Gravetter & Wallnau, 2009). Researchers utilized the r squared (r2) statistic to examine the effect size of the bivariate correlation. To evaluate the effect size of a bivariate correlation Gravetter and Wallnau (2009) indicated that r2 should be used.

Results

This study sought to describe the effect of virtual reality on anxiety in welders in a welding training program. The intent of objective one was to describe the participants' susceptibility to anxiety as measured with the Zung (1971) SAS instrument. The results are shown in Table 1. Out of the 23 participants in the study, only two participants exhibited a susceptibility to anxiety in the range of minimal to moderate. The other 21 participants fell into the normal range of anxiety susceptibility. The two participants that had the higher susceptibility to anxiety were in the 75 percent virtual reality to 25 percent traditional and 100 percent virtual reality groups.

Table 1

Anxiety Susceptibility of Participants by Welding Training Program

Program Type	*n*	%
Overall		
Normal	21	91.3
Minimal - Moderate	2	8.7
50/50 VR/Trad.[a]		
Normal	4	100.0
Minimal - Moderate	0	0.0
100 VR[a]		
Normal	4	100.0
Minimal - Moderate	0	0.0
50/50 VR/Trad.[b]		
Normal	6	100.0
Minimal - Moderate	0	0.0
75/25 VR/Trad.[b]		
Normal	4	80.0
Minimal - Moderate	1	20.0
100 VR[b]		
Normal	3	75.0
Minimal - Moderate	1	25.0

Note. VR = virtual reality, Trad. = Traditional

[a]One week training program utilizing VRTEX® Mobile.

[b]Two week training program utilizing the VRTEX® 360.

Objective two sought to describe participants' visual inspection pass/fail rate of completed test welds. The overall results are shown in Table 2. Overall the participants in this study had an even pass/fail rate (n = 38, 50.0%) of the 76 test welds completed. Only two welding training programs visually failed a majority of the test welds. The two training programs were the one-week 50 percent virtual reality to 50 percent traditional and two-week 50 percent virtual reality to 50 percent traditional groups. The program that exhibited the highest percentage of test welds that failed inspection (n = 7, 87.5%) was the one-week 50 percent virtual reality to 50 percent traditional training program. When examining the pass/fail rates by weld type, the participants visually passed more of the simple welds (2F and 1G, 56.5%) than the complex welds (3F and 3G, 43.5%)

Table 2
Visual Inspection Pass/Fail Rates of Participants' Test Welds by Program Type

Program Type	*n*	Pass *f* (%)	Fail *f* (%)
Overall	76	38 (50.0)	38 (50.0)
50/50 VR/Trad.[a]	8	1 (12.5)	7 (87.5)
100 VR[a]	8	6 (75.0)	2 (25.0)
50/50 VR/Trad.[b]	24	10 (41.7)	14 (58.33)
75/25 VR/Trad.[b]	20	11 (55.0)	9 (45.0)
100 VR[b]	16	10 (62.5)	6 (37.5)

Note. VR = virtual reality, Trad. = traditional
[a]One week training program utilizing VRTEX® Mobile.
[b]Two week training program utilizing the VRTEX® 360.

The relationship between the visual pass/fail rate and participants' susceptibility to anxiety was examined for objective three. To determine if any relationship existed between the two variables a bivariate correlation was calculated. The results of the bivariate correlation can be seen in Table 3. The results showed no statistical significance between the average participant susceptibility of anxiety and visual inspection pass/fail rate for any test weld type.

Table 3
Bivariate Correlation of Average Participants' Susceptibility of Anxiety and Visual Inspection Pass/Fail Rates by Weld Type

SMAW Weld Type	*n*	*r*	*p*
2F	23	-.271	.212
1G	23	-.131	.551
3F	15	.207	.459
3G	15	-.026	.926

To examine if the type of welding training program had an effect, researchers examined the correlation by the type of welding training program. The statistically significant results of the bivariate correlation between the average participants' susceptibility of anxiety and visual inspection pass/fail rate by welding training program type are shown in Table 4. The only statistically significant relationship was between participants' susceptibility to anxiety was with the 2F weld from the 100 virtual reality training program utilizing the VRTEX® 360 ($p = .000$). To interpret the magnitude of the relationship the researchers calculated r squared (r2) following the suggestions of Gravetter and Wallnau (2009). To interpret r2 Gravetter and Wallnau (2009) suggested using the following scale: 0.01 = small effect; 0.09 = medium effect; 0.25 = large effect. In this instance, participant susceptibility of anxiety had a very large effect ($r2 = 1.00$) on the visual inspection pass/fail rate.

Table 4

Portion of Bivariate Correlation of Average Participants' Susceptibility of Anxiety and Visual Inspection Pass/Fail Rates by Training Program

SMAW Weld Type	*n*	*r*	*p*	r^2
100 VR[a]				
2F	4	-1.00	.000	1.00

Note. VR = virtual reality, Trad. = traditional

[a]Two week training program utilizing the VRTEX® 360.

Researches sought to examine the number of times participants exhibited anxiety during the completion of test welds for objective four. To determine the number of instances that participants exhibited anxiety researchers utilized the ECG readings and counted the number of spikes in heart rate above the initial basal readings for participants. When examining the one-week training session, the 100 VR group on average experienced anxiety more than the 50/50 VR/Traditional group. The same trend was seen within the two-week training program. Also in the two-week training programs, the average number of times anxiety that was experienced decreased between the welding positions. This trend was seen in all three variations of training programs in varying degrees. Table 5 displays the average of number of instances of anxiety by training group and by welding position.

Table 5

Average number of instances of Anxiety by Training Group and Welding Position

Training Program	Flat Position *n(M)*	Vertical Position *n(M)*	Overall *n(M)*
50/50 VR/Trad.[a]	34 (8.5)	-	34 (8.5)
100 VR[a]	33 (11)	-	33 (11)
50/50 VR/Trad.[b]	39 (6.5)	32 (6.4)	71 (11.8)
75/25 VR/Trad.[b]	39 (7.8)	28 (5.6)	67 (13.4)
100 VR[b]	33 (8.25)	26 (6.5)	59 (14.75)

Note: VR = virtual reality, Trad. = traditional

[a]One week training program utilizing VRTEX® Mobile.

[b]Two week training program utilizing the VRTEX® 360.

In objective five, the researchers analyzed data to determine if a relationship existed between participant anxiety, in terms of heart rate and breathing rate, to the visual inspection pass/fail rate. A bivariate correlation was calculated to determine if any relationships did exist. The significant results are shown in Table 6. Not all the weld types had shown a statistically significant relationship with the overall anxiety measures of heart rate and breathing rate. The 3F – SMAW weld type indicated statistical significance with the minimum heart rate ($r = .736$, $p < .01$) and average heart rate ($r = .750$, $p < .01$) on test day of week 1. Also, the 3F – SMAW weld shown a significant relationship with the maximum heart rate ($r = .770$, $p < .01$) during test day during week two. The other welds that the bivariate correlation indicated a statistical relationship with heart rate or breathing rate included the 2F and 3G in SMAW and 1G, 3F, and 3G in GMAW.

When examining the magnitude of the relationships indicated between participant anxiety measures and weld types, Gravetter and Wallnau (2009) indicated that r2 should be used. The results of the r2 calculations can be seen in Table 6. Gravetter and Wallnau (2009) suggested the following scale when interpreting the r2 statistic: 0.01 = small effect; 0.09 = medium effect; 0.25 = large effect. The 2F – SMAW weld type and the maximum breathing rate on test day of week one was the only relationship to display a medium effect size. The other significant relationships display a large to very large effect size.

Table 6
Portion of Bivariate Correlation (r) and Effect Size (r2) of relationships between Participant Anxiety Measures and Visual Inspection Pass/Fail Rates

Weld Type/ Anxiety measure	2F-SMAW	3F-SMAW	3G-SMAW	1G-GMAW	3F-GMAW	3G-GMAW
Week 1						
HR – Min		.736** (0.541)				
HR – Max	-.497* (0.247)					
HR – Avg		.750** (0.562)			.632* (.399)	
BR – Min				.497* (0.247)		
BR – Max	-.446* (.198)					
Week 2						
HR – Max		.770** (.592)				
BR – Min						-.713** (.508)
BR – Max	-.562* (.315)		-.626* (.391)			

*Note: r(r2), **p* < .01, **p* < .05. HR = heart rate, BR = breathing rate.

To examine if the training program type had an effect on the relationship between anxiety measures and the visual inspection pass/fail rates the data was separated by training program types. The 3F – SMAW weld type has statistical relationships with five anxiety related measures. When examining the weld types, the four complex welds all have statistical significant relationships with anxiety related measures. The two-week 50/50 virtual reality to traditional training method utilizing the VRTEX® 360 revealed the largest number of statistical relationships. Whereas, the one-week 100 percent virtual reality training method utilizing the VRTEX® Mobile shown no statistical relationships. Following the suggestions by Gravetter and Wallnau (2009) all the relationships found have a large magnitude.

To further examine the relationship between participant anxiety and the visual inspection pass/fail rate, a bivariate correlation was calculated between the average number of instances participants experienced anxiety and the visual inspection pass/fail rate. Only two instances of

statistical significance were found. The two weld types that shown statistical significance were the 2F ($r = .448$, $p = .036$) and 3F ($r = .530$, $p = .042$). When examining the magnitude of the relationships, anxiety exhibited a medium effect on the 2F ($r2 = 0.20$) and a large effect on the 3F ($r2 = 0.28$) weld types.

Objective six sought to identify triggers of anxiety during the completion of test welds. The identification of anxiety triggers were identified by utilizing the logged ECG readings and the video recordings of the participants test welds. Moments of anxiety were identified by using an individual's basal ECG reading and comparing that to the ECG readings during the individuals test weld. Time stamps were used to pin point the moment during the video recordings to identify what may have caused an individual's anxiety.

The following results were present during all the training sessions of this study. In the flat position test welds moments of anxiety were present at various times during the welding process such as before the weld, starting the weld, during the weld, completing the weld, and afterward the weld was completed. Several participants revealed anxiety while setting up their weldments in preparation of beginning the welding process. This was identified by participants practicing the psychomotor skills needed prior to striking an arc and shuffling the weldment around trying to get in a better position to perform the weld. Multiple participants revealed anxiety was at the start of the weld. Identified anxiety triggers of participants at the beginning of a weld were the electrode sticking while trying to establish an arc and an arc not being established while striking the electrode.

Several participants experienced anxiety during the welding process. The identification of the triggers in several cases was impossible due to the participants blocking the view of the camera. The anxiety triggers that was identified included moments when the participants realized they were either at the wrong travel/work angles or off position with the bead. These indicators were identifiable by the participants shifting their hands and body position. Another anxiety trigger was stopping a weld and trying to start it back. Finishing out a weld properly was another time in which participants exhibited anxiety. Several participants' anxiety was triggered once they realized they did not completely finish out a weld or realized the weld was poor. Not properly finishing out a weld refers to participants running out of an electrode before reaching the end of a weldment. The most common time that participants' anxiety was triggered was after a weld was completed. After a weld was completed, all participants had to chip away the protective slag covering left by the flux and clean the weld with a wire brush. Anxiety was identified in most participants during the chipping and cleaning phase after a weld.

Conclusions and Discussion

Several conclusions can be drawn from the results of this study. First, one trend that was identified was anxiety susceptibility was normal, but participants experienced anxiety during the completion of test welds. Pflanz and Heidel (2003) postulated that anxiety could have a negative effect on job performance. The pass/fail rate of the test welds reinforces the notion of Pflanz and Heidel (2003). It can also be concluded that participants' susceptibility to anxiety did not affect the chances of passing or failing a test weld. Although participants experienced anxiety during the completion of weld tests does not relate to participants being susceptible to anxiety. This

conclusion leads to the question, is the Zung (1971) SAS appropriate to access anxiety susceptibility for a welding training program?

Another conclusion that can be drawn is that participants' heart rate during the completion of test welds did effect the ability to produce a passing weldment. The increase in heart rate could be an indication from the participants that the triggers of anxiety could be harmful. Rachman's (2004) model of anxiety portrays harm as being directed at an individual mentally or physically. The manner that the anxiety trigger could be harmful in the present study might not represent harm as Rachman (2004) describes, but harmful to the weldment causing the weldment to fail visual inspection. Furthermore, the subsequent passing or failing of the weldment by the CWI could create harm as described by Rachman (2004). The participants in the present study all reacted to the anxiety triggers in the same manner, by coping with it and completing the test welds.

Furthermore, the number of instances anxiety was experienced also shown an effect the completion of test welds. One trend that can be identified is that as the percent of virtual reality training goes up so did the number of instances anxiety was experienced. In addition, the number of instances of anxiety decreased from the flat to the vertical position. This could be because the participants are becoming more familiar with the welding environment and are able to cope with the anxiety, as suggested by Rachman (2004).

Lastly, anxiety did have an effect on an individual's ability to complete a weldment that would pass visual inspection. The effect of anxiety had may be linked to the action of focused attention as described in Rachman's (2004) model of anxiety. When an individual noticed that a mistake had occurred they might have focused their attention on how the mistake might affect the ability to pass visual inspection by the CWI, instead of on the weld being performed.

Recommendations

Conclusions from this study lead to several recommendations. First, it is recommended that welding programs prepare trainees for the anxiety triggers, highlighted in this study, during the training program to reduce the effect during the completion of certification test welds. With the high need of welders, it is imperative to create an environment that is conducive to learning and not to triggering anxiety in trainees. By utilizing an instrument that assesses an individual's susceptibility could allow a welding training program to create separate training groups. By employing groups can allow the instructor to utilize different teaching methods better suited to the individuals susceptible to anxiety.

It is recommended that training program utilize teaching methods and strategies that are proven to reduce anxiety in both formal and informal instructional settings. Whether that be evaluating various transitioning schedules from virtual reality to a real welding booth. This might include having students that exhibit a susceptibility to anxiety to observe a certified welder to help acclimate to a real welding situation. The ability to acclimate an individual to a situation by placing them into it, but only allowing them to observe might lead to a reduced level of anxiety when the individual tries to complete the same task.

Future studies are recommended to further assess the ability of an individual's level of susceptibility to anxiety to predict future performance by purposively selecting participants. Researchers also recommend utilizing various instruments that assess susceptibility to anxiety to determine if there is an instrument better suited for a welding training program. Purposively selecting participants will allow for a higher ratio of individuals susceptible to anxiety, than the present study.

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