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The Impact of Batch Size on Worker Stress Perception

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I am submitting herewith a thesis written by EWERTON ESDRAS RODRIGUES DE ARAUJO entitled "The Impact of Batch Size on Worker Stress Perception." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

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The Impact of Batch Size on Worker Stress Perception

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ABSTRACT

The current global competitiveness has led organizations to improve their processes, and Lean Production has been a responsive tool to cost reduction and efficiency improvement. Batch size plays an important role in production control, encompassing the introduction of Lean Production in several organizations. However, the application and sustainability of Lean Production have had their effectiveness contested. Several authors explain that the continuous search for improvement has created pressure among the workforce impacting their stress levels and well-being, causing issues in focus control, authority, moral disengagement, and others. This study aims to check the impact that Batch size has on the workforce stress perception. Using the NIOSH Generic Job-Stress Questionnaire (GJBQ), a Pilot Study was performed to check the reliability of the instrument. Subsequently, a Batch size Simulation using Lego Blocks to simulate a factory environment was performed with 50 participants and three trials with different Batch size s of 10, 5, and 1 respectively. A set of different roles were played by the participants, and that wasdivided into two categories (i) operators and (ii) Production supervisors. The GJSQ was applied at the end of each trial. Six factors were analyzed: (i) mental demands, (ii) quantitative workload, (iii) variance in workload, (iv) role conflict, (v) role ambiguity, and workload using Factors Analysis. Results indicate that the items are grouped differently from those proposed by NIOSH, indicating the existence of a new factor – Cognitive Demand. Results also indicated that the perception of stress increased while the Batch size decreased.

Furthermore, males tend to have higher stress scores than females. The operational staff tends to present higher levels of stress whereas when moving from a Batch size of 10 to 1, the Production supervisors staff stress levels reduced. Responsibility for People increased in all trials, and within the roles, Variance in Workload increased only for the operators, and Quantitative Workload only for administrative roles. On the other hand, Cognitive Demands, and Mental Demand was reduced.

Key-words: Batch size , Lean Production, Stress, NIOSH.

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ABBREVIATIONS AND SYMBOLS

ANOVA - Analysis of Variance

APA – American Psychological Association

CI – Confidence Interval

df – Degree of freedom

GJSQ - Generic Job Stress Questionnaire

HFACS - Human Factors Analysis and Classification System

KMO - Kaiser-Meyer-Olkin

LP – Lean Production

M – Mean

MANOVA – Multivariate Analysis

NASATLX - NASA Task Load Index

NIOSH - National Institute for Occupational Safety and Health

NIRS - Near Infrared Spectroscopy

OSI - Occupational Stress Index

PPCA - Probabilistic Principal Component Analysis

SD – Standard deviation

Sig. – Significance

SOFI - Swedish Occupational Fatigue Inventory

UMM - Unweighted Marginal Means

WCM - Work Compatibility Model

χ^2 - Chi-Square

CHAPTER ONE
INTRODUCTION AND GENERAL INFORMATION

1.1. Introduction

The current global market competitiveness, enhanced by the worldwide recession faced since the beginning of the twenty-first century, has led Lean Production (LP) to transition from an alternative philosophy to a well-established model that organizations are implementing (Sawhney, Subburaman, Sonntag, & Venkateswara, 2010). LP has been translated into a reliable response to cost reduction, and efficiency improvement in modern organizations because of waste reduction without additional requirements of resources (Koukoulaki, 2014).

This continuous pressure for improvement has filled companies with several LP projects. Bhamu and Sangwan (2014) explain that the number of LP projects have increased since the beginning of the century among organizations. Alves, Sousa, Carvalho, Moreira, and Lima (2011), mention the case of Portugal, one of the countries most affected by the economic crisis of 2008, that experienced an increase of 200% of LP projects from 2008 to 2011.

Despite studies that show that employees tend to be more active and creative when inserted in a LP environment (Landsbergis & Schnall, 1999; Seppalla & Klemola, 2004), the application and sustainability of LP have failed over time and, consequently, their effectiveness contested (Sawhney, Pradhan, Matias, De Anda, Araujo, Trevino & Arbogast, 2019). Mejabi (as cited by Sawhney et al., 2019) explains that the origin of those failures is related to “executive, cultural, management, implementation, and technical issues.”

Indeed, Rubrich (2004) presents that LP efforts executed in different organizations have not produced the expected results. Furthermore, according to the Lean Enterprise Institute (2004), only 4% of the companies that implement LP initiatives reach an advanced stage of implementation in their facilities. Ransom (2007) points out that 95% of the LP projects have failed, and Bhasin (2012) showed that only 10% of organizations have applied LP in their integral form. Considering the human aspect, Ferreira and Saurin (2009) explain that the application of LP principles increases worker's stress.

1.2. Studies About Stress

In recent years, stress has been a source of analyzes and studies performed by different institutes. The causes that lead to stress can be diverse, varying from small casualties to big life-threats. In US society, the leading causes of stress are related to financial problems or work, followed by economic problems at the national level, relationships, family, health problems, job stability, and personal safety (Beehr & Newman, 1978; Ganster & Schaubroeck, 1991; American Psychological Association [APA], 2011; Leemans et al., 2003).

The perception of stress among genders also differs. According to APA (2011), women have a 12% more probability of feeling more stressed than men. Furthermore, the levels of importance that women attribute on how to handle stress differ when compared to men, e.g., 68% of the women consider it extremely/very important to manage stress while 52% of men consider the same.

Preliminary information points out that since the 2010s, a full-time American worker spends 1,780 hours every year at work, a number that puts the USA in the Top 10 countries with a higher than average annual hours worked rate. Similarly, the number of long hours worked has increased by 10%. Meanwhile, life satisfaction and time devoted to leisure have decreased by 2% and 0.5% respectively (OCDE, 2018; OCDE, 2019). A survey applied by Paychex (2017) with 2,000 fulltime American workers, showed that 95% consider themselves having some stress level, while 5% are highly stressed.

In the organizational level, the first mechanisms to investigate and measure stress in the work environment emerge during the late 1970s, assessing the causes that lead to stress in the workplace and its impact on the workforce well-being. Bheer and Newman (1978) showed stress causes absenteeism, lethargy and even the complete dismissal of an employee. Ivancevich and Matteson (1980) identified four different levels of work stressors, being (i) physical environment, (ii) individual level, (iii) group level, (iv) and organizational level. Karasek (1979) identifies two, (i) job demands and (ii) work control as the factors that most affect the worker's quality of life.

The most relevant study was performed by The National Institute for Occupational Safety and Health (NIOSH), in 1976. In this occasion, researchers related to job demands on different factors such as, mental and quantitative demands, variance in the workload, role conflict, and others on the impact of stress perception. This study is going to focus on the stressor factors defended by NIOSH (see chapter 3).

Few studies analyze how LP initiatives affect the level of stress of the workforce. Conti et al. (2006), using the model presented by Karasek (1979), assessed the level of stress of employees of companies with different levels of Lean Production implementation. Ferreira and Saurin (2009), presented the impact of LP on working conditions using a structured questionnaire among different stakeholders, and the application of questionnaires within assembly workers in a harvester assembly company in Brazil. Results indicated that workers were stressed, pointing characteristics of the production system such as, Batch size production, workload, high work-pace, and others as the main reasons associated with stress levels.

1.3. Lean and Stress

LP has practices that promotes improvements with less resources. Organizations have been facing issues to maintain a fast-changing work environment and have utilized Lean Production principles as an immediate answer for a long-standing issue, generating criticisms (Arbogast, 2018), and Batch size is one of the decision variable that influences production process, and leads to improvement, cost and inventory reduction (Glock, 2012; Balgamis, Basol & Kocadag 2016). Thus, the incessant search for improvement has led organizations to pressure employees for better results, continuously increasing the job demands and requirements, leading managers and leaders to implement LP projects that focus exclusively on the productive aspect (Arbogast, 2018).

Tajri and Cherkaoui (2015) show that although the implementation of LP brings benefits to the organization, it has a contrary effect on its employees creating anxiety, lack of motivation, drug abuse, depression, and others. In this scenario, LP systems have been heavily criticized because of the creation of a stressful environment where creativity and innovation of the people involved are not promoted (Landsbergis et al., 1999; Conti et al., 2006).

More interestingly, Stimec and Grima (2018) checked the impact of the continuous improvement implementations project upon the occupational stress of employees. High stress levels can come with disadvantageous effects on productivity and efficiency, creating an adverse effect on the worker's quality of life and job satisfaction, which contradicts the principles of respect for people, defended by Ohno when he established the principles of TPS (Glazer & Beehr, 2005).

1.4. Problem Definition

The continuous search for improvements has led organizations to intensify the number of Lean Project based projects within their facilities, resulting in modifications in the production line, or in the method that processes are performed. This phenomenon has created pressure among the workforce impacting their stress levels and well-being in different degrees, depending on their attributions.

A system that enhances stress is not sustainable, and Batch size is a critical component that influences the production method, impacting the cell design as well as contribute to the operator’s workload. Thus, Batch size plays an important role, allowing organizations the ability to lead with dynamic customer demands. In this context the impact that stress has on people’s well-being, it is important to identify the factors that lead to stress and how it behaves in the different organizational levels.

1.5. Objectives

Lean Production consists in different initiatives - 5S initiatives, in-line inspection, cellular design, and others. The general objective of this study is to analyze the impact that batch production has on workers’ stress levels.

As the specific objectives we will highlight:

The impact of Batch size in stress measured by NIOSH have on the Production supervisors and operational workforce

The occurrence of alternative factors that influence stress on the workforce

The creation of an Overall Stress Index

1.6. Research Questions

This study seeks to analyze the connections between the impact that Batch size has on the overall stress on gender, and on operators and operators' supervisors. Figure 1 presents the connection among the analyzed variables.

Thus, this study aims to answer to three questions, as it follows:

Does Batch size have an impact on the overall stress?

Does Batch size impact stress among operational and production supervisor staff differently?

Does Batch size impact males and females differently?

Further details are presented in Chapter 4.

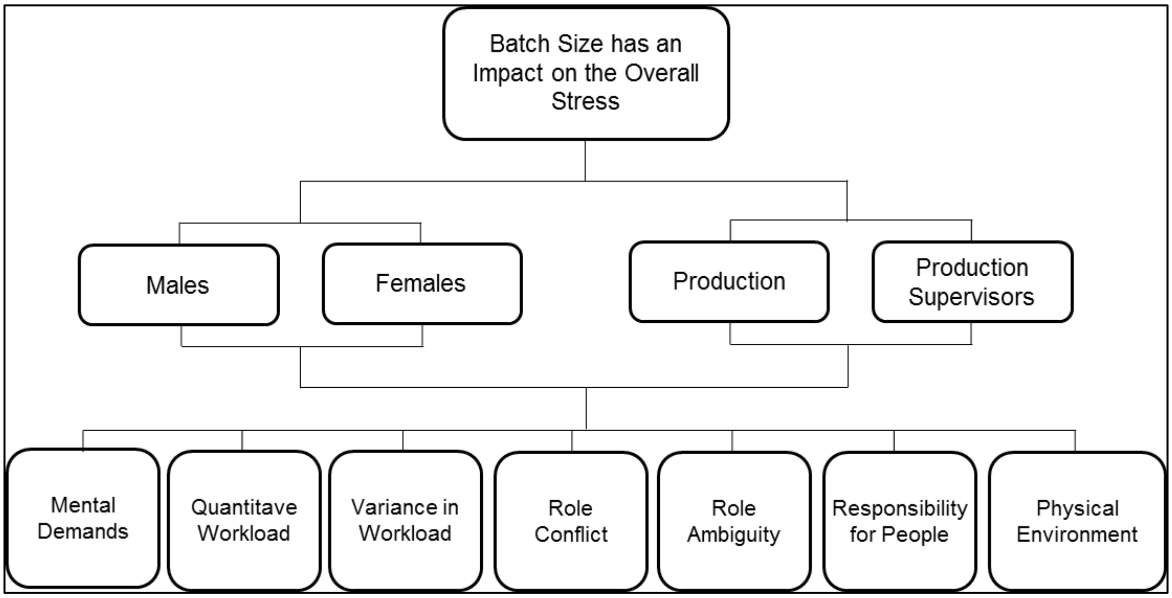


Figure 1 - Variables Analized

1.7. Research Categorization

The research is defined by its (i) nature, (ii) objective, (iii) technical procedures, and (iv) problem approach. According to its nature, the research is characterized as a quali-quantitative case-study, because of the investigation of a contemporary phenomenon in a real-life context (Yin, 1984; Johnson, Onwuegbuzie, Turner, 2007). According to its objectives, this research is categorized as qualitative and quantitative, or quali-quantitative nature, as well as the application of the survey as a mechanism to collect data. Johnson, Onwuegbuzie, and Turner (2007) point out that the quali-quantitative research consists of the collection of data and its respective statistical analysis, and a subjective analysis based on the given problem.The development of this study is divided into six main phases that comprehend the structure of the research as shown in figure 2.

In chapter 1 – Introduction - presents the failure of LP and how it has caused stress among the workforce. Also, the general and specific objectives of this research, as well as the hypothesis formulated, are presented. Chapter 2 regards the Literature Review, and presents the relationship between LP and stress factors, elucidating factors that lead to stress, as well as the measurement mechanisms for stress assessment. A brief analysis of LP Systems is introduced with a brief historical review. It is also introduces the use of simulations when obtaining and validating data.

In chapter 3, the Data Collection Procedures used for this study are presented. In Chapter 4 the characterization of the Pilot Study is presented, as well as the activities and operations from it. Subsequently, the case study is introduced, with the presentation of the events that took place during the sessions, with the presentation of the data and their findings. Chapter 5 shows the conclusions and possible recommendations for addressing the problem identified in Chapter 1 and discussed in Chapter 4.

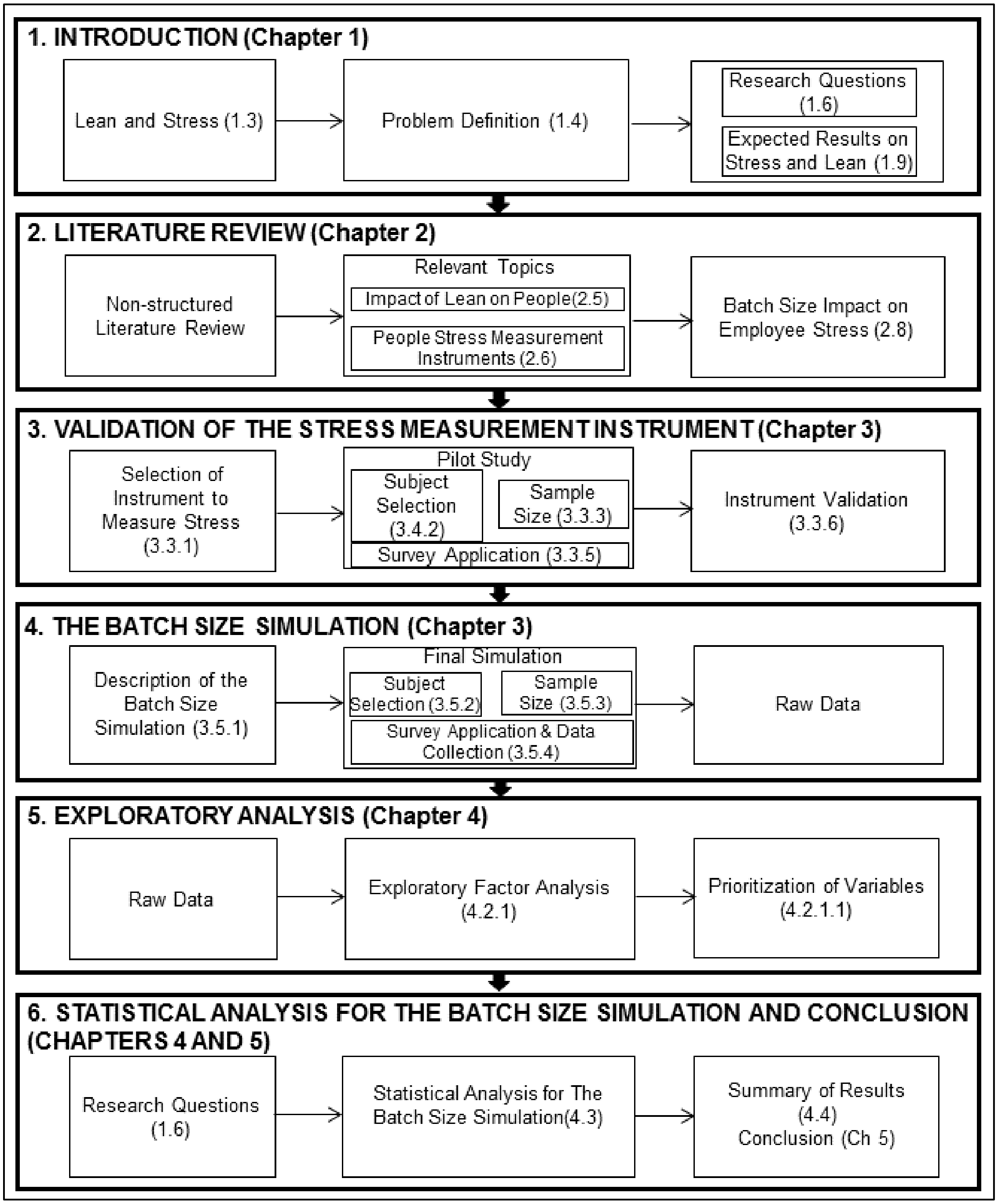


Figure 2 - Activity Research-Based Diagram

1.8. Research Context

1.8.1. The Six Phases of Lean

LP follows the principles of TPS, impacting production flow and improving throughput. According to Macias de Anda (2018), LP is divided into six different phases and it is represented in figure 3.

Phase 1 is related to the basic principles of LP initiatives within an organization, envolving te development of a Continous Improvement Culture.

Phase 2 sets the stage for the development of a stable process, creating consistency in the production flow.

Phase 3 refers to the idea of workplace redesign via process standardization, and aims the ability of a person is going to have in understanding and operating different parts of the process.

Phase 4 states that in a LP setting, it is important to have a well-established process with realiable outputs.

Phase 5 aims the Batch size Reduction to improve the scheduling for process runs, in a continous procedure until achive one-piece flow.

Phase 6 refers to Production Scheduling and Sequencing, integrating the idea of pull systems, producing what is necessary when it is necessary, promotin invetory reduction.

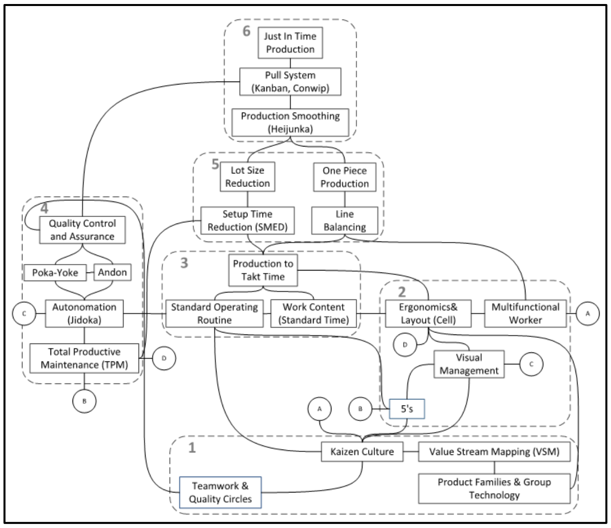
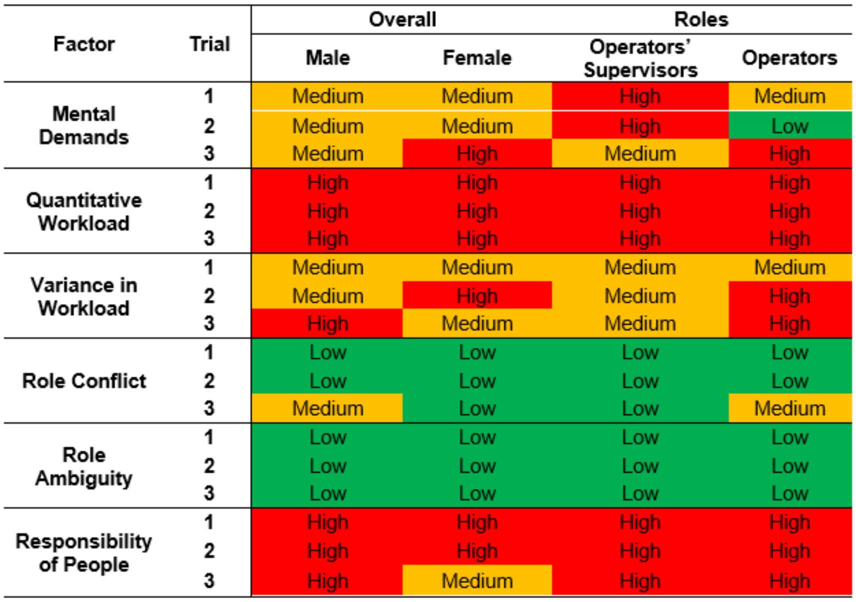


Figure 3 - The Six Phases of Lean Production
Source: Macias de Anda (2018).

As presented in topic 1.5 and 1.6, this research aims to understand the impact that Batch size has on employee fitting in the Phase 5 of the proposed model. Further details about the Batch size reduction are presented in Chapters 3 and 4.

1.9. Expected Results on Stress and Lean

The Batch size Simulation performed to check the influence of Batch size variation on stress shows that the perception of stress varies among the stakeholders as we are moving towards a batch production to one-piece flow. Thus, it is expected that differences will be observed among the analyzed factors and its relationship with genders and the played roles. It is anticipated that Mental Demands, Quantitative Workload, Variance in Work Load and Responsibility for People will present a medium to high impact on the stressors. The opposite of Role Conflict and Role Ambiguity, which are expected to show low impact. Figure 4 introduces the anticipated results of this study.



Factor	Trial	Overall		Roles	
		Male	Female	Operators' Supervisors	Operators
Mental Demands	1	Medium	Medium	High	Medium
	2	Medium	Medium	High	Low
	3	Medium	High	Medium	High
Quantitative Workload	1	High	High	High	High
	2	High	High	High	High
	3	High	High	High	High
Variance in Workload	1	Medium	Medium	Medium	Medium
	2	Medium	High	Medium	High
	3	High	Medium	Medium	High
Role Conflict	1	Low	Low	Low	Low
	2	Low	Low	Low	Low
	3	Medium	Low	Low	Medium
Role Ambiguity	1	Low	Low	Low	Low
	2	Low	Low	Low	Low
	3	Low	Low	Low	Low
Responsibility of People	1	High	High	High	High
	2	High	High	High	High
	3	High	Medium	High	High

Figure 4 - Expected Results

Similarly, expected results for the roles are presented, and it is anticipated that Mental Demands, Quantitative Workload, Variance in Work Load and Responsibility for People present a medium to high impact in the stressor components for the administrative and operators' roles. Whereas, Role Conflict and Role Ambiguity present a low effect on the stressor for each role.

1.10. Study Limitations

Although several measures have been taken to guarantee the scientific character of the present study, it is important to highlight some limitations of this research.

The literature review does not consider methods of mitigating stress in the organizational environment. Also, it only presents the primary tools of verification and measurement of stress using questionnaires and other methods for self-assessment. Different methodologies of assessing stress are out of the scope of this research, i.e., we do not present computational methods, machines/equipment, and gadgets that can capture the physiological information of the individuals and interpret them like stress or non-stress, i.e., elevation of heart rate and brain waves, headaches, hormonal changes. Regarding simulation methods, the literature review seeks to approach the topic in such way that generates debate about the use of the same in academic spheres and organizations, not necessarily attempting to show which method is the most effective.

Regarding the adopted methodology, it is important to mention that the simulations performed do not seek evidence of the physiological effects that stress can generate in the human body, but only the perception of it in the administrative and operational function. Also, the proposed method does not seek to verify the interactions in a real factory environment, considering that it has variables that cannot be controlled such as demand variation, different customer requests, possible personal problems external to the organization that can contribute to the increase of the perception of stress, and others.

The method also does not seek to present a method to mitigate stress, but only to show its behavior according to the different interactions performed. Also, it is important to mention that both literature and method do not seek to verify the correlation between cultures and the perception of stress. Thus, it is important to note that the verification and application of the presented method are limited to the context of the present study and may not be directly applicable in other sectors and simulations.

Lastly, due to the nature of this study, the results might not be extended to all organizations, being limited by the scope of the simulation run in the study. Also, during the analysis, this study seeks to present a general trend in how stress is perceived by the different stakeholders, considering general positions (production supervisors and operators) and not specify tasks.

CHAPTER TWO
LITERATURE REVIEW

The theoretical foundations of the research are structured, to contemplate seven thematic pillars: Importance of People at Work, Workplace Impact on Employee, Lean Production, Impact of Lean Production on People, People Stress Measurement Instrument, Simulation Game, and Batch size Impact on Employee. Appendix A illustrates the connection of each topic with this study.

2.1. Introduction

Lean Production has practices that aim to work better with less waste, and the reduction of the Batch size is one of the mechanisms that allow this, trying to get as close as possible to one-piece flow (Bicheno et al., 2001; Johnson, 2003; Arnheite & Maleyeff, 2005). Few studies have shown that Batch size influences the workload level, a factor that is directly related to the job shop operators which can lead to an increase in stress levels.

Thus, research was performed on both Scopus and Science Direct scientific databases using the following keywords and synonyms:

I. Batch size (or batch or lot size or one-piece flow), workload and stress.

It was also researched using combinations of Batch size and workload, and Batch size and stress.

For the first, Scopus presented 938 documents, and 115 at Science Direct (figure 5). For the second, 4,258 documents at Scopus and 1,107 at Science Direct (figure 6).

Lastly, when using all three keywords, only seven documents were found analyzing the seven documents found with all keywords, four are articles, two conference papers, and one conference review. The most relevant studies are presented as it follows.

Hsu, Chuang, Chen, & Yao (2018) describe Batch size as a widely used method in process industry for its flexibility in manufacturing low-volume and high-value-added products. Due to inter-batch variations, the batch duration often varies, which may cause difficulties in operation scheduling and decision-making. The capability of predicting batch completion time offers valuable information to improved capacity utilization, reduced workload, and reduced operating cost. To this end, several data-driven modeling methods have been reported. However, the uncertainty of the predicted completion time has not been well explored in previous research.

In this paper, the challenges for batch-end prediction are discussed by stressing the importance of prediction uncertainty. It has been demonstrated by the application of Probabilistic Principal Component Analysis (PPCA) and quantitative sensitivity analysis to two batch processes. The prediction uncertainty tends to increase substantially when the variable is defining the completion time changes slowly towards the end of the batch. Under such situations, the authors argue that uncertainty should always be considered along with the mean prediction for practical use.

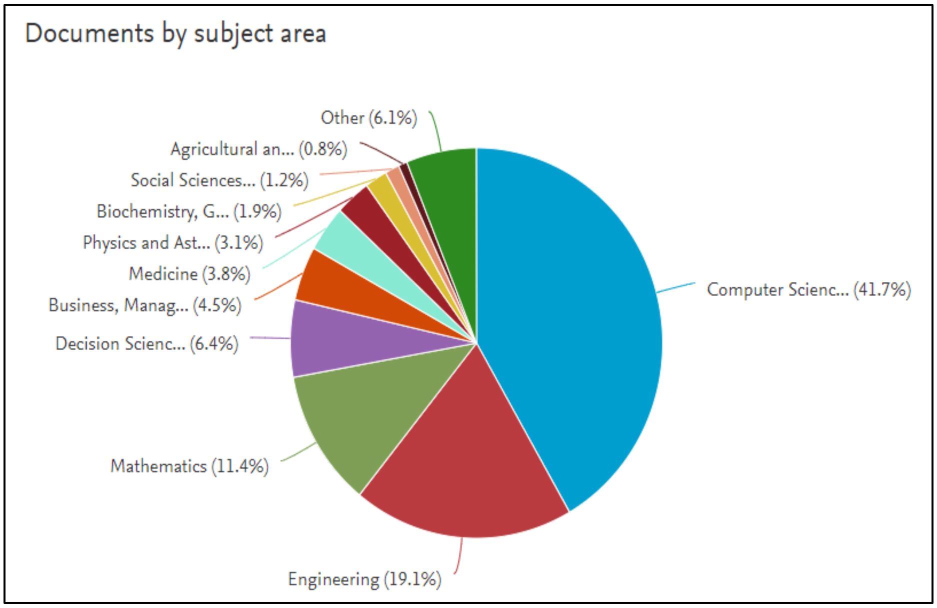


Figure 5 - Literature by Subject Area: Batch size and Workload
Source: Scopus (2019).

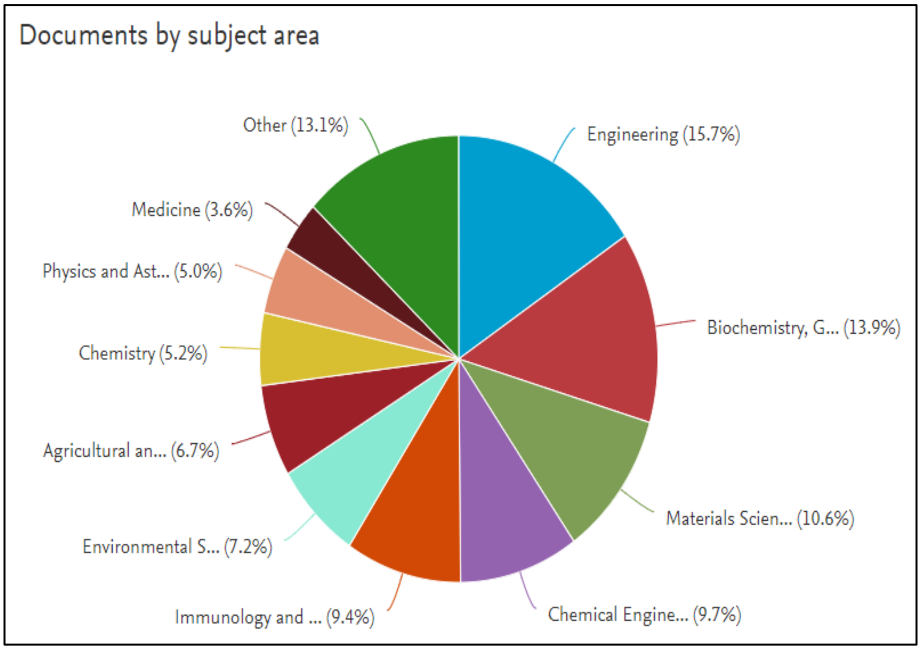


Figure 6 - Literature by Subject Area: Batch Size and Stress
Source: Scopus (2019).

Morvan, Delacroix & Quillerou (2015) described that changes to the organization of work (e.g., “Lean production are strongly suspected of being responsible for reducing worker empowerment and job control, indirectly threatening health and safety. This exploratory ergonomics study aims to better understand the conditions for workers’ room for maneuver, as a key for preventing Musculoskeletal Disorders (MSD), stress, and psychosocial risks. At the time, a “one-piece-flow” organization of production was being implemented in seven new production cells, raising concerns about potential negative health outcomes. The ergonomics intervention took place immediately after the first stages of this organizational change project, allowing comparison of three coexisting configurations. The intervention analysis was based on interviews and observations of workers’ activity in order to identify the room for maneuver and potential adverse outcomes. Results of the assembly tasks performed inside each of the “one-piece-flow” assembly cells, showed rigid work organization, a densification of the activity and strong interdependencies between workers, leading to a loss of room for maneuver and interpersonal conflicts.

Rosén & Haukirauma (2013) in their thesis, worked and examined the benefits and disadvantages of the batch flow and one-piece flow. Generally, the one-piece flow had been considered the most efficient regarding performance and economic aspects. Meanwhile, the batch flow had some benefits associated with it regarding the high level of flexibility to handle several different product variants and better possibilities of governing the material flow compared to one-piece flow. The most crucial factors affecting the choice between one-piece flow and batch flow have also been examined.

2.2. Importance of People at Work

For profitability enhancement in assembling enterprises, the proficiency of specialists assumes a critical job (Shinde & Jadhav, 2012). Since individuals are generally utilized as assets underway frameworks. Understanding the idea of human work is critical when examining choices relating to the structure of sequential systems (Oner, 2017).

Kaplan (1983) clarifies the cooperation between the specialist and the workplace identifying with a procedure-based methodology building up two wellsprings of movement. The first is outside (condition focused) because of the thought that work conditions straightforwardly influence the conduct and, in the result, the results of the workforce. Second, the internal procedure underlines that the reaction of the individual is a consequence of the discernments experienced by every person (Genaidy, Salem, Karwowski & Paez, 2016).

Since the mid-1970s the work markets of industrialized nations endured a progression of significant changes bringing about a dynamic undermining of what had come to be seen in the after-war blast period as ordinary occupations, specifically full-time and generally secure representatives working a predefined time - for the most part amid the day (Quinlan & Bohle, 2001). In the work of O’driscoll & Beehr (2000), how work stressors related to occupation fulfillment and mental strain was inspected: in an example of the U.S. as well as, New Zealand representatives, they perceived that control was connected with higher fulfillment, and lessened strain, yet showed no direct impact on stressor-result connections. The requirement for clearness was a critical arbitrator of the relationship of job equivalence and struggled to both fulfillment and strain, as an alternate outcome to similar creators.

To implement LP in an industry, personnel and their abilities and aptitudes required making trustworthiness and consistent quality of the workforce turn out to be exceptionally huge because LP brings delicacy into the framework by extending it and expelling possibilities (Sawhney, Subburaman, Sonntag, Venkateswara & Capizzi, 2010).

The work performed by people on different systems present challenges and many variables that are required to work together for human safety nowadays. Psychological and physiological factors about the human work conditions and the environment need to be understood more and studied to establish the best conditions to prevent mental and physical consequences to workers.

The plan and assessment of a word related undertaking ought to incorporate an evaluation of mental remaining burden, since intemperate levels of outstanding mental task at hand can cause mistakes or postponed data preparing, and physically requesting work that is performed simultaneously with a subjective errand may affect mental task at hand by hindering mental handling or diminishing execution (Didomenico & Nussbaum, 2011).

The productivity of the worker significantly relies on the characteristics of the production line and its association with the administrative structures, for example, workgroups appointing and engaging laborers to accomplish more with less LP, bringing an expanded interest of learning staff coming full circle in physical and emotional fatigue at work (Barnes & Dyne, 2009; Shinde & Jadhav, 2012).

2.3. Workplace Impact on Employee

Motivation and human behavior are necessary for the effective implementation of improvement projects, as stated by Tajri & Cherkaoui (2015). The authors discuss that the beneficial outcomes of LP on organization execution have not considered the workers' side. Few studies present LP as a stressful organization mode, while the intervention of cognitive ergonomics in its plan and usage appear to be critical to more readily oversee stress and improve employee performance in its work. The distinguishing proof of Lean Production and its ramifications for human execution, is additionally entangled by its conceivable outcomes, likewise identified with the specific circumstance and its usage. It must be normal that the setting of the working environment will have an effect on the intentions in presenting LP, how it is presented, and its importance (Tortorella, Fries, Silva, Amaral, & Fogliatto, 2015).

The model of the work processes play a significant role in the design of human work. In the sense of planning, implementing, and improving, for example, man-machine-interaction, man-robot-collaboration, and man-computer-interaction in these days denotes an impact of human well-being (Finsterbusch & Kuhlang, 2015).

In this scenario, The International Labor Organization has indicated that job satisfaction and occupational stress are considered a genuine threat to the worker force, playing an essential role on a person’s well-being, and by increasing the level of pressure felt by all associates (Maleek, Doostar & Eynollah, 2013). Occupational stress has been associated with the cause of brain damage considered. To Yeow, Ng, Tan, Chin, & Lim (2014), stress can be characterized as a reaction of the body to any change. If a person is stressed, it can cause performance issues. Beehr, Jex, Stacy, & Murray (2000) describe that work stressors are environmental elements that prompt individual strains - aversive and conceivably destructive responses of the person. The most regularly examined activity stressors are viewed as ‘chronic,' e.g., role conflict and role ambiguity (Beehr et al., 2000).

There are a series of organizational stress assessments to study stress in organizations, such as the one presented in the Glazer & Beehr (2005) work (Figure 7). The role stressors are linked to anxiety, which in turn is related to commitment and the intention to leave. The stressors are socio-mental job stressors and incorporate role overload (characterized as requests for an excess of work in too brief a period), role conflict (beyond reconciliation requests), and role ambiguity (absence of clear and unsurprising requests) (Bheer, 1998; Glazer & Beehr, 2005).

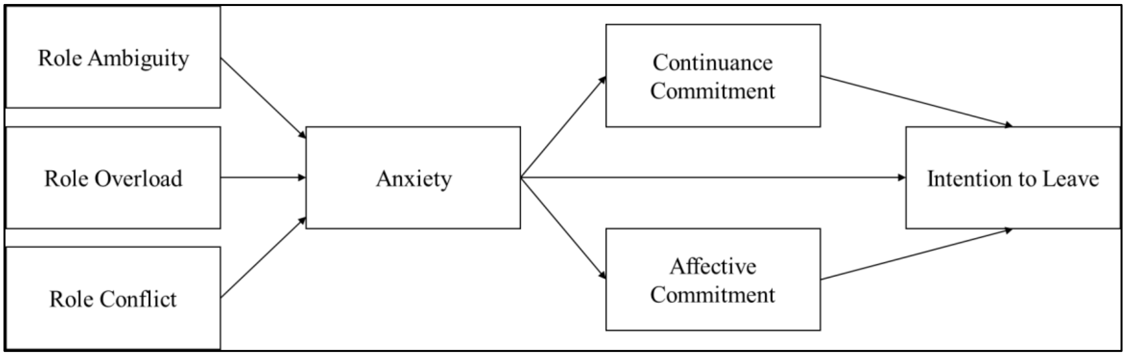


Figure 7 - Path of Variables' Relations in the Stress Model
Source: Glazer & Beehr (2005)

Bischoff, Detienne, Quick, Detienne, & Quick (2018) understand the cause and effect of ethics in the workplace becomes ever more critical in today's work. Finding concepts to comprehend those causes and effects as cognitive moral development, focus control, obedience to authority, moral disengagement, moral awareness, and ethical climate, to name a few.

The psychological stress reverberates on the body and the quality of life of workers in any environment. One characteristic of stress, in general, is fatigue; moral, cognitive, or physical; generating caution in today's work to create an ambiance to personnel so they can be creative, work long hours, or take breaks to maintain their mental and physical health (APA, 2011).

Yeow et al. (2014) defined repetition, fatigue, and work environment as causes of stress at work. For the author, repetition is a monotonous activity with close effort designs rehashed at an intemperate level of recurrence in a given timeframe. Fatigue is portrayed as a type of problem, for the most part, molded by the fatigue of one's muscles because of work and workplace working conditions, for example, typical temperature, scent free, without dust, uncongested and quiet conditions. Fatigue can also be defined as something tiring, causing dislikes, and unwillingness of the present activity (J. De Vries, Michielsen, & Heck, 2003).

Aaronson et al. (1999) defined fatigue as given the intricate communication of the organic procedures, psychosocial wonders, and conduct appearances included, recognizing common weakness from obsessive and mental exhaustion while others see ordinary fatigue as an intense and neurotic weakness as chronic. From a physiological point of view, fatigue is defined as functional organ failure.

In LP, the work of Koukoulaki (2014) examined the risks of musculoskeletal and psychosocial fatigue over the last 20 years, and the results were: (a) LP was found to negatively affect well-being and hazard factors (most negative discoveries in the car business); (b) the most grounded connections of LP generation with stress were found from qualities in JIT generation that identified with less process duration and decrease of assets; (c) expanded musculoskeletal hazard side effects were identified with increments in work pace and absence of recuperation time additionally found in JIT frameworks.

To Balkin, Horrey, Graeber, Czeisler, & Dinges (2011), there are various diverse procedures to alleviate the impacts of weakness in transportation and other word related settings. Administrative or authoritative practices, for example, work booking limitation and business screening. The creators talked about the difficulties and open doors for innovative ways to deal with weakness administration and the primary and exceptional issues identified with human collaboration with these frameworks, including client acknowledgment and consistency.

Stress and fatigue are discussed when it comes to mind human at work systems and industry, their issues and consequences. On the other hand, there are methods of measuring fatigue, mental stress, work, and human error, and these techniques are available to work ambiance to control these items.

2.4. Lean Production

Some authors have used different terminologies to describe it: Lean, Lean Manufacturing (LM), Lean Production (LP), Lean Management (LMng), Lean Thinking (LT), Lean Systems (LS) (Tajri & Cherkaoui, 2015). In this work, the term Lean Production will be used as synonymous for all mentioned terms.

LP is an embracing philosophy that combines some elements of Japanese production management - whose engineers developed first at Toyota - and applying Total Quality Management concepts developed in the U.S. W. Edwards Deming, Joseph Juran, and others (Landsbergis and Schnall, 1999).

Following Taylor's and Ford's approaches, the Japanese industry, with Toyota as its lead representative, through the ideas of Taiichi Ohno, Shigeo Shingo, and associates, showed that it was possible to have a higher level of flexibility and productivity through the basic principles of "just in time", workforce versatility, zero stock, continuous flow production and continuous improvement (Paipa-GaLeano, Jaca-Garcia, Santos-Garcia, Viles-Diez, Mateo-Duñas, 2011).

LP is based on the Toyota Production System (TPS) of post-World War II Japan (Ohno, 1978), and it was a global phenomenon, first as just-in-time production (JIT), imaginably becoming the competitive standard for assembled products from discrete parts (Conti, Faragher, & Gill, 2006). Its dissemination in the eastern world was promoted by the International Motor Vehicle Project (IMVP), which create the term LP to describe all improvements resulted from JIT initiatives (Womack, Jones, & Roos, 1992).

LP is understood as an effort to reduce obstacles to production flow through non-stop improvement (kaizen) in productivity and quality, just-in-time (JIT), inventory systems (kanban), and elimination of misused time and motion (Muda), where small groups of hourly workers - quality circles - meet to resolve quality and productivity troubles (Landsbergis & Schnall, 1999).

After initial implementation, LP is based on the earlier improvements made by the organization, or team-based work, to enhance the drift of a production emphasizing consumer needs and reducing the activities and costs that do not add value to the customer, as well as the elimination of waste in all levels of the process. LP can be interpreted as a philosophy that aims the mitigation and elimination of unnecessary process/procedures that so not significantly impact the quality of product or process, seeking the reduction of several resources for production such as area, personnel, and support (Seppälä & Klemola, 2004; Azadeh, Yazdanparast, Abdolhossein, & Esmail, 2017).

Nowadays, there is no consensus on the definition of Lean Production despite the importance of this organization mode (Tajri & Cherkaoui, 2015). The implementation of LP consists of a set of tools and techniques whose applicability can change from one company to another depending on the size, culture, and sector of activity.

Cirjaliu & Draghici (2016) listed standard delimitations of LP tools as described:

- Cellular manufacturing: organizes the whole process for a product or similar products into a collection, including all the essential machines, equipment, and operators.
- Just-in-time: a system in which a customer initiates a call for something, and there in turn is transmitted back from the final assembly to raw material, therefore “pulling” all necessities while they are required.
- Kanbans: a signaling system for implementing JIT production.
- Total Preventive Maintenance: employees carry out regular equipment maintenance to find any anomalies. The focal point changed from fixing breakdowns to stopping them.
- Setup time: continually trying to reduce the setup time on a machine.
- Total Quality management: a system of non-stop improvement employing participative management centered on the desires of customers.

- 5S: specializes in effective workplace organization and standardized work processes.

Ohno (1978) defined the early industrial wastes as (a) transport to move products not required to be processed; (b) record of all components, process of work, and complete products not being processed; (c) motion of individuals or machinery moving or walking more than is necessary to accomplish the processing; (d) waiting for the next step in the production, and interruptions of the process throughout a change of shift; (e) overproduction with manufacture ahead of request; (f) over processing, subsequent from a poor tool or product design generating activity; (g) imperfections with effort involved in examining and fixing defects.

Similarly to Ohno, Womack & Jones (1997) describe five “Lean principles” as follows: (a) client oriented to determine what client exactly expects and requests; (b) waste reduction with analyzing each product value flow and then defining all non-value steps added; (c) standard product normalizing all the procedures subsequently designing the most effective product flow; (d) pull system; (e) task management to eliminate non-value steps added and resources used like time and efficiency information.

The LP methods are a dominating force in the organization around the world and have been applied in different sectors beyond manufacturing, creating a belief that significant improvement could be made through cost reduction, being used as a mechanism to recover competitiveness in an economic slowdown (Koukoulaki, 2014). As companies have resisted remaining lucrative during periods of economic slowdown, many of them have accepted LP as an instrument to recover competitiveness (Esfandyari & Osman, 2010; Alves et al., 2011).

Sharma (2012) presented a theoretical framework with Lean Production and human factor interferences for improving business performance as well as better-quality, reduced cost, and faster distribution. Some examples from the literature illustrated the chosen situation in which ergonomics is measured as a combined part of a performance plan. A circumstance from manufacturing engaged in industrial shafts using LP techniques with successful ergonomic or human factors interventions was also inspected.

LP principles were applied in Ng, Vail, Thomas, & Schmidt (2010) work to advance the excellence of care in an emergency sector without any additional resources. Hicks, McGovern, Prior, & Smith (2015) used LP principles to design healthcare accommodations and verified the applicability and efficacy of these principles. Lunardini, Arington, Canacari, Gamboa, Wagner & McGuire (2014), when working with the Lean Production principles in a spine surgery medical center, improved their instruments' utilization.

Klein (1989), Berggren (1992) and, Berggren (1993) point out different downsides of LP, for example, (a) the standardization of cycle time, which prevents workers from managing the pace at which they work; (b) multi-skilling, which often implies job enlargement and work intensification rather than job enrichment; (c) unlimited demands on performance; (d) willingness to work overtime very frequently and on short notice; (e) close surveillance of the individual; (f) excessive regimentation of the workplace; and (g) little emphasis on preventing cumulative trauma injuries, which contrasts with a strong focus on accident prevention.

2.4.1 The Failure of Lean Production

LP implementation has presented some difficulties in the industry. Esfandyari & Osman (2010) reviewed some articles describing that about 10% or fewer companies prospered at implementing Lean Production practices or 10% have the philosophy adequately instituted. Also, despite the numerous methods and knowledge accessible to enhance operational performance overgrows, some unexpected successes in several companies prove that most efforts to use them fail to produce substantial outcomes.

Bhasin (2012) work demonstrates that under 10% of United Kingdom associations have achieved an effective LP execution. In the U.S., an investigation held by the Lean Enterprise Institute (2004) discovered that just four percent of 900 organizations viewed their LP endeavors as at a "propelled" arrangement; to be specific, LP had turned into the standard method for working inside and was being stretched out to their vital suppliers.

According to Niepcel & Molleman (1998), conventional standards of LP, for example, continuous stream and the meaning of work-in-process tops, and accordingly, increment worry in specialists and diminish their independence.

Coetzee, Van der Merwe, & Van Dyk (2016) present why the achievement rate for Lean Production execution remains moderately low. One reason is the exceptional spotlight on LP and systems in detriment to the human side of LP application. The continuous pressure for improvements on the administrative positions promotes an environment that operational employees do not feel esteemed, even though they are the ones who are in the best position to offer recommendations for enhancing the effectiveness of the work that they perform..

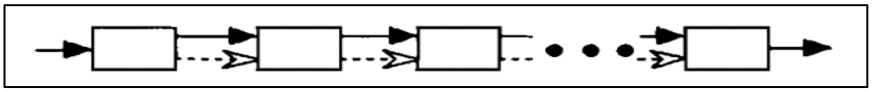
2.4.2. Production Control Classification and Lean Production

The foundation of LP is based on the concept of small production. As defended by Ohno (1978), and Womack & Jones (1997), the size of the production rate, named Batch size, has a direct impact on the number of wastes registered on the assembly lines. Furthermore, changes in the Batch size can influence the production method as well as contribute to the operator’s workload (Demeter & Matyusz, 2011).

Production control is classified into two categories (i) push system or (ii) pull system, as set by the data flow on the production line, with differentiation on the way that (i) information, (ii) demand and (iii) production behave. In the push system, information flows from the beginning to the end of the production line. The demand begins at the initial stage, and the production starts when the required raw material arrives. Once the activity is done, it is moved to the following stage for further handling (figure 8) (Chang & Yih, 1994).

The pull system initiates the creation of the present stage setting off the interest of the subsequent step, inverse to the push system; when demand arrives at the final stage, parts for delivering the item are checked to decide whether they are accessible. Assuming this is the case, the production of this stage starts after a demand is issued to the last stage for the required parts. In such circumstances, just when the needed elements come from the previous step, the production of this stage starts. A comparable strategy is followed backward through each production process until the beginning stage, such that the output of each activity in the present procedure is pulled from its downstream process (figure 9).

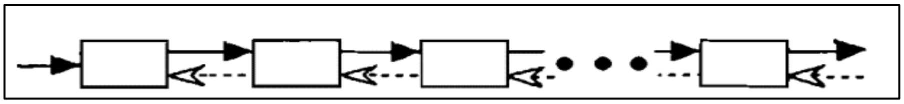
To Boonlertvanich (2005), push systems plan occasional releases of raw materials into the production line, while pull systems approve parts to be handled in response to the actual demand arrival. Pull systems have succeeded in production environments with stable demand and lead times (Hall, 1983), shockingly, systematic interest changes because of the product cycle, regular and monetary condition changes and are inevitable. The pull system parameters derived from long-term averages are frequently false (Boonlertvanich, 2005).



Box = workstation; closed arrow = material flow; open arrow = information flow.

Figure 8 - Push System

Source: Chang & Yih (1994).



Box = workstation; closed arrow = material flow; open arrow = information flow.

Figure 9 - Pull System

Source: Chang & Yih (1994).

According to Hopp & Spearman (2004), while explicit enhancements are entirely persuasive (e.g., setup reduction, production balancing), there are three primary logistical explanations for the improved performance of pull systems: (i) Less Congestion; (ii) Easier Control: Work-in-Process is less demanding to control than throughput since it very well may be watched individually; Throughput is commonly controlled regarding limit, controlled by specifying an input rate; (iii) WIP Cap, i.e, pull systems are a more effective way to improve production (Hopp & Spearman, 2004).

To Murray (2017), picking is the phase in which merchandise of a legitimate sum are hauled out from its stock zone to fit into various requests. It is the most labor-consuming procedure and accounts for 55% of complete warehousing cost. As indicated by Tran (2018), as far as incorporating levels in each pick, it ties in four techniques, which are (i) wave, (ii) zone, (iii) batch, and (iv) main order. Batch picking permits different requests being incorporated and picked together in one excursion; then, the orders are isolated by utilizing different packs or boxes inside the picking cart. An ordinary Batch size varies between 4 to 12 orders (which had some extent of the similar items (Tran, 2018).

To Myerson (2012), the advantages of smaller Batch size incorporate reduced lead times, setup time, stock reduction, adaptability to demand fluctuation, better quality with reduced scrap and rework, less floor space utilized, enhanced capacity, and decreased expenses.

The work process has a high likelihood to be poor as indicated by hypothesis, especially if the Batch sizes are not ideal and if the machine's efficiency varies a great deal. The work process can be enhanced by scaling the profitability, keeping a low batch estimate as could be allowed and confining the cradle sizes. This ought to likewise bring down the outstanding task at hand and stress of the influenced employees at the bottleneck apparatus, in any case, the batch stream can be de-persuading for the staff. (Rosén & Haukirauma, 2013).

In the inventory management literature, Batch size is a crucial variable in the production control that encompasses the introduction of LP and has been treated as a variable that might fluctuate within given limits. Thus, Batch size optimization would have a direct impact on the consumable renewal process, cost and stock reduction, and management of goods (Balgamis, Basol & Kocadag, 2016).

2.5. Impact of Lean Production on People

The Lean Production way is to improve business competitiveness, diminish the extra expenses and increment gainfulness, and for that, LP should not be regarded merely as an arrangement of systems and devices, but as an administration style dependent on human components, which proposes that representatives work in an attitude situated to decrease waste and losses (Tajri & Cherkaoui, 2015). It additionally necessitates that representatives are dynamic, creative, multiskilled, and consistently propelled to recommend enhancements simultaneously and process methods (Seppälä & Klemola, 2004).

Womack et al. (1992) depict the opportunity to control one's work replaces the mind-desensitizing pressure of large-scale manufacturing. Armed with the abilities they have to monitor their condition, laborers in a Lean Production plant have to open the door to think effectively, and proactively to take care of working environment issues. This imaginative pressure makes work humanly satisfying (Landsbergis & Schnall, 1999).

According to Coetzee et al. (2016), Taiichi Ohno (Ohno, 1978) understood the significance of incorporating individuals in accomplishing constant enhancement when he made “the second, and equally important pillar, namely respect for people” in his book, Toyota Production System: Beyond Large-Scale Production. The association of workers in the ceaseless enhancement process impacts fruitful LP change, when they embrace the change, however, if they are not dedicated to getting change going, the change can fall flat. A LP change lies significantly in the hands of the representatives who are in charge of implementing the change (Coetzee et al., 2016).

The actual state of the new work association relies upon an assortment of variables including mechanical relations, preparing frameworks, and work economic situations. Because of changing world markets, heightened rivalry, new advances, and special requests, administrators are required to rearrange work in vital, and sometimes, significant ways. Such development, some portion of bigger procedures of mechanical rebuilding and creation redesign, is one of the focal highlights of the cutting-edge work environment. In any case, the new methods and effects of work reorganization can be translated in various ways (Turner & Auer, 1994).

Ferreira & Saurin (2009) discovered that 48% of the references suggested positive effects and 52% suggested adverse effects while examining the LP qualities. They say that this vagueness might be a consequence of various components like the impact of each organization's authoritative culture, the diverse levels of development of an organizations' LP frameworks, and the financial setting of the locale where the plant is found (e.g., joblessness rates; work measures, the job of associations). To Conti et al., (2006), it depends strongly on administration decisions in planning and working Lean Production frameworks for the outcomes of human work in the business.

To James & Jones (2013), the LP idea has two implications in the writing: "that Lean creation is a proficient, humanistic machine and that Lean (rational) associations are moral, with distributive equity streaming out of them", and "that Lean production is an extremely modern jail, and that Lean assembling breaks even with mean assembling".

Despite the LP ways filled in as an enhancement instrument for assembling and administration frameworks, numerous specialists have demonstrated that organization inclinations to discover low-cost arrangements may have driven them to Leaner yet more powerless conditions, and turbulence and instability are the fundamental characters of the present market and assembling systems (Azadeh et al., 2017).

2.6. People Stress Measurement Instruments

The need for instruments to assess human behavior in the work environment dates back to the late 1970s. The scientific literature presents numerous articles discussing stress, fatigue, mental and physical health. It is important to study these subjects as thorough as possible to prevent, to control, and to balance people’s lives as holistic as possible. For that, the role of methods to measure these problems in the workplace is extremely pertinent.

Nowadays when speaking of total quality management, business process re-designing, it is neglectful in its attempt and tried profitability, as well as its execution estimation approaches (Baines & Baines, 2006). The basic procedure of measurement can be resumed in a three-stage procedure: analysis, data collection/measurement, and synthesis (Baines & Baines, 2006). Following these steps can assist in choosing the best technique to measure human behavior and its consequences in any work environment.

Akram, Sawhney, & Ganji (2016) displayed that the first-generation assessment techniques were the first to be created to help chance assessors anticipate and measure the likelihood of human error, and these methods have identified human as a mechanical segment, disregarding the parts of dynamic connection with the workplace. The authors continued explaining that the first-generation approaches encouraged investigators to decompose a task into its components and then consider the potential impact of adjusting variables, for example, time weight, gear structure, and stress; later consolidating these components to decide Human Error Potential (HEP). The second-generation human reliability assessment methods were first introduced in 1990, being more conceptual with qualitative techniques to assess human error. The third generation emerged based on the previous techniques, and it was designed to be a quick and basic technique for measuring the danger of human blunder, being relevant to any circumstance or industry where human reliability is important (Akram Sawhney, & Ganji 2016).

Several instruments have been developed by different researchers, such as Karasek (1979), Srivastava & Singh, (1981), Hart (1986). NIOSH Job Stress Questionnaire was developed during the 1970s, that are still in use, and are examples of the development of research in this area. The following section aims to elucidate the four main Stress Assessment Models in the literature. Other instruments are presented at the end of the chapter.

2.6.1. The Job Demands-Control Model

Karasek (1979), considered the pioneer in this area of study, developed a model called Job-Demands Control (JDC), that is still in use today. The JDC assumes that the main elements in the work environment that affect worker’s well-being, as well as their quality of life, are related to the (i) job demands and (ii) work control.

Karasek (1979), defines the job demands as the reflection of the amount of work that an employee is required to do while considering the pressure and control, they face in performing their tasks within the organization. The work control is related to the amount of flexibility the employee has while performing his or her tasks, that can vary from boredom to a very stressful environment depending on the organization management (Dwyer & Ganster, 1991).

Karasek (1979) suggests that psychological issues that arise in the work environment derive from the interactions between these two elements. The author explains that the proposed model allows controlling buffers that influence job demands on the strain, therefore, helping to enhance an employee’s job satisfaction. Furthermore, the model allows for engaging the stakeholder's changing themselves in new tasks, promoting the learning changes between agents.

Studies about the JDC have presented contradictory findings. Sargent & Terry (1998) report that several studies present inconsistent support when doing the cross-sectional analysis. Park, Jang & Noh (1994) show that the effects of the factors “were not substantial in scope.” On the other hand, Bradley (2004) has analyzed several studies involving the JDC Model from 1979 to 2003 and identified that most of them supported the idea that job control buffers the job demands-strain connection.

2.6.2. Occupational Stress Index

Developed by Srivastava & Singh (1981) during the early 1980s, the Occupational Stress Index (OSI) focuses on the leading sociological work stressor models that are relevant to the cardiovascular system (Belkic, Savic, Theorell & Cizinsky; Belkic & Savic, 2008). According to Srivastava & Singh (1981), OSI uses cognitive ergonomics and brain research correlating to a load of work processes for the employees. The model correlates the source of stress with individual characteristics with a coping strategy to analyze the symptoms caused by stress. Figure 10 represents the conceptual model for OSI.

According to the National Institute for Occupational Safety and Health [NIOSH] (2018), the OSI has been widely used mainly due to its distinct properties, as well as its consistent reliability and validity. Indeed, several studies present inconsistencies regarding the reliability of the tool. Studies developed by Swan, De Moraes, Cooper (1993), and Robertson, Cooper, Williams & Williams (1990) show that the Cronbach's alpha – an index used to measure reliability – is over 0.80 for the source of stress, but lower to 0.60 for the remaining scales.

Some authors believe that the model does not include other significant stressors. For instance, Johnson and Hall (1995) mention that work safety, suitability of pay, lack of control over one's job plan and institutional policy are not variables analyzed by the model. Furthermore, as pointed out by Belkic et al. (1995), the lack of emotional factors related to the work environment turns the model into a weak instrument to indicate the stressor factors.

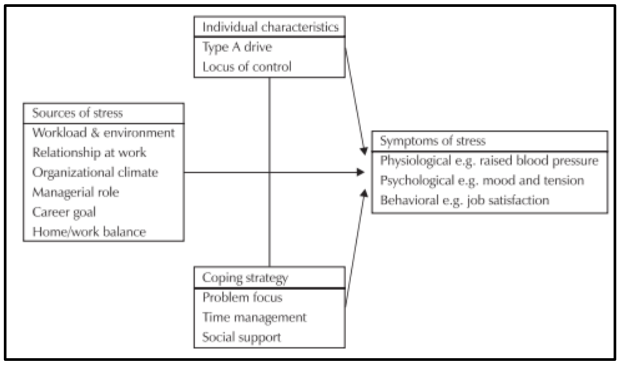


Figure 10 - Occupational Stress Index Conceptual Model
Source: Du, Lin, Lu, & Tai (2011).

2.6.3. The NASA Task Load Index

Developed during the early 1980’s to measure workload in the aviation sector, the NASA Task Load Index (NASATLX) has been primarily used to assess workload for different sectors and activities such as flying, driving, decision making, data entry, in healthcare, manufacturing and business scenarios (Hart, 1986; Hart, 2006).

The NASATLX consists of six factors: mental, physical, and temporal demands, performance, effort, and frustration, which the overall workload can be represented by a combination of the before mentioned factors. Table 1 presents the factors as well as their descriptions.

Thus, as presented by Nygren (1991), and Hendy, Hamilton & Landry (1993), the instrument is considered one of the few apparatuses that asses physical workload. The authors also attest that the main benefit of the instrument resides in its easy applicability and administration. Furthermore, due to its reliability and validity of nature, the tool has been widely accepted in the research community.

Table 1 - Factors in the NASATLX

Factor	Description
Mental Demand	Measures the mental and perceptual activity required.
Physical Demand	Measures the physical activity required to perform the task.
Temporal Demand	Measures the time pressure perceived by the operators regarding the rate or pace of the activity.
Performance	Measures the worker perception about his/her performance in accomplishing the goals of the task.
Effort	Measures how hard the worker had to do an activity to accomplish the performance level.
Frustration	Measures workers perception about motivation, irritation, relaxation during the task.

Source: Hart (1986).

Casner & Gore (2010) list the main advantages of using NASATLX. Among them the tool (i) is more accommodative of various methods for conceptualizing the idea of outstanding burden, offering (ii) adaptability of gathering remaining burden measures while members play out the assignment or instantly after consummation of an errand, enabling the specialist to utilize it for exercises that require more intellectual interest or in others that the psychological prerequisite is not utilized in a 'full mode"; likewise, (iii) the instrument endeavors to oblige any inclinations about the remaining burden that may emerge from administrators' impression of the nature of their own execution.

Salmon, Stanton, Walker, & Green (2006) adds to the advantage list the fact that NASATLX provides a reliable and simple estimation of an operator's mental demand – workload, with an electronic format that allows flexibility in its application.

However, there are some negative aspects of using NASATLX. As presented by Bustamante & Spain (2008), and later by Casner & Gore (2010), the method requires more time than other different instruments since it validates six different factors. Also, the authors cite the "scale loading problems" presented the fact that several times the operators did not assimilate the value of 50 as the midpoint moving linearly toward the two ends of the scale as perceived workload rises and falls.

2.6.4. The Generic Job Stress Questionnaire

Established in 1970 by the Occupational Safety and Health Act, the National Institute for Occupational Safety and Health (NIOSH) has focused on understanding the elements that impact worker's health and safety. Among the last 48 years, since its foundation, the NIOSH has been leading several types of research and developing methods to measure and validate employees' well-being, making several recommendations to prevent work-related injury and illness. Besides this, the agency has been providing education, training, and information in organizational safety and health (NIOSH, 2018).

As presented in NIOSH (2018), to achieve its mission for the quadrennium 2016-2020, the agency has been focusing on three main goals:

I. Conduct research to reduce worker illness and injury, and advance worker well-being.
II. Promote safe and healthy workers through interventions, recommendations, and capacity building.
III. Enhance worker safety and health through global collaborations.

NIOSH has a current bibliographical database with more than 60,000 citations within 2,584 different publications. This number is continuously growing at a rate of 1,600 citations per year (NIOSH, 2018a). These publications are the result of the projects, programs and research developed that varies from Agriculture to Wholesale and Retail trade and are divided into seven cross-sector programs presented in Appendix B (NIOSH 2018b).The Generic Job Stress Questionnaire (GJSQ) was developed by researchers at the U.S. National Institute for Occupational Safety and Health (NIOSH), upon the framework proposed by House (1974), Caplan, Cobb, French, Harrison, & Pinneau (1975), and Cooper & Marshall (1976). The proposed model assesses 13 stressors and was also allowed to collect information about stress reactions in 20 different individual scales.

As pointed out by Hiro, Kawakami, Tanaka, & Nakamura (2007), the main benefit of this instrument is its design. Developed in a modular design, the questionnaire allows researchers to adjust which forms and scales will be used to suit each investigation. Another benefit of the GJSQ refers to its reliability and validity as presented by Haratani (cited at Hiro et al., 2007), and Kazronian Zakerian, Saraji, and Hosseini (2013).

2.6.5. Other Measurement Scales

The Work Compatibility Model (WCM) gives the center established to address hierarchical issues utilizing a base up methodology, guaranteeing ideal work conditions for every individual laborer (wellbeing and security) bringing about ideal authoritative yields (quality, efficiency, and development) and ensuring economic growth (Genaidy et al., 2016).

The WCM is executed inside the setting of the Work Compatibility Improvement Framework (WCIF) that can be characterized as the distinguishing proof, enhancement and upkeep of the prosperity attributes of the workforce through the use of designing, prescription, administration, and human sciences procedures, advances and best practices (Genaidy et al., 2016).

Cintron (2015) discusses the use of the Human Factors Analysis and Classification System (HFACS) to investigate accidents examining human contributions and the causal factors caused by human errors in many domains. The author exemplifies that the HFACS has been used in several fields such as the military, air traffic control, maritime, mining, and railroad industries, supporting the use of it in other domains to investigate human error. Figure 11 presents the taxonomy with four main tier categories, each protective layer and classified the unsafe acts and potential conditions.

The conscious control of individual exercises, or physical errands with mental load (intellectual, perceptual, and full of feeling forms), is one of the essential elements of the mind (Basahel, Young, & Ajovalasit, 2012). To measure the impact of workload on brain activities, a recent method in neuroergonomics is being used called Near Infrared Spectroscopy (NIRS). This is used to examine, in Basahel Young, & Ajovalasit (2012) work, the impacts of physical lifting and mental outstanding burden associations on sound-related mental tasks (verbal and spatial).

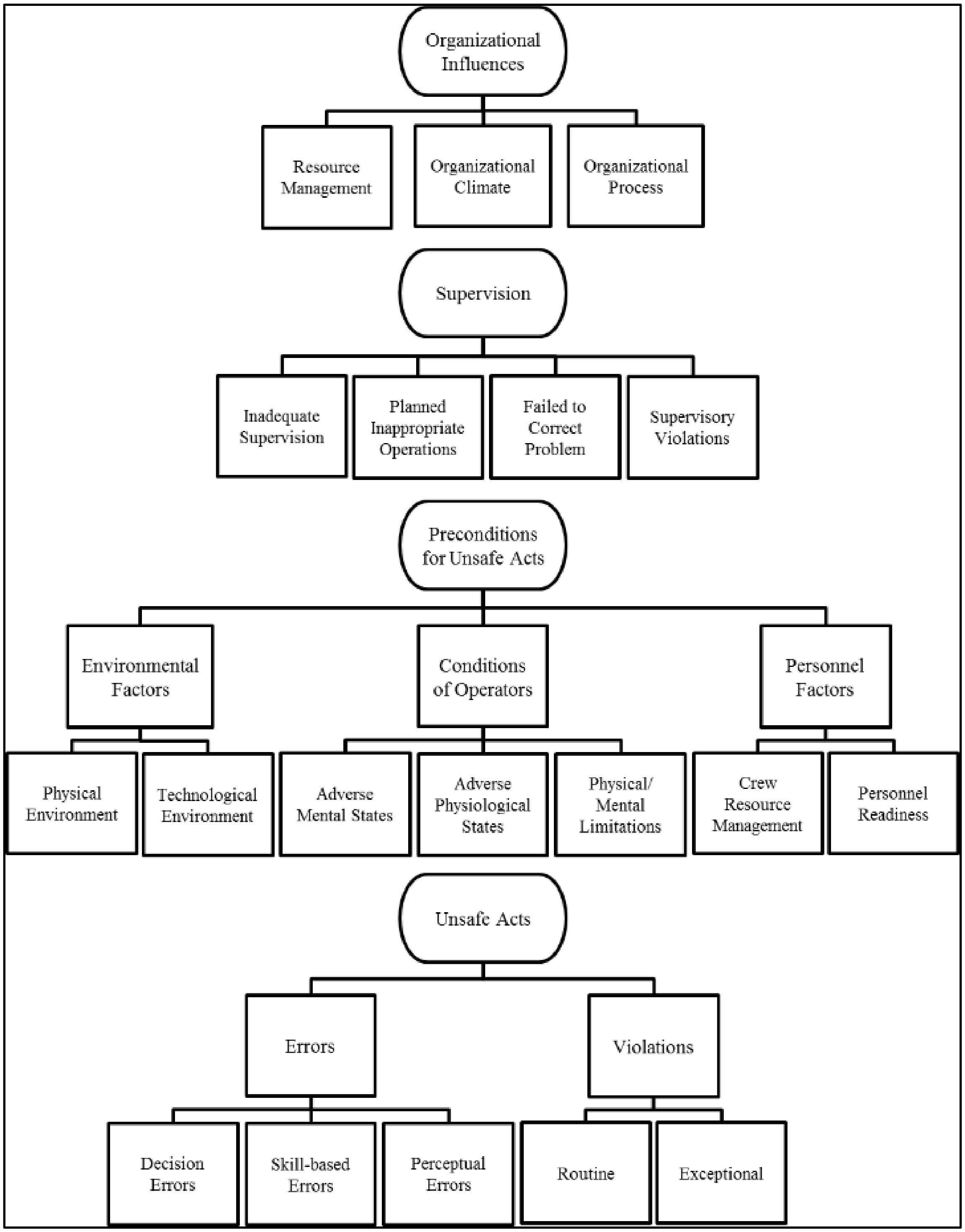


Figure 11 - The HFACS Taxonomy

Source: Shappell & Wiegmann (2001).

Chalder, Berelowtiz, Pawlikowska, Watts, Wright, and Wallace, (1993) developed a Fatigue scale examining the fact that weariness is both an omnipresent manifestation and is hard to characterize. The Fatigue Scale is a self-directed questionnaire for estimating the degree and seriousness of weakness inside both clinical and non-clinical, epidemiological populaces, despite the fact that the scale was changed and is generally used to gauge the severity of 'tiredness' as opposed to simply interminable weariness disorder (Jackson, 2015).

Jackson (2015) portrays the Fatigue Scale as a short survey, expressed in basic English with a direct noting framework, giving a concise apparatus to quantify both physical and mental weakness. The items ask about sensations and functionality, and each of the 11 elements is answered on a 4-point scale ranging from the asymptomatic to maximum symptomologies, such as ‘Better than usual,’ ‘No worse than usual,’ ‘Worse than usual’ and ‘Much worse than usual’. Using the Likert scoring method, the respondent’s global score can range from 0 to 33 and is also divided into two dimensions – physical and psychological fatigue.

The Swedish Occupational Fatigue Inventory (SOFI) was developed based on the outcomes of SOFI questionnaire where the following five terms were represented in each factor: (1) Lack of energy; (2) Physical exertion; (3) Physical discomfort; (4) Lack of motivation; (5) Sleepiness. SOFI questionnaire was a result of a study that analyzed other personal qualities of fatigue. There were 705 people who answered the questionnaire. They were employed in 16 different professions and rated the apparent fatigue during an activity which they observed as being characteristic of their occupation. The results offered a new qualitative and quantitative explanation of the physical (the factors Physical exertion and Physical discomfort) and intellectual (the factors Lack of motivation and Sleepiness) extents of apparent fatigue (Åhsberg, Gamberale, & Kjellberg, 1997).

2.7. Simulation Game

In the past, the use of games-based elements has become a common practice in both business and educational environments. Wolfe & Crookall (1998) discuss the first use of games to reproduce or recreate a real-world situation and conclude that it was done in China 5,000 years ago with the “battle games.” In that occasion, the games were used to help improve possible strategies in the field. Cohen and Rhenman (1961) reveal that chess is the direct predecessor of the game-based setting, a hypothesis also accepted by Lane (1995) that adds that war chess was also played during the 1700s.

In recent history, Faria and Wellington (2004) present that the use of games in business and educational environments dates back to the middle of the 20th century. According to the authors The Business Management Game in 1958, and the Top Management Decision Game in 1981, are examples of the modern simulation games applied to the business executive needs. Indeed, according to Kibbee, Craft, & Nanus (1961), by the year 1960 more than 100 game-based materials were in existence in the U.S., being used by over 30,000 business executives and innumerable students. This number grew surprisingly fast over that decade and culminated with the launch of The Business Games Handbook in 1969.

Horn & Cleaves (1980) present that by the year 1980, more than 200 business games were in use. As shown by Rohn (1986), Klabbers (1994), Chang, Ma, & Lee (1998), Mota et al. (2012) and LaCruz (2017), this trend continued to improve and reached Europe, Asia, and Latin America in a movement known as “gamification”, originated in the digital media industry and refers to the use of game-based elements to promote knowledge. Researches developed in the area show that the main benefits of games-based elements in regard to (i) people engagement, (ii) motivating action, (iii) learning enhancement and (iv)the development of problem-solving skills. These benefits are only possible because of the creation of a problem-based environment that stimulates the absorption of concepts and information in a context previously not allowed through traditional techniques (Deterding et al., 2011; Kapp, 2012; Schwartz, 2013; Borges et al., 2014).

Borges et al. (2014) highlight that the primary motivations for using games are due to the fact that the participant can develop an effective method of approaching the problem. This method allows using systems thinking which contributes to a behavioral and social change. Furthermore, due to its active nature, the usage of frames facilitates to increase the level of difficulty enhancing the contribution to the learning experience. Due to its characteristics, these sorts of games were named Business Games and, in some cases, Simulation Games.

To understand the concepts of Business and Simulation Games, we need to first outline the idea of Game. Bloomer (1973), defines a game as a contest among opponents for a common goal. Elington et al. (1982) describe a game as a set of rules and guidelines that provoke a competition. The term Business Game can be defined as an activity that combines features of both business and game environments, i.e., a setting composed by instructions and a goal, in a learning situation as pointed by Greco, Nonimo, and Baldissin (2013). Ruohomaki (1995) defines Simulation Game (SG) as a combination of game elements - rules, participants, competition - with critical features of reality, with different scenarios. The definition used by Usherwood (2018) defines simulation games as “a recreation of a real-world situation, designed to explore key elements of that situation. It is a simplification and essentialization of some object or process that allows participants to experience that object or process”.

Several issues have risen in the literature questioning the use of SG for research purposes. Keys and Wolfe (1990), Snow, Gehlen, and Green (2002), Dickinson, Gentry, and Burns (2004), and Grey (2004) argue that an SG is not able to provide all elements necessary to reproduce a real-life firm environment, and it would yield little improvement in practice. This idea was also perceived by Jalali, Sigel, and Madnick (2017) when analyzing over 1,400 simulation games run in his study about the effectiveness of inexperienced and experienced decision-makers. According to the author, the use of Simulation Games in the inexperienced group was not enough to avoid errors in the real-world setting despite the better results presented by the experienced subjects.

Despite the critics, as pointed out by Laurel (1991), the SG segment has become a well-organized niche with its research in a range of disciplines that vary from philosophy through engineering. According to the before mentioned author, this phenomenon was possible because of the intrinsic properties the SGs have, as it mentions:

a) SGs can be designed in such a way the players can receive prompt feedback about the consequences of their actions.
b) The SG manager can add, remove or adjust different factors within the game.
c) SGs is a cheaper option when compared to real-world training.
d) It is possible to enable risky actions to take on a safe environment.

In 2009, Faria, Hutchinson, and Wellington conducted a study reviewing a total of 304 papers in the areas of business simulation education and business simulation learning. They conclude that the main topics covered by the literature reside in five categories:

a) experience gained through business games,
b) strategy aspects of business games,
c) the decision-making experience gained through business games,
d) the learning outcomes provided by business games, and
e) the teamwork experience provided through business games.

In this context, Severengiz, Roeder, Schindler & Seliger (2018), attest that the primary application of the simulation game is to meet real-world problems in its participants, considering that it reproduces the intricacy of the networked thinking.

Thus, due to its characteristics, and according to the literature, there are five main sectors where the simulation games are used (table 2).

In the business and economic sectors, simulations are generally used to simulate decision-making situations. Cronan, Douglas & Schmidt (2011) have developed a Simulation Game in the Business context using the Enterprise Resource Planning method. The authors run an experiment with 82 participants to measure the learning effectiveness through an SG and conclude that participants had a positive learning experience. Lainema (2014) finds the SG is beneficial for the holistic development mindset of business decision-making processes. Faria (2014) writes about the effectiveness of simulation games in the strategic management scenario highlighting its benefits correlating both uses of simulations and business performance.

Boyle et al. (2016), in his work reviewing 143 papers in the economic environment, concluded that use of SGs has a positive outcome especially in what concerns behavior change, perceptual and cognitive and physiological outcomes. Idris & Yusuf (2015) introduce a different concept when utilizing a simulation game as a teaching method in economics to students at the secondary level.

Anderson Jr. & Morrice (2000), Acquila-Natale, Agudo-Peregrina, Hernández-García, Chaparro-Peláez, & Iglesias-Pradas (2018) and Tortorella, Miorando & Castillo (2018), introduce the idea of using simulation games in the engineering sector as a useful teaching tool.In the social scenario, Ahmadi, Mitrovic, Najmi & Rucklidge (2015) improve the social problem-skills of children who have ADHD through SGs. Costanza et al. (2014) conclude that the use of SGs allow us to develop our understanding and decide how to manage systems to sustain and improve human well-being. The literature also mentions other simulation games used in other areas such as the military, as presented by Kirriemuir & McFarlane (2014) where the use of a safe-real-world combat setting training is created.

Table 2 - Example of Applications of Simulation Games in Different Sectors

Sector	Authors
Business	Cronan, Douglas & Schmidt (2011); Lainema (2014); Faria (2014); Boyle et al. (2016); Qian & Clark (2016).
Economics	Santos (2002); Faria (2014); Idris & Yusuf (2017).
Engineering	Anderson Jr. & Morrice (2000); Bodnar, Anastasio, Enszer & Burkey (2016); Braghirolli, Ribeiro, Weise & Pizzolato (2016); Acquila-Natale, Agudo-Peregrina, Hernández-García, Chaparro-Peláez, & Iglesias-Pradas (2018); Tortorella, Miorando & Castillo (2018).
Medicine	Allery (2004); Evans et al. (2015); McCoy et al. (2015); Chen, Kiersma, Yehle & Plake (2015); Dankbaar, Alsma, Jansen, Van Merrienboer, Van Saase & Schuit (2016).
Psychology	Boyle et al. (2016); Miguel, Carvalho & Dionísio (2017); Nebel, Schneider, Schledjewski & Rey (2017); Hill & Lance (2002). Edsell (2010); Nguyen and Zeng (2017); Noh (2017).
Social	Costanza et al. (2014); Ahmadi, Mitrovic, Najmi & Rucklidge (2015); Hou (2015); Schlenker and Bonoma (1978), Watson and Blackstone (1989), Mathiew and Schulze (2006), Hambrick (2007), Panosch (2008).

On the other hand, several authors, such as Schlenker and Bonoma (1978), Watson and Blackstone (1989), Mathiew and Schulze (2006), Hambrick (2007), Panosch (2008), consider SG as an essential mechanism for social research, human behavior, data gathering, and team process relationship. They defend the idea that SGs complexities can be managed to achieve a realistic representation by increasing or decreasing its complexity depending on the final goal. The main complexity factors, as pointed out by the authors, include qualitative variables, such as motivation, performance, and satisfaction. Furthermore, Scalzo & Tuner (2014) and Dieguez-Barreiro et al. (2014), say that SG is the most effective way to test and validate communication flows, organizational structures or leadership styles.

Hill & Lance (2002) studied the effects of games and simulations on student stress and verified that it was not eliminated from the activity. Edsell (2010), investigate both environmentally sound and social interaction as concurrent stressors affecting anxiety via SG. More recently Monroe (2015) checked the effects of decision-making in a possible crisis for men and women. Nguyen and Zeng (2017) measure the psychological measure of mental stress and mental effort through simulation in a game-based environment. Park, Jang, and Noh (2017) investigate the psychological stress and resistance of smoking in a simulation gamed experience. Crookall and Promduangsri (2018) perceived the relationship between emotions in a simulation game debriefing.

2.8. Batch Size Impact on Employee Stress

The control of Batch size, when implementing LP solutions, is a common denominator among LP specialists and by controlling Batch size, the organization has the ability to allocate the right resources towards its best performance. However, its application leads to several hidden improvements that are necessary to make in order to achieve the organizational goals, causing continuous pressure on staff members. Studies performed by Conti et al. (2006), and Ferreira and Saurin (2009) have identified that this continuous pressure has contributed to the dissemination of a stress environment where staff members are not allowed to use their innovative skills and to suppress their autonomation, contributing to poor personal performance.

Conti et al. (2006) use the Job-Demands Control, proposed by Karasek (1979), to assess worker stress in a quantitively way. Other studies are presented such as Ferreira and Saurin (2009), where the stress is measured qualitatively. Besides the different Stress Measurement Instruments presented, the Literature Review points out the lack of evidence in the method used to assess worker stress, especially in a controlled Lean Production environment, where the Batch size could be appropriately measured.

CHAPTER THREE
MATERIALS AND METHODS

3.1. Research Plan

Taylor and Bodgan (1998), as well as Minayo and Deslandes (2003), refer to the methodology as the “form in which reality occurs,” where problems arise, and answers are presented. Gil (1999) defines the scientific method as "a set of intellectual and technical procedures adopted to achieve knowledge" that is classified as qualitative, quantitave or both – quali-quanti. For Ylmaz (2013) qualitative research is defined as a method of scientific investigation that focuses on the subjective character of the analyzed object, while quantitative research uses different statistical techniques to quantify opinions and information for a given study. To Barros and Lehfeld (2000), the method is related to the set of procedures that are used through a technique and can be understood as a description of the action.

The present study is a research of a qualitative and quantitative nature, via case study using one Pilot Study and one Batch size Simulation. The proposed method for this study is composed of four steps, as presented in figure 12.

Step A presents the Instrument used to Measure Stress and presents details about the method used to assess its reliability. This phase also introduces the key factors that is analyzed in this study.

Step B presents the Pilot Study performed to assess the validation of the Instrument used to Measure Stress. It is described the entire experiment as well as presents how the subject selection and survey application occurred.

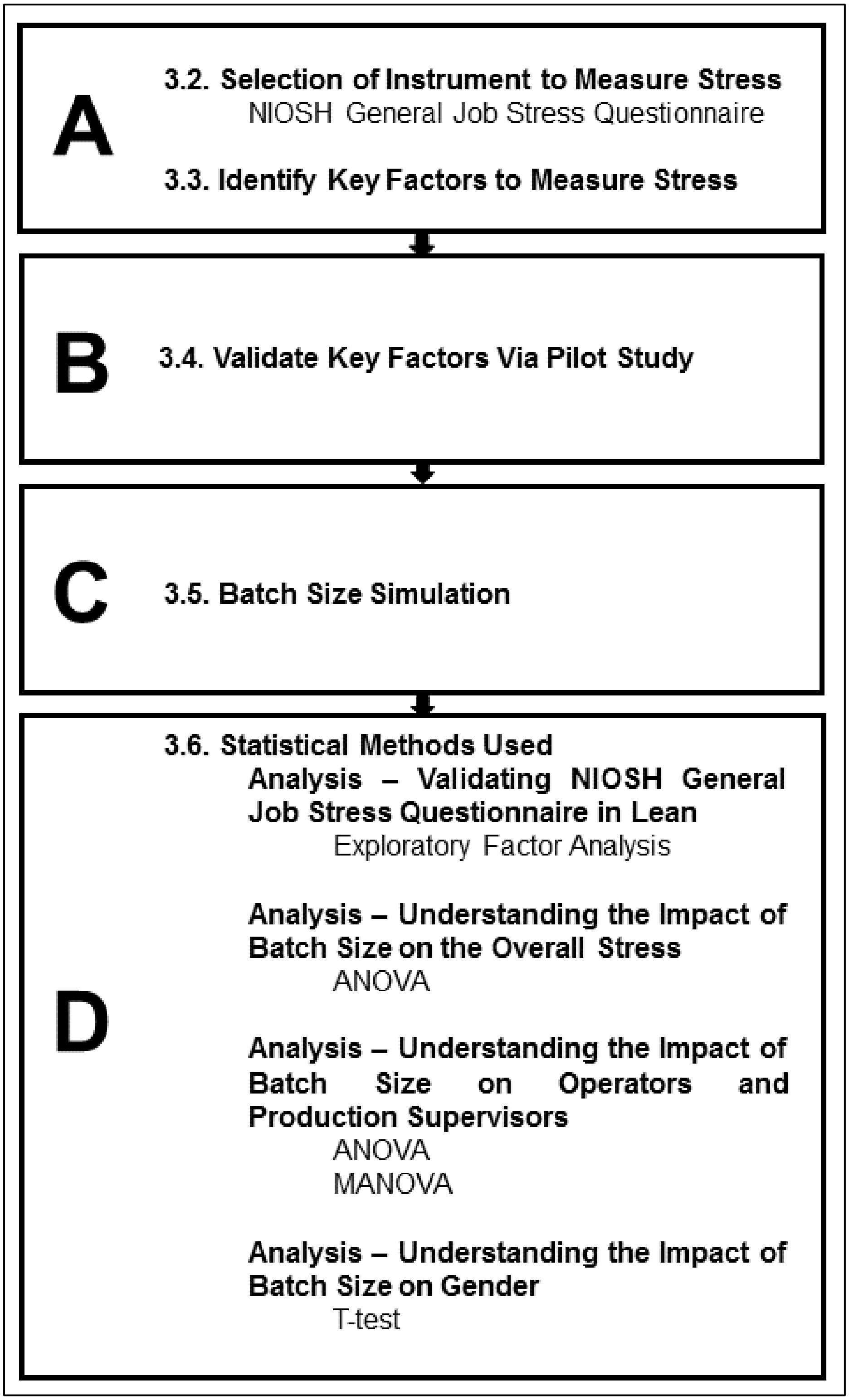


Figure 12 - Method Proposed Diagram

Step C introduces the Batch size Simulation and represents the core of this study. In this step is presented the trials, the subject selection and how the survey was applied to the participants.

Step D presents the different statistical methods that supports this study.

3.2. Selection of Instrument to Measure Stress

A self-administered survey was used to obtain information on demographics. The analyzed factors were derived from those used in previous investigations of the NIOSH on worker-related well-being. More specifically, the NIOSH Generic Job-Stress Questionnaire (NIOSH, 1976) provided the basis for the present survey. The survey design used allowed the researcher to examine the relationship between Batch size and stress and the items are presented in Appendix C.

3.2.1. The Method Used to Assess Research Instrument Reliability

The evaluation of the reliability of a dataset is an important mechanism to check its validity. Developed during the early 1950s, the Cronbach Alpha is a commonly employed index of test reliability, providing a measure of the internal consistency of a test or scale, especially in survey and questionnaires with multiple Likert scales. Its values vary from 0 to 1 and ensure that the items that make part of a given concept or construct are correlated internally (Tavakol and Dennick, 2011; Hair, 2006).

Nunnaly (1978) recommends that the acceptable value for alpha is, at least, 0.7, but it cannot surpass the value of 0.9. Also, the author explains that a value of alpha above 0.9 may indicate redundancies in the items or that the instrument should be reduced.

Murphy & Saccuzzo (1988), in their study about psychological testing, defend that alpha-values should range from 0.7 to 0.9 oscillating among low, medium and high levels of reliability (table 3). Furthermore, the authors defend that constructs below 0.6 should not be acceptable. Thus, in this study, we are going to use the reliability levels for alpha levels proposed by Murphy and Saccuzzo (1988).

Concerns regarding the ideal sample size to Cronbach's Alpha value have been echoed by several authors, indicating that a sample of 100 or even 300 is required to have an accurate measurement. Nevertheless, recent studies have demonstrated that a sample size of 30 is enough to provide a good accuracy of Cronbach's Alpha value (Yurdugul, 2008).

However, it is the work of Bujang, Omar, & Baharum. (2018) that provides information on how the sample size should be estimated when working with a Likert Scale in different levels, presenting the following formula:

$$n = \left[\frac{\frac{2k}{(k-1)}\left(Z_{\alpha/2} + Z_{\beta}\right)^2}{\ln(\partial)^2}\right] + 2$$

Where:

$n =$ sample size
$k =$ number of items or factors
$\alpha =$ Confidence interval
$\beta =$ Power
$\partial = \frac{1 - Cronbach's\ Alpha\ initial}{1 - Cronbach's\ Alpha\ expected}$

The authors recommend setting $\beta = 0.1$, $Cronbach's\ Alpha\ initial = 0$, $Cronbach's\ Alpha\ initial = 0.7$.

Table 3 - Alpha-Values and Reliability Levels

Values	Reliability Level
>0.6	Not acceptable
0.61 – 0.7	Low reliability
0.71 – 0.8	Moderate reliability
0.81 – 0.9	High reliability

Source: Murphy and Saccuzzo (1988).

3.3. Identification of Key Factors to Measure Stress

As mentioned in topic 3.2, The NIOSH Generic Job Stress Questionnaire was applied to collect information regarding impact that Batch size has on the worker stress perception. The survey aimed to collect information about the following different factors: (i) mental demands, (ii) quantitative workload, (iii) variance in workload, (iv) role conflict, (v) role ambiguity, (vi) Physical Environment, and (vii) responsibility of people (Appendix D). Those factors were later analyzed. It was verified that the items were distributed in three different Likert scales - from 1 to 4, 1 to 5, and 1 to 7. In this study, the scales were standardized so that all ranged from 1 to 5. The reliability analysis was performed for each factor (subscale) to assess the internal consistency.

3.4. Validation of the Stress Measurement Instrument Via Pilot Study

3.4.1 Description of Pilot Study

A total of 10 electrical boxes and their parts were given to the participants. They should assemble and disassemble each box. The production rate was determined by each team, followig one-piece flow guidelines; however, the “winner team” would be the one with the highest number of finished electrical boxes and the least number of quality problems. The rules consisted of keeping the production line working for the total time of 50 minutes.

The process flowchart is presented in figure 13. The process started with the production of the (a) Top Faceplate and (b) the Bottom Plate. The Top Faceplate was composed of 11 parts; (i) one plate, (ii) one light switch, (iii) two Phillips head screws, (iv) three screw-nuts, (v) one outlet and (vi) three flat head screws. The Bottom Plate was composed of five parts; (i) bottom box, (ii) one top conduit, (iii) one top nut, (iv) one bottom conduit, and (v) one bottom nut. The Top Faceplate and the Bottom Plate are presented in figure 14.

After production, the part proceeded to the final assembly. During the last assembly operation, the parts were put together, and two Phillips head screws were placed in, one on the right top corner and left bottom corner respectively. After assembly, the electrical box proceeded to the next stage.

During the inspection, the person responsible should check the final quality of the product. If a problem was found, the piece should go to the disassembly stage immediately. A piece would be considered defective if (i) the switch was not in the “off position,” (ii) the outlet with the neutral phase on the top position, (iii) if the screws were misplaced, or (iv) if the top and bottom conduit were misplaced.

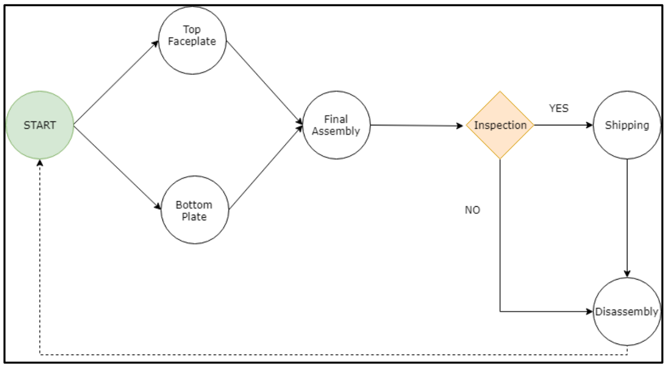


Figure 13 - Elecrical Box Flow Chart

Figure 14 - Top Faceplate, Bottom Plate And Electrical Box

A set of different roles were given to the participants of each team, in a total of eight positions. The positions were dived into two categories (i) operator and (ii) Production supervisors, as presented in table 4. The Top Faceplate Assembler was divided into two positions: (i) Top faceplate assembler 1, was responsible for assembling the light switch of the electrical box, and (ii) Top faceplate assembler 2, was responsible for assembling the outlet. They were also responsible for checking the quality of the parts. The bottom plate assembler was responsible for assembling the electric conduits of the electrical box.

Moreover, the Final assembler was responsible for assembling the top faceplate and the bottom plate, this being the last step of the production. The Material Handler was responsible for sending the parts to each station. Also, he/she was responsible for collecting the pieces from the disassembly station and distributing them within the assembly production line. There were two Time Keepers. They were randomly assigned to different stations. Their primary responsibility was to check the operation time of the activities and record the data.

The Quality Manager was responsible for assuring the quality of the final product. In case of any failure, the product was discarded and went to the disassembly operation immediately. The quality manager was also responsible for collecting the data regarding the number of defective items. The plant manager had to assure that the production pace was happening accordingly.

Table 4 - Roles During the Pilot Study

Position	Category	Position	Category
Top Faceplate Assembler	Operator	Material Handler	Production Supervisor
Bottom Plate Assembler	Operator	Time Keeper	Production Supervisor
Final Assembler	Operator	Quality Manager	Production Supervisor
Disassembler	Operator	Plant Supervisor	Production Supervisor

3.4.2 Subject Selection

The study involves the application of a Pilot Study at the Supply Chain Laboratory in the Department of Industrial Engineering at the University of Tennessee at Knoxville. The sample was executed by 36 undergraduate students in the IE 202 (Work Measurements and Introduction to Manufactured Process) course of the said institution, offered during Spring 2018. All the students were in the age group between 18 and 24 years old.

3.4.3. Survey Application

Training was provided to all students for three 50 -minutes class meetings, in a total of 2 hours and 30 minutes of training, and information regarding process flow, method, and best practices was covered. The students were divided into three teams of 9, 13 and 14 participants each. The simulation was run in two different sessions (on April 3rd and 5th, 2018), according to the participants' schedules. The experiment sessions were observed by the researcher and was recorded for later review if needed. The survey was administrated at the end of the trial.

3.4.4 Sample Size for Pilot Study

The study about the recommended sample size for pilot studies is controversial. Isaac and Michael (1981) suggested that a sample size between 10 and 30 has the ability to test hypothesis. Similarly, Hill (1998) suggested a recommended sample size between 10 to 30 participants for pilots when survey research is used as instrument.

3.5. The Batch Size Simulation

The use of Lego Blocks to simulate a factory environment is not new. Several studies have presented the use of this tool since early 1990 within Industrial Engineering undergraduate courses and Lean Production training in the business field (Riis, Johansen, Mikkelsen, 1994). Studies such as Riis, Johansen & Mikkelsen, (1994), Badurdeen, Marksberry, Hall, and Gregory (2010), Leal, Martins, Torres, Queiroz, and Montevechi (2018) show the benefits of this game in the educational process.

3.5.1 Description of Batch Size Simulation

A set of different roles were played by the participants, in a total of 16 positions, 15 being related to the factory itself, and the last one to the customer. The positions in the factory environment were divided into two main categories: (i) operators and (ii) Production supervisors, as presented in table 5.

The operators were requested to produce the parts as shown in Figure 15, and it represents (a) Base, (b) Top Right Arm (Longarm), and (c) Top Left Arm (Short arm) respectively. Figure 16 represents (a) Assembled Top Right Arm and (b) Assembled Left Arm. One product is considered ready with both parties paired.

The Material Handler was responsible for sending the parts to each station, identifying where all the movements were necessary, also responsible for collecting the defective items and sending them to the correct stations. The Timekeeper should track a different colored "base," that should be introduced in the system after the experiment was running for one minute. This piece should be tracked through all activity until it got out of the system, i.e., delivered to the customer. Furthermore, the Time Keeper should collect the information regarding the time the piece was in the system.

The Line Supervisor should check the production rate and its quality of the Base, Top Left Arm, and Top Right Arm stations. Similar responsibility was given to the End of Product Supervisor, which should check the Inspection, Shipping and Final Assembly stations. The Plant Manager had to observe the production and identify the areas that were facing some issues, making suggestions to improve the system and how it would be done.

The Accountant was responsible for keeping track of the number of produced parts, work-in-process items, and defective products. Also, it was responsible for checking the factory finances. The CEO should review the financial statements of the company and make decisions based on the information provided.

Table 5 - Roles in the Batch size Simulation

Position	Category	Position	Category
Base	Operator	Material Handler	Production supervisors
Top Left Arm (short arm)	Operator	Time Keeper	Production supervisors
Top Right arm (long arm)	Operator	Line Supervisor	Production supervisors
Left Assembly	Operator	End of Product Supervisors	Production supervisors
Right Assembly	Operator	Plant Manager	Production supervisors
Inspection	Operator	Accountant	Production supervisors
Shipping	Operator	CEO	Production supervisors

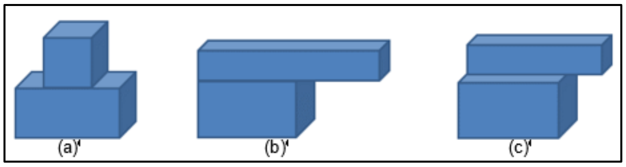


Figure 15 - Parts to be Produced

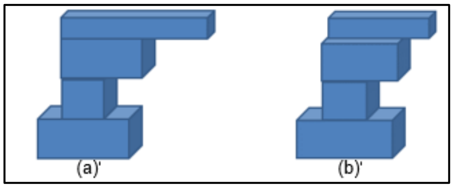


Figure 16 - Parts to be Assembled

The customer was requesting his/her products every 30 seconds. In the case of not having the pieces, he/she should show discontentment with the company’s CEO, requiring the proper delivery.

It was performed three different trials. Trials 1 and 2 ran for five minutes each, and Trial 3 ran for 2.5 minutes, the Batch size was set as ten, five and one units respectively. The participants were divided into two groups of 25 students. Both groups performed the same simulation at the same time. in order to avoid the noise of learning curve, or practice from the different groups, all calculations were based on the average of the results of both groups. The design of the simulation is based as proposed by Leal et al (2018), and details for each trial is presented as it follows. Table 6 presents the main modifications occurred during the trials.

During Trial 1, the Batch size was set to 10 units, i.e. the movement of material as well as finished parts just move forward to next phase in every 10 pieces. The amount of work necessary to have each part produced as well as the setup of each workstation was balanced in the line, as proposed by Macias de Anda (2018).

Table 6 - Main Attributes Modifications Within Batch-Size Simulation Trials

	People		Material	Layout	Schedule
	Operators	Production Supervisors			
Trial 1	Production pace remains the same for all operators	Production pace remains the same for all production supervisors	The right amount of parts was distributed to produce 50 pairs	7 workstations	Batch size of 10 units
Trial 2	Production pace increases for Material Handler	Production pace decreases for all production supervisors	The right amount of parts was distributed to produce 50 pairs	8 workstations	Batch size of 5 units
Trial 3	Production pace increases for Material Handler	Production pace decreases for all production supervisors	The right amount of parts was distributed to produce 50 pairs	7 workstations	One-piece flow

For Trial 2, the production was set in a Batch size of 5 units. This difference promoted a change in the production line with the addition of one workstation, in a total of 8, and one Material Handler. The decrease in the Batch size increased the flow of material and information among workstations, impacting primarily the Material Handler.

In order to compare the different Batches sizes, during Trial 3 the production line was set as one-piece flow, the number of workstations required to produce the parts were reduced by one, in a total of 7. Due to the fast pace of the production the material flow increased significantly within the systems, and its major impact could be felt by the Material Handler.

More details of each trial are provided in sections 3.5.1.1, 3.5.1.2, and 3.5.1.3.

3.5.1.1 Trial 1

The first experiment was run for five minutes, and a Batch size of 10 parts was considered in-between workstations. The 10 parts batch is moved by one material handler throughout the system. There were seven workstations, one customer and one material handler. The customer should request the final assembled parts once every 30 seconds and writes down the number of times parts were received or not.

The trial was composed of seven stations with one operator each (figure 17). The process started with the timer activation. The main components (i) Top Left Arm, (ii) Top Right Arm, and (iii) Base were produced in parallel. The operators could only send the parts for the next stage in batches of 10 units, and inside a container. The only person that could deliver the work-in-process was the Material Handler, that was called every time a batch was ready to go to the Final Assembly.

In the Final Assembly, the person in charge had to place the Top Left Arm on one Base. The same procedure should be done to the Top Right Arm. After this stage, the parts were named Short Arm and Long Arm respectively. After the Final Assembly station, the parts followed to the Inspection Station. The operator should check the quality of the pieces, identifying the one that had quality issues, and send them back to the beginning of the production line that should stop immediately and fix the problem. The only person who could send them back to the correct production line was the Material Handler. At this stage, no Batch size was required. Also, it was the responsibility of the Material Handler to transport the final product to the next step.

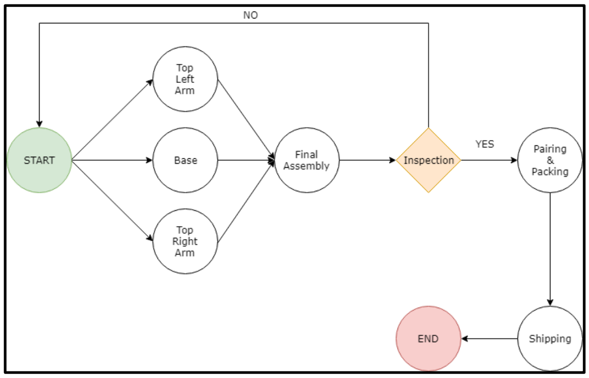


Figure 17 - Flowchart Trial 1

Subsequently, at the inspection station, the different parts were paired – one Long Arm and one Right Arm – and sent to the Shipping station. The shipping station should deliver the final products to the customer. The customer had the responsibility of checking the number of pieces received, the final quality and check if it was given with the right specifications.

3.5.1.2 Trial 2

The procedure remained the same as settled on Trial 1. Similar to the last trial, the simulation ran for five minutes, and a Material Handler was added. This modification resulted in a new flowchart that is presented in figure 18.The operators could only send the parts for the next stage in batches of 5 units, and inside a container. Other elements, such as customer requirements, remained the same. Similar to the last trial, the trial run for 5 minutes.

The trial was composed of eight workstations with one operator each. The process started with the timer activation. The main components (i) Top Left Arm, (ii) Top Right Arm, and (iii) Base were produced in parallel. However, the Base station should feed two Final Assembly Stations, one for the Top left arm, and the other for the Top right arm. The two Material Handlers should only work with one of the parts (i) or (ii). The subsequent stages remained the same as presented in Trial 1.

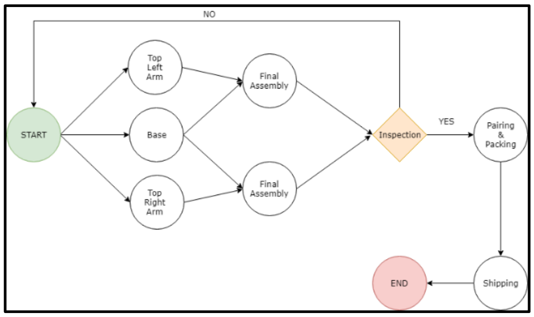


Figure 18 - Flowchart Trial 2

3.5.1.3 Trial 3

The rules have not changed. However, the Batch size was reduced to one part, i.e., one-piece flow. In other to accommodate the one-piece flow requirement, a reorganization of the line was made, and the number of stations decreased to seven. One Material Handler was fired. The shipping station was absorbed by the Pairing & Packing. It was required that each station inspected the product fo quality issues. The flowchart for trial three is presented in figure 19. The customer requirements remained the same.

This trial was composed of seven stations with one operator each. Similar to the previous trials, the production started with the timer activation. The main components (i) Top Left Arm, (ii) Top Right Arm, and (iii) Base were produced in parallel. However, the Base station should feed two Final Assembly Stations, one for the Top left arm, and the other for the Top right arm. The operators could only send the parts for the next stage in batches of 1 unit.

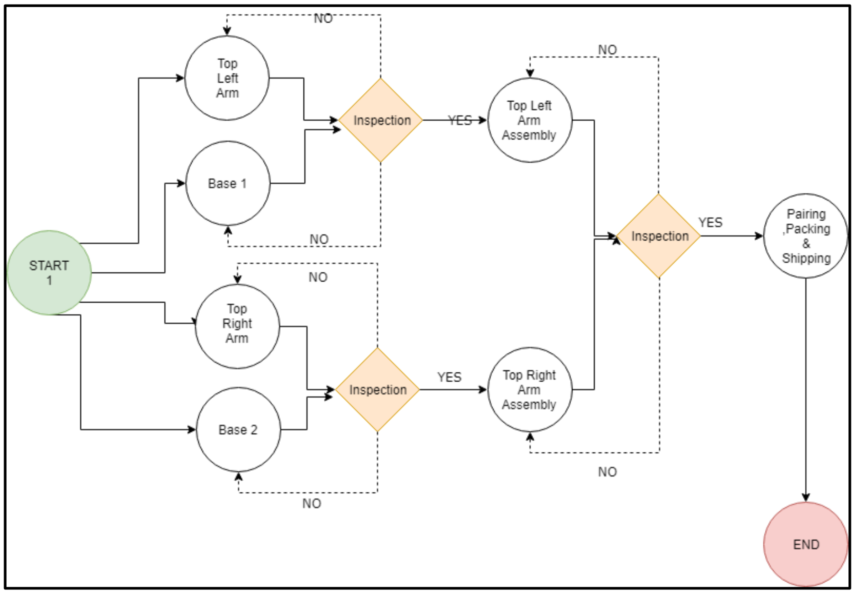


Figure 19 - Flowchart Trial 3

3.5.2 Subject Selection

Using Lego blocks to simulate a real manufacturing setting, The Batch size Simulation was run on July 5th, 2018 within the University of Tennessee Lean Summer Program Class, with a total of 50 undergraduate students of Industrial Engineering, Business, and related fields. All participants had previous knowledge of Lean Production. All the students were in the age group between 18 and 29 years old.

3.5.3 Sample Size

In this study, the criteria behind the determination of sample size are divided into three parts:

I. the sample size required to Perform Cronbach's Alpha test
II. the sample size required to use Factor Analysis methodology, and
III. sample size to use Inferential Statistics Techniques.

3.5.3.1 The Sample size required to Perform Cronbach's Alpha

In this study, the approach proposed by Bujang et al. (2018) is used and presented in topic 3.2.1

$$n = \left[\frac{\frac{2k}{(k-1)} \left(Z_{\alpha/2} + Z_{\beta} \right)^2}{\ln(\partial)^2} \right] + 2$$

$$= \left[\frac{\frac{2 \times 37}{(36)} (1.96 + 1.282)^2}{\ln(3.33)^2} \right] + 2$$

$$= \left[\frac{77.07}{1.2} \right] + 2$$

$$= 55.6$$

Thus, 55.6 is the minimum number of sample size required to assess Cronbach's Alpha. In this study, a sample size of 110 is considered, indicating the proper usage of the technique.

3.5.3.2 The Sample size required to use Factor Analysis

The use of Factor Analysis is a conventional method used in research (Henson & Roberts, 2006), but its proper sample size determination is still contradictory. Guilford (1954) and Gousuch (1974) recommended a minimum sample size of 200 is the most indicated to avoid errors within the analysis. On the opposite side, Comrey & Lee (2013) present that pursuing a sample size of 1,000 is the ideal scenario.

Other studies presented a different panorama indicating that the ideal sample size could be influenced by the number of analyzed factors. In this context, Cattel (2012) recommends a minimum number between 3 to 6 outputs per variable while Hair, Anderson, Tatham, and Black (2005) recommend a ratio of 20 outputs per variable. In this study, the recommendation proposed by Cattel (2012) it is followed.

3.5.3.3 Sample Size to Use Inferential Statistics Techniques

For the proper delimitation of the sample size, it was assumed that the knowledge level of the participants in LP, in the conditions performed during the Batch size Simulation, represents at least 95% of staff members that deal with LP projects implementation and operation. Thus, the following formula is used to determine the ideal number of respondents.

$$n_0 = \frac{Z_{\alpha/2}^2 \times p \times (1-p)}{e^2}$$

Where:

n_0: sample size
p: probability of sample size representation (assumed 0.95)
e: error margin (assumed 0.5)
$\alpha,$ indicates 0.05

$$n_0 = \frac{1.96^2 \times 0.95 \times (1 - 0.95)}{(0.05)^2} =$$

$$= 72.99 \sim 73$$

Hence, considering the minimum required amount of 73 responses, and the total amount of responses obtained during the Batch size Simulation of 110 responses, the study exceeds the minimum requirements.

3.5.4 Survey Application and Data Collection

Similar to the Pilot Study, the NIOSH Generic Job Stress Questionnaire was used to collect information regarding the worker stress perception. However, items regarding PE was not considered. The data obtained through the survey was scored using the NIOSH scoring key. The Batch size Simulation was run on July 5th, 2018 within the University of Tennessee Lean Summer Program Class and it was composed of three trials as presented in the topic 3.4.1.

The survey was applied immediately after each trial. To alleviate the different learning curves, we are considering the average value obtained in each position for both groups. The experiment sessions were observed by the researcher and it was recorded for later review if needed.

Appendix E illustrates the labeling and sequence of the survey items.

3.6. Statistical Methods Used

Different statistical techniques were used to verify the hypotheses presented. Considering the limitation of sample size and to satisfy the basic requirements of the sample size, as well as the number of variables to be analyzed simultaneously; four statistical techniques were used in this study, which are: (i) Exploratory Factor Analysis, (ii) Analysis of Variance (ANOVA), (iii) Independent t-test, and (iv) MANOVA. The final presentation of the results was done through graphs and tables, as well as by the inferential analyses of the relationships between the variables detected in the study. All statistical tests were performed in IBM SPSS Statistics Software 23.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Validation of the Stress Measurement Instrument Via Pilot Results

The primary purpose of the Pilot Study was the validation of the data collection instrument. Thus, a reliability test in SPSS was conducted per each factor. The results are presented in table 7.

Of the seven proposed factors, only one, Physical Environment (PE), presented a value below 0.7, and as presented by Nunnaly (1978), it was not considered during the Batch size Simulation. This result was expected, considering that all participants were in an environment with controlled air conditioning, no external or internal noise, right lighting, and safe. Responsibility of People (RP) presented a value above 0.9 however, because of the mathematical proximity, it will not be considered as redundancy. Thus, the Pilot Study has proven that the NIOSH Generic Job-Stress Questionnaire is a reliable measurement instrument for this study.

Table 7 - Reliability of the Factors For the Pilot Study

Factor	No. of Items	Cronbach's Alpha Std.
Mental Demands	5	0.846
Physical Environment	6	0.674
Quantitave Workload	7	0.779
Role Ambiguity	6	0.897
Role Conflict	8	0.708
Responsibility of People	4	0.908
Variance in Workload	7	0.848

4.2. The Batch Size Simulation - Results

A total of 50 undergraduate students of Industrial Engineering, Business, and related fields, from different nationalities, participated in the Batch size Simulation. There were 62% originally from Mexico, 20% from Brazil, and 18% from China. All participants had previous knowledge of Lean Production and its principles and were in the age group between 18 and 29 years old. Geographic information regarding the participants is presented in table 8.

The concentration of respondents in the range of 18-24 is common in a sample of students, considering that regular students ranges in this age (US Census, 2018; National Center for Education Statistics, 2018). However, a concentration in the male gender is still verified in studies carried out in the field of science and technology (Freitas & Luz, 2017).

The dataset was checked for outliers by using boxplot, and no outliers were identified in the factors analyzed (figure 20). Furthermore, outliers in the roles performed in each trial were checked and figure 21 present the outputs.

Table 8 - Geographical Information

Information	Quantity
Country	
Brazil	10
China	9
Mexico	31
Gender	
Male	37
Female	13
Other	0
Age	
18-24	44
25-34	6
Total of participants	**50**

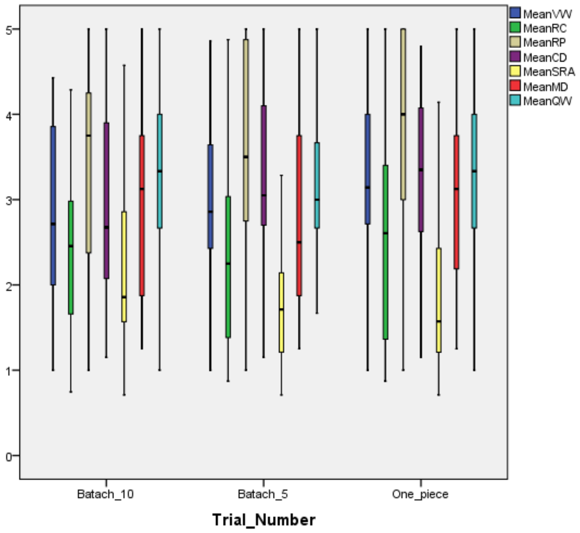


Figure 20 - Boxplot Batch Size *versus* Trials

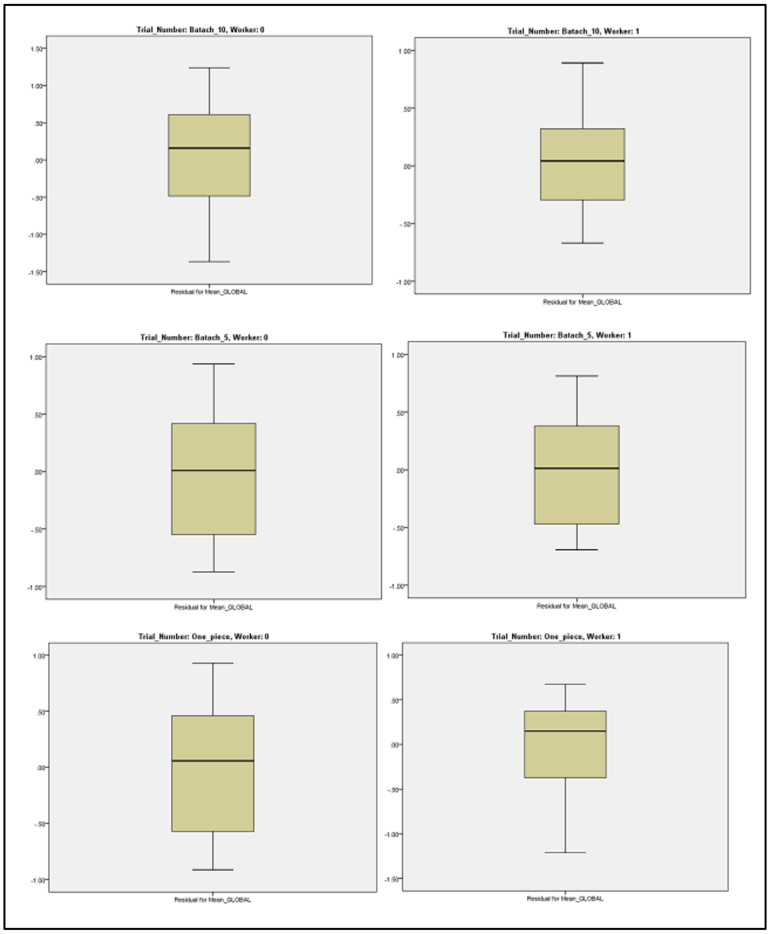


Figure 21 - Boxplots Batch Size *versus* Roles

4.2.1. Exploratory Factor Analysis

The dataset was screened for univariate outliers. No outliers were identified in this stage. The minimum amount of data for factor analysis was satisfied, with a final sample size of 110 responses. The normality of the data collected for each variable was checked. As the sample size is bigger than 30, we used the reference to the Kolmogorov-Smirnov test, instead of the Shapiro-Wilk's test, and it is presented in table 1 in Appendix F.

In this step, it was identified that all variables have a p-value>0.01 indicating they are normally distributed.

4.2.1.1 Prioritization of Variables

It was observed that all items correlated at least 0.3 with at least one other item, suggesting reasonable factorability (Appendix K). After we checked the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, that was 0.707, above the commonly recommended value of 0.6, and Bartlett's test of sphericity was significant (χ^2 (110) = 2470.546, $p < 0.01$). The diagonals of the anti-image correlation matrix were also all over 0.5, except for one item - SR6 - that presented a value of 0.437. The commonality of the analyzed items varies between 0.855 and 0.451 (table 9). All items obtained values higher than 0.3, confirming that each item shared some common variance with other items.

Based on the Kaiser criterion to establish the number of factors, it is recommended that components with eigenvalues under 1.0 should all be dropped. Thus, nine components were considered in the model. The sum of those nine factors was able to explain 69.516% of the variance of the dataset, as shown in the last column of table 10.

Table 9 - Communalities

Item	Initial	Extraction	Item	Initial	Extraction	Item	Initial	Extraction
MD1	1	0.769	**RA2**	1	0.660	**QW1**	1	0.724
MD2	1	0.652	**RA3**	1	0.729	**QW2**	1	0.680
MD	1	0.720	**RA4**	1	0.746	**QW3**	1	0.623
MD4	1	0.716	**RA5**	1	0.633	**QW4**	1	0.727
MD5	1	0.721	**RA6**	1	0.715	**QW5**	1	0.662
VW1	1	0.700	**RC1**	1	0.574	**QW6**	1	0.626
VW2	1	0.731	**RC2**	1	0.505	**QW7**	1	0.674
VW3	1	0.451	**RC3**	1	0.672	**RP1**	1	0.751
VW4	1	0.602	**RC4**	1	0.671	**RP2**	1	0.880
VW5	1	0.780	**RC5**	1	0.705	**RP3**	1	0.885
VW6	1	0.682	**RC6**	1	0.709	**RP4**	1	0.885
VW7	1	0.739	**RC7**	1	0.701	**-**	**-**	**-**
RA1	1	0.622	**RC8**	1	0.697	**-**	**-**	**-**

Table 10 - Eigenvalues and Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	8.476	22.908	22.908	8.476	22.908	22.908	4.527	12.235	12.235
2	4.052	10.952	33.860	4.052	10.952	33.860	4.514	12.200	24.435
3	3.461	9.355	43.216	3.461	9.355	43.216	3.702	10.005	34.440
4	2.691	7.272	50.487	2.691	7.272	50.487	3.258	8.805	43.245
5	1.799	4.863	55.350	1.799	4.863	55.350	2.810	7.595	50.839
6	1.645	4.445	59.795	1.645	4.445	59.795	2.076	5.612	56.451
7	1.269	3.430	63.225	1.269	3.430	63.225	1.948	5.266	61.717
8	1.232	3.330	66.555	1.232	3.330	66.555	1.452	3.924	65.641
9	1.095	2.960	69.516	1.095	2.960	69.516	1.434	3.875	69.516

Given these overall indicators, factor analysis was deemed to be suitable with all items. However, due to the value of the variable RC6 presented in the anti-image correlation matrix, we decided to proceed with the elimination of this variable and rerun the factor analysis.

In this second analysis, all items correlated at least 0.3 as the previous run, indicating that the factorability was still present. The KMO value was 0.762 and Bartlett's test of sphericity was significant (χ^2 (110) = 2332.769, $p < 0.01$). The diagonals of the anti-image correlation matrix were also all over 0.5except for one item – QW1 - that presented a value of 0.438. The communalities were all above .3. In this analysis, nine factors were identified, explaining 69.775% of the variance in the model. Appendix H presents the outputs of the second analysis.

Due to the value of the variable QW1, presented in the anti-image correlation matrix, we decided to proceed with the elimination of this variable and run a third-factor analysis.

In the third analysis, all items correlated at least 0.3. The KMO value was 0.775, and Bartlett's test of sphericity was significant (χ^2 (110) = 2223.877, $p < .01$). The diagonals of the anti-image correlation matrix were also all over 0.5. The communalities were all above 0.3. In this analysis, eight factors were identified, explaining 67.646% of the variance in the model. Later, the values presented in the "Rotated Component Matrix" were verified, which presents the load that factor can explain each of the original variables. Here, it has been seen that the variable SRC4 was impacting several factors in low intensities, which may cause some issues in the model. Thus, we opted to remove this variable and run another factor analysis. Appendix I presents the outputs of the third analysis.

In this fourth and last exploratory analysis of the data screening, the variable RC4 was not considered. All items scored at least 0.3 in the correlation matrix. The KMO value was 0.770, and Bartlett's test of sphericity was significant (χ^2 (110) =

2223.877, p < 0.01). The diagonals of the anti-image correlation matrix were also all over 0.5. The communalities were all above .3. In this analysis, seven factors were identified, explaining 65.363% of the variance in the model. The values presented in the "Rotated Component Matrix" were verified, and no problems were identified. Appendix J presents the outputs of the fourth analysis.

Despite the fact that analysis three had given good results regarding KMO values and the variance explained, it was decided to use the factors presented in analysis 4. It was chosen because the KMO value had a difference of only 0.005, which is not significant, and the model presented that seven factors is more straightforward than the previous analysis.

Table 11 summarizes all the analyses carried during the data screening process.

Thus, the number of variables was reduced to 34 – initially we had 37. The factors label proposed by NIOSH (1976) suited the extracted factors and were maintained. The difference is only in regard to factor 4 – Cognitive Demands - which was not mentioned before indicating a new factor in this study. Based on the characteristics of the variables that compose factor 4, it was decided to name it Cognitive Demands. The mean of each factor per each response was calculated. After, a general mean, called “Stress_Index,” calculated per each response.

The new set of variables per factor are introduced in table 2 in Appendix F.

Table 11 - Main Outputs of the Factor Analyses

Analysis	KMO Value	Sphericity		The problem in the Anti-image Correlation Matrix	Number of Factors	Variance Explained	Item removed
		χ2	p-value				
1	0.707	2470.54	.000	YES	9	69.516%	RA6
2	0.762	2332.76	.000	YES	9	69.775%	QW1
3	0.775	2274.72	.000	NO	8	67.646%	RC4
4	0.770	2223.87	.000	NO	7	65.363%	-

4.2.1.2 Reliability of The Factors

As presented in Table 3 in Appendix F, of the seven proposed factors, all items presented a value equal or above 0.7, thus showing that the factors obtained during this analysis are reliable and the variables within each factor correlate with each other. Within this new format, it is seen that the items proposed by NIOSH still present a high Cronbach’s Alpha number, indicating the instrument represents a reliable method to be used in this study.

4.3. Statistical Analysis for the Batch Size Simulation

The analysis of the Batch size Simulation is divided into three main sections. The first one is to compare the effects of the changes of all participants in the trials. Similarly, the second one compares the different effects among the roles. The third and last one presents the different stress perception among the genders. Table 4 in Appendix F presents the relationship between the Research Questions formulated in topic 1.6. and the hypothesis formulated to approach those questions.

4.3.1. Analysis - Understanding the Impact of Batch Size on the Overall Stress

Initially, we tried to show whether or not there is statistical significance between the different trials performed during the simulation. Thus, a One-way ANOVA was conducted to determine if the perception of stress (Stress_Index score) was different for the different scenarios within the Batch size Simulation. Therefore, the hypothesis raised is based on the behavior of the Stress_Index score, and it is as follows:

$$H1_0: \mu_i = \mu$$

$$H1_1: At\ least\ one\ \mu_i\ differs$$

Where:

μ_i is the average result of Stress_Index for trial of Batch size *i*.
i = {10,5,1}.

Participants responded to a survey at the end of each trial: trial 1 (n = 40), trial 2 (n = 35), trial 3 (n = 35). There were no outliers, as assessed by boxplot; data was normally distributed for each group, as measured by the Shapiro-Wilk test (p > 0.05).

The homogeneity of variance was evaluated by the Levene's test of homogeneity of variances (p = 0.989), indicating variances were homogeneous (table 5 in Appendix F)

The Stress_Index score increased from trial 1 (M = 2.73, SD = 0.55), to trial 2 (M = 2.77, SD = 0.52), to trial 3 (M = 2.92, SD = 0.54), in that order, but the differences between these groups were not statistically significant, F(2, 107) = 1.223, p = 0.298 , indicating to reject the null hypothesis.

Despite the nonoccurrence of statistical relevance, the growth trend is perceived as presented in figure 1 in Appendix F, demonstrating that the participants showed signs of increased levels of stress as they move from a batch-size flow of 10 towards one-piece flow.

Comparing Trail 1 and Trail 3, the decrease in the Batch size resulted in an increase of 7% on the overall Stress_Index score of the participants. This fact could be explained by the fast pace of the work performed by the operators when moving to a one-piece flow environment.

Appendix L presents the detailed output for Hypothesis 1.

4.3.2. *Analysis - Understanding the Impact of Batch Size on Operators And Production Supervisors*

4.3.2.1. Understanding the Impact of Batch Size on All Roles

A One-way ANOVA was conducted to determine if the perception of stress was different for production supervisor and operators. The hypothesis presented is based on the behavior of the Stress_Index score, and it is as follows:

$$H2_0: \mu_k = \mu$$

$$H2_1: At\ least\ one\ \mu_k\ differs$$

Where:

μ_k is the average result of Stress_Index for each role k.

k: {production supervisor, operators}.

Production supervisors (n = 43) and operators (n = 67). There were no outliers, as assessed by boxplot; data was normally distributed for each group, as measured by the Shapiro-Wilk test (p > .05). The homogeneity of variance was evaluated by the Levene's test of homogeneity of variances (p = .018), indicating variances were homogeneous (table 6 in Appendix F).

The Stress_Index score remained almost the same from Production supervisors' personnel (M = 2.80, SD = 0.65), to operator personnel (M = 2.81, SD = 0.47). The difference between these groups was not statistically significant, F(1, 108) = 0.017, p = 0.896 (table 7 in Appendix F), indicating a partial failure in rejecting the null hypothesis.

Results indicates that both Production supervisors and Operators have, in the overall, the same perception of stress. The small difference in the Stress_Index score of only 0.01 could be a reflection of the amount of the sample size of the roles. However, the standard deviation suggests the individual scores suffered variation in the means indicating that within the different positions played the scores behaved differently.

Appendix M presents the detailed output for Hypothesis 2.

4.3.2.2. Understanding the Impact of Batch Size on Operators And Production Supervisors in Each Trial

A two-way ANOVA was conducted to examine the effects of trials and roles on stress perception. The hypothesis presented is based on the behavior of the Stress_Index score, and it is as follows:

1. $H3_0: \mu_i = \mu$

$H3_1: \mu_i \neq \mu$

2. $H3a_0: \mu_k = \mu$

$H3a_1: \mu_k \neq \mu$

3. $H3b_0: There\ is\ no\ interection\ between\ i\ and\ j$

$H3b_1: There\ is\ interection\ between\ i\ and\ j$

Where:

μ_i: is the average result of Stress_Index for trial of Batch size i.

i = {10,5,1}.

μ_k: average result of Stress_Index for each role k.

k: {production supervisor, operators}

Residual analysis was performed to test for the assumptions of the two-way ANOVA. Outliers were assessed by inspection of a boxplot; normality was assessed using Shapiro-Wilk's normality test for each cell of the design and homogeneity of variances was assessed by Levene's test. There were no outliers, residuals were normally distributed ($p > 0.05$), and variances were homogeneous ($p = 0.057$).

The interaction effect between trials and roles on stress perception was not statistically significant, F(2, 104) = 1.108, p = 0.092, partial $\eta^2 = 0.020$. An analysis of the main effect for the role was performed, but no indication of statistical significance was identified. The Unweighted Marginal Means (UMM) of "Roles" scores for trial 1, were 2.77 (SE= 0.137) for production supervisor and 2.71 (SE = 0.112) for operators. For trial 2, the UMM scored 2.854 (SE = 0.141) for production supervisor roles, and 2.711 (SE = 0.122) for operational roles. During trial 3, the UMM scored 2.76 (SE = 0.158) for production supervisor, and 3.007 (SE = 0.114) for operators (table 12). Thus, we can affirm that the results partially fail to reject the null hypothesis.

Thus, despite the nonoccurrence of statistical relevance, those numbers indicate that along the implementation of a LP project, the perception of stress remains the same for operators and slightly increase within the production supervisor staff. However, when Lean Production is fully implemented the stress perception within operators increase meanwhile the production supervisor decrease (figure 22).

As mentioned in topic 3.5.1, during trails 1 and 2, the batch size decreased from 10 to 5 units, impacting the flow of material and information that increased among the workstations. This effect was perceived with higher intensity by the Production supervisors, where the Stress_Index score increased in 2.87% from trial 1 to trial 2.

Analyzing Trial 2 and Trial 3, i.e. Batch size of 5 and one-piece flow respectively, the Stress_Index score decreased 3% for Production supervisors and increased 9.84% for operators. This difference is explained by the intense material and parts movement within the system while working in one-piece flow environment; activity primarily performed by the Material Handler (operator). On the other hand, the system design promotes a better understanding of the systems, facilitating its control, causing the decrease in the Stress_Index score.

Table 12 - Descriptive Statistics per Role and Trial

Role	Trial	Mean	Standard Deviation	Standard Error	N	Shapiro- Wilk test	Levene's Test
Production Supervisor	1	2.772	0.744	0.137	16	0.872	0.057
	2	2.854	0.607	0.141	15	0.360	
	3	2.769	0.598	0.158	12	0.681	
	Sub-total	2.800	0.645	0.145	43	.	
Operator	1	2.715	0.401	0.112	24	0.746	
	2	2.711	0.465	0.122	20	0.278	
	3	3.007	0.516	0.114	23	0.200	
	Sub-total	2.814	0.476	0.116	67	.	
	Total	**2.808**	**0.545**	**0.203**	**110**		

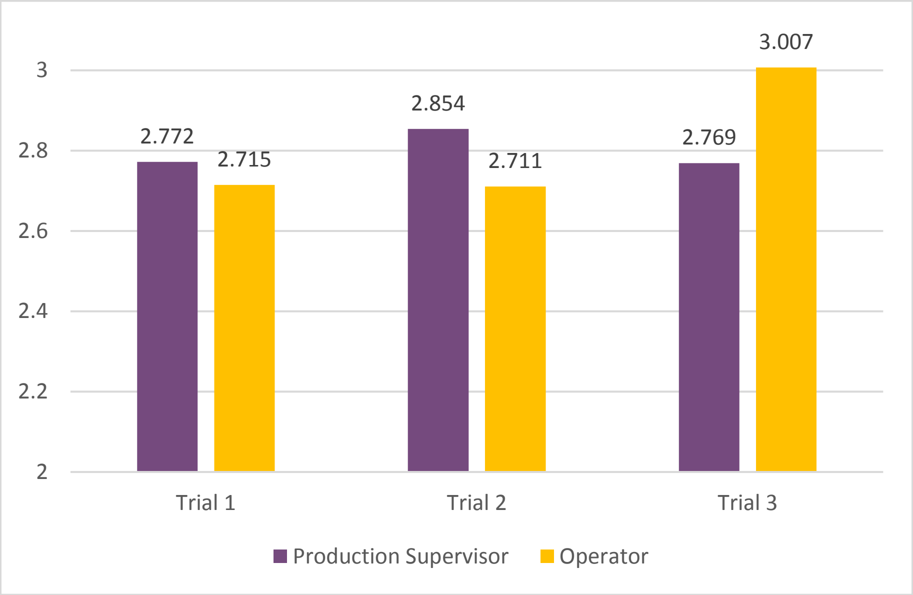


Figure 22 - Perception of Stress per Trial *versus* Role

Thus, the results indicate that the causes of stress might differ not only between trials but also within the different roles. Appendix N presents the detailed output for Hypothesis 3.

4.3.2.3. Understanding the Impact of Batch Size on Operators and Production Supervisors for Each Factor in the Different Trials

A two-way MANOVA was conducted to determine the difference of each factor among the trials and roles. The hypothesis presented is based on the behavior of the Stress_Index score, and it is as follows:

$$H4_0: \mu_{i,j,k} = 0$$

$$H4_1: \mu_{i,j,k} \neq 0$$

Where:
$\mu_{i,j,k}$ is the average result for trial l of Batch size i, factor j, and role k.
i: = {10,5,1}
$j: factor = \{CD, MD, QW, VW, RC, RA, RP\}$
k: role = {production supervisor, operators}

The two independent variables – Trial Number and Stress Factor – and seven dependent variables – VW, RC, RP, CD, RA, MD, and QW. The combined Trial Number and Role scores were used to assess Stress Perception. The data was assumed as being normal.

The interaction effect between Trial Number and Role on the combined dependent variables was not statistically significant, F(14, 196) = 1.106, p = 0.353, Wilks' Λ = .859, partial η^2 = 0.073.

Follow up univariate two-way ANOVA was run, and the main effect of roles considered. There was a statistically significant main effect of Trial Number and Role for the Mental Demands factor, F(2, 104) = 4.323, p < .001, partial η^2 = .017, but not for other interactions, indicating the results reject the null hypothesis. As such, Tukey pairwise comparisons were run for the differences of the mean for each factor and the Role, presented in table 8 in Appendix F.

Despite the nonoccurrence of statistical significance, it was identified that the values of the means of each trail in the different roles presented variance, pointing that, besides the non-significance of the p-values, the perception of stress varied among the peers along the trials. Figure 23 presents the means for each factor in the different trials per role.

In the Variance of Workload factor was observed an increase of 17% for the Operators Stress_Index score from Trial 1 to Trial 3. On the other hand, the Stress_Index score decreased almost 6% for Production supervisors, indicating that Operators felt an increase in the number of tasks they should perform in one piece-flow design.

For the Role Conflict factor, the values presented small variance within the trials, remaining almost the same Production supervisors. However, in Trial 3 the Operators had an increase of 13% in their Stress_Index score, indicating that different demands were placed on them during one-piece flow design increasing their pressure levels.

However, in the Responsibility of People, we see an increasing trend in the means for both roles within the trials, which can indicate both that people feel more responsible for the activity they are performing while they are moving towards a LP operation, but also that this level of responsibility worries them, causing stress.

An interesting finding is seen in both cognitive and mental demands where the level of stress for operators increase while moving from a Batch size of ten to a one-piece flow.

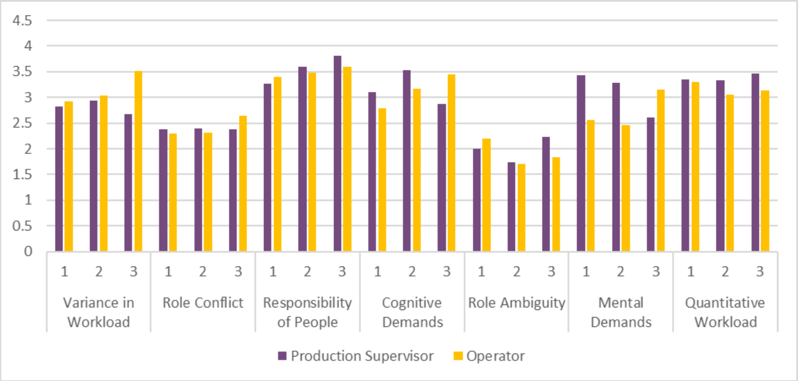


Figure 23 – Means of Each Factor per Trial and Role

The Stress_Index in the Cognitive Demands specifically increased 12% and 20% in trials 2 and 3 respectively for operators, while for Production supervisors increased 12% in Trial 2, and decreased 22% during Trial 3, indicating that the attention to details had a higher impact for the operators. This effect also shows that the systems design is, indeed, easier to supervise and control with less impact on the Production supervisors, and despite the efforts of production stabilization, more cognitive demands are required from the operators. This fact is well observed in Trial 3 where the Cognitive Demand factor scored 2.88 (SE = 0.282) for production supervisor versus 3.45 (SE = 0.204) for operators, a difference of 16%.

For the Mental Demands factor, all three trials presented significant marginal means but different for each role. While in Trial1, a Stress_Index score of 3.44 (SE = 0.280) for production supervisor and 2.55 (SE = 0.229) for operators were verified; in trial 2 a score of 3.29 (SE = 0.289), and 2.47 (SE = 0.251) for production supervisor and operators respectively, representing a decrease of 4% for production supervisors and 3% for operators. However, during the third trial the operators scored 3.15 (SE = 0.234) versus 2.60 (SE = 0.323) for production supervisor, indicating an increase of almost 20% for operators and a decrease of 32% for production supervisors, showing that the tasks performed by the operators were more complex during one-piece flow design than on trials 1 and 2.

For Quantitative Workload, especially on trial 3, we can see a difference between the roles. Production supervisor works scored 3.43 (SE = 0.263) versus 3.13 (SE = 0.190) for operators, a difference of 10% indicating that the perception of having more work to do that can be realistically completed in a given time higher for the production supervisor staff.

Thus, we can assume that there is significant statistics within factors among the different roles in each trial. Appendix O presents the detailed output for Hypothesis 4.

4.3.3. Analysis - Understanding the Impact of Batch Size on Gender

4.3.3.1. Understanding the Impact of Batch Size on Both Genders

An independent-samples t-test was run to determine if there were differences in stress perception between males and females. The hypothesis presented is based on the behavior of the Stress_Index score, and it is as follows:

$$H5_0: \mu_{male} - \mu_{famale} \ = 0$$

$$H5_1: \mu_{male} - \mu_{famale} \ \neq 0$$

Where:

μ_{male} : $\sum \frac{Stress\_Index_{male}}{Number\ of\ males}$, and

μ_{female} : $\sum \frac{Stress\_Index_{female}}{Number\ of\ females}$.

There were 81 male and 29 female participants. No outliers were found in the data, as assessed by inspection of a boxplot. Table 13 presents descriptive statistics to summarize and describe the features of the data.

Table 13 - Descriptive Statistics per Gender

Gender	Mean	Standard Deviation	N
Male	2.8859	0.48736	81
Female	2.5910	0.64278	29
Total	**2.7384**	**0.56507**	**110**

The mean stress scored different values for men (M = 2.88.73, SD = 0.48), and women (M= 2.59, SD = 0.64). A statistically significant mean difference of 0.29, 95% CI [0.06, 0.52], t(108) = 2.56, p = 0.012, d = 0.52. The presented values indicate that the perception of stress is higher for men when compared to women, rejecting the null hypothesis.

However, the results go against of the ones proposed by APA (2011) and present in topic 1.2. This phenomenon could be explained by the concentration of male gender in the field of science and technology as beforementioned by Freitas and Luz (2017) on topic 4.2. that leaded to heterogeneity within sample contributing for the Stress_Index scores discrepancy.

Appendix P presents a detailed output for Hypothesis 5.

4.3.3.2. Understanding the Impact of Batch Size of Each Factor on Both Genders

An independent-sample t-test was run to determine if there were differences between the gender among the studied factors. The hypothesis presented is based on the behavior of the Stress_Index score, and it is as follows:

$$H6_0: \mu_{j,male} - \mu_{j,famale} = 0$$

$$H6_1: \mu_{j,male} - \mu_{j,famale} \neq 0$$

Where:

j: $factor = \{CD, MD, QW, VW, RC, RA, RP\}$

$\mu_{male} = \sum \frac{Stess\_Index_{male}}{Number\ of\ males}$, and

$\mu_{female} = \sum \frac{Stress\_Index_{female}}{Number\ of\ females}$.

There were no outliers in the data, as assessed by inspection of a boxplot. The scores for each level of gender were assumed to be normally distributed. The homogeneity of variances was assessed by Levene's test for equality of variances table 9 in Appendix F).

The Role Conflict factor was more engaged to male participants (M = 2.55, SD = 1.04) than female participants (M = 1.96, SD = 0.90), a statistically significant difference, M = 0.59, 95% CI [0.18, 0.99], t(108) = 2.70, p = 0.005, showing that males trend to feel that they are responding to different demands simultaneously.

Table 10 in Appendix F summarizes the main results found in this step. Regarding Responsibility of People factor, the male gender respondents (M = 3.65, SD = 1.14) have a higher degree of agreement than the female participants (M = 3.11, SD = 1.53), a statistically significant difference, M = 0.54, 95% CI [-0.01, 1.08], t(108) = 1.94, p = 0.055, indicating that in males participants the sense of belonging were felt with higher intensity.

The Cognitive Demands factor scored higher for male individuals (M = 3.28, SD = 0.10) than female participants (M = 2.77, SD = 0.21), with a statistically significant difference, M = 0.50, 95% CI [0.09, 0.90], t(108) = 2.408, p = 0.018, showing that the attention to details as well as the mental set up were more present to males participants. The Quantitative Workload factor presented a higher score for females (M = 3.62, SD = 0.94) than males (M = 3.11, SD = 0.85), presenting a statistically significant difference, M = 0.50, 95% CI [-0.90, -0.10], t(108) = -2.64, p = 0.015, indicating that females participants were overwhelmed by the amount of tasks that should be performed in the system.

For the VW, RA, and MD evidence of statistical significance was not found in the data, which indicates that those factors do not generally impact the perception of stress on either group. However, we must highlight that despite the non-significance, the obtained means differ in each group.

The VW seems to have more influence in the males (M = 3.08, SD =0.0980) than female participants (M = 2.85, SD= 1.170). RA scored slightly higher for men (M = 1.96, SD=0.90) than for women (M = 1.89, SD = 0.17). MD followed the same pattern, and it seems to be a higher stressor factor for males (M = 2.91, SD = 1.16) than for females (M = 2.84, SD = 1.17). Thus, it could be concluded that the results fail to reject the null hypothesis.

Appendix Q presents the detailed output for Hypothesis 6.

4.4. Summary of Results

The proposed analysis carried out in this study points out that the NIOSH General Job-Stress Questionnaire is a reliable instrument to assess workforce stress in a controlled environment within a Lean Production context. The Pilot Study performed shows that only the Physical Environment factor does not contribute in the perception of Stress, a condition that could be explained by the controlled environment nature of this study, without any changes on temperature, light or noise. All the other factors presented Cronbach’s Alpha values higher than 0.7.

After scoring the data, the results were analyzed based on Batch size and one-piece flow. An exploratory analysis of the data was performed, using Factor Analysis. Four interactions were performed, and the variables that did not meet the Factor Analysis criteria were removed. After the variables were removed, they were grouped as recommended by the Component Matrix SPSS output and the reliability levels were verified using Cronbach’s Alfa reliability levels.

The Factor Analysis performed in this study allowed the researcher to identify how the questions proposed by NIOSH (1976) loads into each factor. Results indicate that, in the scope of this study, the items are grouped differently from the proposal presented by NIOSH (1976). Results also identified a factor not mentioned by NIOSH (1976) before, called Cognitive Demands (CD), which plays an important role in the calculation of the Stress_Index. This index is used to indicate how the Batch size Simulation participants perceive stress.

The study presented an increase in the Stress_Index scores when decreasing the Batch size, indicating that the reduction of the batch leads to a positive trend on the general perception of stress felt by the employees, with an increase of almost 10% in the Stress_Index score.

Regarding the roles within the Batch size Simulation, the results indicated that the operational staff tend to present higher Stress_Index scores whereas production supervisor staff have their Stress_Index score reduced. It was concluded that the Stress_Index for RP increased in all trials and within the roles. VW increased only for the operators, and QW only for production supervisor roles. On the other hand, CD and MD were reduced.

Table 14 presents a summary of the results found during the hypothesis test.

Furthermore, confirming the studies performed by APA (2011), it was verified that males and females perceive stress in different ways. Considering the analyzed variable (Batch size), males tend to have higher Stress_Index scores when compared to females 2.8859 and 2.5910 respectively. From the seven factors, only Quantitative Workload (QW) presents a higher score for females. Role Conflict (RC), Responsibility of People (RP), Cognitive Demands (CD), Variance in Workload (VW), and Mental Demands (MD) present higher scores for males.

Table 14 - Summary of Results

Research Question	Description	Matemathical Formulation	Statistical Method Used
Does Batch Size have an impact on the overall stress?	Understanding the Impact of Batch Size on the Overall Stress	$H1_0: \mu_i = \mu$ $H1_1: At\ least\ one\ \mu_i\ differs$	Reject $H1_0$
Does Batch Size impact stress among operational and production supervisor staff differently?	Understanding the Impact of Batch Size on all Roles	$H2_0: \mu_k = \mu$ $H2_1: At\ least\ one\ \mu_k\ differs$	Partial Failure in Rejecting $H2_0$
	Understanding the Impact of Batch Size on Operators and Production Supervisors in Each Trial	1. $H3_0: \mu_i = \mu$ $H3_1: \mu_i \neq \mu$ 2. $H3a_0: \mu_k = \mu$ $H3a_1: \mu_k \neq \mu$ 3. $H3b_0: There\ is\ no\ interection\ between\ i\ and\ j$ $H3b_1: There\ is\ interection\ between\ i\ and\ j$	Fail to Reject the Null Hypothesis
	Understanding the Impact of Batch Size on Operators and Production Supervisors for Each Factor in the Different Trials	$H4_0: \mu_{i,j,k} = 0$ $H4_1: \mu_{i,j,k} \neq 0$	Reject $H4_0$
Does Batch Size impact males and females differently?	Understanding the Impact of Batch Size on Both Gender	$H5_0: \mu_{male} - \mu_{famale} = 0$ $H5_1: \mu_{male} - \mu_{famale} \neq 0$	Reject $H5_0$
	Understanding the Impact of Batch Size of Each Factor on Both Genders	$H6_0: \mu_{j,male} - \mu_{j,famale} = 0$ $H6_1: \mu_{j,male} - \mu_{j,famale} \neq 0$	Fail to Reject $H6_0$

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

The incessant search for continuous improvement has led organizations around the world to implement Lean Production projects to reduce cost. In this context, the human factor has been neglected leading to job dissatisfaction and creating a stressful environment among their peers and an organization that leads to stress is not sustainable.

After a refined Literature Review, it was concluded that only seven papers had studied the impact that Lean Production has on workload and stress. Also, studies as Conti et al. (2006), and Ferreira and Saurin (2009) introduced the concept that LP practices impact the perception of stress, in order to do this, the authors use different methodologies (i) Job-Demands Control, and (ii) survey respectively. In this context, this study aims to discuss this topic by utilizing the NIOSH General Job-Stress Questionnaire to assess worker's stress perception when variating the Batch size.

In the scope of this study, the proposed method uses a Pilot Study to check the reliability of the instrument in the abovementioned scenario and indicates that the items related to the Physical Environment cannot be used. After this step, a Batch size Simulation was performed with the application of the survey consisted of a sample size of 110 responses. The controlled environment present in the Batch size Simulation allowed the researcher to analyze the factors presented within the organizational context that lead to stress when implementing the LP project without the noise that external elements can cause, such as disease problems or personal problems faced by the participants. Considering those elements, it was perceived that the participants presented a significant increase in their perception of stress when migrating from a Batch size of ten units to the one-piece flow environment. This stress indicator presented in different ways among the participants. Results showed that men and women have different perceptions of results among the analyzed factors as well as the roles.

It is important to highlight the problem faced after the implementation of one-piece flow, and presented in this study, such as the unsustainability of LP, and people resistance, could be explained by the increase by these results. Furthermore, the increase in the levels of stress, when implementing LP, shows a conflict presented in the TPS model, and, consequently, in LP when it presents the impact of a change as a positive turn on people’s quality of life.

It is important to managers and directors, to investigate the effects that Quantitative Workload, Cognitive Demands, and Role Conflict have when designing a LP project, and how those factors can impact, not only their business, but the life of their employees, mitigating possible problems and sustaining the improvement made. We believe this study shows the importance of how understanding people and their different attributes are relevant when implanting change in an organization.

As future research, we recommend the application of the same methodology in a bigger sample size. Also, it is essential to conduct a similar experiment in a non-controlled environment and check how these factors behave in a non-controlled context. Furthermore, researches can be performed in the area of biological effects of stress when implementing a Lean Production solution.

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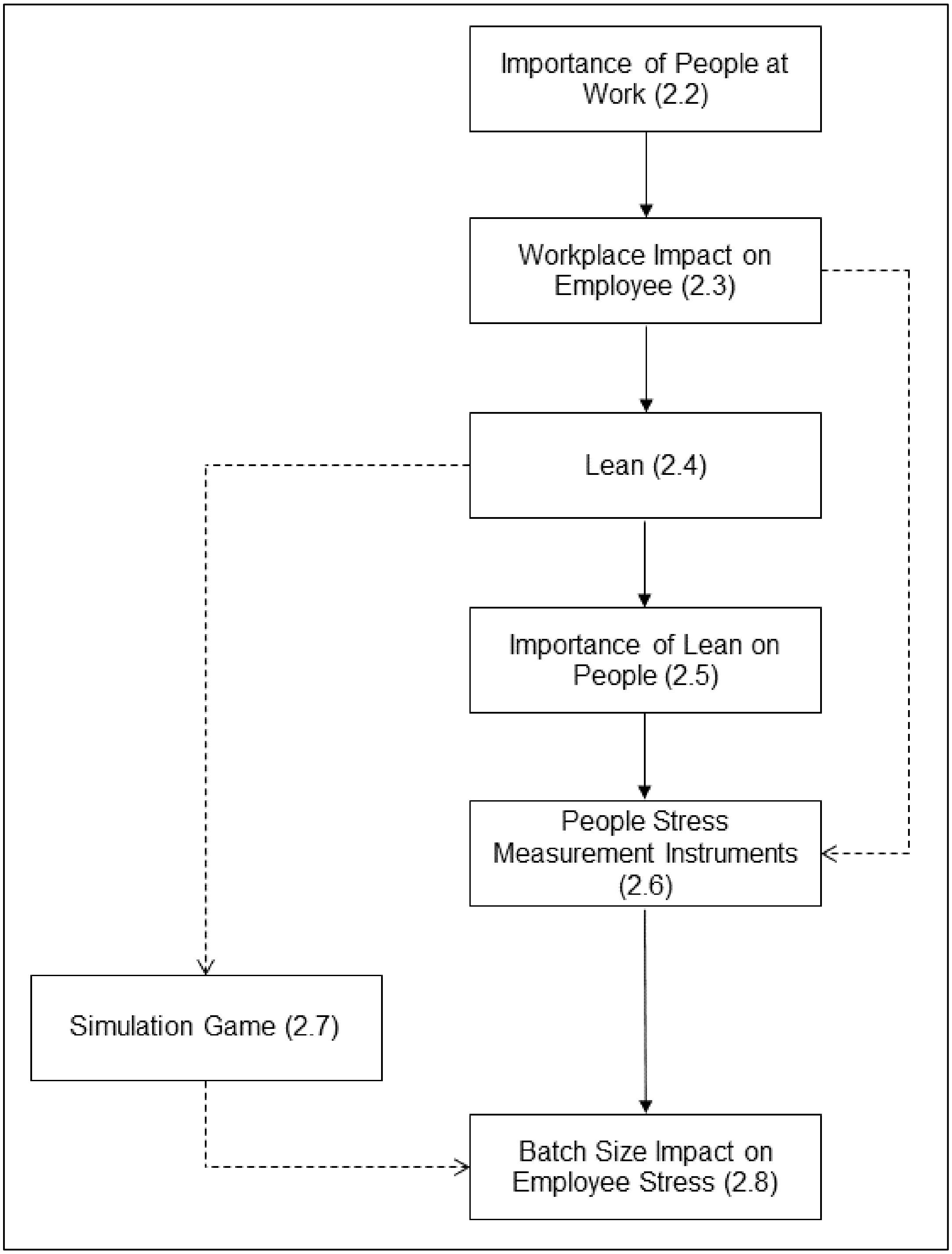
APPENDICES

Appendix A: Thematic Pillars



Appendix B: NIOSH Cross-Sector Programs

Cross-Sector Programs	Goal
Cancer, reproductive, and cardiovascular disease	Provide leadership in the prevention of several different work-related diseases and conditions.
Hearing loss prevention	Provide national and world leadership to reduce the prevalence of occupational hearing loss.
Immune, infectious, and dermal disease prevention	Reduce the incidence of immune, infectious and dermal diseases associated with workplace exposures
Musculoskeletal health	Reduce the burden of work-related Musculoskeletal Disorders (MSD) through a focused program of research and prevention that protects workers from MSDs, helps management mitigate related risks and liabilities, and helps practitioners improve the efficacy of workplace interventions
Respiratory health	Provide national and international leadership for preventing work-related respiratory diseases and optimizing workers’ respiratory health by generating new knowledge and transferring that knowledge into practice to benefit workers.
Traumatic injury prevention	Reduce and prevent work-related injury and death, across all industries, due to acute trauma or violence
Healthy work design and well-being	Protect and advance worker safety, health, and well-being by improving the design of work, management practices, and the physical and psychosocial work environment

Source: NIOSH (2018b).

Appendix C: NIOSH Generic Job Stress Questionnaire

Please, indicate the degree to which you agree or disagree with the following statements about your job. Please select your choice.

	Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree
Q1 My job requires a great deal of concentration				
Q2 My job requires me to remember many different things				
Q3 I must keep my mind on my work all times				
Q4 I can take it easy and still get my work done				
Q5 I can let my mind wander and still do the work				

Now we would like you to indicate how often certain things happen at your job. Please, select your choice.

	Rarely	Occasionally	Sometimes	Fairly Often	Very Often
Q6 How often does your job require you to work very fast					
Q7 How often does your job require you to work very hard?					
Q8 How often your job leave you with little time to get things done?					
Q9 How often is there a great deal do be done?					
Q10 How often is there a marked increase in the work load?					
Q11 How often is there a marked increased in the amount of concentration required on your job?					
Q12 How often is there a marked increase in how fast you have to think?					
Q13 How often does your job let you use the skills and knowledge you learned in school?					
Q14 How often are you given a change to do the things you do the best?					
Q15 How often can you use the skills from your previous experience and training?					

How accurate are each of the following statements in describing your job?

	Very Inaccurate	Mostly Inaccurate	Slightly Inaccurate	Uncertain	Slightly Accurate	Mostly Accurate	Very Accurate
Q16 I feel certain about how much authority I have							
Q17 There are clear, planned goals and objectives for my job							
Q18 I have to do things that should be done differently							
Q19 I know that I have dived my time properly							
Q20 I receive an assignment without the help I need to complete it							
Q21 I know what my responsibilities are							
Q22 I have to bend or break a rule or policy in order to carry out an assignment							

Q23 I work with two or more groups who operate quite differently
Q24 I know exactly what is expected of me
Q25 I receive incompatible requests from tow or more people
Q26 I do things that are apt to be accepted by one person and not accepted by others
Q27 I receive an assignment without the adequate resources and materials to execute it
Q28 Explanation is clear about what has to be done on my job

Q29 I work on unnecessary things	

The next few items are concerned with various aspects of your work activities. Please indicate how much of each aspect you have on your job by selecting the appropriate scale.

	Hardly any	A little	Some	A lot	A great Deal
Q30 How much slowdown in the work load do you experience?					
Q31 How much time do you have to think and contemplate?					
Q32 How much work load do you have?					
Q33 What quantity of work do others expect you to do?					
Q34 How much time do you have to do all your work?					
Q35 How many projects, assignments, or tasks do you have?					
Q36 How many lulls between heavy work load periods do you have?					

Q37 How much responsibility do you have for the future of others?

Q38 First Name

Q 39 Last Name

Q40 Nationality

○ American

○ Brazilian

○ Chinese

○ Mexican

Q41 Trial Number

○ 1

○ 2

○ 3

Q42 Gender

○ Male

○ Female

Q43 Only for Line Workers - What is your station? (If you are administrative, select "Administrative", and choose your role in the next question)

○ Station 1 - Base

○ Station 1a - Base 2

○ Station 2 - Left arm (short)

○ Station 3 - Right arm (long)

○ Station 4 - Assembly Left

○ Station 5 - Assembly Right

○ Station 6 - Inspection

○ Station 7 - Shipping

○ Administrative

Q44 Only for Administrative positions - What is your role? (If you are line worker, select "Line worker")

○ Line worker

○ Owner

○ Plant Manager

○ Supervisor

○ Material Handler 1

○ Material Handler 2

○ Time Keeper

○ Customer

○ Observer

○ Accountant

○ Baseline Supervisor

○ Assembly Supervisor

Appendix D: Key Factors to Measure Stress

Factor	Description	Items	Scale	Label
Mental Demands	The degree of mental effort and work needed to complete a work task. The greater the mental effort, the more complex the task.	5	1 – 4	MD
Quantitative Workload	Having more work to accomplish than can be realistically completed in the given time. There is a difference between the actual amount of work and an Individuals perception of the workload.	7	1 – 5	QW
Variance in Workload	The difference in current work value and the baseline work value for any given task.	7	1 – 5	VW
Role Conflict	Role conflict occurs when incompatible demands are placed upon a person such that compliance with both would be difficult. Persons experience role conflict when they find themselves pulled in many different directions as they try to respond to the many statuses they hold.	8	1 – 7	RC
Role Ambiguity	The extent to which one's work responsibilities and degree of authority are unclear is one of the most widely studied variables in the field of occupational stress. Because it represents a subjective judgment of one's work situation, it is typically assessed using employees' self-reports.	6	1 – 7	RA
Physical Environment Evaluation	The physical environment includes components of the tangible workplace environment that comprise employee's working conditions such as ergonomic workstation designs, noise, violence and aggression-free work environment, available workplace policies and procedures.	10	1 – 2	PE
Responsibility for People	The state of being accountable for something or someone that is under one's control. An instance of being responsible; a burden of obligation. The person or thing for which another is responsible.	4	1 – 5	RP

Source: NIOSH (1976).

Appendix E: Labeling of Survey Items

Factor	Label	Question No.	Factor	Label	Question No.
Cognitive Demands	MD	Q1	Role Conflict	RC1	Q20
Cognitive Demands	MD1	Q2	Role Conflict	RC2	Q21
Cognitive Demands	MD2	Q3	Role Conflict	RC3	Q22
Metal Demands	MD4	Q4	Role Conflict	RC4	Q23
Metal Demands	MD5	Q5	Role Conflict	RC5	Q24
Quantitave Workload	QW1	Q6	Role Conflict	RC6	Q25
Quantitave Workload	QW2	Q7	Role Conflict	RC7	Q26
Variance in Workload	QW3	Q8	Role Conflict	RC8	Q27
Variance in Workload	QW4	Q9	Role Ambiguity	RA1	Q28
Quantitave Workload	QW5	Q10	Role Ambiguity	RA2	Q29
Role Conflict	QW6	Q11	Role Ambiguity	RA3	Q30
Quantitave Workload	QW7	Q12	Role Ambiguity	RA4	Q31
Variance in Workload	VW1	Q13	Role Ambiguity	RA5	Q32
Variance in Workload	VW2	Q14	Role Ambiguity	RA6	Q33
Variance in Workload	VW3	Q15	Responsibility of People	RP1	Q34
Variance in Workload	VW4	Q16	Responsibility of People	RP2	Q35
Variance in Workload	VW5	Q17	Responsibility of People	RP3	Q36
Cognitive Demands	VW6	Q18	Responsibility of People	RP4	Q37
Cognitive Demands	VW7	Q19			

Appendix F: Results of Chapter 4

Table 1 - Normality Test

Item	Kolmogorov-Smirnov[a]			Item	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.		Statistic	df	Sig.
MD1	0.235	110	0	**RC2**	0.177	110	0
MD2	0.185	110	0	**RC3**	0.270	110	0
MD	0.214	110	0	**RC4**	0.134	110	0
MD4	0.207	110	0	**RC5**	0.200	110	0
MD5	0.194	110	0	**RC6**	0.186	110	0
VW1	0.185	110	0	**RC7**	0.188	110	0
VW2	0.164	110	0	**RC8**	0.233	110	0
VW3	0.161	110	0	**QW1**	0.202	110	0
VW4	0.172	110	0	**QW2**	0.211	110	0
VW5	0.188	110	0	**QW3**	0.171	110	0
VW6	0.153	110	0	**QW4**	0.190	110	0
VW7	0.157	110	0	**QW5**	0.191	110	0
RA1	0.175	110	0	**QW6**	0.208	110	0
RA2	0.233	110	0	**QW7**	0.178	110	0
RA3	0.204	110	0	**RP1**	0.236	110	0
RA4	0.307	110	0	**RP2**	0.199	110	0
RA5	0.266	110	0	**RP3**	0.192	110	0
RA6	0.278	110	0	**RP4**	0.210	110	0
RC1	0.198	110	0	-			

Table 2 - New Factors Based on the Factorial Analysis

	Factor	Label	Items	Number of items
1	Variance in Workload	VW	VW5, VW1, VW4, VW2, VW3, QW3, QW4	7
2	Role Conflict	RC	RC7, RC6, RC5, RC3, RC2, RC1, QW6, RC8	8
3	Responsibility of People	RP	RP1, RP2, RP3, RP4	4
4	Cognitive Demands	CD	MD2, MD1, VW7, VW6, MD	5
5	Role Ambiguity	RA	RA2, RA4, RA3, RA1, RA5	5
6	Mental Demands	MD	MD4, MD5	2
7	Quantitative Workload	QW	QW5, QW7, QW2	3
			Total of items	**34**

Table 3 - Reliability of the Factors of the Lego Simulation

Factor	N of Items	Cronbach's Alpha Std.
VW	7	0.852
RC	8	0.855
RP	4	0.933
CD	5	0.846
RA	5	0.752
MD	2	0.740
QW	3	0.700

Table 4 - Hypothesis Description

Research Question	Subcomponent	Description	Matemathical Formulation	Statistical Method Used
Does Batch Size have an impact on the overall stress?		Understanding the Impact of Batch Size on the Overall Stress	$H1_0: \mu_i = \mu$ $H1_1: At\ least\ one\ \mu_i\ differs$	ANOVA
Does Batch Size impact stress among operational and production supervisor staff differently?	4.3.2.1.	Understanding the Impact of Batch Size on all Roles	$H2_0: \mu_k = \mu$ $H2_1: At\ least\ one\ \mu_k\ differs$	ANOVA
	4.3.2.2.	Understanding the Impact of Batch Size on Operators and Production Supervisors in Each Trial	1. $H3_0: \mu_i = \mu$ $H3_1: \mu_i \neq \mu$ 2. $H3a_0: \mu_k = \mu$ $H3a_1: \mu_k \neq \mu$ 3. $H3b_0: There\ is\ no\ interection\ between\ i\ and\ j$ $H3b_1: There\ is\ interection\ between\ i\ and\ j$	ANOVA
	4.3.2.3.	Understanding the Impact of Batch Size on Operators and Production Supervisors for Each Factor in the Different Trials	$H4_0: \mu_{i,j,k} = 0$ $H4_1: \mu_{i,j,k} \neq 0$	MANOVA
Does Batch Size impact males and females differently?	4.3.3.1	Understanding the Impact of Batch Size on Both Gender	$H5_0: \mu_{male} - \mu_{famale} = 0$ $H5_1: \mu_{male} - \mu_{famale} \neq 0$	T-test
	4.3.3.2	Understanding the Impact of Batch Size of Each Factor on Both Genders	$H6_0: \mu_{j,male} - \mu_{j,famale} = 0$ $H6_1: \mu_{j,male} - \mu_{j,famale} \neq 0$	T-test

Table 5 - Descriptive Statistics per Trials

Trial	Mean	Standard Deviation	N	Shapiro-Wilk test	Levene's Test
1	2.7376	0.55539	40	0.270	0.989
2	2.7719	0.52710	35		
3	2.9252	0.54844	35		
		Total	**110**		

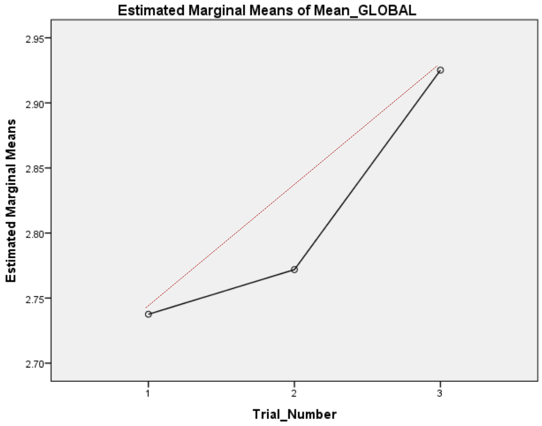


Figure 1 - Means per Trial

Table 6 - Descriptive Statistics per Role

Role	Mean	Standard Deviation	N	Shapiro-Wilk test	Levene’s Test
Production supervisors	2.80	0.644	43	0.484	0.018
Operator	2.81	0.476	67	0.190	
		Total	**110**		

Table 7 - Significance Values for Factors versus Role

Variable	Equal Variance Assumed	Levene's Test		t-test for Equality of Means			95% Confidence Interval	
		F	Sig.	t	df	Sig. (2-tailed)	Lower	Upper
Stress_Index	YES	5.76	0.01	-0.13	108	0.9	-0.22	0.19
	NO	.	.	-0.12	71.01	0.9	-0.24	0.21

Table 8 - Pairwise Comparisons Among Factors versus Trials and Roles

Factor	Trial	Role	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Variance in Workload	1	Production Supervisor	2.821	0.237	2.351	3.292
		Operator	2.917	0.194	2.533	3.301
	2	Production Supervisor	2.943	0.245	2.457	3.429
		Operator	3.043	0.212	2.622	3.463
	3	Production Supervisor	2.667	0.274	2.124	3.210
		Operator	3.516	0.198	3.123	3.908
Role Conflict	1	Production Supervisor	2.371	0.264	1.847	2.894
		Operator	2.295	0.216	1.867	2.722
	2	Production Supervisor	2.391	0.273	1.850	2.932
		Operator	2.309	0.236	1.840	2.777
	3	Production Supervisor	2.384	0.305	1.780	2.989
		Operator	2.638	0.220	2.201	3.075
Responsibility of People	1	Production Supervisor	3.266	0.330	2.611	3.921
		Operator	3.396	0.270	2.861	3.931
	2	Production Supervisor	3.600	0.341	2.923	4.277
		Operator	3.488	0.295	2.902	4.073
	3	Production Supervisor	3.813	0.381	3.056	4.569
		Operator	3.598	0.276	3.051	4.144
Cognitive Demands	1	Production Supervisor	3.100	0.244	2.616	3.584
		Operator	2.788	0.199	2.392	3.183
	2	Production Supervisor	3.530	0.252	3.030	4.030
		Operator	3.165	0.218	2.732	3.598
	3	Production Supervisor	2.879	0.282	2.320	3.438
		Operator	3.454	0.204	3.051	3.858
Role Ambiguity	1	Production Supervisor	2.008	0.234	1.544	2.472
		Operator	2.196	0.191	1.817	2.574
	2	Production Supervisor	1.732	0.242	1.253	2.211
		Operator	1.705	0.209	1.291	2.120
	3	Production Supervisor	2.226	0.270	1.690	2.761
		Operator	1.831	0.195	1.444	2.218
Mental Demands	1	Production Supervisor	3.438	0.280	2.882	3.993
		Operator	2.552	0.229	2.098	3.006
	2	Production Supervisor	3.292	0.289	2.718	3.865
		Operator	2.469	0.251	1.972	2.966
	3	Production Supervisor	2.604	0.323	1.963	3.246
		Operator	3.152	0.234	2.689	3.616
Quantitative Workload	1	Production Supervisor	3.354	0.228	2.903	3.805
		Operator	3.306	0.186	2.937	3.674
	2	Production Supervisor	3.333	0.235	2.867	3.799
		Operator	3.050	0.204	2.646	3.454
	3	Production Supervisor	3.472	0.263	2.951	3.993
		Operator	3.130	0.190	2.754	3.507

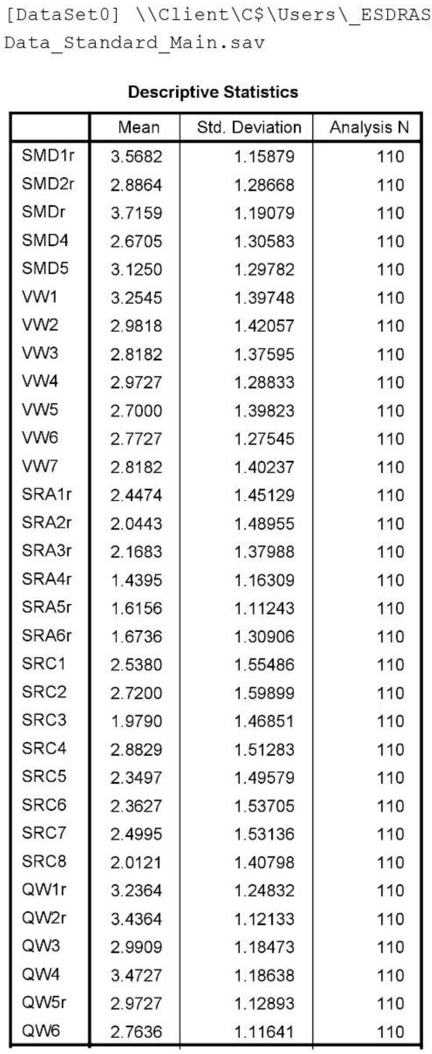
Table 9 - Significance Values for Factors versus Gender

Factor	Equal Variance Assumed	Levene's Test		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	95% Confidence Interval	
							Lower	Upper
VW	YES	3.560	.062	1.106	108	.271	-.183	.645
	NO	.	.	.970	39.995	.338	-.250	.713
RC	YES	1.457	.230	2.698	108	.008	.157	1.024
	NO	.	.	2.907	57.407	.005	.184	.997
RP	YES	7.168	.009	1.941	108	.055	-.012	1.090
	NO	.	.	1.715	40.475	.094	-.096	1.174
CD	YES	4.126	.045	2.408	108	.018	.090	.923
	NO	.	.	2.123	40.310	.040	.024	.989
RA	YES	.590	.444	.352	108	.725	-.332	.475
	NO	.	.	.365	52.759	.717	-.323	.466
MD	YES	.144	.705	.285	108	.776	-.428	.572
	NO	.	.	.283	48.855	.778	-.438	.582
QW	YES	.319	.574	-2.644	108	.009	-.877	-.126
	NO	.	.	-2.529	45.683	.015	-.900	-.102

Table 10 - Summary of Outputs per Gender

Factor	P-value	Mean		Standard Deviation		Statistical Significance
		Male	Female	Male	Female	
VW	0.338	3.08	2.85	0.883	1.170	NO
RC	0.005	2.55	1.96	1.050	0.900	YES
RP	0.055	3.65	3.11	1.182	1.537	YES
CD	0.018	3.28	2.77	0.900	1.117	YES
RA	0.717	1.96	1.89	0.960	0.900	NO
MD	0.778	2.91	2.84	1.160	1.176	NO
QW	0.015	3.11	3.62	0.853	0.937	YES

Appendix G: Factor Analysis SPSS Output 1



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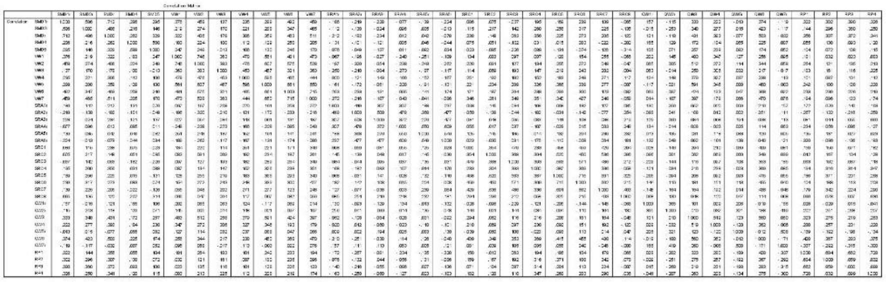
Descriptive Statistics

	Mean	Std. Deviation	Analysis N
SMD1r	3.5682	1.15879	110
SMD2r	2.8864	1.28668	110
SMDr	3.7159	1.19079	110
SMD4	2.6705	1.30583	110
SMD5	3.1250	1.29782	110
VW1	3.2545	1.39748	110
VW2	2.9818	1.42057	110
VW3	2.8182	1.37595	110
VW4	2.9727	1.28833	110
VW5	2.7000	1.39823	110
VW6	2.7727	1.27545	110
VW7	2.8182	1.40237	110
SRA1r	2.4474	1.45129	110
SRA2r	2.0443	1.48955	110
SRA3r	2.1683	1.37988	110
SRA4r	1.4395	1.16309	110
SRA5r	1.6156	1.11243	110
SRA6r	1.6736	1.30906	110
SRC1	2.5380	1.55486	110
SRC2	2.7200	1.59899	110
SRC3	1.9790	1.46851	110
SRC4	2.8829	1.51283	110
SRC5	2.3497	1.49579	110
SRC6	2.3627	1.53705	110
SRC7	2.4995	1.53136	110
SRC8	2.0121	1.40798	110
QW1r	3.2364	1.24832	110
QW2r	3.4364	1.12133	110
QW3	2.9909	1.18473	110
QW4	3.4727	1.18638	110
QW5r	2.9727	1.12893	110
QW6	2.7636	1.11641	110

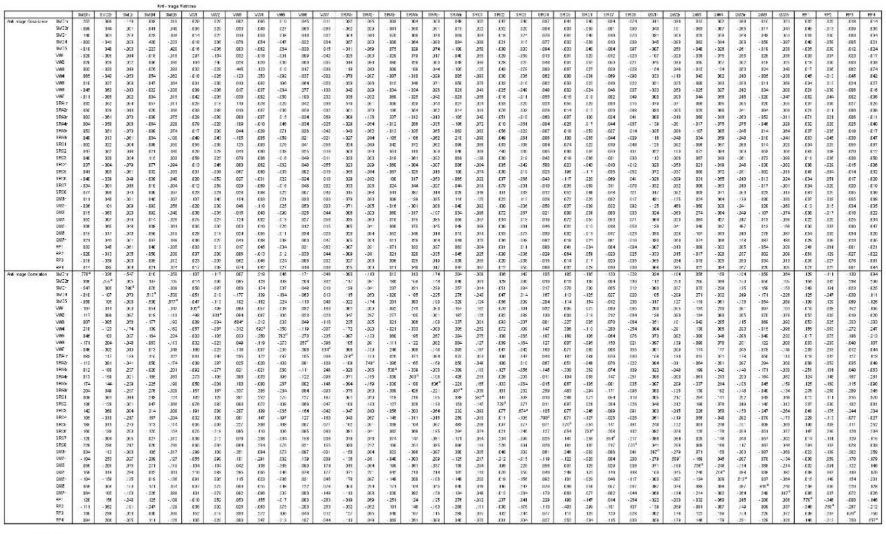
Descriptive Statistics

	Mean	Std. Deviation	Analysis N
QW7r	3.3455	1.19967	110
RP1	3.7636	1.36084	110
RP2	3.3818	1.47755	110
RP3	3.3909	1.42774	110
RP4	3.5000	1.42552	110



KMO and Bartlett's Test

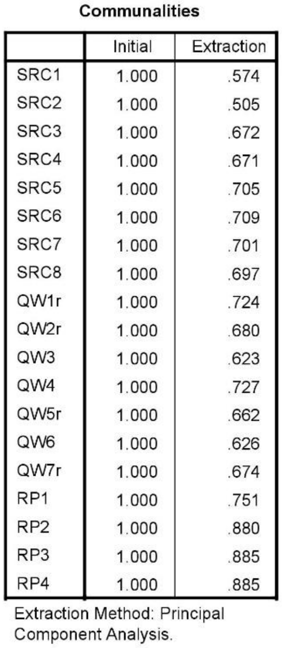
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.707
Bartlett's Test of Sphericity	Approx. Chi-Square	2470.546
	df	666
	Sig.	.000



a. Measures of Sampling Adequacy(MSA)

Communalities

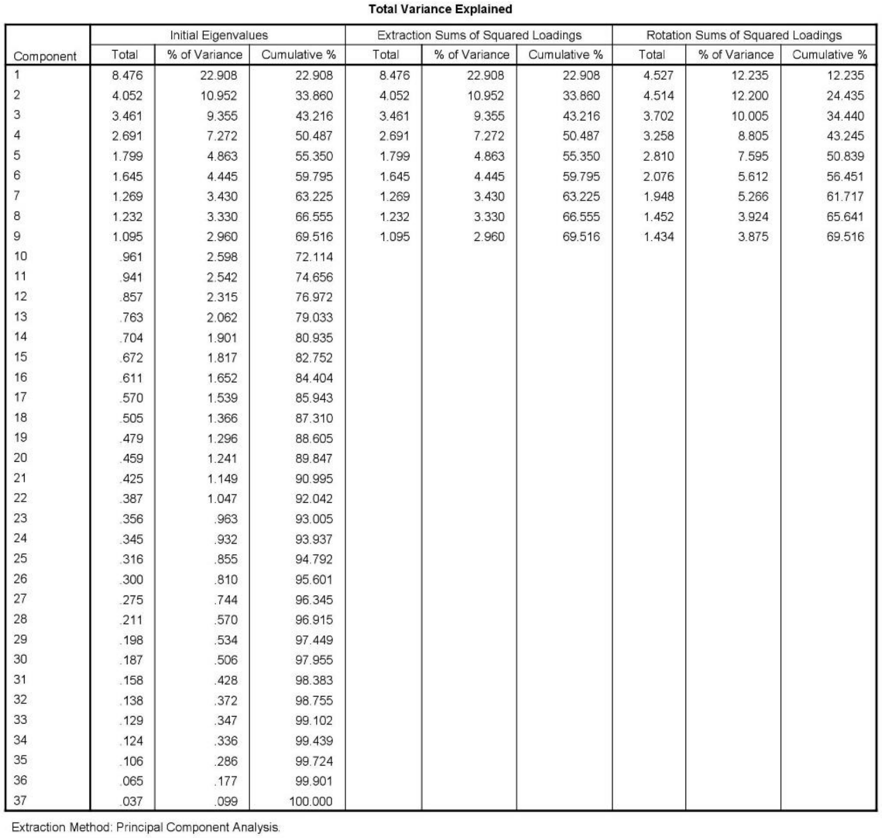
	Initial	Extraction
SMD1r	1.000	.769
SMD2r	1.000	.652
SMDr	1.000	.720
SMD4	1.000	.716
SMD5	1.000	.721
VW1	1.000	.700
VW2	1.000	.731
VW3	1.000	.451
VW4	1.000	.602
VW5	1.000	.780
VW6	1.000	.682
VW7	1.000	.739
SRA1r	1.000	.622
SRA2r	1.000	.660
SRA3r	1.000	.729
SRA4r	1.000	.746
SRA5r	1.000	.633
SRA6r	1.000	.715



Communalities

	Initial	Extraction
SRC1	1.000	.574
SRC2	1.000	.505
SRC3	1.000	.672
SRC4	1.000	.671
SRC5	1.000	.705
SRC6	1.000	.709
SRC7	1.000	.701
SRC8	1.000	.697
QW1r	1.000	.724
QW2r	1.000	.680
QW3	1.000	.623
QW4	1.000	.727
QW5r	1.000	.662
QW6	1.000	.626
QW7r	1.000	.674
RP1	1.000	.751
RP2	1.000	.880
RP3	1.000	.885
RP4	1.000	.885

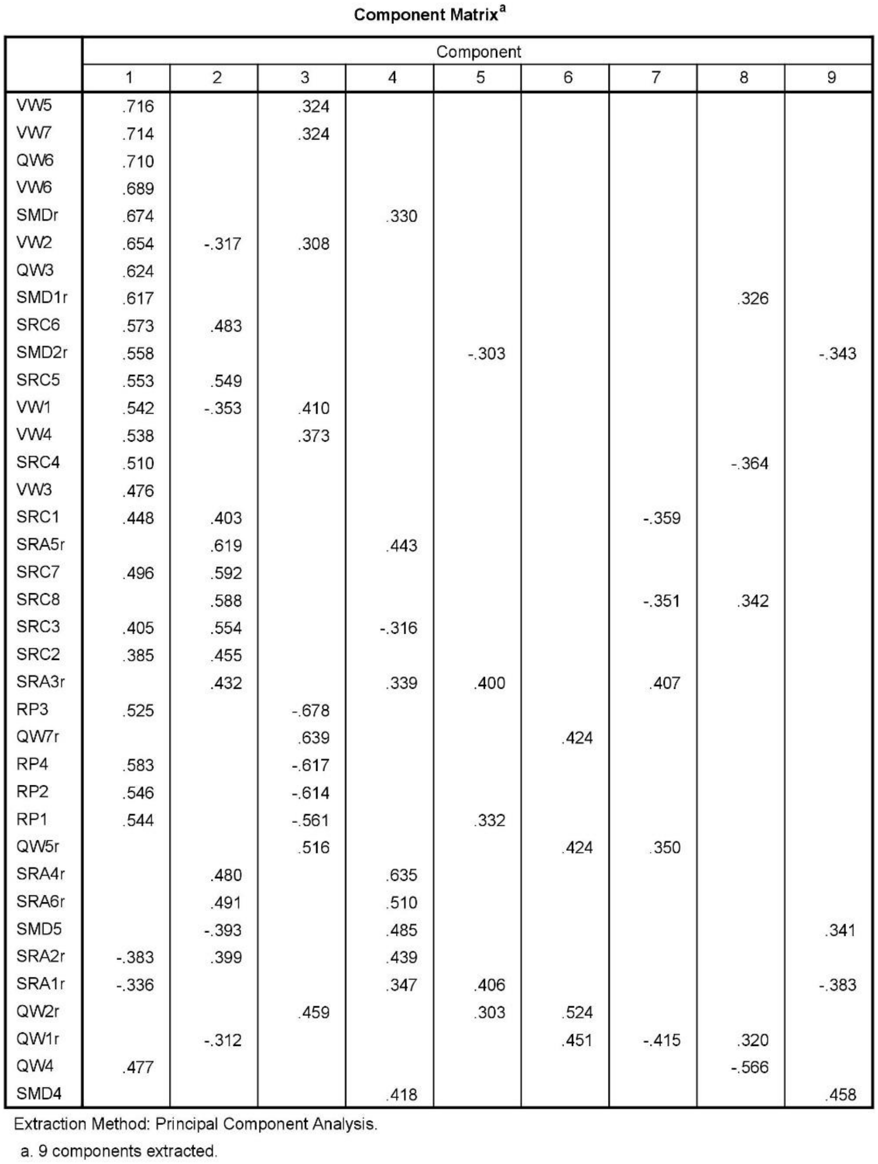
Extraction Method: Principal Component Analysis.



Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.476	22.908	22.908	8.476	22.908	22.908	4.527	12.235	12.235
2	4.052	10.952	33.860	4.052	10.952	33.860	4.514	12.200	24.435
3	3.461	9.355	43.216	3.461	9.355	43.216	3.702	10.005	34.440
4	2.691	7.272	50.487	2.691	7.272	50.487	3.258	8.805	43.245
5	1.799	4.863	55.350	1.799	4.863	55.350	2.810	7.595	50.839
6	1.645	4.445	59.795	1.645	4.445	59.795	2.076	5.612	56.451
7	1.269	3.430	63.225	1.269	3.430	63.225	1.948	5.266	61.717
8	1.232	3.330	66.555	1.232	3.330	66.555	1.452	3.924	65.641
9	1.095	2.960	69.516	1.095	2.960	69.516	1.434	3.875	69.516
10	.961	2.598	72.114						
11	.941	2.542	74.656						
12	.857	2.315	76.972						
13	.763	2.062	79.033						
14	.704	1.901	80.935						
15	.672	1.817	82.752						
16	.611	1.652	84.404						
17	.570	1.539	85.943						
18	.505	1.366	87.310						
19	.479	1.296	88.605						
20	.459	1.241	89.847						
21	.425	1.149	90.995						
22	.387	1.047	92.042						
23	.356	.963	93.005						
24	.345	.932	93.937						
25	.316	.855	94.792						
26	.300	.810	95.601						
27	.275	.744	96.345						
28	.211	.570	96.915						
29	.198	.534	97.449						
30	.187	.506	97.955						
31	.158	.428	98.383						
32	.138	.372	98.755						
33	.129	.347	99.102						
34	.124	.336	99.439						
35	.106	.286	99.724						
36	.065	.177	99.901						
37	.037	.099	100.000						

Extraction Method: Principal Component Analysis.

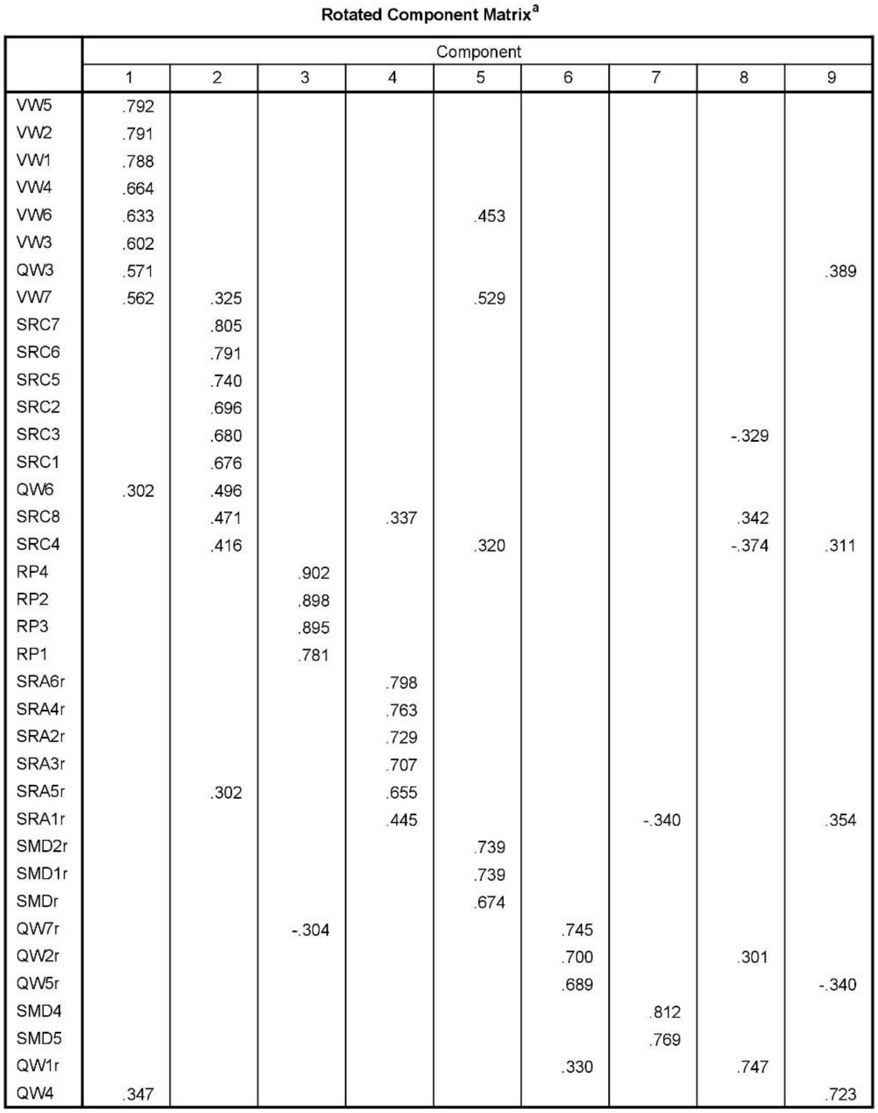


Component Matrix[a]

	Component								
	1	2	3	4	5	6	7	8	9
VW5	.716		.324						
VW7	.714		.324						
QW6	.710								
VW6	.689								
SMDr	.674			.330					
VW2	.654	-.317	.308						
QW3	.624								
SMD1r	.617							.326	
SRC6	.573	.483							
SMD2r	.558				-.303				-.343
SRC5	.553	.549							
VW1	.542	-.353	.410						
VW4	.538		.373						
SRC4	.510							-.364	
VW3	.476								
SRC1	.448	.403					-.359		
SRA5r		.619		.443					
SRC7	.496	.592							
SRC8		.588					-.351	.342	
SRC3	.405	.554		-.316					
SRC2	.385	.455							
SRA3r		.432		.339	.400		.407		
RP3	.525		-.678						
QW7r			.639			.424			
RP4	.583		-.617						
RP2	.546		-.614						
RP1	.544		-.561		.332				
QW5r			.516			.424	.350		
SRA4r		.480		.635					
SRA6r		.491		.510					
SMD5		-.393		.485					.341
SRA2r	-.383	.399		.439					
SRA1r	-.336			.347	.406				-.383
QW2r			.459		.303	.524			
QW1r		-.312				.451	-.415	.320	
QW4	.477							-.566	
SMD4				.418					.458

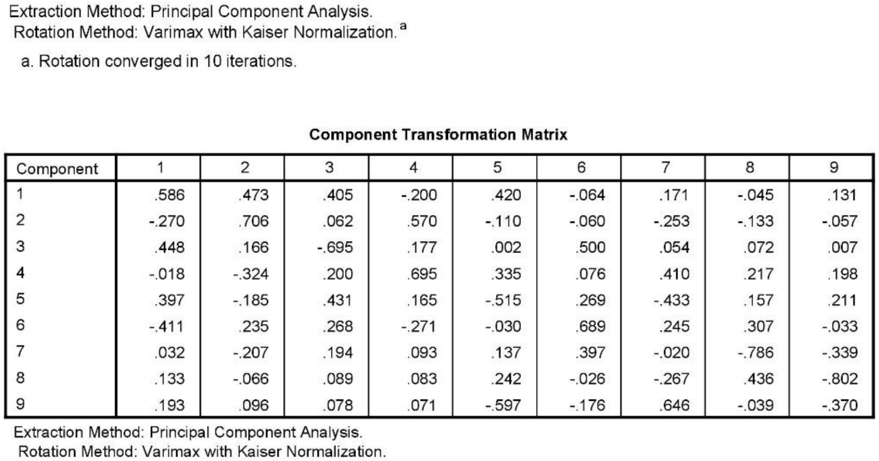
Extraction Method: Principal Component Analysis.

a. 9 components extracted.



Rotated Component Matrix[a]

	Component								
	1	2	3	4	5	6	7	8	9
VW5	.792								
VW2	.791								
VW1	.788								
VW4	.664								
VW6	.633				.453				
VW3	.602								
QW3	.571								.389
VW7	.562	.325			.529				
SRC7		.805							
SRC6		.791							
SRC5		.740							
SRC2		.696							
SRC3		.680						-.329	
SRC1		.676							
QW6	.302	.496							
SRC8		.471		.337				.342	
SRC4		.416			.320			-.374	.311
RP4			.902						
RP2			.898						
RP3			.895						
RP1			.781						
SRA6r				.798					
SRA4r				.763					
SRA2r				.729					
SRA3r				.707					
SRA5r		.302		.655					
SRA1r				.445			-.340		.354
SMD2r					.739				
SMD1r					.739				
SMDr					.674				
QW7r			-.304			.745			
QW2r						.700		.301	
QW5r						.689			-.340
SMD4							.812		
SMD5							.769		
QW1r						.330		.747	
QW4	.347								.723



Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

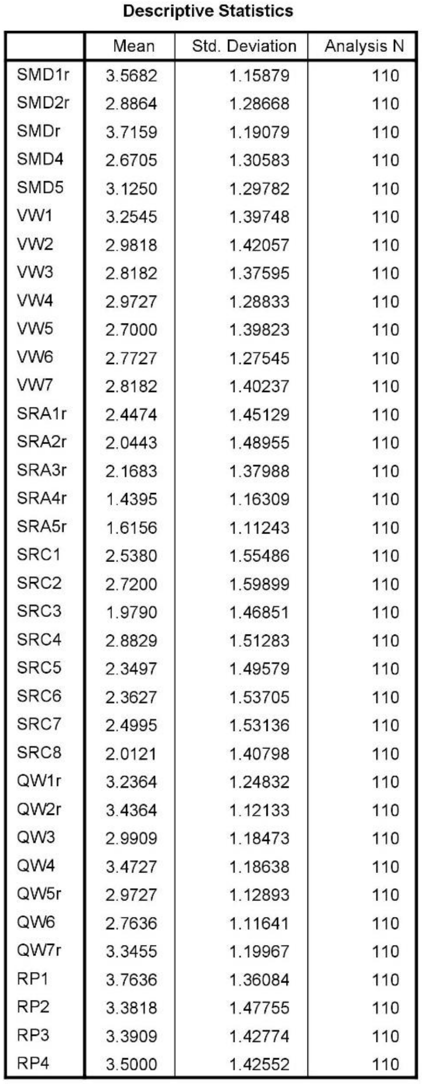
a. Rotation converged in 10 iterations.

Component Transformation Matrix

Component	1	2	3	4	5	6	7	8	9
1	.586	.473	.405	-.200	.420	-.064	.171	-.045	.131
2	-.270	.706	.062	.570	-.110	-.060	-.253	-.133	-.057
3	.448	.166	-.695	.177	.002	.500	.054	.072	.007
4	-.018	-.324	.200	.695	.335	.076	.410	.217	.198
5	.397	-.185	.431	.165	-.515	.269	-.433	.157	.211
6	-.411	.235	.268	-.271	-.030	.689	.245	.307	-.033
7	.032	-.207	.194	.093	.137	.397	-.020	-.786	-.339
8	.133	-.066	.089	.083	.242	-.026	-.267	.436	-.802
9	.193	.096	.078	.071	-.597	-.176	.646	-.039	-.370

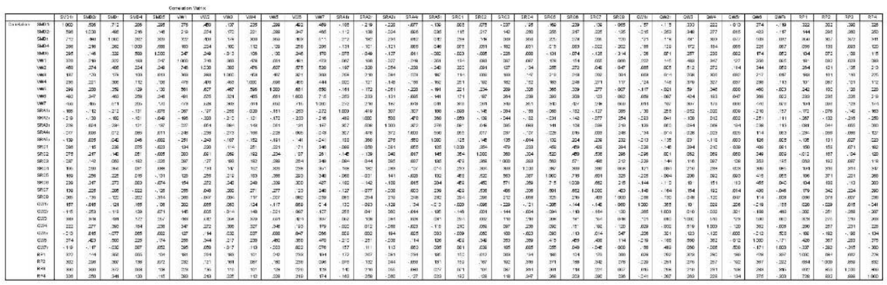
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Appendix H: Factor Analysis SPSS Output 2



Descriptive Statistics

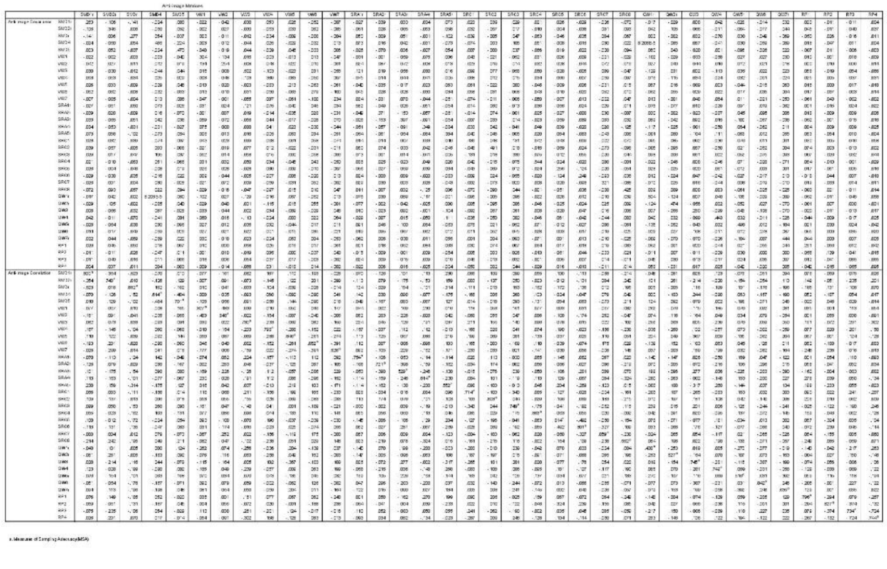
	Mean	Std. Deviation	Analysis N
SMD1r	3.5682	1.15879	110
SMD2r	2.8864	1.28668	110
SMDr	3.7159	1.19079	110
SMD4	2.6705	1.30583	110
SMD5	3.1250	1.29782	110
VW1	3.2545	1.39748	110
VW2	2.9818	1.42057	110
VW3	2.8182	1.37595	110
VW4	2.9727	1.28833	110
VW5	2.7000	1.39823	110
VW6	2.7727	1.27545	110
VW7	2.8182	1.40237	110
SRA1r	2.4474	1.45129	110
SRA2r	2.0443	1.48955	110
SRA3r	2.1683	1.37988	110
SRA4r	1.4395	1.16309	110
SRA5r	1.6156	1.11243	110
SRC1	2.5380	1.55486	110
SRC2	2.7200	1.59899	110
SRC3	1.9790	1.46851	110
SRC4	2.8829	1.51283	110
SRC5	2.3497	1.49579	110
SRC6	2.3627	1.53705	110
SRC7	2.4995	1.53136	110
SRC8	2.0121	1.40798	110
QW1r	3.2364	1.24832	110
QW2r	3.4364	1.12133	110
QW3	2.9909	1.18473	110
QW4	3.4727	1.18638	110
QW5r	2.9727	1.12893	110
QW6	2.7636	1.11641	110
QW7r	3.3455	1.19967	110
RP1	3.7636	1.36084	110
RP2	3.3818	1.47755	110
RP3	3.3909	1.42774	110
RP4	3.5000	1.42552	110



Correlation Matrix

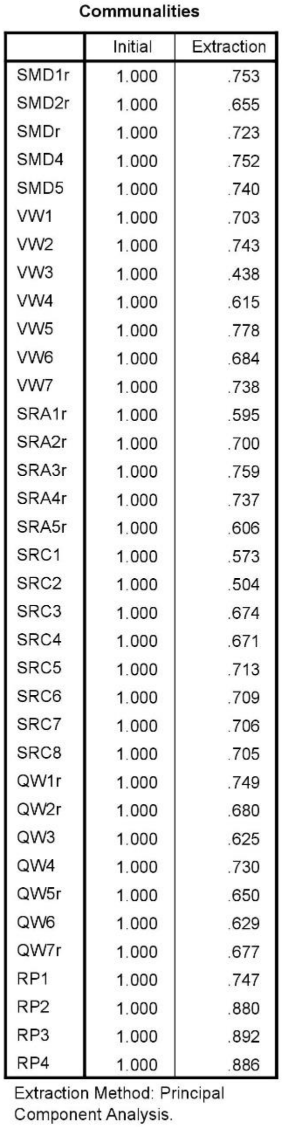
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.762
Bartlett's Test of Sphericity	Approx. Chi-Square	2332.769
	df	630
	Sig.	.000



Anti-image Matrices

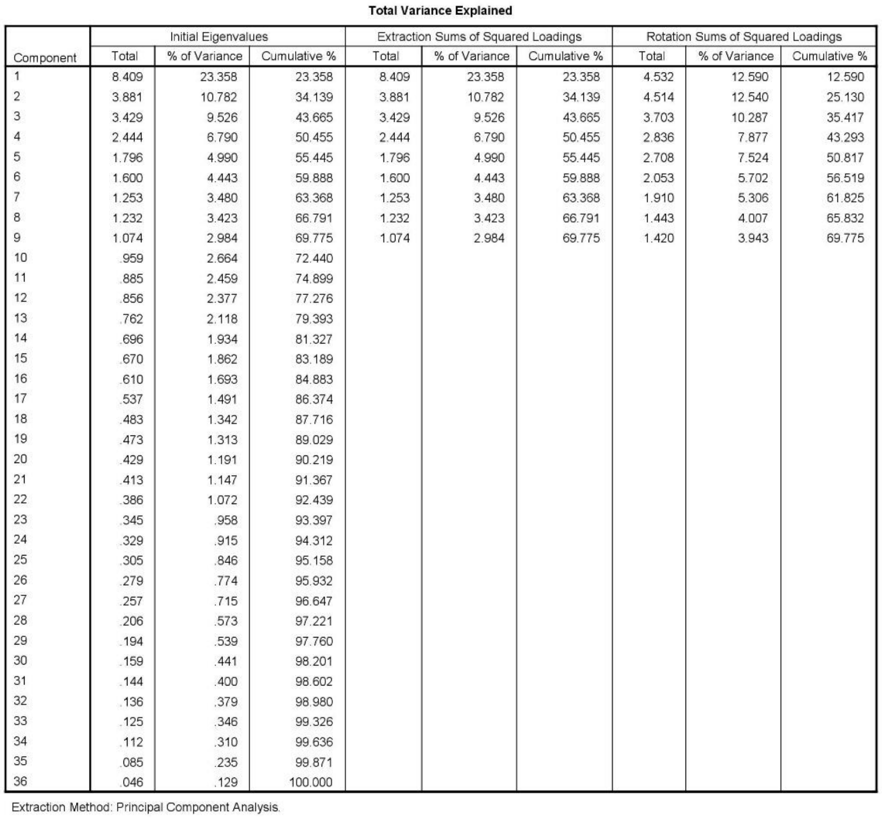
a. Measures of Sampling Adequacy(MSA)



Communalities

	Initial	Extraction
SMD1r	1.000	.753
SMD2r	1.000	.655
SMDr	1.000	.723
SMD4	1.000	.752
SMD5	1.000	.740
VW1	1.000	.703
VW2	1.000	.743
VW3	1.000	.438
VW4	1.000	.615
VW5	1.000	.778
VW6	1.000	.684
VW7	1.000	.738
SRA1r	1.000	.595
SRA2r	1.000	.700
SRA3r	1.000	.759
SRA4r	1.000	.737
SRA5r	1.000	.606
SRC1	1.000	.573
SRC2	1.000	.504
SRC3	1.000	.674
SRC4	1.000	.671
SRC5	1.000	.713
SRC6	1.000	.709
SRC7	1.000	.706
SRC8	1.000	.705
QW1r	1.000	.749
QW2r	1.000	.680
QW3	1.000	.625
QW4	1.000	.730
QW5r	1.000	.650
QW6	1.000	.629
QW7r	1.000	.677
RP1	1.000	.747
RP2	1.000	.880
RP3	1.000	.892
RP4	1.000	.886

Extraction Method: Principal Component Analysis.

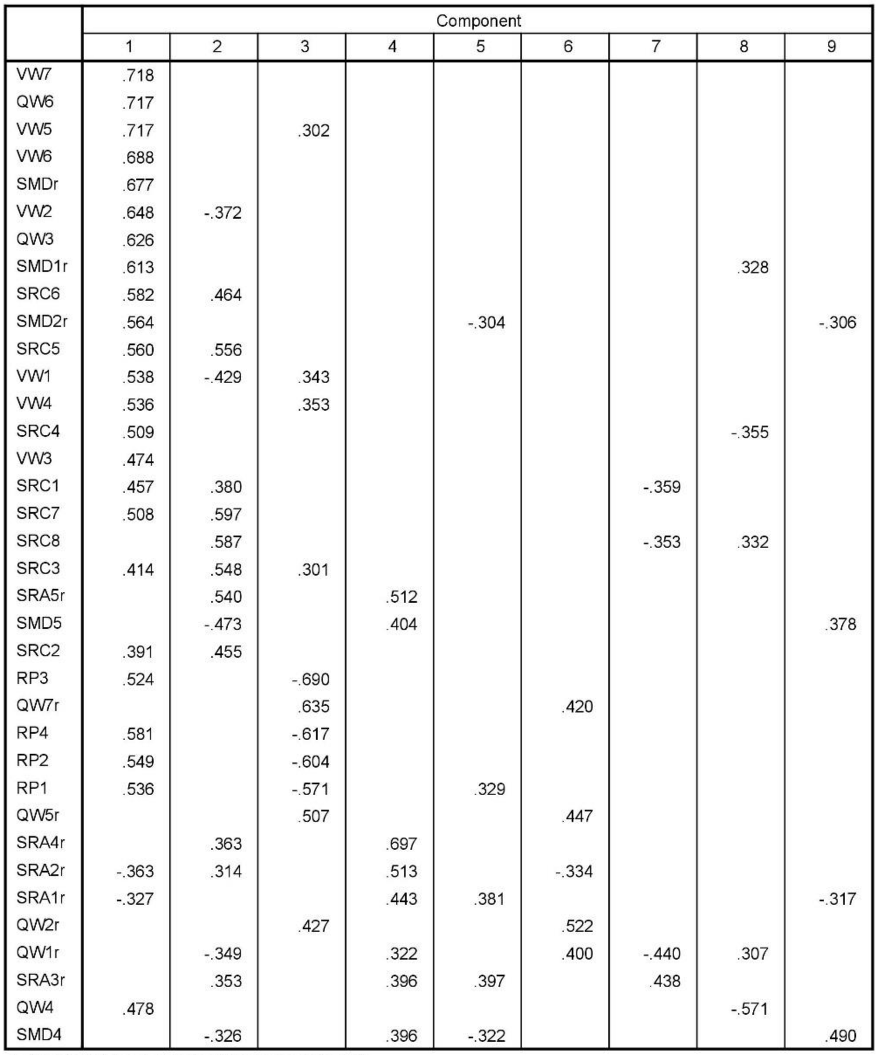


Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.409	23.358	23.358	8.409	23.358	23.358	4.532	12.590	12.590
2	3.881	10.782	34.139	3.881	10.782	34.139	4.514	12.540	25.130
3	3.429	9.526	43.665	3.429	9.526	43.665	3.703	10.287	35.417
4	2.444	6.790	50.455	2.444	6.790	50.455	2.836	7.877	43.293
5	1.796	4.990	55.445	1.796	4.990	55.445	2.708	7.524	50.817
6	1.600	4.443	59.888	1.600	4.443	59.888	2.053	5.702	56.519
7	1.253	3.480	63.368	1.253	3.480	63.368	1.910	5.306	61.825
8	1.232	3.423	66.791	1.232	3.423	66.791	1.443	4.007	65.832
9	1.074	2.984	69.775	1.074	2.984	69.775	1.420	3.943	69.775
10	.959	2.664	72.440						
11	.885	2.459	74.899						
12	.856	2.377	77.276						
13	.762	2.118	79.393						
14	.696	1.934	81.327						
15	.670	1.862	83.189						
16	.610	1.693	84.883						
17	.537	1.491	86.374						
18	.483	1.342	87.716						
19	.473	1.313	89.029						
20	.429	1.191	90.219						
21	.413	1.147	91.367						
22	.386	1.072	92.439						
23	.345	.958	93.397						
24	.329	.915	94.312						
25	.305	.846	95.158						
26	.279	.774	95.932						
27	.257	.715	96.647						
28	.206	.573	97.221						
29	.194	.539	97.760						
30	.159	.441	98.201						
31	.144	.400	98.602						
32	.136	.379	98.980						
33	.125	.346	99.326						
34	.112	.310	99.636						
35	.085	.235	99.871						
36	.046	.129	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix^a



	Component								
	1	2	3	4	5	6	7	8	9
VW7	.718								
QW6	.717								
VW5	.717		.302						
VW6	.688								
SMDr	.677								
VW2	.648	-.372							
QW3	.626								
SMD1r	.613							.328	
SRC6	.582	.464							
SMD2r	.564				-.304				-.306
SRC5	.560	.556							
VW1	.538	-.429	.343						
VW4	.536		.353						
SRC4	.509							-.355	
VW3	.474								
SRC1	.457	.380					-.359		
SRC7	.508	.597							
SRC8		.587					-.353	.332	
SRC3	.414	.548	.301						
SRA5r		.540		.512					
SMD5		-.473		.404					.378
SRC2	.391	.455							
RP3	.524		-.690						
QW7r			.635			.420			
RP4	.581		-.617						
RP2	.549		-.604						
RP1	.536		-.571		.329				
QW5r			.507			.447			
SRA4r		.363		.697					
SRA2r	-.363	.314		.513		-.334			
SRA1r	-.327			.443	.381				-.317
QW2r			.427			.522			
QW1r		-.349		.322		.400	-.440	.307	
SRA3r		.353		.396	.397		.438		
QW4	.478							-.571	
SMD4		-.326		.396	-.322				.490

Extraction Method: Principal Component Analysis.

a. 9 components extracted.

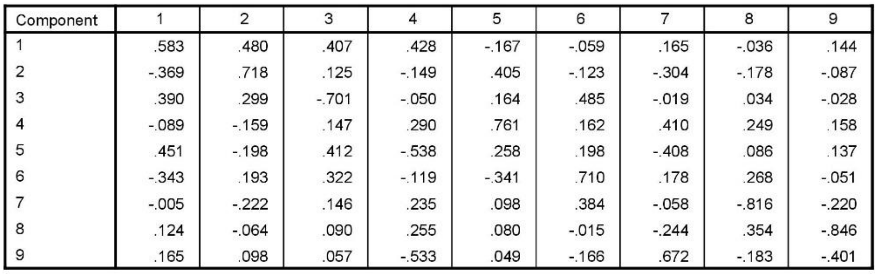
Rotated Component Matrix[a]

	Component								
	1	2	3	4	5	6	7	8	9
VW1	.800								
VW2	.797								
VW5	.788								
VW4	.673								
VW6	.624			.461					
VW3	.582								
QW3	.576								.368
VW7	.547	.324		.546					
SRC7		.806							
SRC6		.789							
SRC5		.738							
SRC2		.694							
SRC1		.678							
SRC3		.676						-.321	
QW6		.500		.303					
SRC8		.487			.364				
SRC4		.397		.325				-.323	.367
RP4			.904						
RP3			.899						
RP2			.896						
RP1			.785						
SMD2r				.746					
SMD1r				.722					
SMDr				.670					
SRA2r					.774				
SRA4r					.740				
SRA3r					.719			-.309	
SRA5r	-.313	.326			.600				
SRA1r					.551				
QW7r			-.303			.747			
QW5r						.696			-.325
QW2r						.690		.320	
SMD4							.840		
SMD5							.788		
QW1r						.321		.772	
QW4	.361								.719

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 9 iterations.

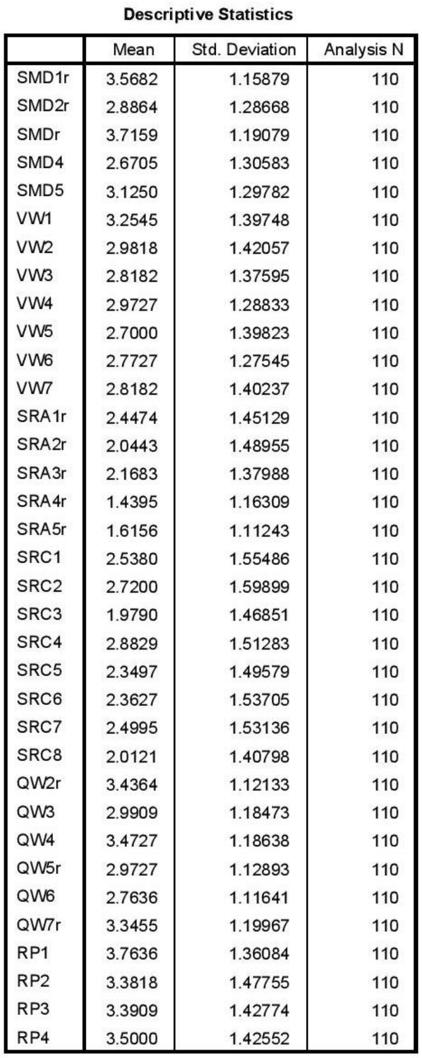
Component Transformation Matrix



Component	1	2	3	4	5	6	7	8	9
1	.583	.480	.407	.428	-.167	-.059	.165	-.036	.144
2	-.369	.718	.125	-.149	.405	-.123	-.304	-.178	-.087
3	.390	.299	-.701	-.050	.164	.485	-.019	.034	-.028
4	-.089	-.159	.147	.290	.761	.162	.410	.249	.158
5	.451	-.198	.412	-.538	.258	.198	-.408	.086	.137
6	-.343	.193	.322	-.119	-.341	.710	.178	.268	-.051
7	-.005	-.222	.146	.235	.098	.384	-.058	-.816	-.220
8	.124	-.064	.090	.255	.080	-.015	-.244	.354	-.846
9	.165	.098	.057	-.533	.049	-.166	.672	-.183	-.401

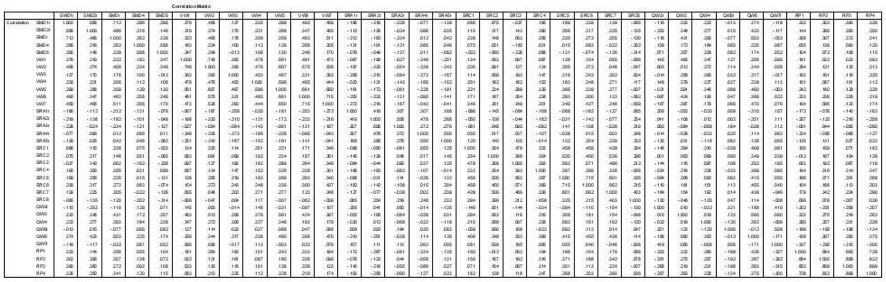
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Appendix I: Factor Analysis SPSS Output 3



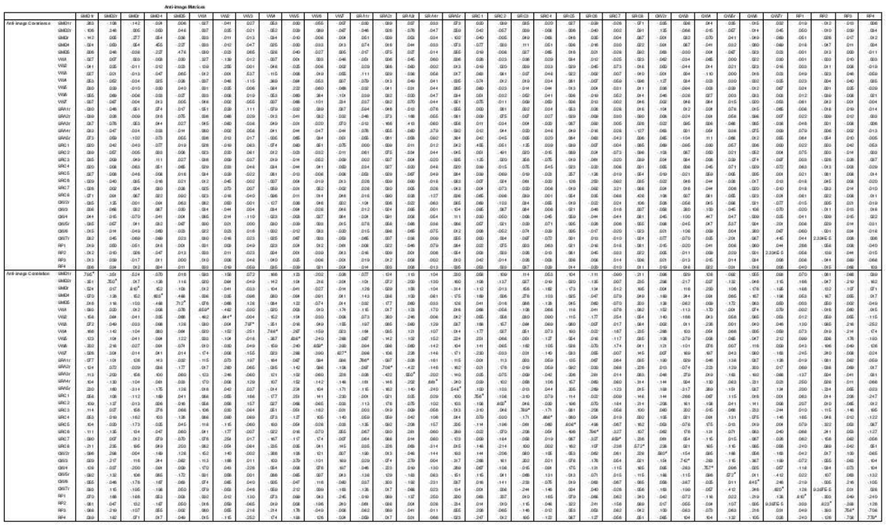
Descriptive Statistics

	Mean	Std. Deviation	Analysis N
SMD1r	3.5682	1.15879	110
SMD2r	2.8864	1.28668	110
SMDr	3.7159	1.19079	110
SMD4	2.6705	1.30583	110
SMD5	3.1250	1.29782	110
VW1	3.2545	1.39748	110
VW2	2.9818	1.42057	110
VW3	2.8182	1.37595	110
VW4	2.9727	1.28833	110
VW5	2.7000	1.39823	110
VW6	2.7727	1.27545	110
VW7	2.8182	1.40237	110
SRA1r	2.4474	1.45129	110
SRA2r	2.0443	1.48955	110
SRA3r	2.1683	1.37988	110
SRA4r	1.4395	1.16309	110
SRA5r	1.6156	1.11243	110
SRC1	2.5380	1.55486	110
SRC2	2.7200	1.59899	110
SRC3	1.9790	1.46851	110
SRC4	2.8829	1.51283	110
SRC5	2.3497	1.49579	110
SRC6	2.3627	1.53705	110
SRC7	2.4995	1.53136	110
SRC8	2.0121	1.40798	110
QW2r	3.4364	1.12133	110
QW3	2.9909	1.18473	110
QW4	3.4727	1.18638	110
QW5r	2.9727	1.12893	110
QW6	2.7636	1.11641	110
QW7r	3.3455	1.19967	110
RP1	3.7636	1.36084	110
RP2	3.3818	1.47755	110
RP3	3.3909	1.42774	110
RP4	3.5000	1.42552	110

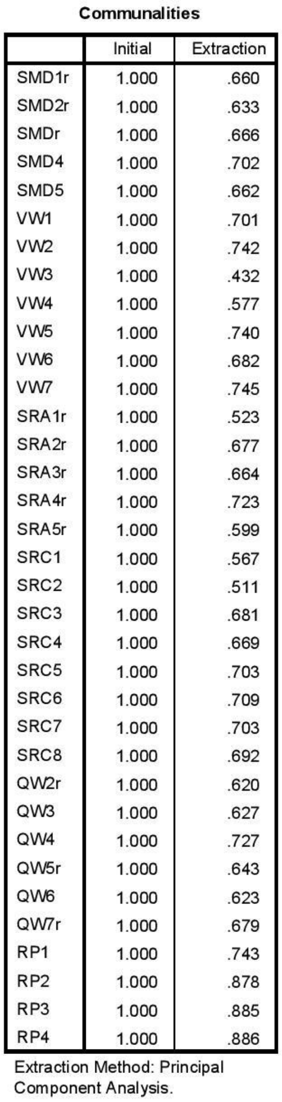

Correlation Matrix

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.775
Bartlett's Test of Sphericity	Approx. Chi-Square	2274.726
	df	595
	Sig.	.000


Anti-image Matrices

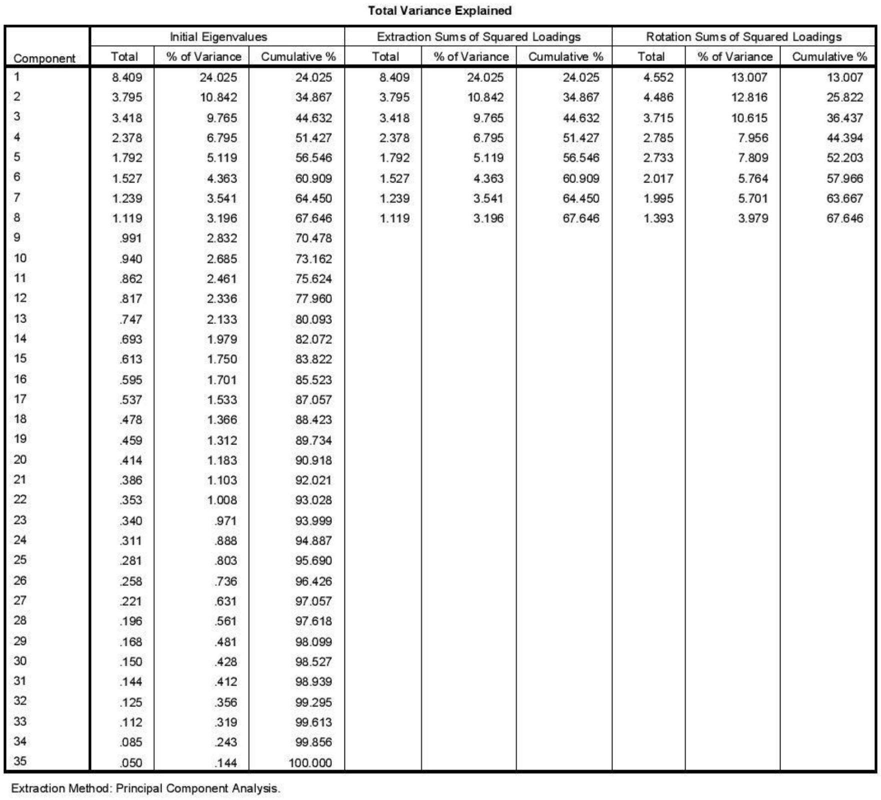
a. Measures of Sampling Adequacy(MSA)



Communalities

	Initial	Extraction
SMD1r	1.000	.660
SMD2r	1.000	.633
SMDr	1.000	.666
SMD4	1.000	.702
SMD5	1.000	.662
VW1	1.000	.701
VW2	1.000	.742
VW3	1.000	.432
VW4	1.000	.577
VW5	1.000	.740
VW6	1.000	.682
VW7	1.000	.745
SRA1r	1.000	.523
SRA2r	1.000	.677
SRA3r	1.000	.664
SRA4r	1.000	.723
SRA5r	1.000	.599
SRC1	1.000	.567
SRC2	1.000	.511
SRC3	1.000	.681
SRC4	1.000	.669
SRC5	1.000	.703
SRC6	1.000	.709
SRC7	1.000	.703
SRC8	1.000	.692
QW2r	1.000	.620
QW3	1.000	.627
QW4	1.000	.727
QW5r	1.000	.643
QW6	1.000	.623
QW7r	1.000	.679
RP1	1.000	.743
RP2	1.000	.878
RP3	1.000	.885
RP4	1.000	.886

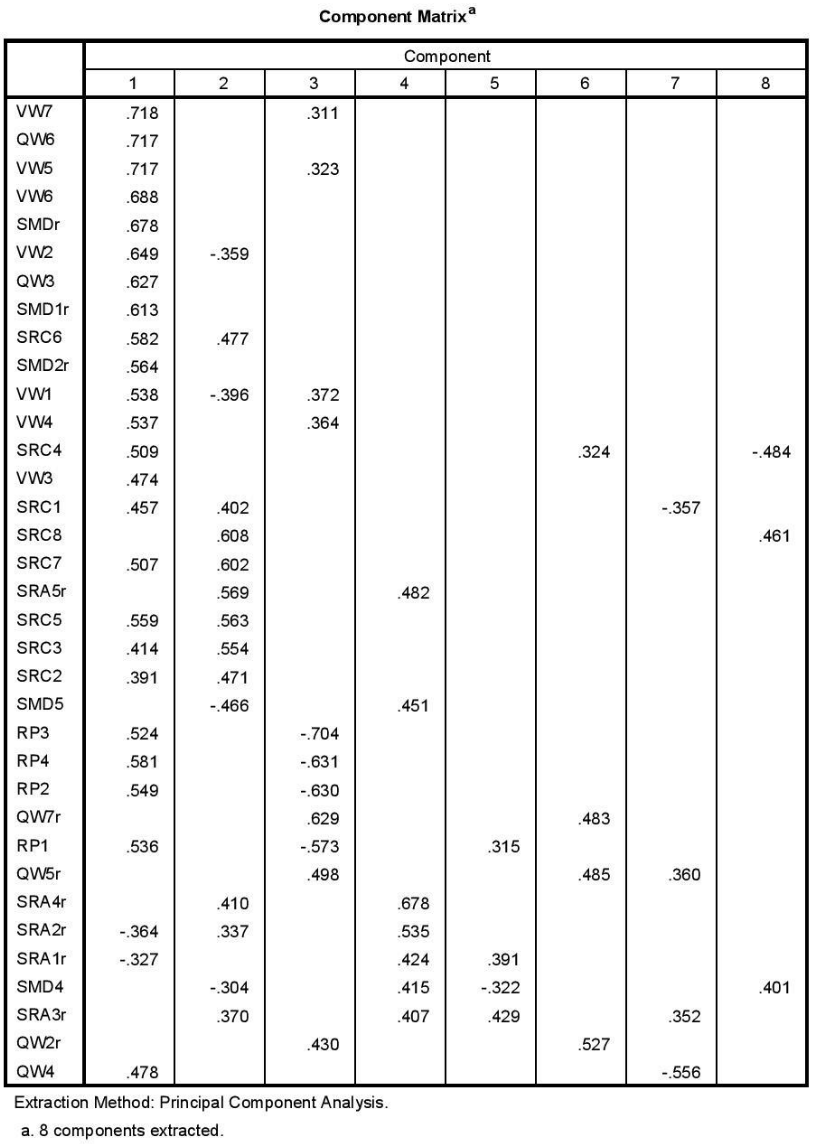
Extraction Method: Principal Component Analysis.



Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.409	24.025	24.025	8.409	24.025	24.025	4.552	13.007	13.007
2	3.795	10.842	34.867	3.795	10.842	34.867	4.486	12.816	25.822
3	3.418	9.765	44.632	3.418	9.765	44.632	3.715	10.615	36.437
4	2.378	6.795	51.427	2.378	6.795	51.427	2.785	7.956	44.394
5	1.792	5.119	56.546	1.792	5.119	56.546	2.733	7.809	52.203
6	1.527	4.363	60.909	1.527	4.363	60.909	2.017	5.764	57.966
7	1.239	3.541	64.450	1.239	3.541	64.450	1.995	5.701	63.667
8	1.119	3.196	67.646	1.119	3.196	67.646	1.393	3.979	67.646
9	.991	2.832	70.478						
10	.940	2.685	73.162						
11	.862	2.461	75.624						
12	.817	2.336	77.960						
13	.747	2.133	80.093						
14	.693	1.979	82.072						
15	.613	1.750	83.822						
16	.595	1.701	85.523						
17	.537	1.533	87.057						
18	.478	1.366	88.423						
19	.459	1.312	89.734						
20	.414	1.183	90.918						
21	.386	1.103	92.021						
22	.353	1.008	93.028						
23	.340	.971	93.999						
24	.311	.888	94.887						
25	.281	.803	95.690						
26	.258	.736	96.426						
27	.221	.631	97.057						
28	.196	.561	97.618						
29	.168	.481	98.099						
30	.150	.428	98.527						
31	.144	.412	98.939						
32	.125	.356	99.295						
33	.112	.319	99.613						
34	.085	.243	99.856						
35	.050	.144	100.000						

Extraction Method: Principal Component Analysis.

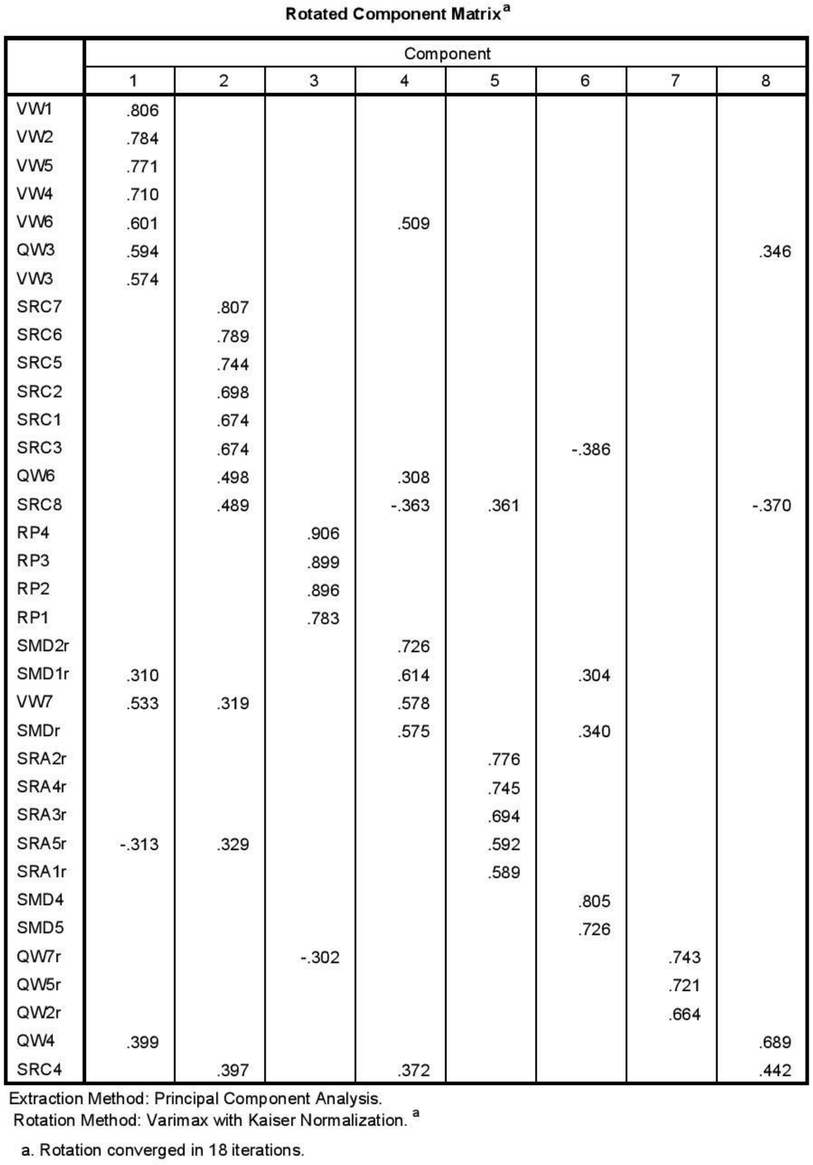


Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
VW7	.718		.311					
QW6	.717							
VW5	.717		.323					
VW6	.688							
SMDr	.678							
VW2	.649	-.359						
QW3	.627							
SMD1r	.613							
SRC6	.582	.477						
SMD2r	.564							
VW1	.538	-.396	.372					
VW4	.537		.364					
SRC4	.509					.324		-.484
VW3	.474							
SRC1	.457	.402					-.357	
SRC8		.608						.461
SRC7	.507	.602						
SRA5r		.569		.482				
SRC5	.559	.563						
SRC3	.414	.554						
SRC2	.391	.471						
SMD5		-.466		.451				
RP3	.524		-.704					
RP4	.581		-.631					
RP2	.549		-.630					
QW7r			.629			.483		
RP1	.536		-.573		.315			
QW5r			.498			.485	.360	
SRA4r		.410		.678				
SRA2r	-.364	.337		.535				
SRA1r	-.327			.424	.391			
SMD4		-.304		.415	-.322			.401
SRA3r		.370		.407	.429		.352	
QW2r			.430			.527		
QW4	.478						-.556	

Extraction Method: Principal Component Analysis.

a. 8 components extracted.

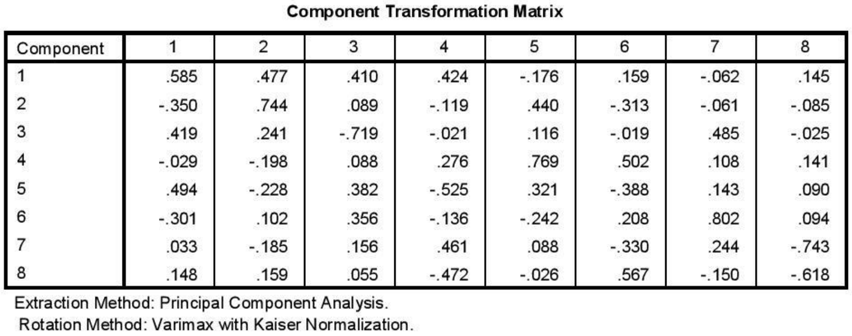


Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
VW1	.806							
VW2	.784							
VW5	.771							
VW4	.710							
VW6	.601			.509				
QW3	.594							.346
VW3	.574							
SRC7		.807						
SRC6		.789						
SRC5		.744						
SRC2		.698						
SRC1		.674						
SRC3		.674				-.386		
QW6		.498		.308				
SRC8		.489		-.363	.361			-.370
RP4			.906					
RP3			.899					
RP2			.896					
RP1			.783					
SMD2r				.726				
SMD1r	.310			.614		.304		
VW7	.533	.319		.578				
SMDr				.575		.340		
SRA2r					.776			
SRA4r					.745			
SRA3r					.694			
SRA5r	-.313	.329			.592			
SRA1r					.589			
SMD4						.805		
SMD5						.726		
QW7r			-.302				.743	
QW5r							.721	
QW2r							.664	
QW4	.399							.689
SRC4		.397		.372				.442

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 18 iterations.

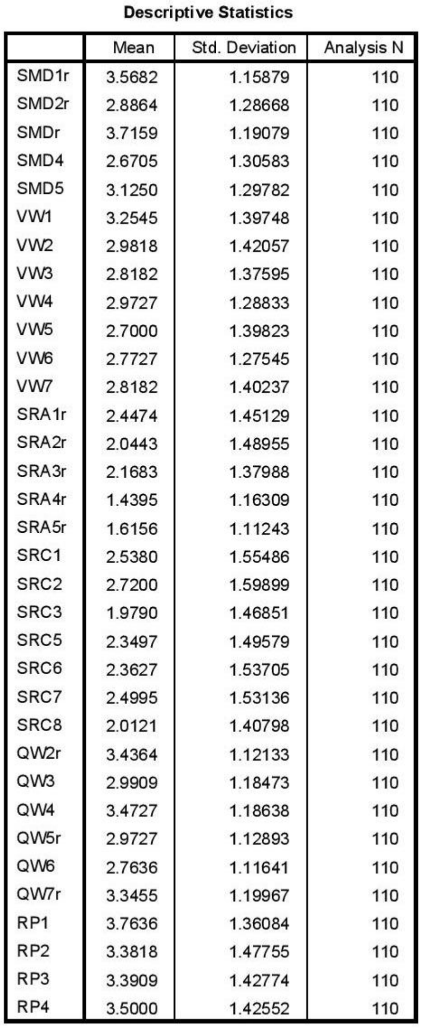


Component Transformation Matrix

Component	1	2	3	4	5	6	7	8
1	.585	.477	.410	.424	-.176	.159	-.062	.145
2	-.350	.744	.089	-.119	.440	-.313	-.061	-.085
3	.419	.241	-.719	-.021	.116	-.019	.485	-.025
4	-.029	-.198	.088	.276	.769	.502	.108	.141
5	.494	-.228	.382	-.525	.321	-.388	.143	.090
6	-.301	.102	.356	-.136	-.242	.208	.802	.094
7	.033	-.185	.156	.461	.088	-.330	.244	-.743
8	.148	.159	.055	-.472	-.026	.567	-.150	-.618

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

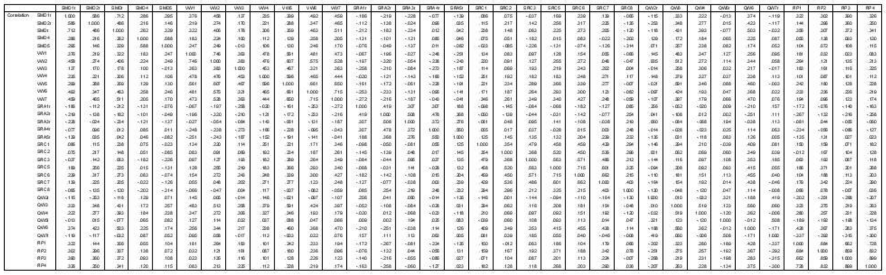
Appendix J: Factor Analysis SPSS Output 4



Descriptive Statistics

	Mean	Std. Deviation	Analysis N
SMD1r	3.5682	1.15879	110
SMD2r	2.8864	1.28668	110
SMDr	3.7159	1.19079	110
SMD4	2.6705	1.30583	110
SMD5	3.1250	1.29782	110
VW1	3.2545	1.39748	110
VW2	2.9818	1.42057	110
VW3	2.8182	1.37595	110
VW4	2.9727	1.28833	110
VW5	2.7000	1.39823	110
VW6	2.7727	1.27545	110
VW7	2.8182	1.40237	110
SRA1r	2.4474	1.45129	110
SRA2r	2.0443	1.48955	110
SRA3r	2.1683	1.37988	110
SRA4r	1.4395	1.16309	110
SRA5r	1.6156	1.11243	110
SRC1	2.5380	1.55486	110
SRC2	2.7200	1.59899	110
SRC3	1.9790	1.46851	110
SRC5	2.3497	1.49579	110
SRC6	2.3627	1.53705	110
SRC7	2.4995	1.53136	110
SRC8	2.0121	1.40798	110
QW2r	3.4364	1.12133	110
QW3	2.9909	1.18473	110
QW4	3.4727	1.18638	110
QW5r	2.9727	1.12893	110
QW6	2.7636	1.11641	110
QW7r	3.3455	1.19967	110
RP1	3.7636	1.36084	110
RP2	3.3818	1.47755	110
RP3	3.3909	1.42774	110
RP4	3.5000	1.42552	110

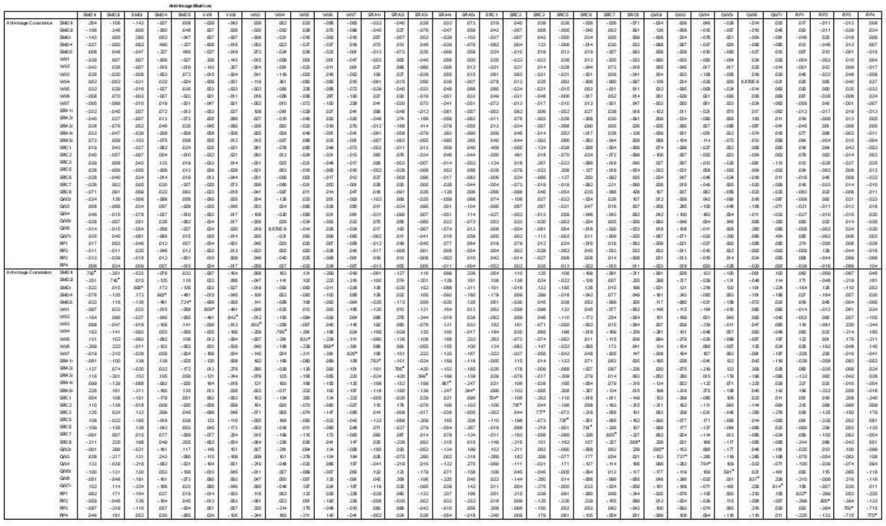
Correlation Matrix



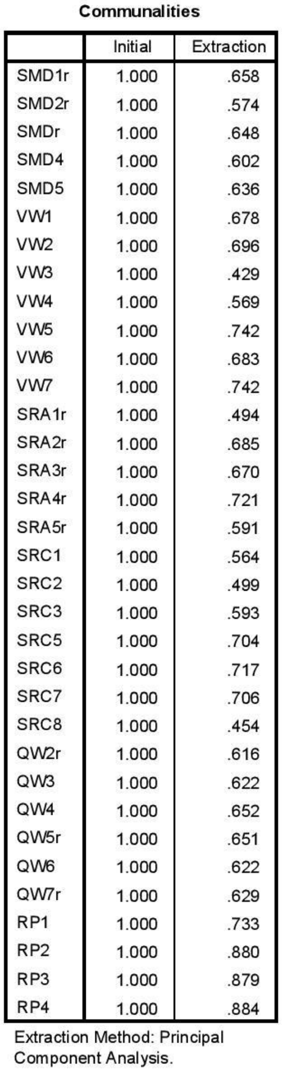
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.770
Bartlett's Test of Sphericity	Approx. Chi-Square	2223.878
	df	561
	Sig.	.000

Anti-image Matrices



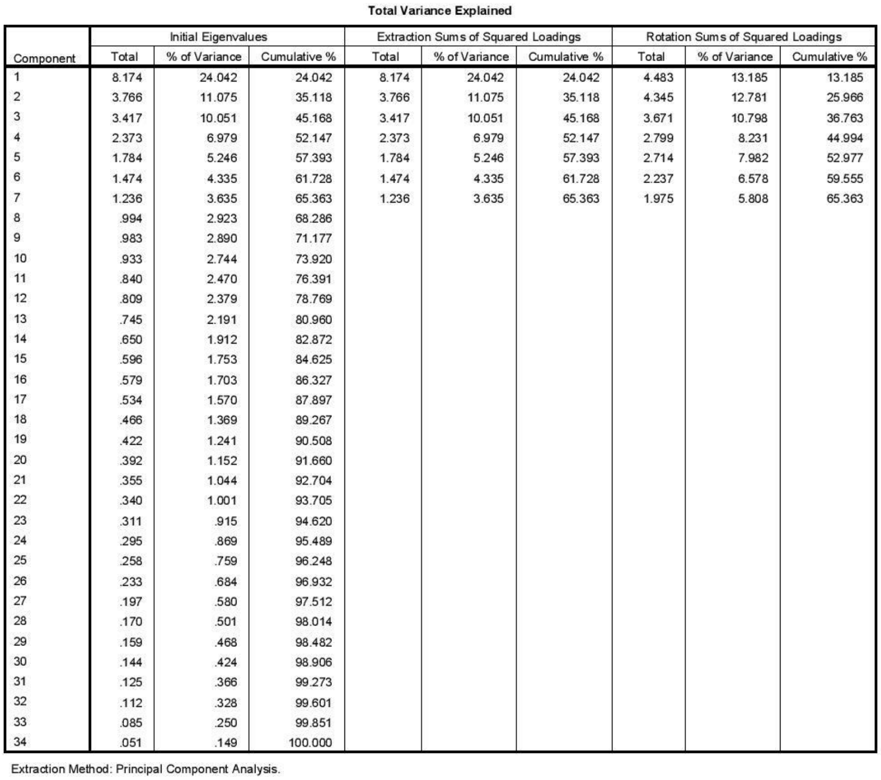
a. Measures of Sampling Adequacy(MSA)



Communalities

	Initial	Extraction
SMD1r	1.000	.658
SMD2r	1.000	.574
SMDr	1.000	.648
SMD4	1.000	.602
SMD5	1.000	.636
VW1	1.000	.678
VW2	1.000	.696
VW3	1.000	.429
VW4	1.000	.569
VW5	1.000	.742
VW6	1.000	.683
VW7	1.000	.742
SRA1r	1.000	.494
SRA2r	1.000	.685
SRA3r	1.000	.670
SRA4r	1.000	.721
SRA5r	1.000	.591
SRC1	1.000	.564
SRC2	1.000	.499
SRC3	1.000	.593
SRC5	1.000	.704
SRC6	1.000	.717
SRC7	1.000	.706
SRC8	1.000	.454
QW2r	1.000	.616
QW3	1.000	.622
QW4	1.000	.652
QW5r	1.000	.651
QW6	1.000	.622
QW7r	1.000	.629
RP1	1.000	.733
RP2	1.000	.880
RP3	1.000	.879
RP4	1.000	.884

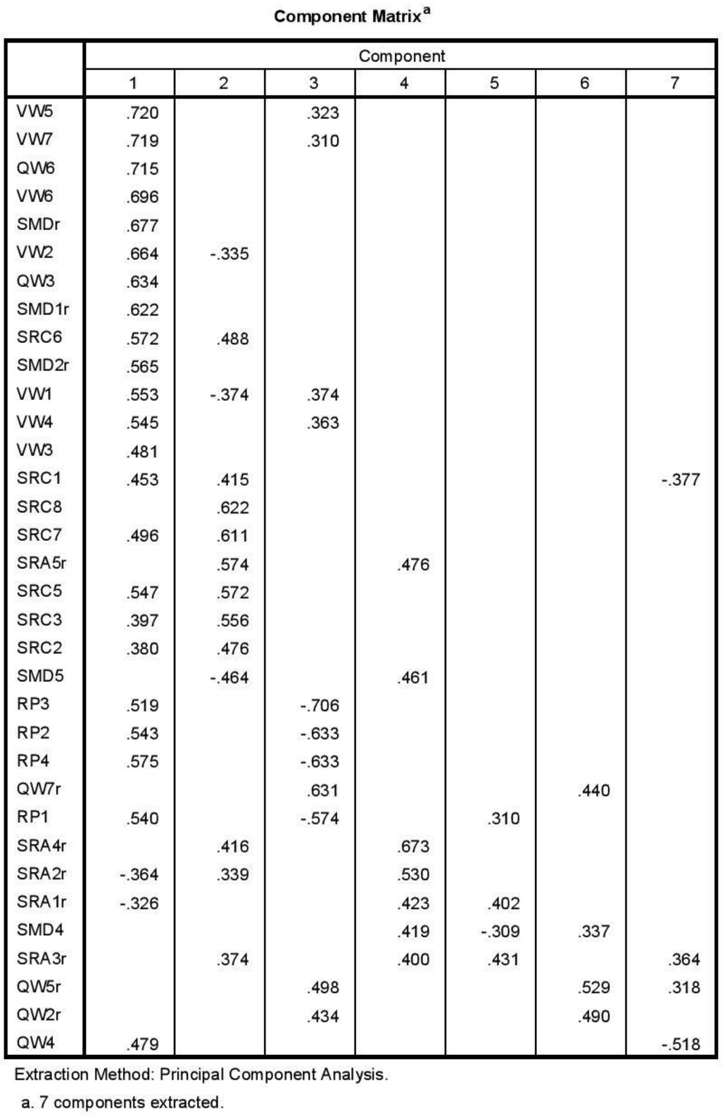
Extraction Method: Principal Component Analysis.



Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.174	24.042	24.042	8.174	24.042	24.042	4.483	13.185	13.185
2	3.766	11.075	35.118	3.766	11.075	35.118	4.345	12.781	25.966
3	3.417	10.051	45.168	3.417	10.051	45.168	3.671	10.798	36.763
4	2.373	6.979	52.147	2.373	6.979	52.147	2.799	8.231	44.994
5	1.784	5.246	57.393	1.784	5.246	57.393	2.714	7.982	52.977
6	1.474	4.335	61.728	1.474	4.335	61.728	2.237	6.578	59.555
7	1.236	3.635	65.363	1.236	3.635	65.363	1.975	5.808	65.363
8	.994	2.923	68.286						
9	.983	2.890	71.177						
10	.933	2.744	73.920						
11	.840	2.470	76.391						
12	.809	2.379	78.769						
13	.745	2.191	80.960						
14	.650	1.912	82.872						
15	.596	1.753	84.625						
16	.579	1.703	86.327						
17	.534	1.570	87.897						
18	.466	1.369	89.267						
19	.422	1.241	90.508						
20	.392	1.152	91.660						
21	.355	1.044	92.704						
22	.340	1.001	93.705						
23	.311	.915	94.620						
24	.295	.869	95.489						
25	.258	.759	96.248						
26	.233	.684	96.932						
27	.197	.580	97.512						
28	.170	.501	98.014						
29	.159	.468	98.482						
30	.144	.424	98.906						
31	.125	.366	99.273						
32	.112	.328	99.601						
33	.085	.250	99.851						
34	.051	.149	100.000						

Extraction Method: Principal Component Analysis.



Component Matrix^a

	Component						
	1	2	3	4	5	6	7
VW5	.720		.323				
VW7	.719		.310				
QW6	.715						
VW6	.696						
SMDr	.677						
VW2	.664	-.335					
QW3	.634						
SMD1r	.622						
SRC6	.572	.488					
SMD2r	.565						
VW1	.553	-.374	.374				
VW4	.545		.363				
VW3	.481						
SRC1	.453	.415					-.377
SRC8		.622					
SRC7	.496	.611					
SRA5r		.574		.476			
SRC5	.547	.572					
SRC3	.397	.556					
SRC2	.380	.476					
SMD5		-.464		.461			
RP3	.519		-.706				
RP2	.543		-.633				
RP4	.575		-.633				
QW7r			.631			.440	
RP1	.540		-.574		.310		
SRA4r		.416		.673			
SRA2r	-.364	.339		.530			
SRA1r	-.326			.423	.402		
SMD4				.419	-.309	.337	
SRA3r		.374		.400	.431		.364
QW5r			.498			.529	.318
QW2r			.434			.490	
QW4	.479						-.518

Extraction Method: Principal Component Analysis.

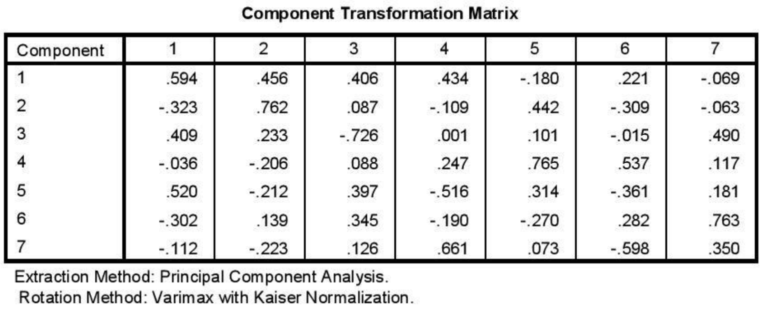
a. 7 components extracted.

Rotated Component Matrix[a]

	Component						
	1	2	3	4	5	6	7
VW5	.777						
VW1	.771						
VW4	.719						
VW2	.712			.355			
QW3	.639					.348	
VW3	.574						
QW4	.543					.456	
SRC7		.811					
SRC6		.793					
SRC5		.747					
SRC3		.700					
SRC2		.687					
SRC1		.677					
QW6	.302	.494		.302		.307	
SRC8		.464			.329	-.318	
RP4			.906				
RP3			.902				
RP2			.899				
RP1			.786				
SMD2r				.664			
SMD1r				.662			
VW7	.500	.311		.605			
VW6	.539			.587			
SMDr				.517		.442	
SRA2r					.787		
SRA4r					.743		
SRA3r					.688	-.327	
SRA1r					.603		
SRA5r	-.343	.328			.582		
SMD5						.718	
SMD4						.714	
QW5r							.786
QW7r			-.304				.688
QW2r				-.350			.627

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

[a] Rotation converged in 10 iterations.

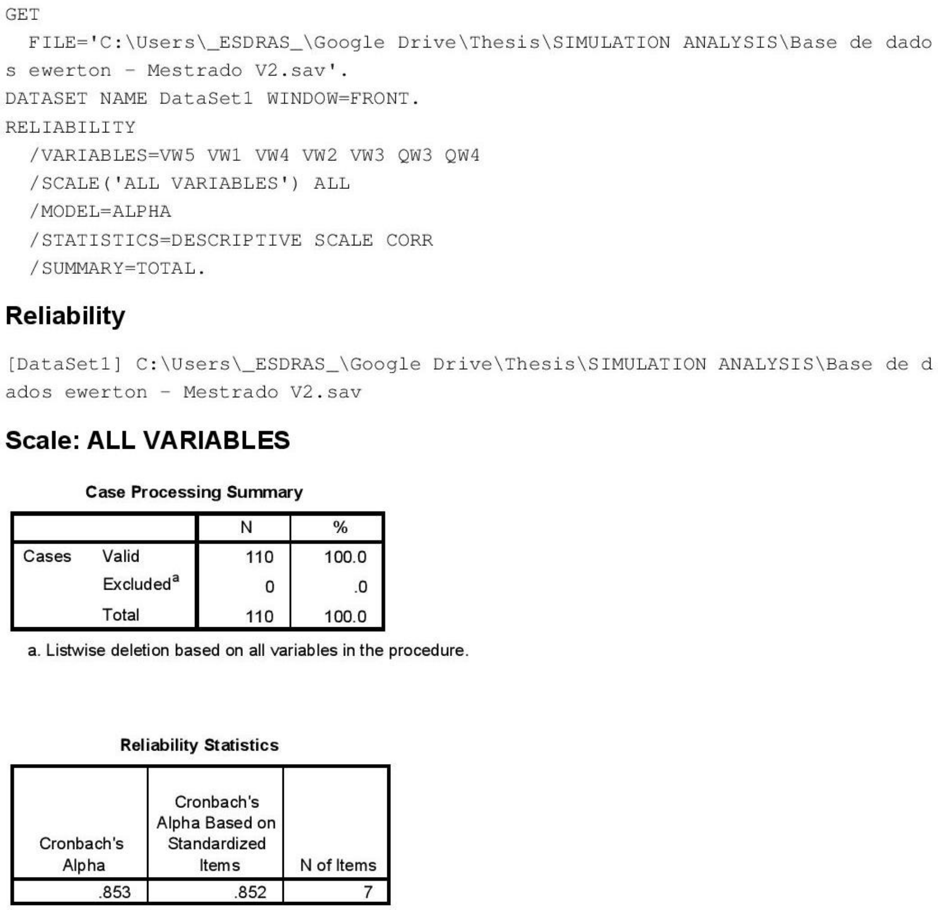


Component Transformation Matrix

Component	1	2	3	4	5	6	7
1	.594	.456	.406	.434	-.180	.221	-.069
2	-.323	.762	.087	-.109	.442	-.309	-.063
3	.409	.233	-.726	.001	.101	-.015	.490
4	-.036	-.206	.088	.247	.765	.537	.117
5	.520	-.212	.397	-.516	.314	-.361	.181
6	-.302	.139	.345	-.190	-.270	.282	.763
7	-.112	-.223	.126	.661	.073	-.598	.350

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Appendix K: Batch Size Simulation Factors Reliability SPSS Output



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GET
  FILE='C:\Users\_ESDRAS_\Google Drive\Thesis\SIMULATION ANALYSIS\Base de dado
s ewerton - Mestrado V2.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
RELIABILITY
  /VARIABLES=VW5 VW1 VW4 VW2 VW3 QW3 QW4
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL.
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Reliability

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[DataSet1] C:\Users\_ESDRAS_\Google Drive\Thesis\SIMULATION ANALYSIS\Base de d
ados ewerton - Mestrado V2.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	110	100.0
	Excluded[a]	0	.0
	Total	110	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.853	.852	7

Item Statistics

	Mean	Std. Deviation	N
VW5	2.7000	1.39823	110
VW1	3.2545	1.39748	110
VW4	2.9727	1.28833	110
VW2	2.9818	1.42057	110
VW3	2.8182	1.37595	110
QW3	2.9909	1.18473	110
QW4	3.4727	1.18638	110

Inter-Item Correlation Matrix

	VW5	VW1	VW4	VW2	VW3	QW3	QW4
VW5	1.000	.561	.596	.607	.467	.591	.346
VW1	.561	1.000	.478	.746	.363	.483	.347
VW4	.596	.478	1.000	.476	.453	.379	.327
VW2	.607	.746	.476	1.000	.383	.512	.272
VW3	.467	.363	.453	.383	1.000	.258	.306
QW3	.591	.483	.379	.512	.258	1.000	.519
QW4	.346	.347	.327	.272	.306	.519	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
VW5	18.4909	32.105	.736	.586	.814
VW1	17.9364	32.739	.689	.596	.821
VW4	18.2182	34.686	.617	.424	.832
VW2	18.2091	32.442	.696	.625	.820
VW3	18.3727	35.685	.495	.299	.850
QW3	18.2000	35.574	.618	.501	.833
QW4	17.7182	37.635	.458	.326	.853

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
21.1909	45.716	6.76132	7

```
RELIABILITY
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  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
```

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 /SUMMARY=TOTAL.
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Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	110	100.0
	Excluded[a]	0	.0
	Total	110	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.856	.855	9

Item Statistics

	Mean	Std. Deviation	N
SRC7	2.4995	1.53136	110
SRC6	2.3627	1.53705	110
SRC5	2.3497	1.49579	110
SRC4	2.8829	1.51283	110
SRC3	1.9790	1.46851	110
SRC2	2.7200	1.59899	110
SRC1	2.5380	1.55486	110
QW6	2.7636	1.11641	110
SRC8	2.0121	1.40798	110

Inter-Item Correlation Matrix

	SRC7	SRC6	SRC5	SRC4	SRC3	SRC2	SRC1	QW6	SRC8
SRC7	1.000	.662	.601	.336	.486	.536	.429	.438	.403
SRC6	.662	1.000	.715	.369	.571	.450	.459	.455	.215
SRC5	.601	.715	1.000	.387	.563	.520	.458	.415	.325
SRC4	.336	.369	.387	1.000	.393	.304	.233	.369	-.058
SRC3	.486	.571	.563	.393	1.000	.368	.479	.353	.212
SRC2	.536	.450	.520	.304	.368	1.000	.354	.349	.296
SRC1	.429	.459	.458	.233	.479	.354	1.000	.409	.294
QW6	.438	.455	.415	.369	.353	.349	.409	1.000	.114
SRC8	.403	.215	.325	-.058	.212	.296	.294	.114	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SRC7	19.6081	61.993	.726	.576	.825
SRC6	19.7448	61.892	.728	.635	.825
SRC5	19.7578	61.973	.749	.610	.823
SRC4	19.2246	69.230	.410	.289	.857
SRC3	20.1285	64.760	.632	.441	.835
SRC2	19.3875	64.429	.579	.367	.841
SRC1	19.5695	65.312	.562	.353	.842
QW6	19.3439	70.732	.526	.319	.846
SRC8	20.0955	72.221	.320	.274	.864

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
22.1075	81.850	9.04708	9

```
RELIABILITY
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  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	110	100.0
	Excluded[a]	0	.0
	Total	110	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.934	.933	4

Item Statistics

	Mean	Std. Deviation	N
RP1	3.7636	1.36084	110
RP2	3.3818	1.47755	110
RP3	3.3909	1.42774	110
RP4	3.5000	1.42552	110

Inter-Item Correlation Matrix

	RP1	RP2	RP3	RP4
RP1	1.000	.684	.662	.728
RP2	.684	1.000	.859	.832
RP3	.662	.859	1.000	.899
RP4	.728	.832	.899	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RP1	10.2727	17.044	.725	.553	.950
RP2	10.6545	14.980	.864	.768	.907
RP3	10.6455	15.148	.887	.850	.899
RP4	10.5364	15.022	.904	.845	.894

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
14.0364	27.045	5.20044	4

```
RELIABILITY
  /VARIABLES=SMD2r SMD1r VW7 VW6 SMDr
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	110	100.0
	Excluded[a]	0	.0
	Total	110	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.844	.846	5

Item Statistics

	Mean	Std. Deviation	N
SMD2r	2.8864	1.28668	110
SMD1r	3.5682	1.15879	110
VW7	2.8182	1.40237	110
VW6	2.7727	1.27545	110
SMDr	3.7159	1.19079	110

Inter-Item Correlation Matrix

	SMD2r	SMD1r	VW7	VW6	SMDr
SMD2r	1.000	.586	.465	.347	.486
SMD1r	.586	1.000	.459	.492	.712
VW7	.465	.459	1.000	.715	.511
VW6	.347	.492	.715	1.000	.463
SMDr	.486	.712	.511	.463	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SMD2r	12.8750	16.939	.572	.402	.833
SMD1r	12.1932	16.648	.704	.607	.799
VW7	12.9432	15.245	.679	.585	.805
VW6	12.9886	16.464	.634	.552	.816
SMDr	12.0455	16.663	.676	.551	.806

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
15.7614	24.650	4.96483	5

```
RELIABILITY
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  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	110	100.0
	Excluded[a]	0	.0
	Total	110	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.747	.752	5

Item Statistics

	Mean	Std. Deviation	N
SRA2r	2.0443	1.48955	110
SRA4r	1.4395	1.16309	110
SRA3r	2.1683	1.37988	110
SRA1r	2.4474	1.45129	110
SRA5r	1.6156	1.11243	110

Inter-Item Correlation Matrix

	SRA2r	SRA4r	SRA3r	SRA1r	SRA5r
SRA2r	1.000	.478	.508	.419	.368
SRA4r	.478	1.000	.372	.307	.550
SRA3r	.508	.372	1.000	.307	.276
SRA1r	.419	.307	.307	1.000	.188
SRA5r	.368	.550	.276	.188	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SRA2r	7.6708	12.936	.633	.409	.653
SRA4r	8.2755	15.272	.584	.410	.681
SRA3r	7.5468	14.671	.507	.288	.705
SRA1r	7.2677	15.140	.415	.199	.742
SRA5r	8.0995	16.598	.452	.319	.724

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
9.7151	21.932	4.68320	5

```
RELIABILITY
  /VARIABLES=SMD4 SMD5
  /SCALE('ALL VARIABLES') ALL
```

```
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE SCALE CORR
/SUMMARY=TOTAL.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	110	100.0
	Excluded[a]	0	.0
	Total	110	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.740	.740	2

Item Statistics

	Mean	Std. Deviation	N
SMD4	2.6705	1.30583	110
SMD5	3.1250	1.29782	110

Inter-Item Correlation Matrix

	SMD4	SMD5
SMD4	1.000	.588
SMD5	.588	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
SMD4	3.1250	1.684	.588	.346	.
SMD5	2.6705	1.705	.588	.346	.

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
5.7955	5.382	2.31993	2

```
RELIABILITY
  /VARIABLES=QW5r QW7r QW2r
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE CORR
  /SUMMARY=TOTAL.
```

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	110	100.0
	Excluded[a]	0	.0
	Total	110	100.0

a. Listwise deletion based on all variables in the procedure.

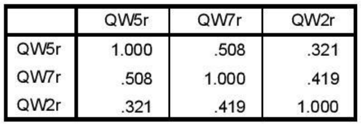
Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.683	.681	3

Item Statistics

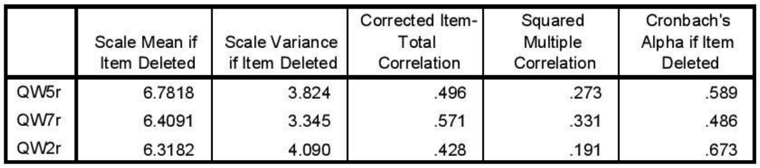
	Mean	Std. Deviation	N
QW5r	2.9727	1.12893	110
QW7r	3.3455	1.19967	110
QW2r	3.4364	1.12133	110

Inter-Item Correlation Matrix



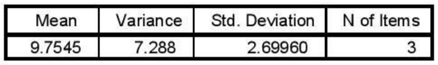
	QW5r	QW7r	QW2r
QW5r	1.000	.508	.321
QW7r	.508	1.000	.419
QW2r	.321	.419	1.000

Item-Total Statistics



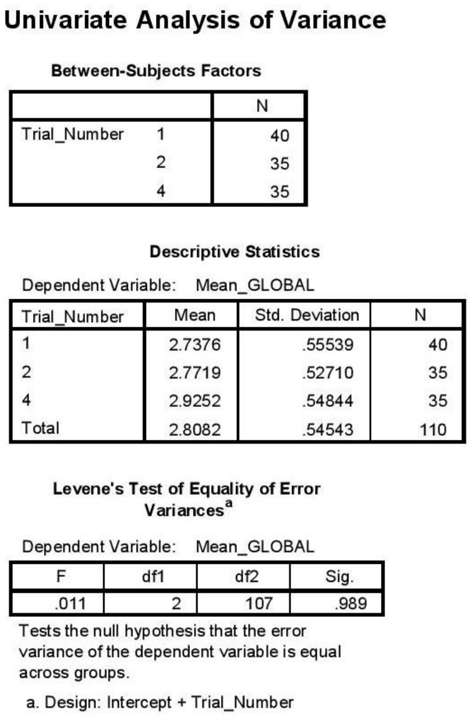
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
QW5r	6.7818	3.824	.496	.273	.589
QW7r	6.4091	3.345	.571	.331	.486
QW2r	6.3182	4.090	.428	.191	.673

Scale Statistics



Mean	Variance	Std. Deviation	N of Items
9.7545	7.288	2.69960	3

Appendix L: Hypothesis 1 SPSS Output



Univariate Analysis of Variance

Between-Subjects Factors

		N
Trial_Number	1	40
	2	35
	4	35

Descriptive Statistics

Dependent Variable: Mean_GLOBAL

Trial_Number	Mean	Std. Deviation	N
1	2.7376	.55539	40
2	2.7719	.52710	35
4	2.9252	.54844	35
Total	2.8082	.54543	110

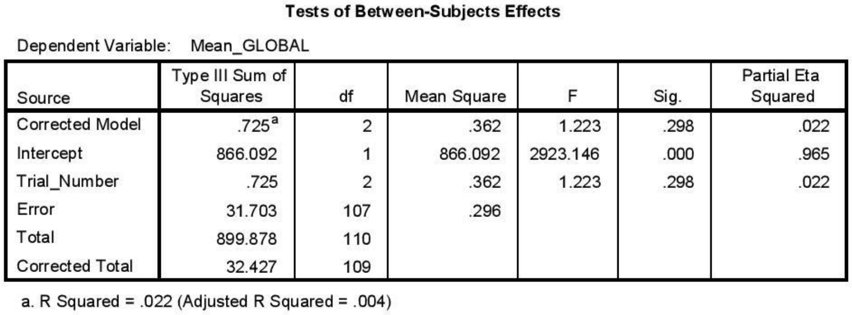
Levene's Test of Equality of Error Variances[a]

Dependent Variable: Mean_GLOBAL

F	df1	df2	Sig.
.011	2	107	.989

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Trial_Number



Tests of Between-Subjects Effects

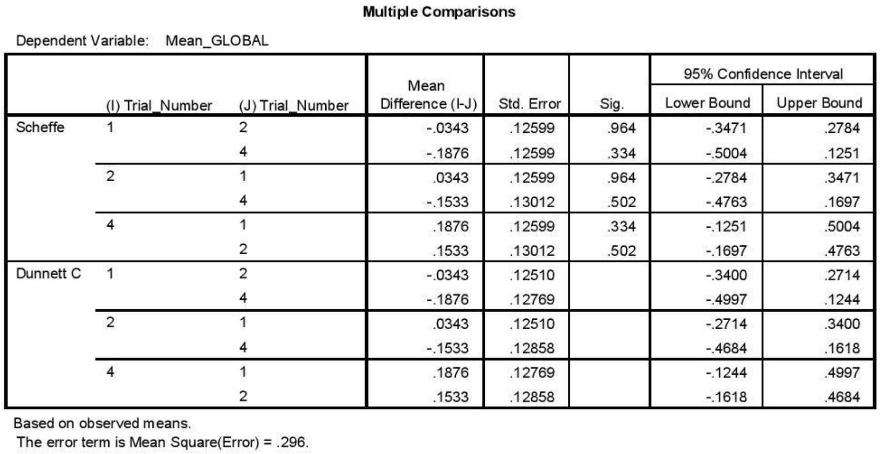
Dependent Variable: Mean_GLOBAL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.725[a]	2	.362	1.223	.298	.022
Intercept	866.092	1	866.092	2923.146	.000	.965
Trial_Number	.725	2	.362	1.223	.298	.022
Error	31.703	107	.296			
Total	899.878	110				
Corrected Total	32.427	109				

a. R Squared = .022 (Adjusted R Squared = .004)

Post Hoc Tests

Trial_Number



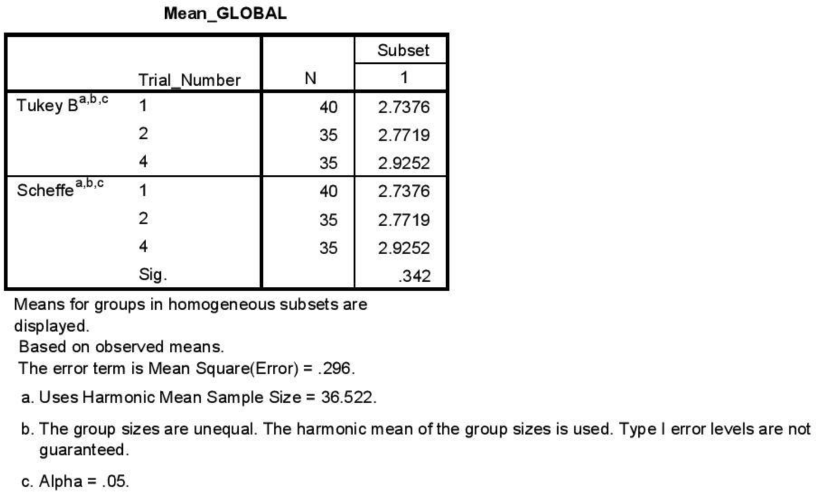
Multiple Comparisons

Dependent Variable: Mean_GLOBAL

	(I) Trial_Number	(J) Trial_Number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Scheffe	1	2	-.0343	.12599	.964	-.3471	.2784
		4	-.1876	.12599	.334	-.5004	.1251
	2	1	.0343	.12599	.964	-.2784	.3471
		4	-.1533	.13012	.502	-.4763	.1697
	4	1	.1876	.12599	.334	-.1251	.5004
		2	.1533	.13012	.502	-.1697	.4763
Dunnett C	1	2	-.0343	.12510		-.3400	.2714
		4	-.1876	.12769		-.4997	.1244
	2	1	.0343	.12510		-.2714	.3400
		4	-.1533	.12858		-.4684	.1618
	4	1	.1876	.12769		-.1244	.4997
		2	.1533	.12858		-.1618	.4684

Based on observed means.
The error term is Mean Square(Error) = .296.

Homogeneous Subsets



Mean_GLOBAL

			Subset
	Trial_Number	N	1
Tukey B[a,b,c]	1	40	2.7376
	2	35	2.7719
	4	35	2.9252
Scheffe[a,b,c]	1	40	2.7376
	2	35	2.7719
	4	35	2.9252
	Sig.		.342

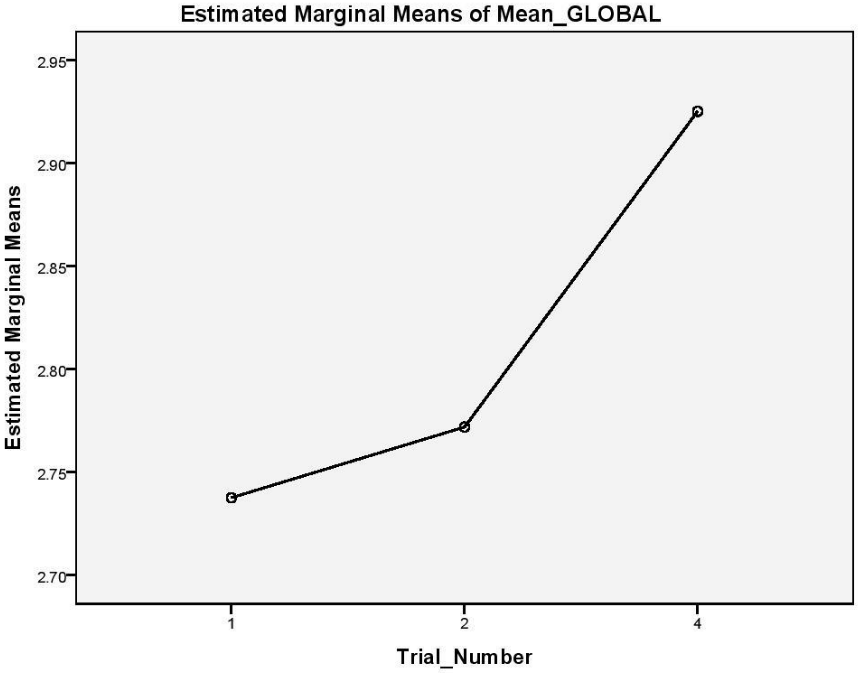
Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .296.

a. Uses Harmonic Mean Sample Size = 36.522.

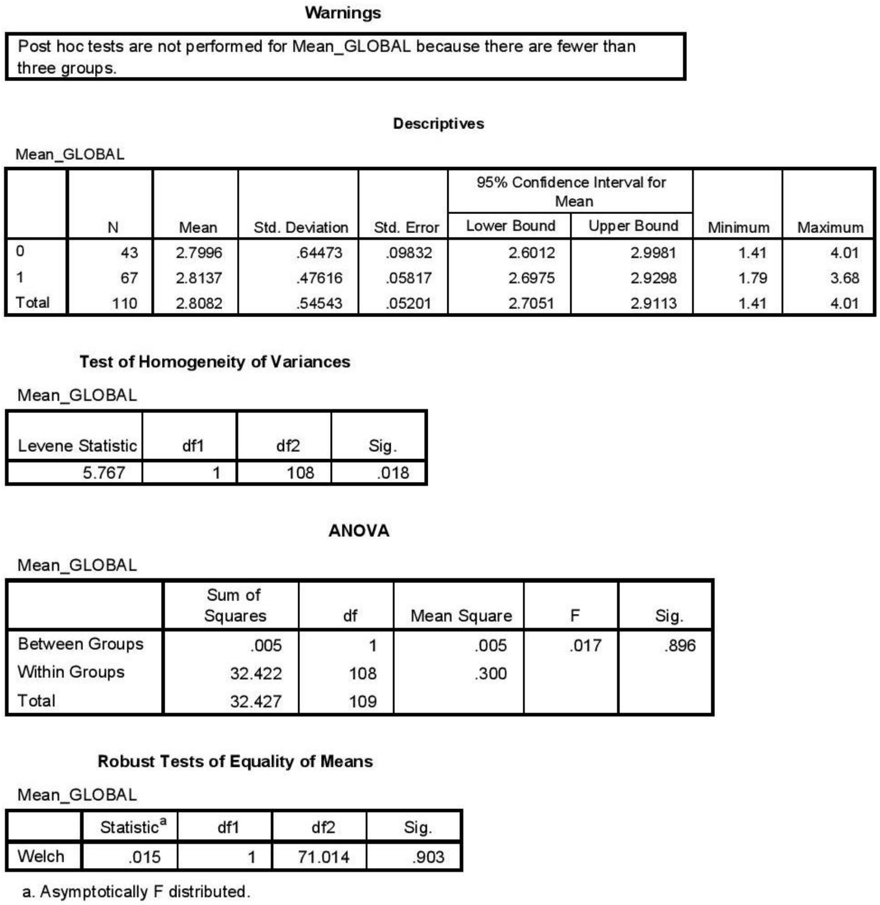
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

Profile Plots


Estimated Marginal Means of Mean_GLOBAL
Estimated Marginal Means
2.95
2.90
2.85
2.80
2.75
2.70
1
2
4
Trial_Number

Appendix M: Hypothesis 2 SPSS Output



Warnings

Post hoc tests are not performed for Mean_GLOBAL because there are fewer than three groups.

Descriptives

Mean_GLOBAL

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	43	2.7996	.64473	.09832	2.6012	2.9981	1.41	4.01
1	67	2.8137	.47616	.05817	2.6975	2.9298	1.79	3.68
Total	110	2.8082	.54543	.05201	2.7051	2.9113	1.41	4.01

Test of Homogeneity of Variances

Mean_GLOBAL

Levene Statistic	df1	df2	Sig.
5.767	1	108	.018

ANOVA

Mean_GLOBAL

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.005	1	.005	.017	.896
Within Groups	32.422	108	.300		
Total	32.427	109			

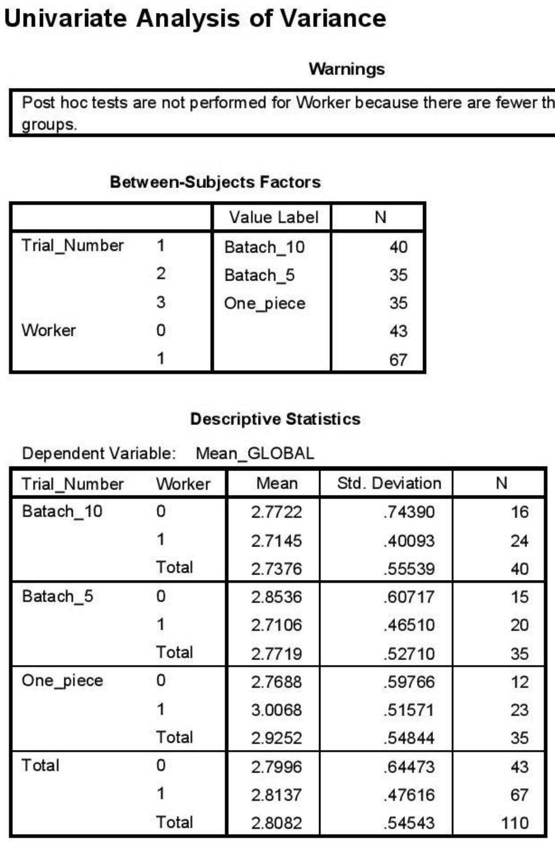
Robust Tests of Equality of Means

Mean_GLOBAL

	Statistic[a]	df1	df2	Sig.
Welch	.015	1	71.014	.903

a. Asymptotically F distributed.

Appendix N: Hypothesis 3 SPSS Output



Univariate Analysis of Variance

Warnings

Post hoc tests are not performed for Worker because there are fewer than three groups.

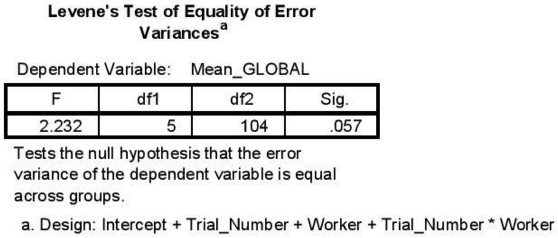
Between-Subjects Factors

		Value Label	N
Trial_Number	1	Batach_10	40
	2	Batach_5	35
	3	One_piece	35
Worker	0		43
	1		67

Descriptive Statistics

Dependent Variable: Mean_GLOBAL

Trial_Number	Worker	Mean	Std. Deviation	N
Batach_10	0	2.7722	.74390	16
	1	2.7145	.40093	24
	Total	2.7376	.55539	40
Batach_5	0	2.8536	.60717	15
	1	2.7106	.46510	20
	Total	2.7719	.52710	35
One_piece	0	2.7688	.59766	12
	1	3.0068	.51571	23
	Total	2.9252	.54844	35
Total	0	2.7996	.64473	43
	1	2.8137	.47616	67
	Total	2.8082	.54543	110



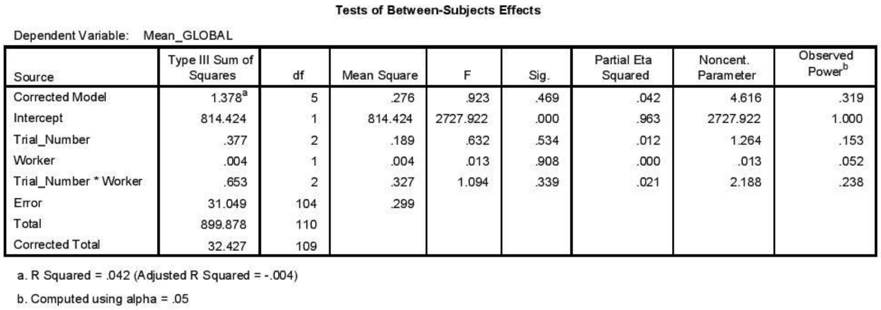
Levene's Test of Equality of Error Variances^{a}

Dependent Variable: Mean_GLOBAL

F	df1	df2	Sig.
2.232	5	104	.057

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Trial_Number + Worker + Trial_Number * Worker



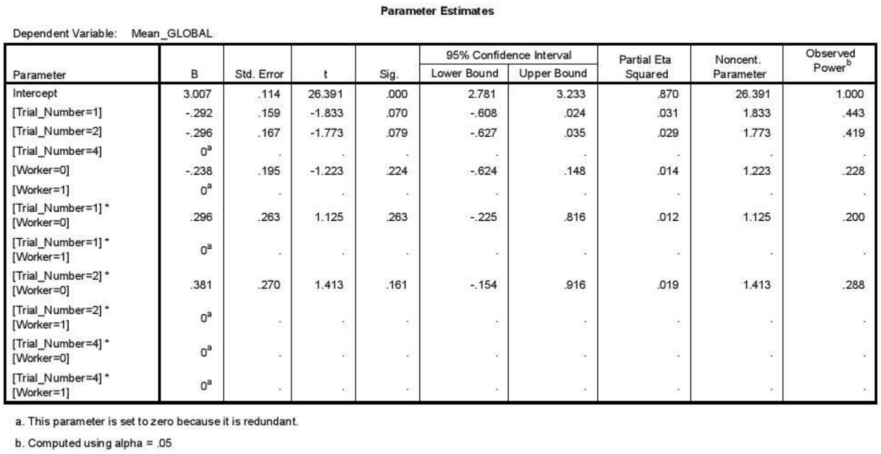
Tests of Between-Subjects Effects

Dependent Variable: Mean_GLOBAL

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power^{b}
Corrected Model	1.378^{a}	5	.276	.923	.469	.042	4.616	.319
Intercept	814.424	1	814.424	2727.922	.000	.963	2727.922	1.000
Trial_Number	.377	2	.189	.632	.534	.012	1.264	.153
Worker	.004	1	.004	.013	.908	.000	.013	.052
Trial_Number * Worker	.653	2	.327	1.094	.339	.021	2.188	.238
Error	31.049	104	.299					
Total	899.878	110						
Corrected Total	32.427	109						

a. R Squared = .042 (Adjusted R Squared = -.004)

b. Computed using alpha = .05



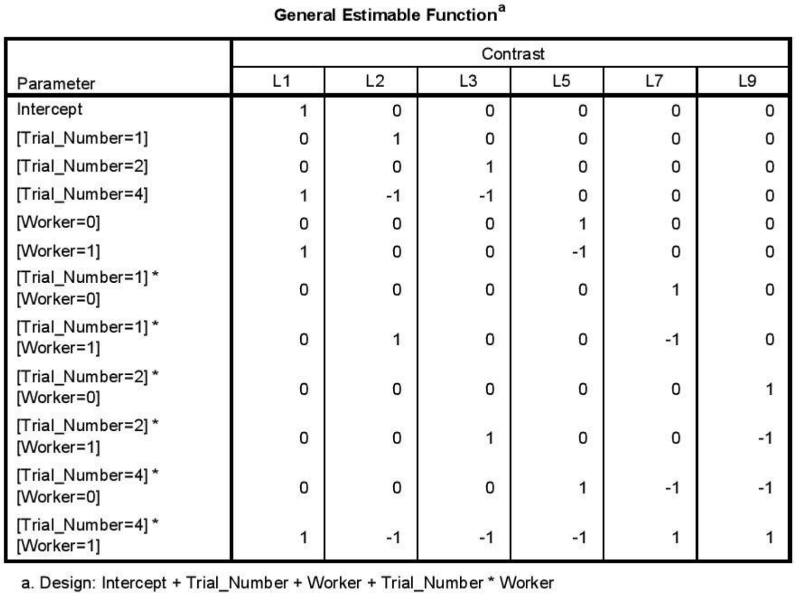
Parameter Estimates

Dependent Variable: Mean_GLOBAL

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
					Lower Bound	Upper Bound			
Intercept	3.007	.114	26.391	.000	2.781	3.233	.870	26.391	1.000
[Trial_Number=1]	-.292	.159	-1.833	.070	-.608	.024	.031	1.833	.443
[Trial_Number=2]	-.296	.167	-1.773	.079	-.627	.035	.029	1.773	.419
[Trial_Number=4]	0[a]	.	.	.	.	.	.	.	.
[Worker=0]	-.238	.195	-1.223	.224	-.624	.148	.014	1.223	.228
[Worker=1]	0[a]	.	.	.	.	.	.	.	.
[Trial_Number=1] * [Worker=0]	.296	.263	1.125	.263	-.225	.816	.012	1.125	.200
[Trial_Number=1] * [Worker=1]	0[a]	.	.	.	.	.	.	.	.
[Trial_Number=2] * [Worker=0]	.381	.270	1.413	.161	-.154	.916	.019	1.413	.288
[Trial_Number=2] * [Worker=1]	0[a]	.	.	.	.	.	.	.	.
[Trial_Number=4] * [Worker=0]	0[a]	.	.	.	.	.	.	.	.
[Trial_Number=4] * [Worker=1]	0[a]	.	.	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

b. Computed using alpha = .05

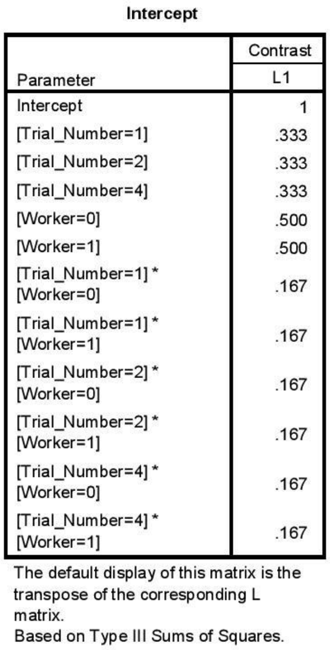


General Estimable Function[a]

Parameter	Contrast					
	L1	L2	L3	L5	L7	L9
Intercept	1	0	0	0	0	0
[Trial_Number=1]	0	1	0	0	0	0
[Trial_Number=2]	0	0	1	0	0	0
[Trial_Number=4]	1	-1	-1	0	0	0
[Worker=0]	0	0	0	1	0	0
[Worker=1]	1	0	0	-1	0	0
[Trial_Number=1] * [Worker=0]	0	0	0	0	1	0
[Trial_Number=1] * [Worker=1]	0	1	0	0	-1	0
[Trial_Number=2] * [Worker=0]	0	0	0	0	0	1
[Trial_Number=2] * [Worker=1]	0	0	1	0	0	-1
[Trial_Number=4] * [Worker=0]	0	0	0	1	-1	-1
[Trial_Number=4] * [Worker=1]	1	-1	-1	-1	1	1

a. Design: Intercept + Trial_Number + Worker + Trial_Number * Worker

Contrast Coefficients (L' Matrix)

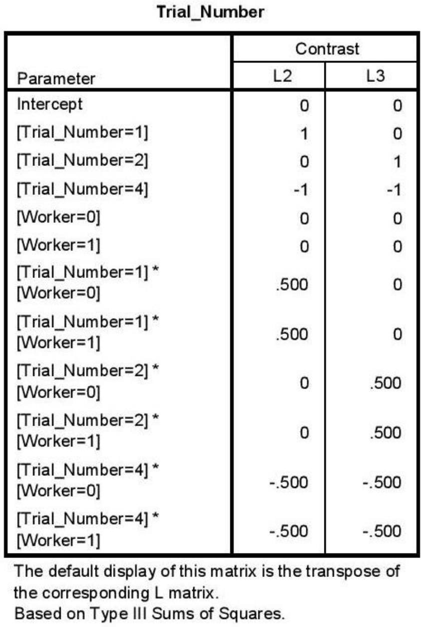


Intercept

Parameter	Contrast L1
Intercept	1
[Trial_Number=1]	.333
[Trial_Number=2]	.333
[Trial_Number=4]	.333
[Worker=0]	.500
[Worker=1]	.500
[Trial_Number=1] * [Worker=0]	.167
[Trial_Number=1] * [Worker=1]	.167
[Trial_Number=2] * [Worker=0]	.167
[Trial_Number=2] * [Worker=1]	.167
[Trial_Number=4] * [Worker=0]	.167
[Trial_Number=4] * [Worker=1]	.167

The default display of this matrix is the transpose of the corresponding L matrix.

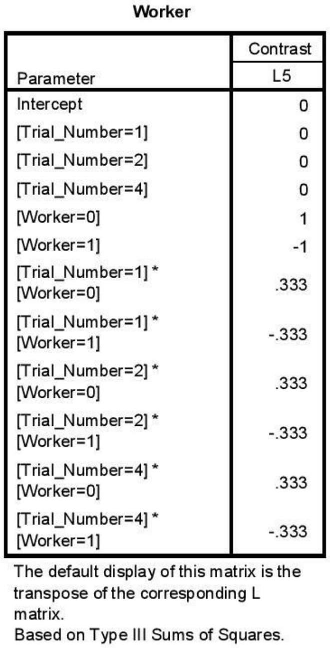
Based on Type III Sums of Squares.



Trial_Number

Parameter	Contrast	
	L2	L3
Intercept	0	0
[Trial_Number=1]	1	0
[Trial_Number=2]	0	1
[Trial_Number=4]	-1	-1
[Worker=0]	0	0
[Worker=1]	0	0
[Trial_Number=1] * [Worker=0]	.500	0
[Trial_Number=1] * [Worker=1]	.500	0
[Trial_Number=2] * [Worker=0]	0	.500
[Trial_Number=2] * [Worker=1]	0	.500
[Trial_Number=4] * [Worker=0]	-.500	-.500
[Trial_Number=4] * [Worker=1]	-.500	-.500

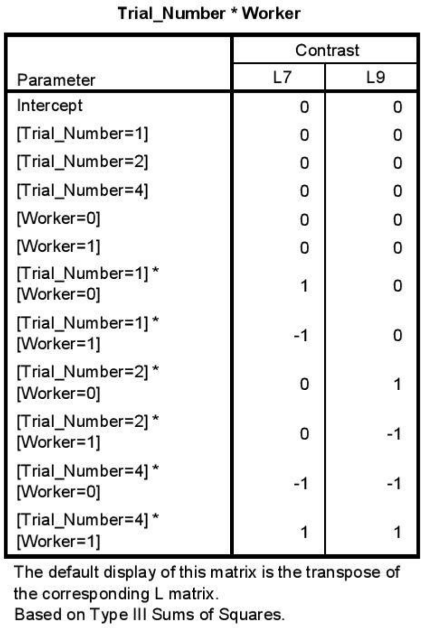
The default display of this matrix is the transpose of the corresponding L matrix.
Based on Type III Sums of Squares.



Worker

Parameter	Contrast
	L5
Intercept	0
[Trial_Number=1]	0
[Trial_Number=2]	0
[Trial_Number=4]	0
[Worker=0]	1
[Worker=1]	-1
[Trial_Number=1] * [Worker=0]	.333
[Trial_Number=1] * [Worker=1]	-.333
[Trial_Number=2] * [Worker=0]	.333
[Trial_Number=2] * [Worker=1]	-.333
[Trial_Number=4] * [Worker=0]	.333
[Trial_Number=4] * [Worker=1]	-.333

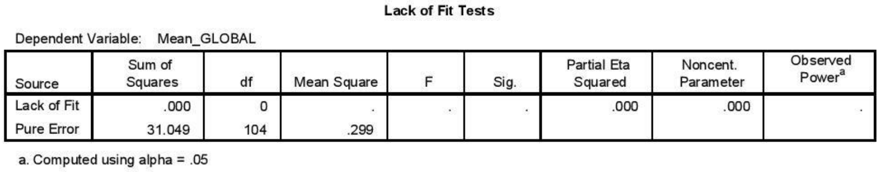
The default display of this matrix is the transpose of the corresponding L matrix.
Based on Type III Sums of Squares.



Trial_Number * Worker

Parameter	Contrast L7	Contrast L9
Intercept	0	0
[Trial_Number=1]	0	0
[Trial_Number=2]	0	0
[Trial_Number=4]	0	0
[Worker=0]	0	0
[Worker=1]	0	0
[Trial_Number=1] * [Worker=0]	1	0
[Trial_Number=1] * [Worker=1]	-1	0
[Trial_Number=2] * [Worker=0]	0	1
[Trial_Number=2] * [Worker=1]	0	-1
[Trial_Number=4] * [Worker=0]	-1	-1
[Trial_Number=4] * [Worker=1]	1	1

The default display of this matrix is the transpose of the corresponding L matrix.
Based on Type III Sums of Squares.



Lack of Fit Tests

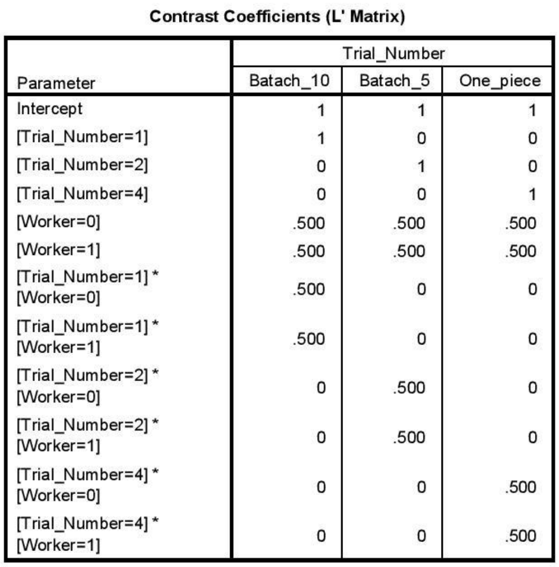
Dependent Variable: Mean_GLOBAL

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Lack of Fit	.000	0	.	.	.	.000	.000	.
Pure Error	31.049	104	.299					

a. Computed using alpha = .05

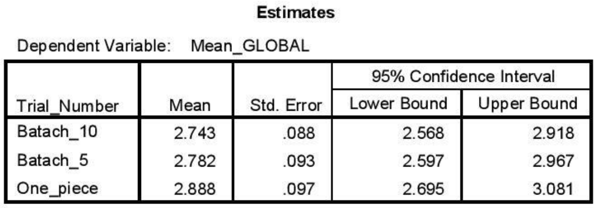
Estimated Marginal Means

1. Trial_Number



Contrast Coefficients (L' Matrix)

Parameter	Trial_Number		
	Batach_10	Batach_5	One_piece
Intercept	1	1	1
[Trial_Number=1]	1	0	0
[Trial_Number=2]	0	1	0
[Trial_Number=4]	0	0	1
[Worker=0]	.500	.500	.500
[Worker=1]	.500	.500	.500
[Trial_Number=1] * [Worker=0]	.500	0	0
[Trial_Number=1] * [Worker=1]	.500	0	0
[Trial_Number=2] * [Worker=0]	0	.500	0
[Trial_Number=2] * [Worker=1]	0	.500	0
[Trial_Number=4] * [Worker=0]	0	0	.500
[Trial_Number=4] * [Worker=1]	0	0	.500



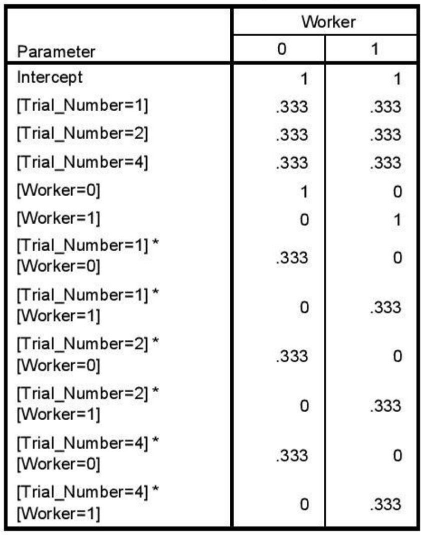
Estimates

Dependent Variable: Mean_GLOBAL

Trial_Number	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Batach_10	2.743	.088	2.568	2.918
Batach_5	2.782	.093	2.597	2.967
One_piece	2.888	.097	2.695	3.081

2. Worker

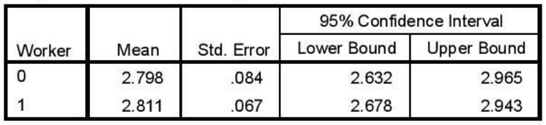
Contrast Coefficients (L' Matrix)



Parameter	Worker	
	0	1
Intercept	1	1
[Trial_Number=1]	.333	.333
[Trial_Number=2]	.333	.333
[Trial_Number=4]	.333	.333
[Worker=0]	1	0
[Worker=1]	0	1
[Trial_Number=1] * [Worker=0]	.333	0
[Trial_Number=1] * [Worker=1]	0	.333
[Trial_Number=2] * [Worker=0]	.333	0
[Trial_Number=2] * [Worker=1]	0	.333
[Trial_Number=4] * [Worker=0]	.333	0
[Trial_Number=4] * [Worker=1]	0	.333

Estimates

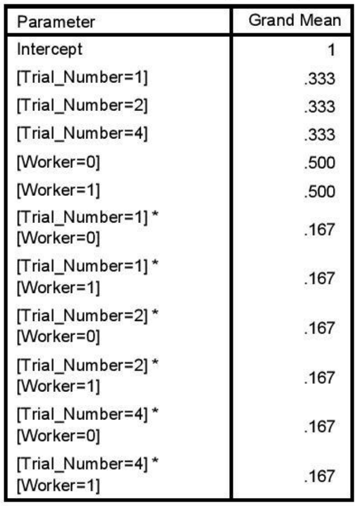
Dependent Variable: Mean_GLOBAL



Worker	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
0	2.798	.084	2.632	2.965
1	2.811	.067	2.678	2.943

3. Grand Mean

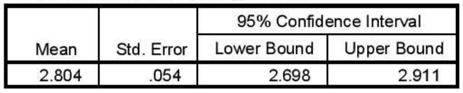
Contrast Coefficients (L' Matrix)



Parameter	Grand Mean
Intercept	1
[Trial_Number=1]	.333
[Trial_Number=2]	.333
[Trial_Number=4]	.333
[Worker=0]	.500
[Worker=1]	.500
[Trial_Number=1] * [Worker=0]	.167
[Trial_Number=1] * [Worker=1]	.167
[Trial_Number=2] * [Worker=0]	.167
[Trial_Number=2] * [Worker=1]	.167
[Trial_Number=4] * [Worker=0]	.167
[Trial_Number=4] * [Worker=1]	.167

Estimates

Dependent Variable: Mean_GLOBAL



Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
2.804	.054	2.698	2.911

Post Hoc Tests

Trial_Number

Multiple Comparisons

Dependent Variable: Mean_GLOBAL

	(I) Trial_Number	(J) Trial_Number	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	Batach_10	Batach_5	-.0343	.12647	.960	-.3350	.2664
		One_piece	-.1876	.12647	.303	-.4883	.1131
	Batach_5	Batach_10	.0343	.12647	.960	-.2664	.3350
		One_piece	-.1533	.13061	.471	-.4639	.1573
	One_piece	Batach_10	.1876	.12647	.303	-.1131	.4883
		Batach_5	.1533	.13061	.471	-.1573	.4639
Scheffe	Batach_10	Batach_5	-.0343	.12647	.964	-.3484	.2798
		One_piece	-.1876	.12647	.337	-.5017	.1265
	Batach_5	Batach_10	.0343	.12647	.964	-.2798	.3484
		One_piece	-.1533	.13061	.504	-.4777	.1711
	One_piece	Batach_10	.1876	.12647	.337	-.1265	.5017
		Batach_5	.1533	.13061	.504	-.1711	.4777

Based on observed means.
The error term is Mean Square(Error) = .299.

Homogeneous Subsets

Mean_GLOBAL

	Trial_Number	N	Subset
			1
Tukey HSD[a,b,c]	Batach_10	40	2.7376
	Batach_5	35	2.7719
	One_piece	35	2.9252
	Sig.		.311
Tukey B[a,b,c]	Batach_10	40	2.7376
	Batach_5	35	2.7719
	One_piece	35	2.9252
Scheffe[a,b,c]	Batach_10	40	2.7376
	Batach_5	35	2.7719
	One_piece	35	2.9252
	Sig.		.345

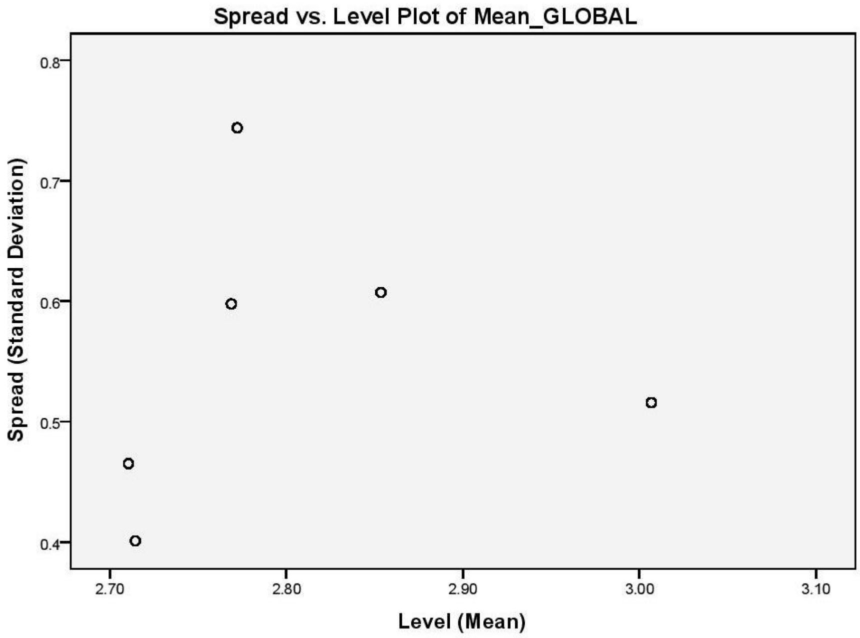
Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .299.

a. Uses Harmonic Mean Sample Size = 36.522.

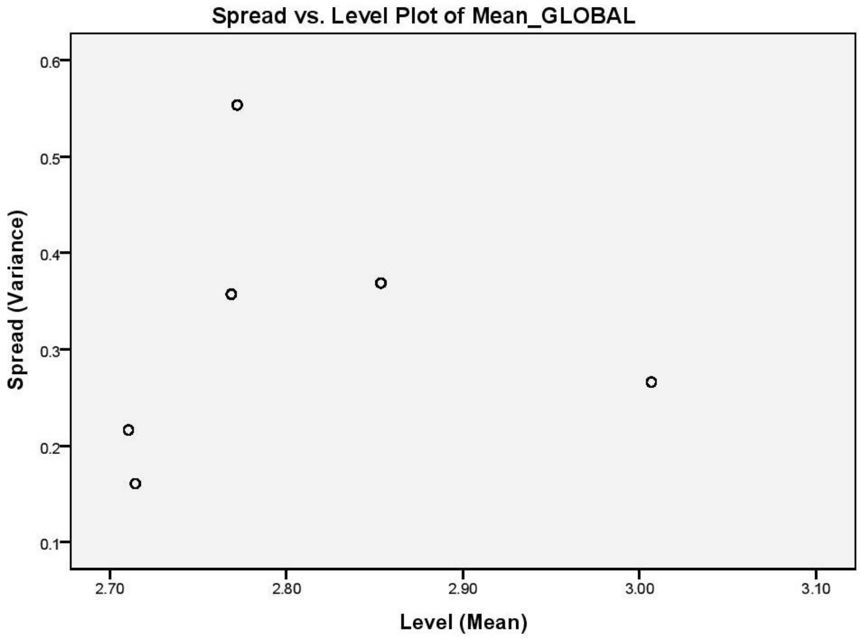
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

Spread-versus-Level Plots

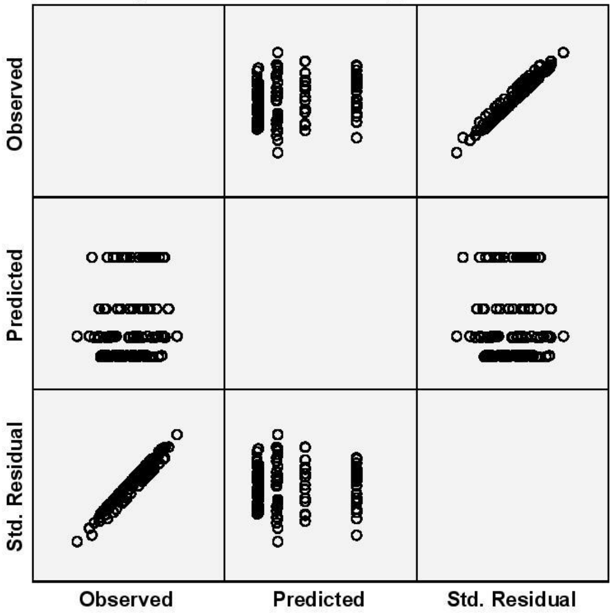


Groups: Trial_Number * Worker



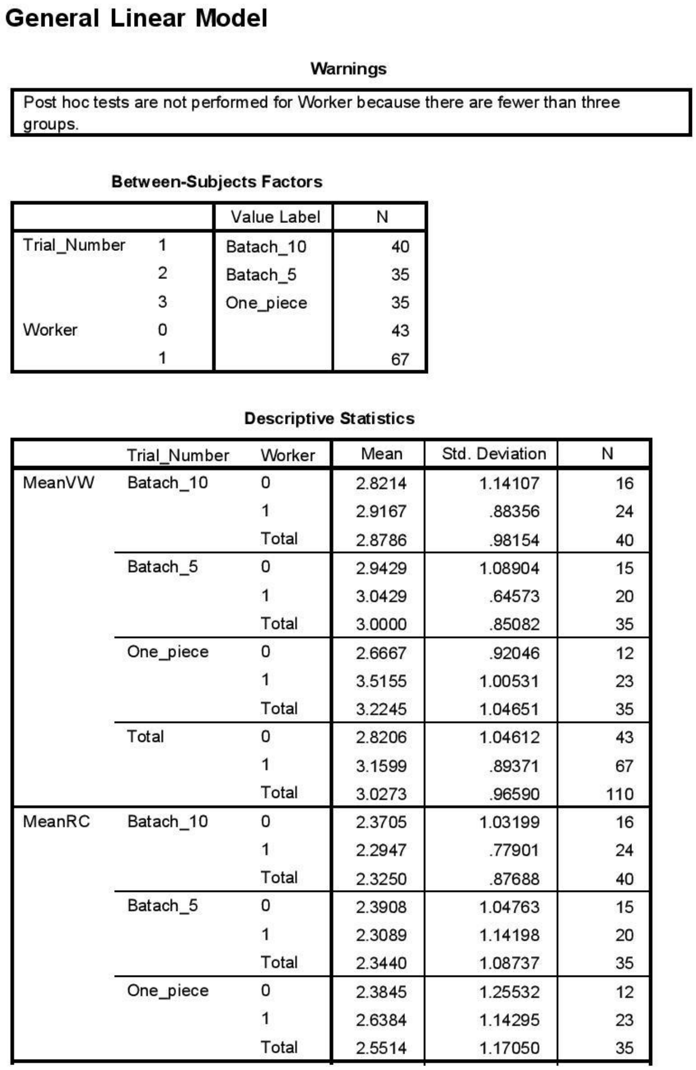
Groups: Trial_Number * Worker

Dependent Variable: Mean_GLOBAL



Model: Intercept + Trial_Number + Worker + Trial_Number * Worker

Appendix O: Hypothesis 4 SPSS Output



General Linear Model

Warnings

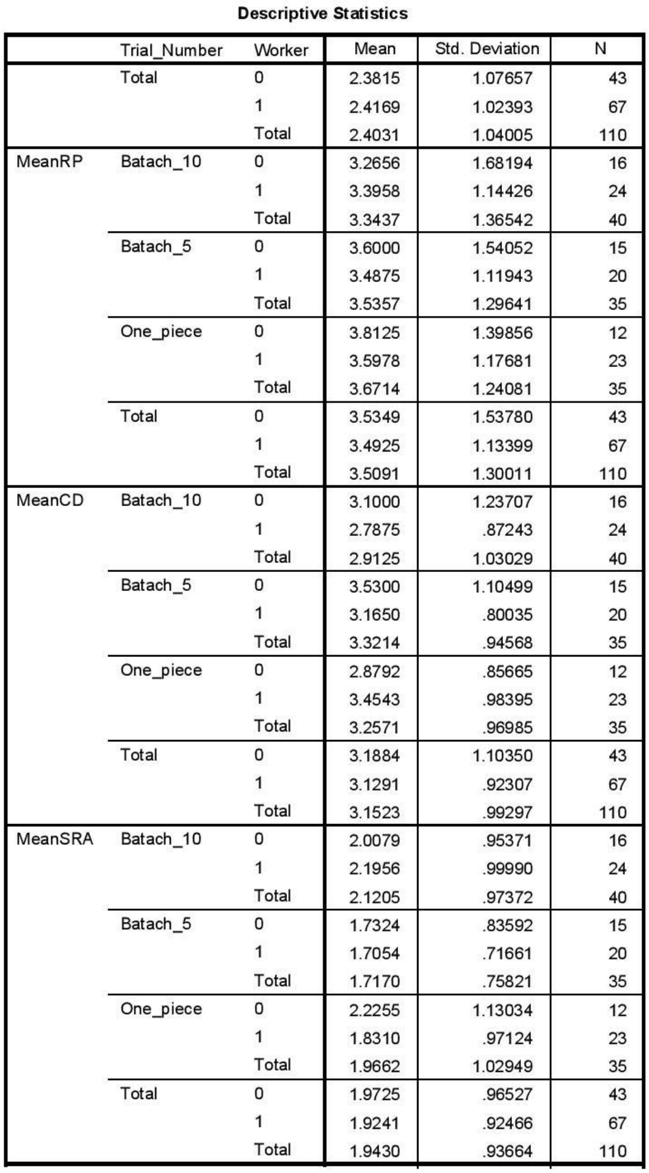
Post hoc tests are not performed for Worker because there are fewer than three groups.

Between-Subjects Factors

		Value Label	N
Trial_Number	1	Batach_10	40
	2	Batach_5	35
	3	One_piece	35
Worker	0		43
	1		67

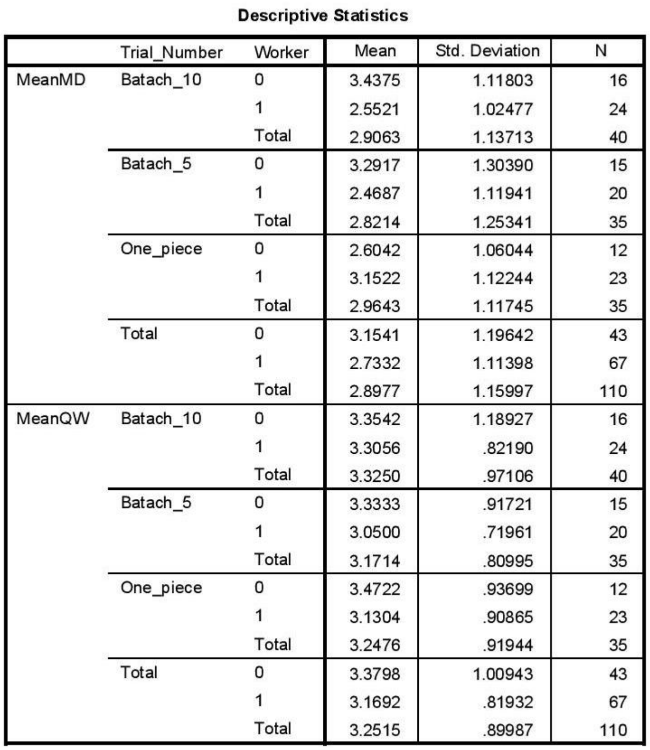
Descriptive Statistics

	Trial_Number	Worker	Mean	Std. Deviation	N
MeanVW	Batach_10	0	2.8214	1.14107	16
		1	2.9167	.88356	24
		Total	2.8786	.98154	40
	Batach_5	0	2.9429	1.08904	15
		1	3.0429	.64573	20
		Total	3.0000	.85082	35
	One_piece	0	2.6667	.92046	12
		1	3.5155	1.00531	23
		Total	3.2245	1.04651	35
	Total	0	2.8206	1.04612	43
		1	3.1599	.89371	67
		Total	3.0273	.96590	110
MeanRC	Batach_10	0	2.3705	1.03199	16
		1	2.2947	.77901	24
		Total	2.3250	.87688	40
	Batach_5	0	2.3908	1.04763	15
		1	2.3089	1.14198	20
		Total	2.3440	1.08737	35
	One_piece	0	2.3845	1.25532	12
		1	2.6384	1.14295	23
		Total	2.5514	1.17050	35



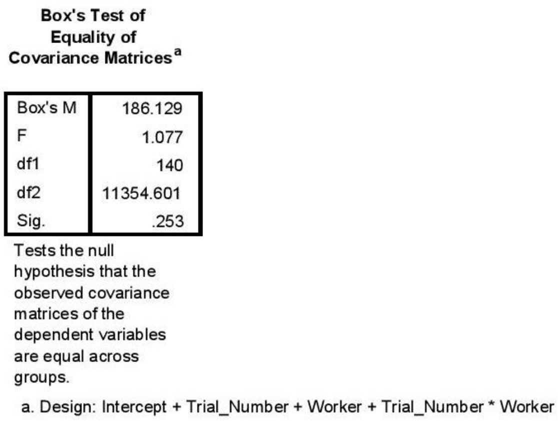
Descriptive Statistics

	Trial_Number	Worker	Mean	Std. Deviation	N
	Total	0	2.3815	1.07657	43
		1	2.4169	1.02393	67
		Total	2.4031	1.04005	110
MeanRP	Batach_10	0	3.2656	1.68194	16
		1	3.3958	1.14426	24
		Total	3.3437	1.36542	40
	Batach_5	0	3.6000	1.54052	15
		1	3.4875	1.11943	20
		Total	3.5357	1.29641	35
	One_piece	0	3.8125	1.39856	12
		1	3.5978	1.17681	23
		Total	3.6714	1.24081	35
	Total	0	3.5349	1.53780	43
		1	3.4925	1.13399	67
		Total	3.5091	1.30011	110
MeanCD	Batach_10	0	3.1000	1.23707	16
		1	2.7875	.87243	24
		Total	2.9125	1.03029	40
	Batach_5	0	3.5300	1.10499	15
		1	3.1650	.80035	20
		Total	3.3214	.94568	35
	One_piece	0	2.8792	.85665	12
		1	3.4543	.98395	23
		Total	3.2571	.96985	35
	Total	0	3.1884	1.10350	43
		1	3.1291	.92307	67
		Total	3.1523	.99297	110
MeanSRA	Batach_10	0	2.0079	.95371	16
		1	2.1956	.99990	24
		Total	2.1205	.97372	40
	Batach_5	0	1.7324	.83592	15
		1	1.7054	.71661	20
		Total	1.7170	.75821	35
	One_piece	0	2.2255	1.13034	12
		1	1.8310	.97124	23
		Total	1.9662	1.02949	35
	Total	0	1.9725	.96527	43
		1	1.9241	.92466	67
		Total	1.9430	.93664	110



Descriptive Statistics

	Trial_Number	Worker	Mean	Std. Deviation	N
MeanMD	Batach_10	0	3.4375	1.11803	16
		1	2.5521	1.02477	24
		Total	2.9063	1.13713	40
	Batach_5	0	3.2917	1.30390	15
		1	2.4687	1.11941	20
		Total	2.8214	1.25341	35
	One_piece	0	2.6042	1.06044	12
		1	3.1522	1.12244	23
		Total	2.9643	1.11745	35
	Total	0	3.1541	1.19642	43
		1	2.7332	1.11398	67
		Total	2.8977	1.15997	110
MeanQW	Batach_10	0	3.3542	1.18927	16
		1	3.3056	.82190	24
		Total	3.3250	.97106	40
	Batach_5	0	3.3333	.91721	15
		1	3.0500	.71961	20
		Total	3.1714	.80995	35
	One_piece	0	3.4722	.93699	12
		1	3.1304	.90865	23
		Total	3.2476	.91944	35
	Total	0	3.3798	1.00943	43
		1	3.1692	.81932	67
		Total	3.2515	.89987	110

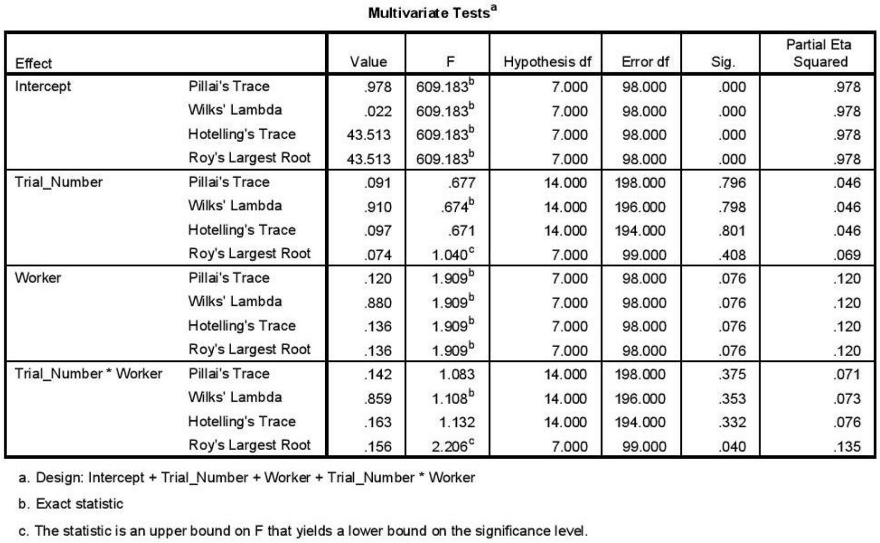


Box's Test of Equality of Covariance Matrices[a]

Box's M	186.129
F	1.077
df1	140
df2	11354.601
Sig.	.253

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Trial_Number + Worker + Trial_Number * Worker



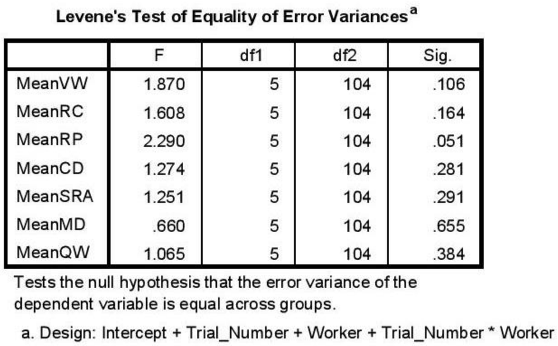
Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.978	609.183[b]	7.000	98.000	.000	.978
	Wilks' Lambda	.022	609.183[b]	7.000	98.000	.000	.978
	Hotelling's Trace	43.513	609.183[b]	7.000	98.000	.000	.978
	Roy's Largest Root	43.513	609.183[b]	7.000	98.000	.000	.978
Trial_Number	Pillai's Trace	.091	.677	14.000	198.000	.796	.046
	Wilks' Lambda	.910	.674[b]	14.000	196.000	.798	.046
	Hotelling's Trace	.097	.671	14.000	194.000	.801	.046
	Roy's Largest Root	.074	1.040[c]	7.000	99.000	.408	.069
Worker	Pillai's Trace	.120	1.909[b]	7.000	98.000	.076	.120
	Wilks' Lambda	.880	1.909[b]	7.000	98.000	.076	.120
	Hotelling's Trace	.136	1.909[b]	7.000	98.000	.076	.120
	Roy's Largest Root	.136	1.909[b]	7.000	98.000	.076	.120
Trial_Number * Worker	Pillai's Trace	.142	1.083	14.000	198.000	.375	.071
	Wilks' Lambda	.859	1.108[b]	14.000	196.000	.353	.073
	Hotelling's Trace	.163	1.132	14.000	194.000	.332	.076
	Roy's Largest Root	.156	2.206[c]	7.000	99.000	.040	.135

a. Design: Intercept + Trial_Number + Worker + Trial_Number * Worker

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

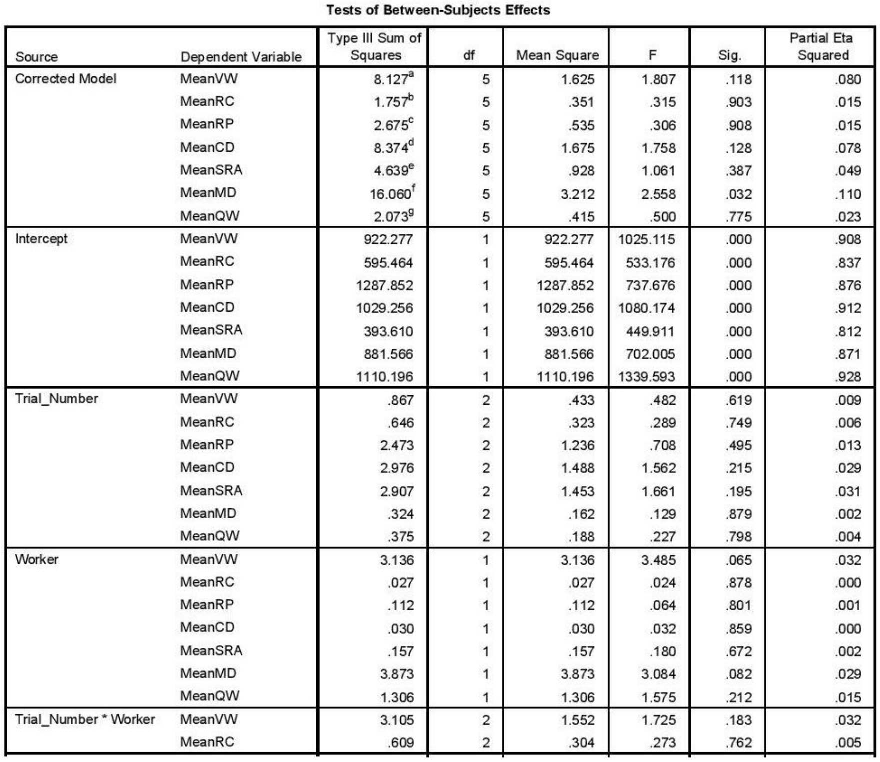


Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
MeanVW	1.870	5	104	.106
MeanRC	1.608	5	104	.164
MeanRP	2.290	5	104	.051
MeanCD	1.274	5	104	.281
MeanSRA	1.251	5	104	.291
MeanMD	.660	5	104	.655
MeanQW	1.065	5	104	.384

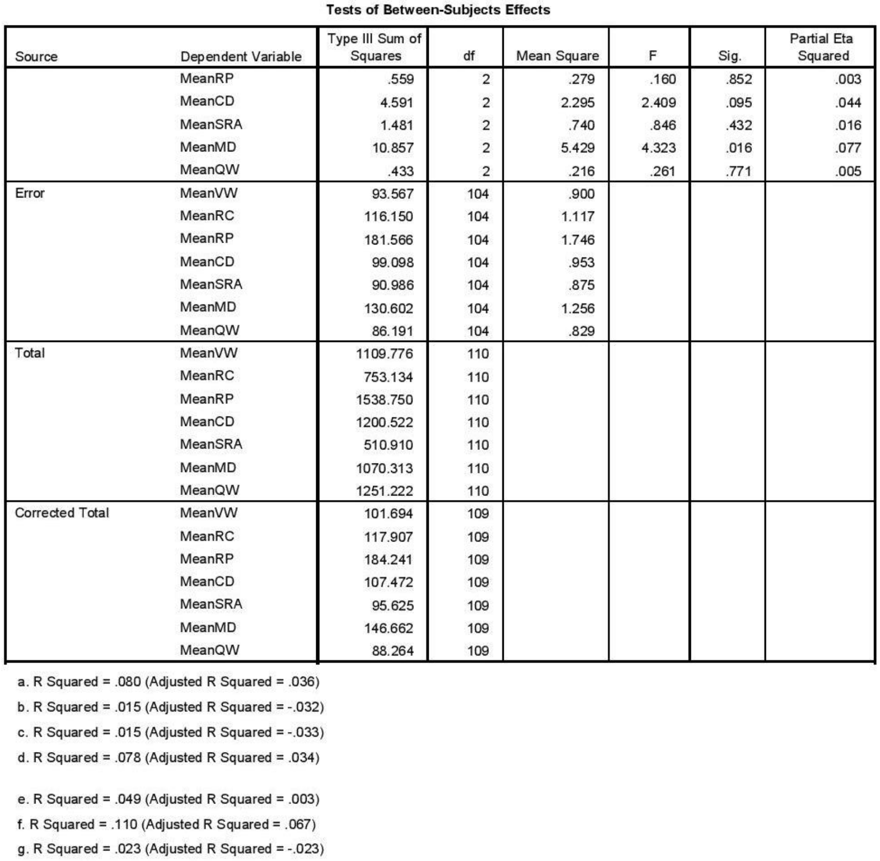
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Trial_Number + Worker + Trial_Number * Worker



Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	MeanVW	8.127[a]	5	1.625	1.807	.118	.080
	MeanRC	1.757[b]	5	.351	.315	.903	.015
	MeanRP	2.675[c]	5	.535	.306	.908	.015
	MeanCD	8.374[d]	5	1.675	1.758	.128	.078
	MeanSRA	4.639[e]	5	.928	1.061	.387	.049
	MeanMD	16.060[f]	5	3.212	2.558	.032	.110
	MeanQW	2.073[g]	5	.415	.500	.775	.023
Intercept	MeanVW	922.277	1	922.277	1025.115	.000	.908
	MeanRC	595.464	1	595.464	533.176	.000	.837
	MeanRP	1287.852	1	1287.852	737.676	.000	.876
	MeanCD	1029.256	1	1029.256	1080.174	.000	.912
	MeanSRA	393.610	1	393.610	449.911	.000	.812
	MeanMD	881.566	1	881.566	702.005	.000	.871
	MeanQW	1110.196	1	1110.196	1339.593	.000	.928
Trial_Number	MeanVW	.867	2	.433	.482	.619	.009
	MeanRC	.646	2	.323	.289	.749	.006
	MeanRP	2.473	2	1.236	.708	.495	.013
	MeanCD	2.976	2	1.488	1.562	.215	.029
	MeanSRA	2.907	2	1.453	1.661	.195	.031
	MeanMD	.324	2	.162	.129	.879	.002
	MeanQW	.375	2	.188	.227	.798	.004
Worker	MeanVW	3.136	1	3.136	3.485	.065	.032
	MeanRC	.027	1	.027	.024	.878	.000
	MeanRP	.112	1	.112	.064	.801	.001
	MeanCD	.030	1	.030	.032	.859	.000
	MeanSRA	.157	1	.157	.180	.672	.002
	MeanMD	3.873	1	3.873	3.084	.082	.029
	MeanQW	1.306	1	1.306	1.575	.212	.015
Trial_Number * Worker	MeanVW	3.105	2	1.552	1.725	.183	.032
	MeanRC	.609	2	.304	.273	.762	.005



Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
	MeanRP	.559	2	.279	.160	.852	.003
	MeanCD	4.591	2	2.295	2.409	.095	.044
	MeanSRA	1.481	2	.740	.846	.432	.016
	MeanMD	10.857	2	5.429	4.323	.016	.077
	MeanQW	.433	2	.216	.261	.771	.005
Error	MeanVW	93.567	104	.900			
	MeanRC	116.150	104	1.117			
	MeanRP	181.566	104	1.746			
	MeanCD	99.098	104	.953			
	MeanSRA	90.986	104	.875			
	MeanMD	130.602	104	1.256			
	MeanQW	86.191	104	.829			
Total	MeanVW	1109.776	110				
	MeanRC	753.134	110				
	MeanRP	1538.750	110				
	MeanCD	1200.522	110				
	MeanSRA	510.910	110				
	MeanMD	1070.313	110				
	MeanQW	1251.222	110				
Corrected Total	MeanVW	101.694	109				
	MeanRC	117.907	109				
	MeanRP	184.241	109				
	MeanCD	107.472	109				
	MeanSRA	95.625	109				
	MeanMD	146.662	109				
	MeanQW	88.264	109				

a. R Squared = .080 (Adjusted R Squared = .036)

b. R Squared = .015 (Adjusted R Squared = -.032)

c. R Squared = .015 (Adjusted R Squared = -.033)

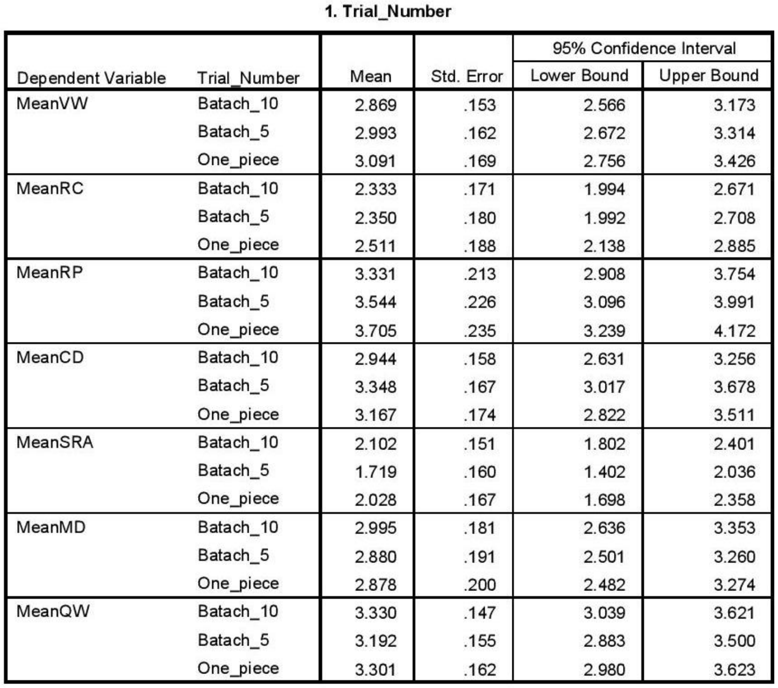
d. R Squared = .078 (Adjusted R Squared = .034)

e. R Squared = .049 (Adjusted R Squared = .003)

f. R Squared = .110 (Adjusted R Squared = .067)

g. R Squared = .023 (Adjusted R Squared = -.023)

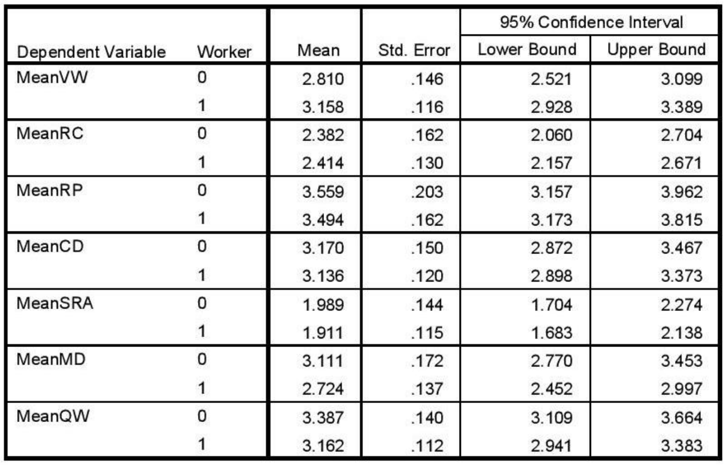
Estimated Marginal Means



1. Trial_Number

Dependent Variable	Trial_Number	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MeanVW	Batach_10	2.869	.153	2.566	3.173
	Batach_5	2.993	.162	2.672	3.314
	One_piece	3.091	.169	2.756	3.426
MeanRC	Batach_10	2.333	.171	1.994	2.671
	Batach_5	2.350	.180	1.992	2.708
	One_piece	2.511	.188	2.138	2.885
MeanRP	Batach_10	3.331	.213	2.908	3.754
	Batach_5	3.544	.226	3.096	3.991
	One_piece	3.705	.235	3.239	4.172
MeanCD	Batach_10	2.944	.158	2.631	3.256
	Batach_5	3.348	.167	3.017	3.678
	One_piece	3.167	.174	2.822	3.511
MeanSRA	Batach_10	2.102	.151	1.802	2.401
	Batach_5	1.719	.160	1.402	2.036
	One_piece	2.028	.167	1.698	2.358
MeanMD	Batach_10	2.995	.181	2.636	3.353
	Batach_5	2.880	.191	2.501	3.260
	One_piece	2.878	.200	2.482	3.274
MeanQW	Batach_10	3.330	.147	3.039	3.621
	Batach_5	3.192	.155	2.883	3.500
	One_piece	3.301	.162	2.980	3.623

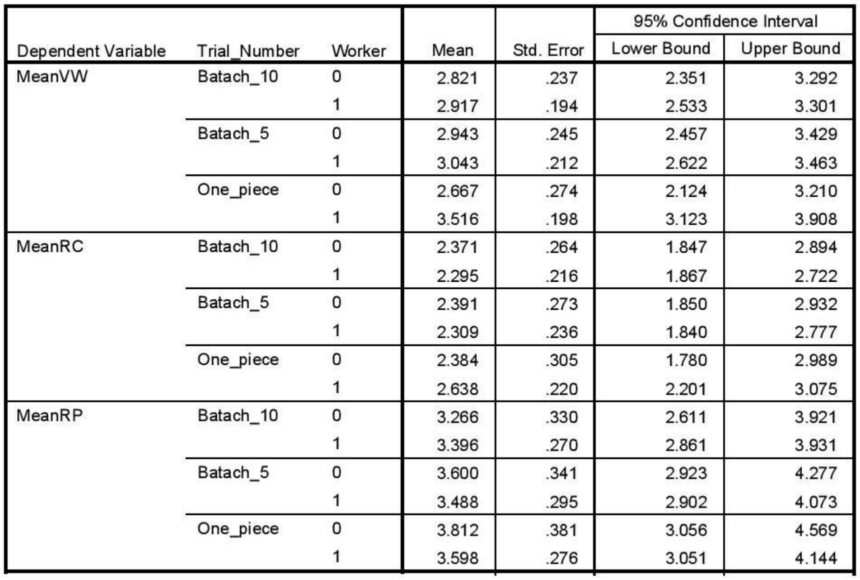
2. Worker



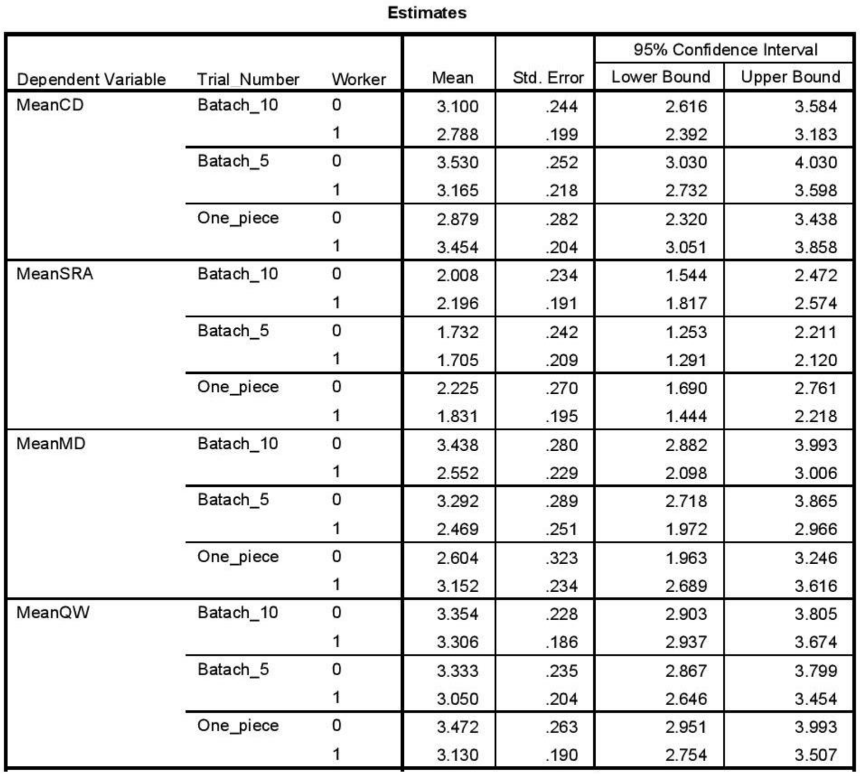
Dependent Variable	Worker	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
MeanVW	0	2.810	.146	2.521	3.099
	1	3.158	.116	2.928	3.389
MeanRC	0	2.382	.162	2.060	2.704
	1	2.414	.130	2.157	2.671
MeanRP	0	3.559	.203	3.157	3.962
	1	3.494	.162	3.173	3.815
MeanCD	0	3.170	.150	2.872	3.467
	1	3.136	.120	2.898	3.373
MeanSRA	0	1.989	.144	1.704	2.274
	1	1.911	.115	1.683	2.138
MeanMD	0	3.111	.172	2.770	3.453
	1	2.724	.137	2.452	2.997
MeanQW	0	3.387	.140	3.109	3.664
	1	3.162	.112	2.941	3.383

3. Trial_Number * Worker

Estimates

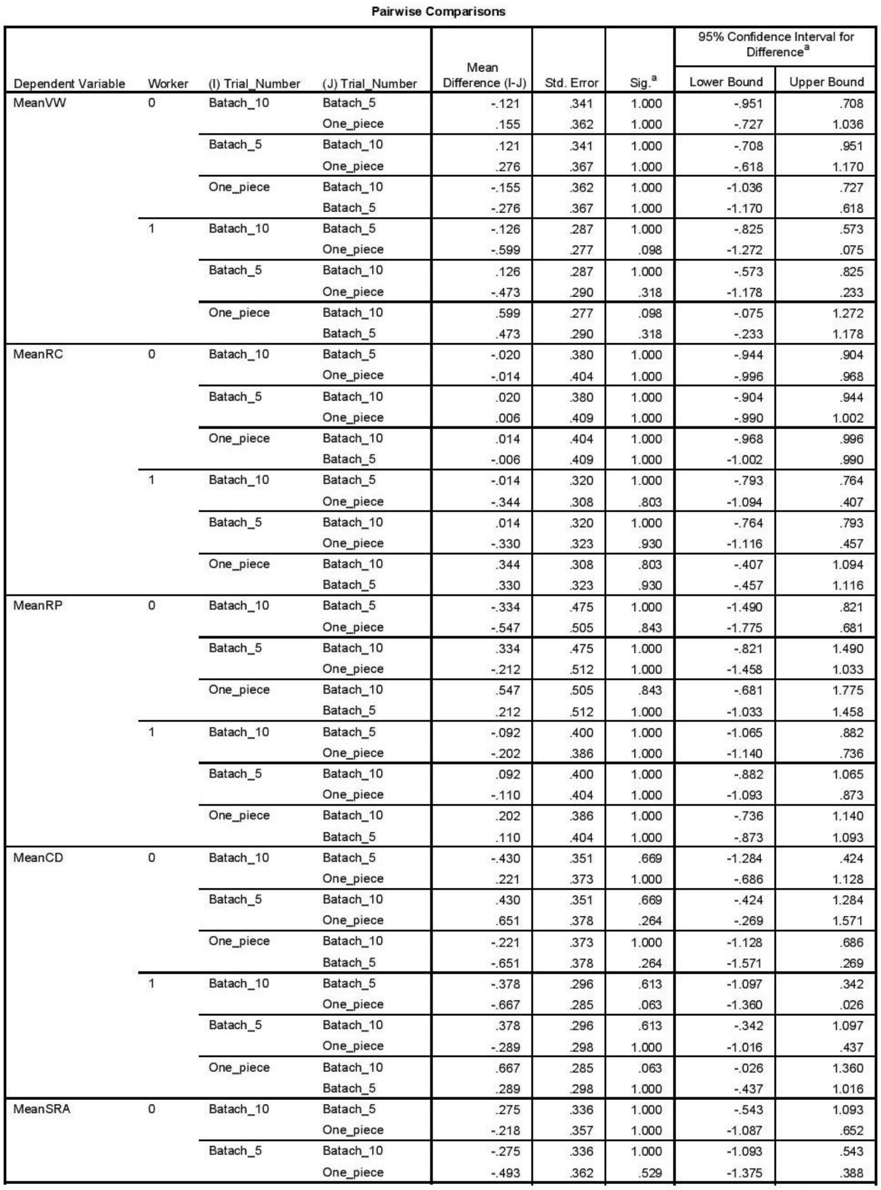


Dependent Variable	Trial_Number	Worker	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
MeanVW	Batach_10	0	2.821	.237	2.351	3.292
		1	2.917	.194	2.533	3.301
	Batach_5	0	2.943	.245	2.457	3.429
		1	3.043	.212	2.622	3.463
	One_piece	0	2.667	.274	2.124	3.210
		1	3.516	.198	3.123	3.908
MeanRC	Batach_10	0	2.371	.264	1.847	2.894
		1	2.295	.216	1.867	2.722
	Batach_5	0	2.391	.273	1.850	2.932
		1	2.309	.236	1.840	2.777
	One_piece	0	2.384	.305	1.780	2.989
		1	2.638	.220	2.201	3.075
MeanRP	Batach_10	0	3.266	.330	2.611	3.921
		1	3.396	.270	2.861	3.931
	Batach_5	0	3.600	.341	2.923	4.277
		1	3.488	.295	2.902	4.073
	One_piece	0	3.812	.381	3.056	4.569
		1	3.598	.276	3.051	4.144



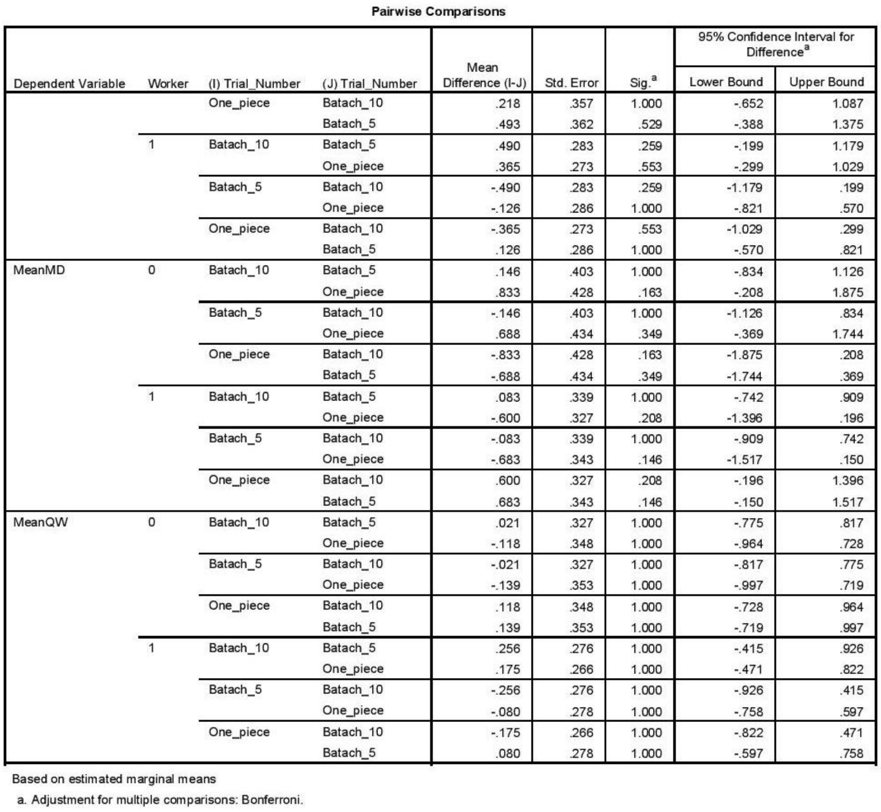
Estimates

Dependent Variable	Trial_Number	Worker	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
MeanCD	Batach_10	0	3.100	.244	2.616	3.584
		1	2.788	.199	2.392	3.183
	Batach_5	0	3.530	.252	3.030	4.030
		1	3.165	.218	2.732	3.598
	One_piece	0	2.879	.282	2.320	3.438
		1	3.454	.204	3.051	3.858
MeanSRA	Batach_10	0	2.008	.234	1.544	2.472
		1	2.196	.191	1.817	2.574
	Batach_5	0	1.732	.242	1.253	2.211
		1	1.705	.209	1.291	2.120
	One_piece	0	2.225	.270	1.690	2.761
		1	1.831	.195	1.444	2.218
MeanMD	Batach_10	0	3.438	.280	2.882	3.993
		1	2.552	.229	2.098	3.006
	Batach_5	0	3.292	.289	2.718	3.865
		1	2.469	.251	1.972	2.966
	One_piece	0	2.604	.323	1.963	3.246
		1	3.152	.234	2.689	3.616
MeanQW	Batach_10	0	3.354	.228	2.903	3.805
		1	3.306	.186	2.937	3.674
	Batach_5	0	3.333	.235	2.867	3.799
		1	3.050	.204	2.646	3.454
	One_piece	0	3.472	.263	2.951	3.993
		1	3.130	.190	2.754	3.507



Pairwise Comparisons

Dependent Variable	Worker	(I) Trial_Number	(J) Trial_Number	Mean Difference (I-J)	Std. Error	Sig.^{a}	95% Confidence Interval for Difference^a	
							Lower Bound	Upper Bound
MeanVW	0	Batach_10	Batach_5	-.121	.341	1.000	-.951	.708
			One_piece	.155	.362	1.000	-.727	1.036
		Batach_5	Batach_10	.121	.341	1.000	-.708	.951
			One_piece	.276	.367	1.000	-.618	1.170
		One_piece	Batach_10	-.155	.362	1.000	-1.036	.727
			Batach_5	-.276	.367	1.000	-1.170	.618
	1	Batach_10	Batach_5	-.126	.287	1.000	-.825	.573
			One_piece	-.599	.277	.098	-1.272	.075
		Batach_5	Batach_10	.126	.287	1.000	-.573	.825
			One_piece	-.473	.290	.318	-1.178	.233
		One_piece	Batach_10	.599	.277	.098	-.075	1.272
			Batach_5	.473	.290	.318	-.233	1.178
MeanRC	0	Batach_10	Batach_5	-.020	.380	1.000	-.944	.904
			One_piece	-.014	.404	1.000	-.996	.968
		Batach_5	Batach_10	.020	.380	1.000	-.904	.944
			One_piece	.006	.409	1.000	-.990	1.002
		One_piece	Batach_10	.014	.404	1.000	-.968	.996
			Batach_5	-.006	.409	1.000	-1.002	.990
	1	Batach_10	Batach_5	-.014	.320	1.000	-.793	.764
			One_piece	-.344	.308	.803	-1.094	.407
		Batach_5	Batach_10	.014	.320	1.000	-.764	.793
			One_piece	-.330	.323	.930	-1.116	.457
		One_piece	Batach_10	.344	.308	.803	-.407	1.094
			Batach_5	.330	.323	.930	-.457	1.116
MeanRP	0	Batach_10	Batach_5	-.334	.475	1.000	-1.490	.821
			One_piece	-.547	.505	.843	-1.775	.681
		Batach_5	Batach_10	.334	.475	1.000	-.821	1.490
			One_piece	-.212	.512	1.000	-1.458	1.033
		One_piece	Batach_10	.547	.505	.843	-.681	1.775
			Batach_5	.212	.512	1.000	-1.033	1.458
	1	Batach_10	Batach_5	-.092	.400	1.000	-1.065	.882
			One_piece	-.202	.386	1.000	-1.140	.736
		Batach_5	Batach_10	.092	.400	1.000	-.882	1.065
			One_piece	-.110	.404	1.000	-1.093	.873
		One_piece	Batach_10	.202	.386	1.000	-.736	1.140
			Batach_5	.110	.404	1.000	-.873	1.093
MeanCD	0	Batach_10	Batach_5	-.430	.351	.669	-1.284	.424
			One_piece	.221	.373	1.000	-.686	1.128
		Batach_5	Batach_10	.430	.351	.669	-.424	1.284
			One_piece	.651	.378	.264	-.269	1.571
		One_piece	Batach_10	-.221	.373	1.000	-1.128	.686
			Batach_5	-.651	.378	.264	-1.571	.269
	1	Batach_10	Batach_5	-.378	.296	.613	-1.097	.342
			One_piece	-.667	.285	.063	-1.360	.026
		Batach_5	Batach_10	.378	.296	.613	-.342	1.097
			One_piece	-.289	.298	1.000	-1.016	.437
		One_piece	Batach_10	.667	.285	.063	-.026	1.360
			Batach_5	.289	.298	1.000	-.437	1.016
MeanSRA	0	Batach_10	Batach_5	.275	.336	1.000	-.543	1.093
			One_piece	-.218	.357	1.000	-1.087	.652
		Batach_5	Batach_10	-.275	.336	1.000	-1.093	.543
			One_piece	-.493	.362	.529	-1.375	.388

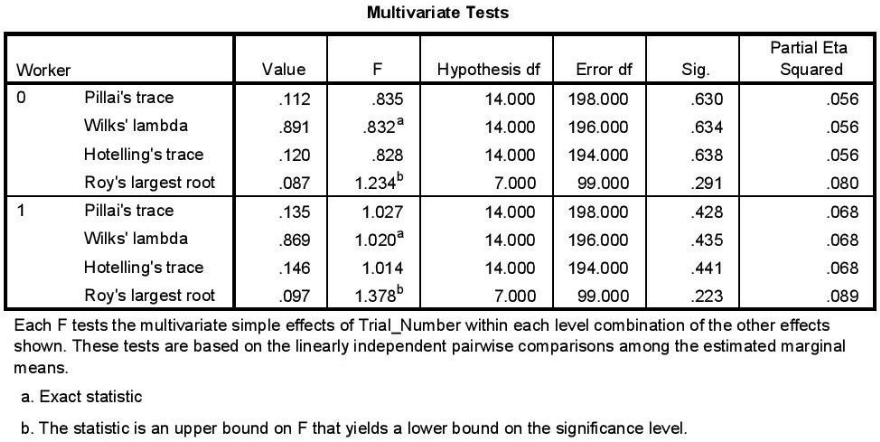


Pairwise Comparisons

							95% Confidence Interval for Difference[a]	
Dependent Variable	Worker	(I) Trial_Number	(J) Trial_Number	Mean Difference (I-J)	Std. Error	Sig.[a]	Lower Bound	Upper Bound
		One_piece	Batach_10	.218	.357	1.000	-.652	1.087
			Batach_5	.493	.362	.529	-.388	1.375
	1	Batach_10	Batach_5	.490	.283	.259	-.199	1.179
			One_piece	.365	.273	.553	-.299	1.029
		Batach_5	Batach_10	-.490	.283	.259	-1.179	.199
			One_piece	-.126	.286	1.000	-.821	.570
		One_piece	Batach_10	-.365	.273	.553	-1.029	.299
			Batach_5	.126	.286	1.000	-.570	.821
MeanMD	0	Batach_10	Batach_5	.146	.403	1.000	-.834	1.126
			One_piece	.833	.428	.163	-.208	1.875
		Batach_5	Batach_10	-.146	.403	1.000	-1.126	.834
			One_piece	.688	.434	.349	-.369	1.744
		One_piece	Batach_10	-.833	.428	.163	-1.875	.208
			Batach_5	-.688	.434	.349	-1.744	.369
	1	Batach_10	Batach_5	.083	.339	1.000	-.742	.909
			One_piece	-.600	.327	.208	-1.396	.196
		Batach_5	Batach_10	-.083	.339	1.000	-.909	.742
			One_piece	-.683	.343	.146	-1.517	.150
		One_piece	Batach_10	.600	.327	.208	-.196	1.396
			Batach_5	.683	.343	.146	-.150	1.517
MeanQW	0	Batach_10	Batach_5	.021	.327	1.000	-.775	.817
			One_piece	-.118	.348	1.000	-.964	.728
		Batach_5	Batach_10	-.021	.327	1.000	-.817	.775
			One_piece	-.139	.353	1.000	-.997	.719
		One_piece	Batach_10	.118	.348	1.000	-.728	.964
			Batach_5	.139	.353	1.000	-.719	.997
	1	Batach_10	Batach_5	.256	.276	1.000	-.415	.926
			One_piece	.175	.266	1.000	-.471	.822
		Batach_5	Batach_10	-.256	.276	1.000	-.926	.415
			One_piece	-.080	.278	1.000	-.758	.597
		One_piece	Batach_10	-.175	.266	1.000	-.822	.471
			Batach_5	.080	.278	1.000	-.597	.758

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.



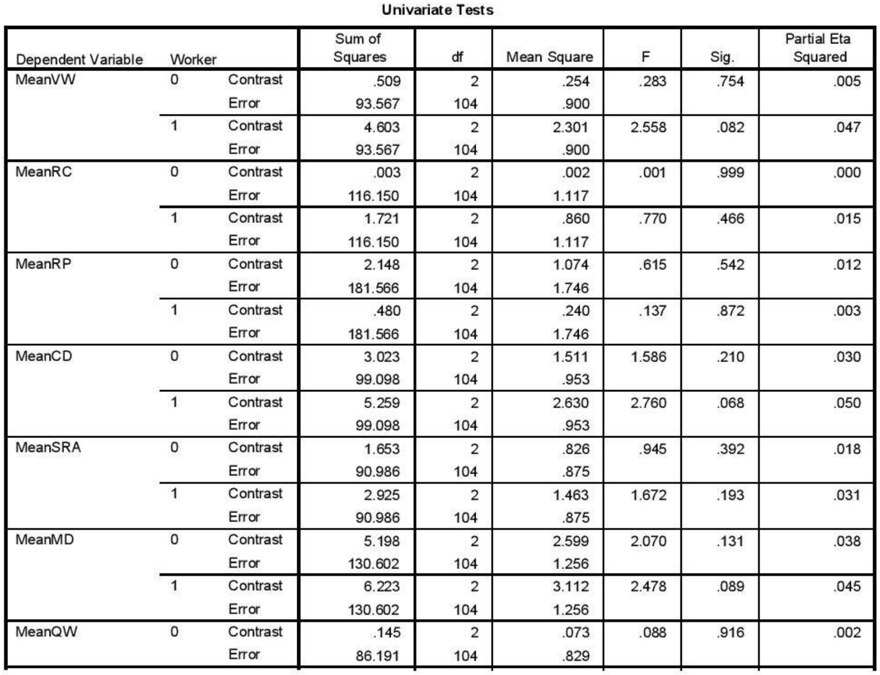
Multivariate Tests

Worker		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
0	Pillai's trace	.112	.835	14.000	198.000	.630	.056
	Wilks' lambda	.891	.832[a]	14.000	196.000	.634	.056
	Hotelling's trace	.120	.828	14.000	194.000	.638	.056
	Roy's largest root	.087	1.234[b]	7.000	99.000	.291	.080
1	Pillai's trace	.135	1.027	14.000	198.000	.428	.068
	Wilks' lambda	.869	1.020[a]	14.000	196.000	.435	.068
	Hotelling's trace	.146	1.014	14.000	194.000	.441	.068
	Roy's largest root	.097	1.378[b]	7.000	99.000	.223	.089

Each F tests the multivariate simple effects of Trial_Number within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. The statistic is an upper bound on F that yields a lower bound on the significance level.



Univariate Tests

Dependent Variable	Worker		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
MeanVW	0	Contrast	.509	2	.254	.283	.754	.005
		Error	93.567	104	.900			
	1	Contrast	4.603	2	2.301	2.558	.082	.047
		Error	93.567	104	.900			
MeanRC	0	Contrast	.003	2	.002	.001	.999	.000
		Error	116.150	104	1.117			
	1	Contrast	1.721	2	.860	.770	.466	.015
		Error	116.150	104	1.117			
MeanRP	0	Contrast	2.148	2	1.074	.615	.542	.012
		Error	181.566	104	1.746			
	1	Contrast	.480	2	.240	.137	.872	.003
		Error	181.566	104	1.746			
MeanCD	0	Contrast	3.023	2	1.511	1.586	.210	.030
		Error	99.098	104	.953			
	1	Contrast	5.259	2	2.630	2.760	.068	.050
		Error	99.098	104	.953			
MeanSRA	0	Contrast	1.653	2	.826	.945	.392	.018
		Error	90.986	104	.875			
	1	Contrast	2.925	2	1.463	1.672	.193	.031
		Error	90.986	104	.875			
MeanMD	0	Contrast	5.198	2	2.599	2.070	.131	.038
		Error	130.602	104	1.256			
	1	Contrast	6.223	2	3.112	2.478	.089	.045
		Error	130.602	104	1.256			
MeanQW	0	Contrast	.145	2	.073	.088	.916	.002
		Error	86.191	104	.829			

Univariate Tests

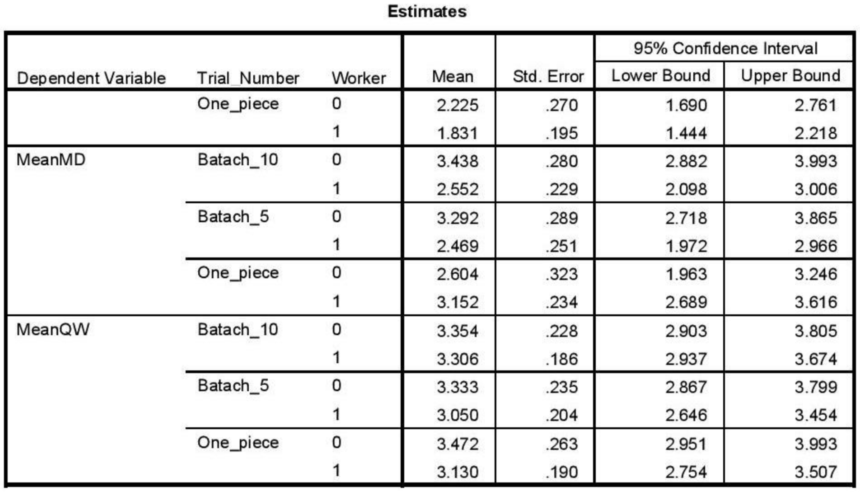
Dependent Variable	Worker		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
	1	Contrast	.765	2	.382	.462	.632	.009
		Error	86.191	104	.829			

Each F tests the simple effects of Trial_Number within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

4. Trial_Number * Worker

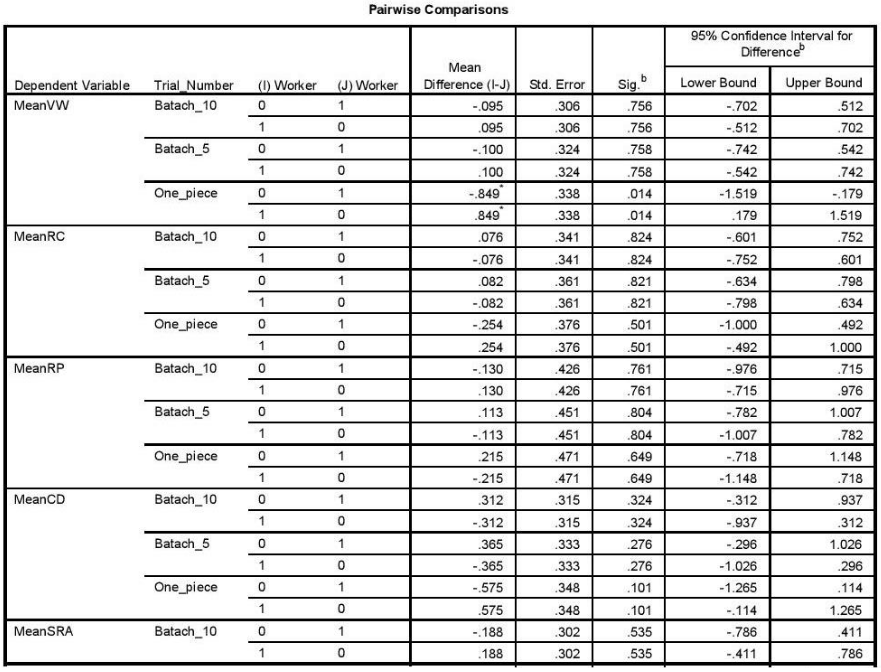
Estimates

					95% Confidence Interval	
Dependent Variable	Trial_Number	Worker	Mean	Std. Error	Lower Bound	Upper Bound
MeanVW	Batach_10	0	2.821	.237	2.351	3.292
		1	2.917	.194	2.533	3.301
	Batach_5	0	2.943	.245	2.457	3.429
		1	3.043	.212	2.622	3.463
	One_piece	0	2.667	.274	2.124	3.210
		1	3.516	.198	3.123	3.908
MeanRC	Batach_10	0	2.371	.264	1.847	2.894
		1	2.295	.216	1.867	2.722
	Batach_5	0	2.391	.273	1.850	2.932
		1	2.309	.236	1.840	2.777
	One_piece	0	2.384	.305	1.780	2.989
		1	2.638	.220	2.201	3.075
MeanRP	Batach_10	0	3.266	.330	2.611	3.921
		1	3.396	.270	2.861	3.931
	Batach_5	0	3.600	.341	2.923	4.277
		1	3.488	.295	2.902	4.073
	One_piece	0	3.812	.381	3.056	4.569
		1	3.598	.276	3.051	4.144
MeanCD	Batach_10	0	3.100	.244	2.616	3.584
		1	2.788	.199	2.392	3.183
	Batach_5	0	3.530	.252	3.030	4.030
		1	3.165	.218	2.732	3.598
	One_piece	0	2.879	.282	2.320	3.438
		1	3.454	.204	3.051	3.858
MeanSRA	Batach_10	0	2.008	.234	1.544	2.472
		1	2.196	.191	1.817	2.574
	Batach_5	0	1.732	.242	1.253	2.211
		1	1.705	.209	1.291	2.120



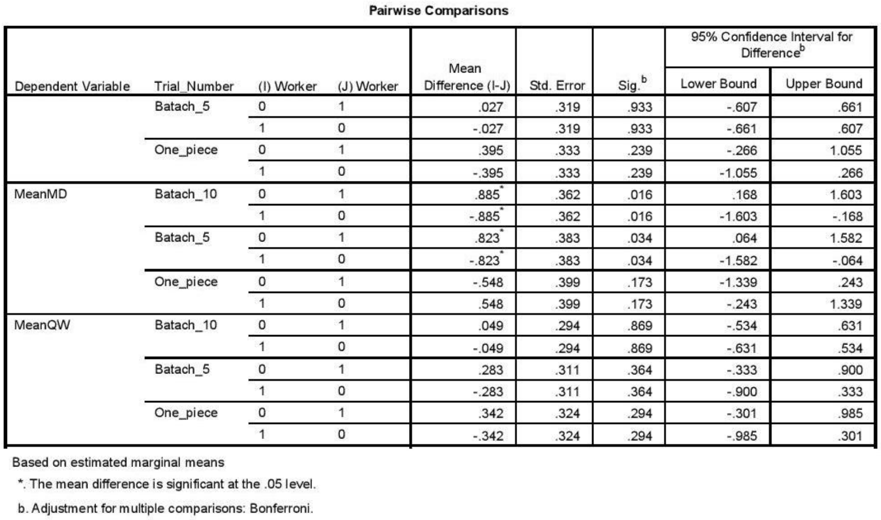
Estimates

Dependent Variable	Trial_Number	Worker	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
	One_piece	0	2.225	.270	1.690	2.761
		1	1.831	.195	1.444	2.218
MeanMD	Batach_10	0	3.438	.280	2.882	3.993
		1	2.552	.229	2.098	3.006
	Batach_5	0	3.292	.289	2.718	3.865
		1	2.469	.251	1.972	2.966
	One_piece	0	2.604	.323	1.963	3.246
		1	3.152	.234	2.689	3.616
MeanQW	Batach_10	0	3.354	.228	2.903	3.805
		1	3.306	.186	2.937	3.674
	Batach_5	0	3.333	.235	2.867	3.799
		1	3.050	.204	2.646	3.454
	One_piece	0	3.472	.263	2.951	3.993
		1	3.130	.190	2.754	3.507



Pairwise Comparisons

Dependent Variable	Trial_Number	(I) Worker	(J) Worker	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	95% Confidence Interval for Difference[b] Upper Bound
MeanVW	Batach_10	0	1	-.095	.306	.756	-.702	.512
		1	0	.095	.306	.756	-.512	.702
	Batach_5	0	1	-.100	.324	.758	-.742	.542
		1	0	.100	.324	.758	-.542	.742
	One_piece	0	1	-.849*	.338	.014	-1.519	-.179
		1	0	.849*	.338	.014	.179	1.519
MeanRC	Batach_10	0	1	.076	.341	.824	-.601	.752
		1	0	-.076	.341	.824	-.752	.601
	Batach_5	0	1	.082	.361	.821	-.634	.798
		1	0	-.082	.361	.821	-.798	.634
	One_piece	0	1	-.254	.376	.501	-1.000	.492
		1	0	.254	.376	.501	-.492	1.000
MeanRP	Batach_10	0	1	-.130	.426	.761	-.976	.715
		1	0	.130	.426	.761	-.715	.976
	Batach_5	0	1	.113	.451	.804	-.782	1.007
		1	0	-.113	.451	.804	-1.007	.782
	One_piece	0	1	.215	.471	.649	-.718	1.148
		1	0	-.215	.471	.649	-1.148	.718
MeanCD	Batach_10	0	1	.312	.315	.324	-.312	.937
		1	0	-.312	.315	.324	-.937	.312
	Batach_5	0	1	.365	.333	.276	-.296	1.026
		1	0	-.365	.333	.276	-1.026	.296
	One_piece	0	1	-.575	.348	.101	-1.265	.114
		1	0	.575	.348	.101	-.114	1.265
MeanSRA	Batach_10	0	1	-.188	.302	.535	-.786	.411
		1	0	.188	.302	.535	-.411	.786



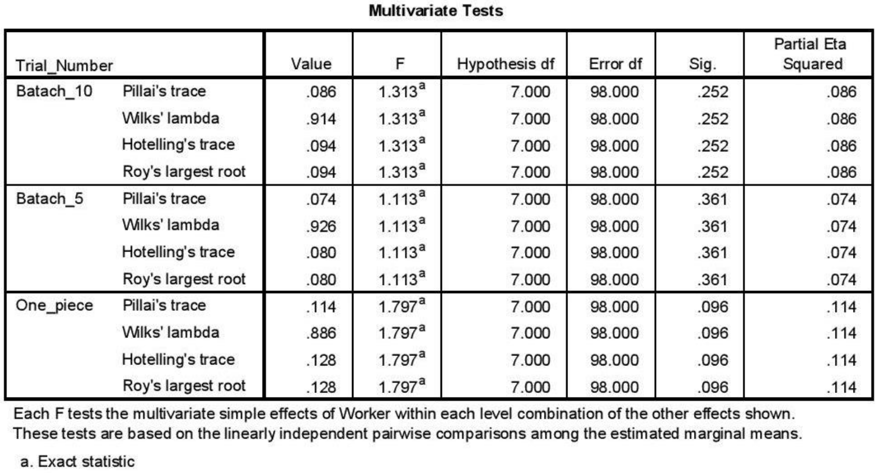
Pairwise Comparisons

Dependent Variable	Trial_Number	(I) Worker	(J) Worker	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
							Lower Bound	Upper Bound
	Batach_5	0	1	.027	.319	.933	-.607	.661
		1	0	-.027	.319	.933	-.661	.607
	One_piece	0	1	.395	.333	.239	-.266	1.055
		1	0	-.395	.333	.239	-1.055	.266
MeanMD	Batach_10	0	1	.885[*]	.362	.016	.168	1.603
		1	0	-.885[*]	.362	.016	-1.603	-.168
	Batach_5	0	1	.823[*]	.383	.034	.064	1.582
		1	0	-.823[*]	.383	.034	-1.582	-.064
	One_piece	0	1	-.548	.399	.173	-1.339	.243
		1	0	.548	.399	.173	-.243	1.339
MeanQW	Batach_10	0	1	.049	.294	.869	-.534	.631
		1	0	-.049	.294	.869	-.631	.534
	Batach_5	0	1	.283	.311	.364	-.333	.900
		1	0	-.283	.311	.364	-.900	.333
	One_piece	0	1	.342	.324	.294	-.301	.985
		1	0	-.342	.324	.294	-.985	.301

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

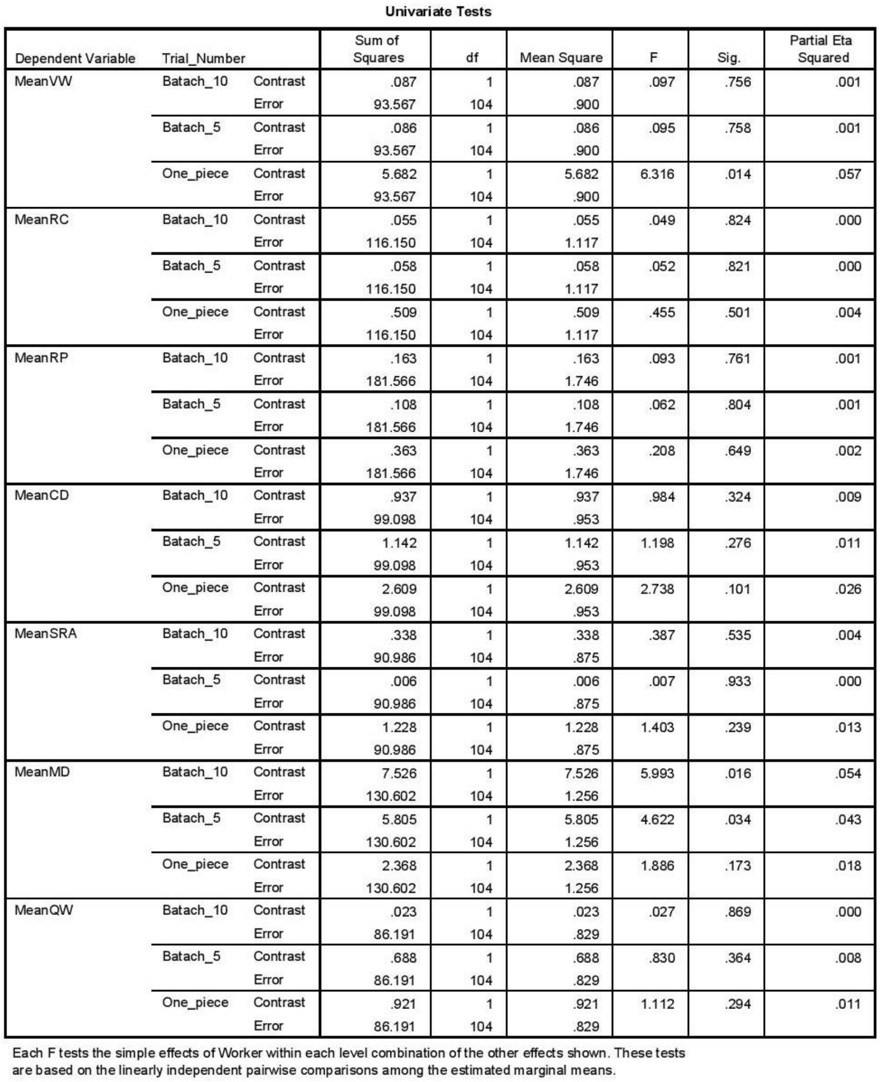


Multivariate Tests

Trial_Number		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Batach_10	Pillai's trace	.086	1.313[a]	7.000	98.000	.252	.086
	Wilks' lambda	.914	1.313[a]	7.000	98.000	.252	.086
	Hotelling's trace	.094	1.313[a]	7.000	98.000	.252	.086
	Roy's largest root	.094	1.313[a]	7.000	98.000	.252	.086
Batach_5	Pillai's trace	.074	1.113[a]	7.000	98.000	.361	.074
	Wilks' lambda	.926	1.113[a]	7.000	98.000	.361	.074
	Hotelling's trace	.080	1.113[a]	7.000	98.000	.361	.074
	Roy's largest root	.080	1.113[a]	7.000	98.000	.361	.074
One_piece	Pillai's trace	.114	1.797[a]	7.000	98.000	.096	.114
	Wilks' lambda	.886	1.797[a]	7.000	98.000	.096	.114
	Hotelling's trace	.128	1.797[a]	7.000	98.000	.096	.114
	Roy's largest root	.128	1.797[a]	7.000	98.000	.096	.114

Each F tests the multivariate simple effects of Worker within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

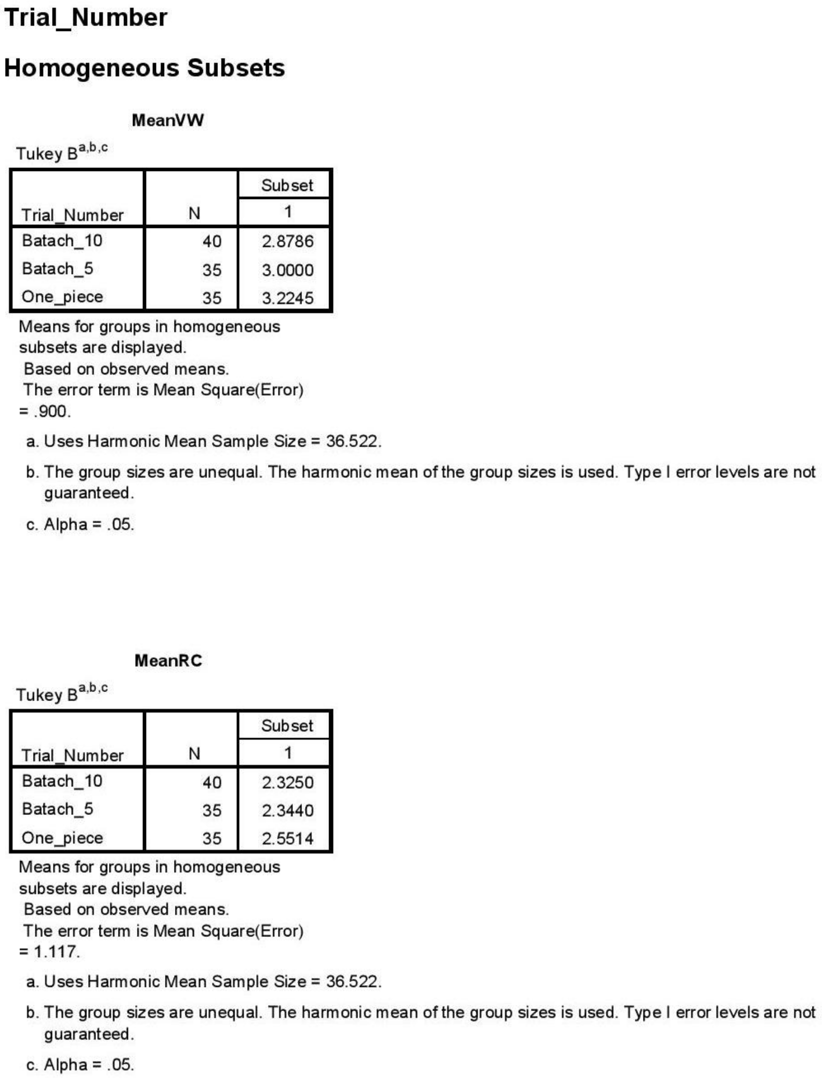


Univariate Tests

Dependent Variable	Trial_Number		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
MeanVW	Batach_10	Contrast	.087	1	.087	.097	.756	.001
		Error	93.567	104	.900			
	Batach_5	Contrast	.086	1	.086	.095	.758	.001
		Error	93.567	104	.900			
	One_piece	Contrast	5.682	1	5.682	6.316	.014	.057
		Error	93.567	104	.900			
MeanRC	Batach_10	Contrast	.055	1	.055	.049	.824	.000
		Error	116.150	104	1.117			
	Batach_5	Contrast	.058	1	.058	.052	.821	.000
		Error	116.150	104	1.117			
	One_piece	Contrast	.509	1	.509	.455	.501	.004
		Error	116.150	104	1.117			
MeanRP	Batach_10	Contrast	.163	1	.163	.093	.761	.001
		Error	181.566	104	1.746			
	Batach_5	Contrast	.108	1	.108	.062	.804	.001
		Error	181.566	104	1.746			
	One_piece	Contrast	.363	1	.363	.208	.649	.002
		Error	181.566	104	1.746			
MeanCD	Batach_10	Contrast	.937	1	.937	.984	.324	.009
		Error	99.098	104	.953			
	Batach_5	Contrast	1.142	1	1.142	1.198	.276	.011
		Error	99.098	104	.953			
	One_piece	Contrast	2.609	1	2.609	2.738	.101	.026
		Error	99.098	104	.953			
MeanSRA	Batach_10	Contrast	.338	1	.338	.387	.535	.004
		Error	90.986	104	.875			
	Batach_5	Contrast	.006	1	.006	.007	.933	.000
		Error	90.986	104	.875			
	One_piece	Contrast	1.228	1	1.228	1.403	.239	.013
		Error	90.986	104	.875			
MeanMD	Batach_10	Contrast	7.526	1	7.526	5.993	.016	.054
		Error	130.602	104	1.256			
	Batach_5	Contrast	5.805	1	5.805	4.622	.034	.043
		Error	130.602	104	1.256			
	One_piece	Contrast	2.368	1	2.368	1.886	.173	.018
		Error	130.602	104	1.256			
MeanQW	Batach_10	Contrast	.023	1	.023	.027	.869	.000
		Error	86.191	104	.829			
	Batach_5	Contrast	.688	1	.688	.830	.364	.008
		Error	86.191	104	.829			
	One_piece	Contrast	.921	1	.921	1.112	.294	.011
		Error	86.191	104	.829			

Each F tests the simple effects of Worker within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

Post Hoc Tests



Trial_Number

Homogeneous Subsets

MeanVW

Tukey B[a,b,c]

Trial_Number	N	Subset
		1
Batach_10	40	2.8786
Batach_5	35	3.0000
One_piece	35	3.2245

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .900.

a. Uses Harmonic Mean Sample Size = 36.522.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

MeanRC

Tukey B[a,b,c]

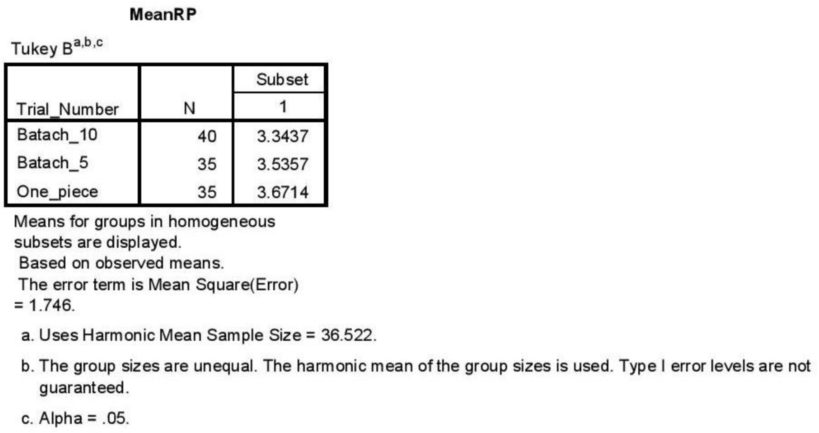
Trial_Number	N	Subset
		1
Batach_10	40	2.3250
Batach_5	35	2.3440
One_piece	35	2.5514

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 1.117.

a. Uses Harmonic Mean Sample Size = 36.522.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.



MeanRP

Tukey B[a,b,c]

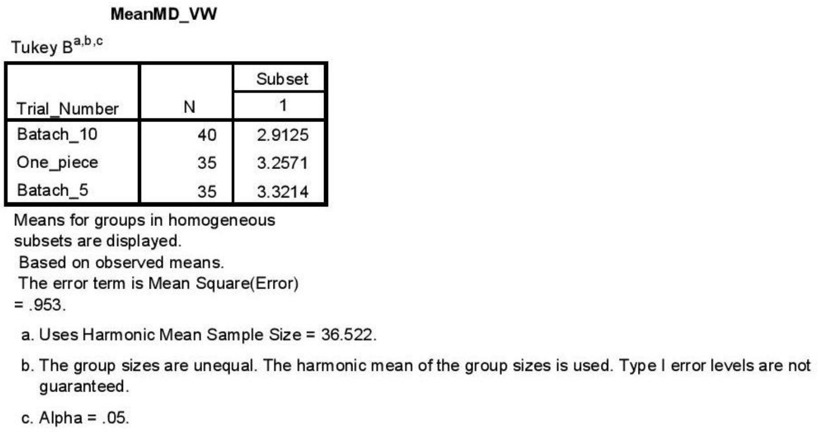
Trial_Number	N	Subset
		1
Batach_10	40	3.3437
Batach_5	35	3.5357
One_piece	35	3.6714

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 1.746.

a. Uses Harmonic Mean Sample Size = 36.522.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.



MeanMD_VW

Tukey B[a,b,c]

Trial_Number	N	Subset
		1
Batach_10	40	2.9125
One_piece	35	3.2571
Batach_5	35	3.3214

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .953.

a. Uses Harmonic Mean Sample Size = 36.522.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

MeanSRA

Tukey B^{a,b,c}

Trial_Number	N	Subset 1
Batach_5	35	1.7170
One_piece	35	1.9662
Batach_10	40	2.1205

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .875.

a. Uses Harmonic Mean Sample Size = 36.522.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

MeanMD

Tukey B^{a,b,c}

Trial_Number	N	Subset 1
Batach_5	35	2.8214
Batach_10	40	2.9063
One_piece	35	2.9643

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 1.256.

a. Uses Harmonic Mean Sample Size = 36.522.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

MeanQW

Tukey B^{a,b,c}

Trial_Number	N	Subset 1
Batach_5	35	3.1714
One_piece	35	3.2476
Batach_10	40	3.3250

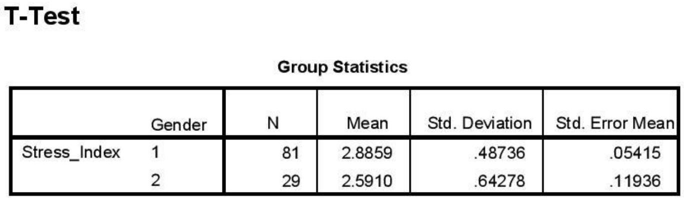
Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .829.

a. Uses Harmonic Mean Sample Size = 36.522.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

c. Alpha = .05.

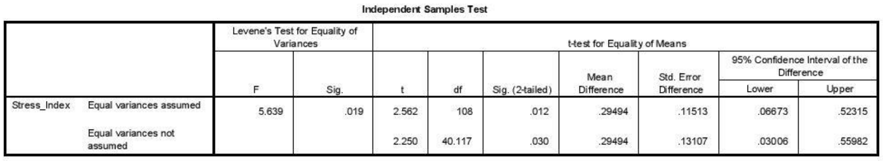
Appendix P: Hypothesis 5 SPSS Output



T-Test

Group Statistics

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Stress_Index	1	81	2.8859	.48736	.05415
	2	29	2.5910	.64278	.11936



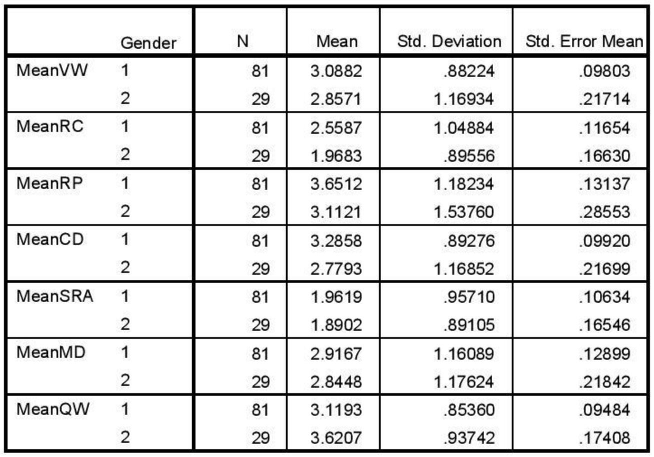
Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Stress_Index	Equal variances assumed	5.639	.019	2.562	108	.012	.29494	.11513	.06673	.52315
	Equal variances not assumed			2.250	40.117	.030	.29494	.13107	.03006	.55982

Appendix Q: Hypothesis 6 SPSS Output

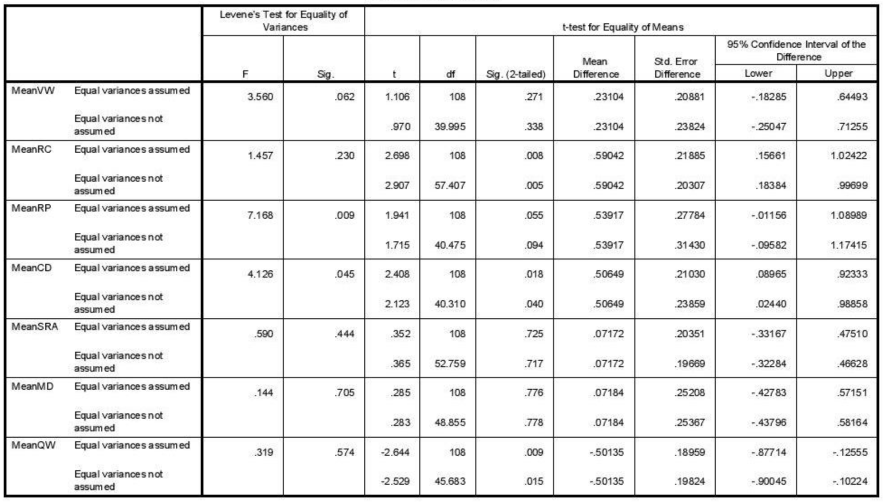
T-Test

Group Statistics



	Gender	N	Mean	Std. Deviation	Std. Error Mean
MeanVW	1	81	3.0882	.88224	.09803
	2	29	2.8571	1.16934	.21714
MeanRC	1	81	2.5587	1.04884	.11654
	2	29	1.9683	.89556	.16630
MeanRP	1	81	3.6512	1.18234	.13137
	2	29	3.1121	1.53760	.28553
MeanCD	1	81	3.2858	.89276	.09920
	2	29	2.7793	1.16852	.21699
MeanSRA	1	81	1.9619	.95710	.10634
	2	29	1.8902	.89105	.16546
MeanMD	1	81	2.9167	1.16089	.12899
	2	29	2.8448	1.17624	.21842
MeanQW	1	81	3.1193	.85360	.09484
	2	29	3.6207	.93742	.17408

Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
MeanVW	Equal variances assumed	3.560	.062	1.106	108	.271	.23104	.20881	-.18285	.64493
	Equal variances not assumed			.970	39.995	.338	.23104	.23824	-.25047	.71255
MeanRC	Equal variances assumed	1.457	.230	2.698	108	.008	.59042	.21885	.15661	1.02422
	Equal variances not assumed			2.907	57.407	.005	.59042	.20307	.18384	.99699
MeanRP	Equal variances assumed	7.168	.009	1.941	108	.055	.53917	.27784	-.01156	1.08989
	Equal variances not assumed			1.715	40.475	.094	.53917	.31430	-.09582	1.17415
MeanCD	Equal variances assumed	4.126	.045	2.408	108	.018	.50649	.21030	.08965	.92333
	Equal variances not assumed			2.123	40.310	.040	.50649	.23859	.02440	.98858
MeanSRA	Equal variances assumed	.590	.444	.352	108	.725	.07172	.20351	-.33167	.47510
	Equal variances not assumed			.365	52.759	.717	.07172	.19669	-.32284	.46628
MeanMD	Equal variances assumed	.144	.705	.285	108	.776	.07184	.25208	-.42783	.57151
	Equal variances not assumed			.283	48.855	.778	.07184	.25367	-.43796	.58164
MeanQW	Equal variances assumed	.319	.574	-2.644	108	.009	-.50135	.18959	-.87714	-.12555
	Equal variances not assumed			-2.529	45.683	.015	-.50135	.19824	-.90045	-.10224

VITA

Ewerton Esdras Rodrigues de Araújo was born and raised in João Pessoa, Brazil. Before attending The University of Tennessee Knoxville, he attended the Federal University of Paraíba, Brazil, where he earned a Bachelor of Science in Production Engineering in 2016. While his bachelor's degree, he had the opportunity of working in different companies in the area of quality control and process improvement. From 2013 to 2014, he earned a scholarship to attend the University of Tennessee, where he had the opportunity of being an intern in the Industrial and Systems Engineering Department.

While his master's degree, Esdras served in different roles within the Center for Advanced Systems Research and Education, acting as vice Coordinator of the Lean Institute, coordinating the Lean Enterprise and Systems Summer Program, and being the liaison between the center and its international partners.