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Personalised work instructions for an inclusive neurodiverse workforce: Exploring the fit between unique needs and instructions in relation to assembly complexity

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Abstract

This research addresses the lack of understanding of the unique needs of neurodivergent workers and investigates the role of personalised work instructions in improving inclusive accommodation in relation to assembly complexity. This relatively large minority, between 15-20% of the world population, experiences labour market disadvantages and despite the growing recognition of neurodiversity in the workplace, there is still limited research on how to accommodate their unique needs. This research consists of a current-state analysis and an experimental study, which mostly use qualitative research methods, such as interviews and observations in a multiple-case study approach to explore the experiences, perspectives, and needs of the neurodiverse workforce related to work instructions. The current-state analysis mainly reveals insights into assembly complexity, work instruction personalisation, and the use of technology. It emphasises the importance of providing engaging work for neurodiverse workers and the challenges in implementing work instructions. The current-state analysis also highlights the benefits of technology for work instruction generation and customisation. The experimental study uncovers the varying needs of neurodivergent workers and demonstrates the positive impact of clear visual instructions in reducing cognitive load. Based on the findings of this study, it is concluded that personalised work instructions have the potential to improve accommodation for neurodiverse workers. While challenges exist in terms of implementation and management of a work instruction, technology can play a crucial role in overcoming these difficulties. Although the immediate cost-effectiveness of personalised work instructions may be a concern, the long-term benefits, such as enhanced job satisfaction, improved performance, and increased inclusion in the workforce, make personalised instructions a valuable investment.

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Preface

This thesis is written as the final part of the MSc in Technology and Operations Management at the University of Groningen. In this preface, I would like to thank the people who have provided me with support, feedback, and valuable insights.

First of all, I would like to thank both Dr. J.A.C. Bokhorst and Prof. Dr. J. Riezebos for their guidance throughout the entire research. A special thanks to my first assessor, Dr. J.A.C. Bokhorst, for providing me with a network of organisations relevant to the topic of this research and for his excellent supervision, guidance, and support. His participation has made a significant contribution to this research.

Furthermore, I want to express my gratitude to all the participants of the interviews and experiments. The discussions that arose from the interviews and the enthusiasm with which the experiments were conducted clearly demonstrate why this social issue is so important.

Finally, as my studies are coming to an end, I want to show my appreciation to my friends and family who have supported me throughout my six years of studies.

Robin Slottje,

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1. Introduction

The world of work is rapidly evolving, where shifting societal values ask for a workforce that is more inclusive than ever in terms of demographics, background, and ways of thinking (Packard, Gentilini, Grosh, O'keefe, Robalino & Santos, 2019). Consequently, the recognition of neurodiversity in the workplace has become increasingly important in recent years, since the relatively large minority of neurodivergent workers - between 15-20% of the world population (Montvelisky, 2021) - is experiencing labour market disadvantages (Doyle, & McDowall, 2021; Mahto, Hatfield, Sniderman & Hogan, 2022). Neurodiversity refers to the idea that neurological differences, such as autism, AD(H)D, and dyslexia, are normal variations of the human brain, rather than disorders (Baumer & Frueh, 2021). As a result of the increasing recognition and inclusion, more employers are seeking ways to accommodate the unique needs and strengths of neurodivergent workers (Austin & Pisano, 2017).

However, despite the growing recognition and inclusion of neurodiversity in the workplace, there is a lack of understanding about the cognitive characteristics of neurodiverse workers, and how these characteristics can impact individual performance in the workplace (Doyle, 2020). For instance, a neurodiverse worker may have difficulties with time management, concentration, communication and teamwork, and processing speed (Prevatt & Yelland, 2013; Coetzer & Gibbison, 2016). However, a neurodiverse worker may also excel in innovative and creative thinking, computing, and visual reasoning (White & Shah, 2006; Meilleur, Jelenic, & Mottron, 2014).

Accommodating neurodiverse strengths and weaknesses calls for suitable adjustments to the design of work (Doyle, 2020). Neurodiverse characteristics may affect performance in the workplace, where neurodiverse workers can struggle to perform (relatively complex) tasks effectively and efficiently, leading to decreased productivity for the company and frustration for the employee (Bennett & Gibb, 2022). If neurodiverse workers do not feel supported in the workplace, they may feel disengaged and are more likely to leave their job, resulting in high turnover rates for the company (Morris, Begel & Wiedermann, 2015). According to a recent survey conducted among 985 neurodiverse workers (McDowall, Almuth & Doyle, 2023), decreased job satisfaction is undoubtedly the biggest reason neurodiverse people want to leave their current employer.

To the best of my knowledge, recent studies mainly state the significance of engaging a neurodiverse workforce and accompanying challenges (Bewley & George, 2016; Austin & Pisano, 2017; Kirby & Smith, 2021). These researches also state the unique strengths and perspectives of a neurodiverse workforce. However, there is still limited research on how to support and accommodate their unique needs. This knowledge gap in both literature and practice has resulted in limited support and accommodations for neurodiverse workers and has contributed to a lack of inclusiveness and diversity in the workforce (Walkowiak, 2021). Addressing this knowledge gap, and thereby improving neurodiverse accommodation, can help solve the underemployment and unemployment of many neurodiverse individuals.

Studies that do address accommodating neurodiversity in the workplace only address a small scale and mainly environmental factors that cannot be directly linked to a job itself. They address issues such as the work environment, where workspaces can be dedicated as quiet and/or low-traffic areas (Ovaska-Few, 2018), where equipment, such as noise-cancelling headphones, can provide sound-related accommodation (Patton, 2022) or where lighting change control can be used for visual-related accommodation (Hensel, 2017). Furthermore, some studies considered time aspects of work design where flexible start times and working patterns based on a workers' preferred routine were researched (Adamou et al., 2013; Johnson & Joshi, 2016).

While these previously mentioned studies have focused on indirect accommodations for neurodiverse individuals in the workplace, some researchers highlight the importance of flexible accommodations for a neurodiverse workforce (Doyle, 2020; Weber, Krieger, Häne, Yarker & McDowall, 2022), including personalised work instructions. This type of work instruction may provide direct accommodations that are tailored to individual needs. Personalised work instructions are customised work instructions that are adapted to different learning styles, work preferences, and skills to suit the specific needs of individual workers (Kucirkova, Gerard, & Linn, 2021). For example, personalised work instructions can provide instructions in a format that is easier for individuals to understand, such as visual aids, shorter sentences, or step-by-step instructions (Fletcher et al., 2020). They can also adjust the pace of instructions, provide more breaks, or reduce distractions to help individuals stay focused and manage their workload. Personalised work instructions have proven to be successful for people with a distance to the labour market in the past where Stöhr, Schneider, and Henkel (2018) demonstrated increased satisfaction and improved performance with adapted work instructions.

The aim of this research is to identify the role of personalised work instructions (and accompanying technologies) to improve inclusive accommodation for the neurodiverse workforce in relation to assembly complexity. The research seeks to address the gap in knowledge by exploring the cognitive characteristics of neurodivergent workers and how the application of personalised work instructions can accommodate the ensuing needs to achieve high individual performance. Additionally, the knowledge characteristics of a job are taken into account as they are likely to affect the needs for work instructions, however, this has yet to be determined in practice. Together, these insights make a valuable contribution to the field of operations management.

This research consists of two parts: a current-state analysis, and an experimental study. In the current-state analysis, a round of semi-structured interviews is conducted with nine organisations that perform assembly work using work instructions and have neurodiverse workers to address their current activities, opinions, and challenges with work instructions. Furthermore, an interview is conducted with an expert in the field of neurodiversity at work to gain more insights on the topic. Together, the interviews with the organisations and the expert establish a status quo, which is used to put practice in perspective with theory. The experimental study explores personalised work instructions for a relatively more complex assembly, to address the needs of neurodiverse workers for work instructions, the design of personalised work instructions, and the effectiveness of its support to neurodiverse workers.

First, the theoretical background is provided. Afterwards, the methodology, the case description and the findings are addressed separately for each of the two studies. Finally, the discussion and the conclusion are presented.

2. Theoretical Background

In this section, the existing literature on the research topic is described and critically reflected. The important aspects of this research are addressed separately in this chapter and also captured in a conceptual model, which is visualised below in *Figure 2.1*. Here, the knowledge and skills characteristics of neurodivergent workers are placed out of the scope of the empirical part of this research. However, since these characteristics define the unique needs of neurodivergent workers for work instructions, the characteristics are included in the model and the theoretical background.

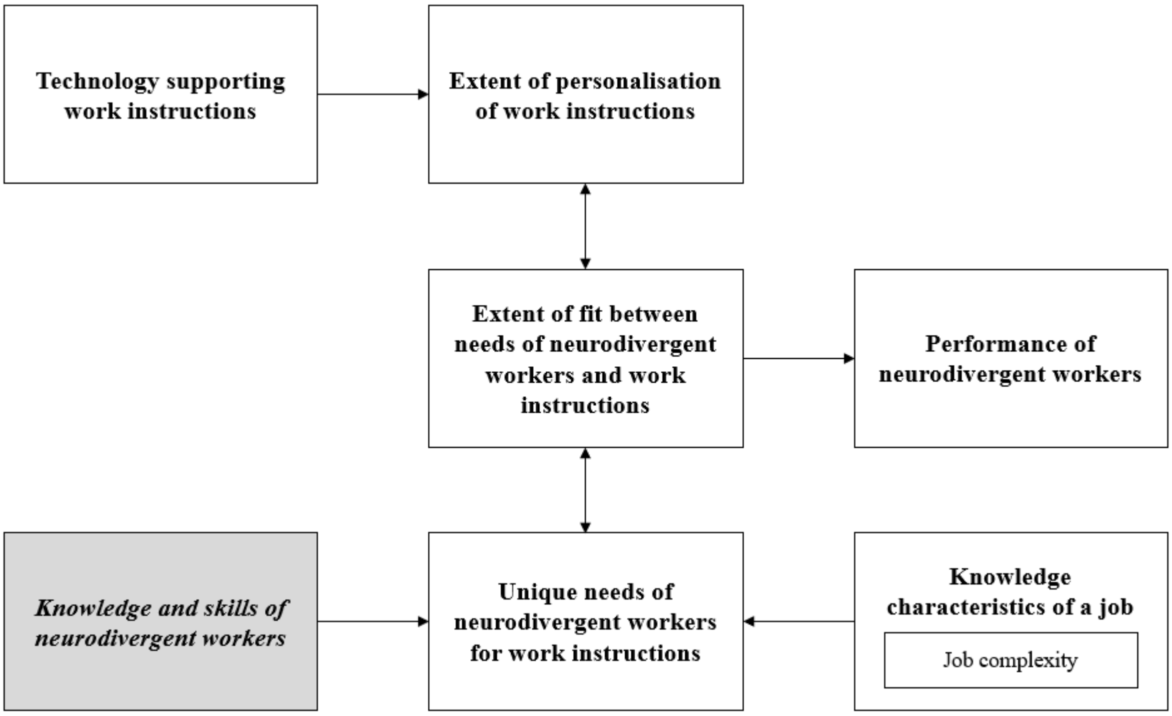

Figure 2.1 – Conceptual model

The knowledge and skills characteristics of neurodivergent workers (such as time management, concentration, and processing speed) and the complexity of a job affect the unique needs of the workers for work instructions. The main variable in this research is the extent of fit between the mentioned needs and the extent of personalisation of the work instructions presented, which has an interaction with both aspects. Technology can play a supporting role in, for example, generating or visualising work instructions and therefore affects the extent of personalisation of work instructions. In this research, it is assumed that the extent of fit affects the performance of neurodivergent workers.

2.1 Neurodiversity and cognitive characteristics of neurodivergent workers

The concept of neurodiversity refers to the natural variation in the human brain and how individuals perceive, learn, and process information (Baumer & Frueh, 2021). This includes neurological differences such as autism, ADHD, and dyslexia, among others. Neurodiverse workers have unique cognitive characteristics that can impact their job performance (Doyle, 2020). For example, individuals with autism may have exceptional attention to detail and the ability to identify patterns that others may miss (Meilleur et al., 2014), while individuals with ADHD may have a high level of creativity and problem-solving skills (Prevatt & Yelland, 2013). However, these individuals may also have weaknesses such as difficulty with social cues or sensory overload (Coetzer & Gibbison, 2016).

Neurodiverse people often face challenges in the labour market due to the lack of understanding and accommodation for their unique needs (Robertson, 2009). These challenges can include difficulties in communication, social interaction, and sensory processing. Several studies have investigated the inclusion and engagement of neurodiverse workers in the workplace. These studies have identified barriers to inclusion such as a lack of understanding and awareness of neurodiversity, inaccessible recruitment and hiring practices, and inflexible work environments (Patton, 2019; Doyle, 2022). They have also highlighted the importance of accommodations such as sensory-friendly workspaces, flexible schedules, and personalised work instructions (Doyle, 2020; Weber, Krieger, Häne, Yarker & McDowall, 2022). Accommodation through personalised work instructions may assist neurodiverse workers by providing clear and concise information, which can help them to better understand their tasks and responsibilities, reducing stress and anxiety levels (Tomczak, 2022).

2.2 Job knowledge characteristics: Job complexity and assembly complexity

Job complexity refers to the level of difficulty and the need for extensive knowledge and advanced cognitive abilities in tasks associated with a job (Morgeson & Humphrey, 2006). Job complexity involves, among others, task interdependence (the degree to which tasks within a job are interrelated and depend on each other), skill requirements (the level of expertise, education, and experience needed to perform the job), and task variety (the diversity and range of tasks involved in a job). Within job complexity, assembly complexity can be defined following the categorisations of Alkan, Vera, Ahmad, Ahmad, & Harrison (2016). The categorisations of Alkan et al. (2016) are specifically designed for manual assembly and are defined as followed:

[1] product-related factors, [2] process-related factors, [3] personal factors and [4] environmental factors. For this research, the personal and environmental factors are already taken into account, therefore, this framework is used for assessing the product and process-related factors of an assembly.

According to the Job Characteristics Theory proposed by Hackman and Oldham (1976), jobs that involve relatively complex tasks tend to be mentally stimulating, resulting in positive motivational effects for a majority of workers. Therefore, job complexity (and subsequently assembly complexity) plays a crucial role in enhancing motivation and engagement by providing challenging work. Since increased motivation and engagement are one of the most important factors for neurodiverse workers to stay with a current employer (McDowall et al., 2023), the complexity of a job must therefore also be considered.

2.3 Traditional and personalised work instructions

Traditional work instructions are a set of standardised documents that provide detailed guidance on how to perform a specific task or job (Akyar, 2012). They typically follow a linear process with sequential steps and may include required tools and materials, safety precautions, and quality standards. These instructions aim to ensure consistency and precision in industries such as manufacturing and assembly. Most often, they are created by subject matter experts and experienced workers to guarantee that all workers performing the same task follow the same process, resulting in consistent quality and efficiency (Jacobs & Jaseem Bu-Rahmah, 2012).

Personalised (work) instructions, on the other hand, are customised to meet the specific needs of individual workers (Kucirkova et al., 2021). They take into account the worker's preferred method of learning, such as visual or auditory (Fletcher et al., 2020), to increase their understanding and retention of the instructions (Santally & Senteni, 2013). Personalised work instructions may also consider a worker's strengths and limitations, such as their level of experience, cognitive abilities, and physical limitations, and can be adjusted to provide more time or support for specific tasks. By tailoring the instructions to the worker's needs, they can become more engaged and confident in their job, which can improve their overall job satisfaction (Tims & Bakker, 2010). However, despite the growing focus on personalised work instructions, there is currently no literature available specifically addressing the customisation of work instructions for neurodivergent workers.

When both types of work instructions are considered in the light of neurodiversity, it can be noted that traditional work instructions are often presented in a standardised format that may not be effective for neurodiverse workers. Personalised work instructions, however, are tailored to the individual's learning style and preferences, and therefore may make them more effective for individuals with cognitive differences by including for example visual aids, step-by-step instructions, and audio instructions.

2.4 Supporting technologies compatible with work instructions

Technology may play an important role in tailoring the personalisation of work instructions. Several technologies are available and applicable for creating and implementing personalised work instructions. These technologies include virtual and augmented reality, wearable devices, and software applications that allow for the customisation and personalisation of work instructions (Marienko, Nosenko, & Shyshkina, 2020). These technologies can be categorised based on their functionality. Below, a few important examples of these categories are given:

- *Generation and customisation software*: This technology is used as a centralised system for creating, managing, customising, and distributing work instructions by providing flexible templates, version control, and collaboration features. There are also some examples of generation software which semi-automatically creates digital work instruction based on a CAD model (Gors, Put, Vanherle, Witters, & Luyten, 2021).
- *Adaptive learning systems*: Systems which can use algorithms and machine learning techniques to adapt instructions in real-time based on an individual's progress, feedback, and performance (Kabudi, Pappas, & Olsen, 2021), thereby tailoring instructions to an individual's skill level and pace of learning.
- *Visual presentation*: Augmented reality (AR), virtual reality (VR) or projection systems are technologies that overlay digital information, instructions, and guidance onto the physical work environment, thereby enhancing the understanding and performance of a worker (Wang, Z., Bai, X., Zhang, S., Billinghurst, M., He, W., Wang, P., Lan, W& Chen, Y., 2022).
- *Audio presentation*: Systems which can communicate to the worker with verbal instructions to avoid any form of visual instructions (Snyder, 2020). An example is a Voice-Picking System, which is used in warehouses and distribution centres where order pickers receive instructions through a wearable device or headset (Berger, & Ludwig, 2007).

2.5 *Fit between needs and work instruction*

As mentioned previously, a neurodiverse worker's characteristics can affect their ability to effectively complete (relatively complex) tasks, and therefore, the extent of fit between the needs of a neurodiverse worker and the personalisation of work instruction can have a significant impact on their job performance and satisfaction. To acquire the fit between the needs and the work instruction Tsutsumi, Gyulai, Takács, Bergmann, Nonaka, and Fujita (2020) propose a 3-step flow process: [1] measure the worker's reaction to different types of work instructions, [2] calculate the optimal training method for beginners by performing step-by-step changes in the work instructions, [3] provide the optimal training method for beginners and collect feedback. This black-box approach may lead to an optimal fit between the needs of workers and the work instructions, however, the main focus of this method is on the solution, rather than the needs of a worker. According to Morrison, Ross, Morrison, and Kalman (2019), during the instructional design of a work instruction, a worker's needs should be included to alleviate a problem rather than focusing on what content to cover in the work instruction.

Haug (2015) identified fifteen quality criteria for good work instructions, which, besides the content of the work instruction such as the correctness of the information, also include the presentation and understandability of the work instruction. A part of these criteria can be elaborated on an individual level and thus be personalised for an increased fit between needs and instruction. These personalisable criteria are found in *Table 2.1.*

Table 2.1 – Personalisable quality criteria of work instructions, adapted from Haug (2015)

Criteria	**Description**
Clarity, Complexity	How specific are the subjects described?
Essentiality	What information is needed/necessary for the worker?
Repetition	How often should an activity/task be repeated in the instruction?
Conciseness, Amount of information	What level of detail is needed; elaboratively or globally?
Understandability	Can the worker understand the content of the instruction?
Accessibility	Where can the work instruction be retrieved? Are there barriers?

There are some quantitative tools to measure the level of these criteria. The Flesch-Kincaid Scale, for example, is a readability formula designed to assess the complexity of a written text (Zamanian & Heydari, 2012). It measures the reading ease and grade level required to understand the content. For individuals with dyslexia, using the Flesch-Kincaid Scale can be beneficial for increasing the readability and clarity of a text (Hagen, Verberne, Macdonald, Seifert, Balog, Nørvåg, & Setty, 2015), such as a work instruction.

2.6 Neurodivergent workforce performance

The performance of a worker refers to the measurable results that individuals achieve in their work (Vischer, 2007). This can include a variety of outcomes, such as completing tasks, meeting goals, producing high-quality work, collaborating effectively with colleagues, and contributing to the overall success of the organisation.

However, Kirby and Smith (2021) argue that traditional measures of job performance, such as productivity and efficiency, may not accurately reflect the contributions that neurodiverse individuals can make to a company. Instead, they suggest that companies should focus on creating an inclusive work environment that allows neurodiverse workers to use their strengths and talents to their fullest potential. Therefore, Kirby and Smith (2021) suggest that in the ideal situation, where neurodiverse workers are accommodated on their strengths and talents, companies should develop new metrics for measuring job performance that takes into account these specific strengths. For example, a metric that measures the ability to identify patterns or to come up with innovative solutions to complex problems. However, since most organisations already struggle to understand the cognitive characteristics of neurodiverse workers, and how these characteristics can impact individual performance in the workplace, let alone accommodating neurodiverse strengths and weaknesses, (Doyle, 2020) traditional metrics are preferable for now.

The performance of a neurodiverse person can be impacted by several factors, including the accommodations and support provided to them, the fit between their strengths and the requirements of the task or job, and their level of engagement and motivation (Morris et al., 2015). As mentioned before, personalised work instructions may increase this accommodation, thereby directly affecting the overall individual performance of the neurodiverse workforce.

3. Methodology

From theory, personalised work instructions appear to be an adequate tool for improving inclusive accommodations for neurodiverse workers. However, for the validity of this research, it is a good practice to test these theoretical assumptions in real-life case studies. Therefore, this study consists of two parts, a current-state analysis based on multiple cases, and an exploratory in-depth experimental study within one case.

In the current-state analysis, a round of semi-structured interviews was conducted with relevant organisations and an expert on neurodiversity at work to establish a status quo. The goal of this current-state analysis is to review the core of the entire research from the literature with practice, to see where the practice stands and what the challenges are regarding this topic. The experimental study explored the experimentation with personalised work instructions for a relatively more complex assembly, to address the needs of neurodiverse workers for work instructions, the design of personalised work instructions, and the effectiveness of its support to neurodiverse workers. The goal of this experimental study is to generate insights and create an understanding of the usage of personalised work instructions to improve the accommodation and inclusion of a neurodiverse workforce in relation to assembly complexity.

Defining the status quo and the insights into the usage of personalised work instructions requires an in-depth understanding of both the organisational experiences and the perspectives and needs of the neurodiverse workforce and their interactions with personalised work instructions. Qualitative research methods, such as interviews, focus groups, and observations, are well-suited for exploring and understanding complex phenomena (Nassaji, 2015).

Case study methods involve an in-depth investigation of a specific phenomenon or problem within its real-life context (Zainal, 2017). Karlsson (2016) highlights that multiple case studies are useful when the research question involves understanding a phenomenon that is context-specific and cannot be easily explained by a single case study.

By studying multiple cases, it is possible to identify similarities and differences across cases and develop more robust and generalisable theories (Karlsson, 2016). Furthermore, Karlsson explains that multiple case studies are useful for theory-building and can help to develop new theoretical concepts. Therefore, a multiple-case study was chosen for both parts of the research.

According to Yin (2013), a multiple case study design consists of three stages: [1] define and design, [2] prepare, collect, and analyse the case studies, and [3] analyse and conclude cross-case. In the define and design stage, the theoretical background is defined and, on its bases, the cases are selected. Furthermore, a protocol to collect the data is designed. In the second stage, the multiple case study is executed by conducting the case studies and writing an individual case report for each case. Finally, the case study design concludes with drawing cross-case conclusions, modifying theory, developing policy implications, and writing a cross-case report.

3.1 Unit of Analysis

The unit of analysis for the first part of this study is the organisation that performs assembly work using work instructions and has neurodiverse workers. The emphasis is on the current activities, opinions, and challenges with work instructions. Therefore, the organisation itself is the primary, and only, unit of analysis for this part of the research.

The unit of analysis for the second part of this study is the individual neurodivergent worker who is using traditional and/or personalised work instructions for their job or tasks. The emphasis is on how these neurodivergent workers interact with and experience traditional or personalised work instructions for a relatively complex task. Therefore, the individual neurodivergent worker is the primary, and only, unit of analysis for this part of the research. In this unit of analysis, information is available to pinpoint the specifically examined spectrum of neurodiversity and to determine the degree of neurodiversity focused on, whether it be the average or the outliers (i.e., neurodivergence). However, due to privacy considerations, it can only be indicated that these target groups had different diagnoses and are outliers within their spectrum and therefore neurodivergent.

According to Yin (2013), research that has a single unit of analysis can be categorised as holistic. For the current-state analysis, it was expected to observe both similarities and differences in the experiences and current situations at the case organisations. For the experimental study, it was expected to observe similarities in needs and the extent of fit between these needs and work instructions across similar cases throughout the research. For both studies, the method, design, and data collection procedures are similar for each of their cases, to allow for comparison. Therefore, a literal replication logic is in place (Yin, 2013).

3.2 Data Collection

For the primary data of the current-state analysis, a round of interviews was conducted with nine organisations that engage in assembly work and employ neurodiverse workers in a high product variety and low production volume context. These interviews provide direct insights and practices related to personalised work instructions. Additionally, an interview was conducted with an expert in the field of neurodiversity at work. This interview serves as a valuable source of secondary data, contributing specialised knowledge and perspectives to the research. The expert's insights help broaden the understanding of the topic and provide context for the findings obtained from the organisational interviews.

Together, the interviews with the organisations and the expert form a collection of data that captures the status quo regarding work instructions in relation to neurodiversity. This data collection serves as a foundation for further analysis and exploration of the experimental study.

For the primary data of the experimental study, information was collected directly from the neurodivergent workforce and their supervisors through semi-structured discussions to gain an in-depth understanding of their experiences, perspectives, and needs in relation to work instructions. It was expected that retrieving information directly from the primary source - the neurodivergent workforce - might had some barriers. Therefore, ethical considerations were in place for this research. These considerations are addressed separately at the end of this chapter.

For the secondary data of the experimental study, information was collected from company records that relate to the content of work instructions and the experiences and needs of the neurodivergent workforce in relation to work instructions, for example, an archive of revisions of work instructions, including a reason for the modification.

3.3 Design and measurement

3.3.1 Current-state Analysis

Two protocols for the semi-structured interviews were drawn up to determine the status quo. The first protocol, which is used for the nine organisations, discusses a number of sub-topics: compiling work instructions, applying work instructions, managing work instructions and current challenges within the context of the organisation that can be linked to work instructions. Within these subtopics, the process behind the work instructions, involving the employee in this process, the use of technologies, and the application of personalised instructions are addressed. The semi-structured interview with the expert on neurodiversity at work was also conducted according to a protocol. However, in this context, greater emphasis was placed on the neurodiverse individuals, where personalised work instructions are presented as an accommodation tool and focus areas were drawn up on the basis of various underlying aspects. Because the topics and associated questions are semi-structured in both protocols, the answers were grouped afterwards and elaborated in a summary that serves as a 'measurement'.

3.3.2 Experimental Study

This exploratory research was conducted through experimental settings where quantification is also in place. The experimental study is designed to measure the effectiveness of personalised work instructions in meeting the needs of neurodiverse individuals (i.e., the fit), which is expressed as individual performance in the conceptual model. This was done by comparing the performance of neurodivergent individuals who perform two identically complex assemblies and receive traditional work instructions for the first assembly and personalised work instructions for the second assembly. Individual performance can be measured using a range of quantitative and qualitative measures. The individual operational performance was measured with quantitative measures such as number of errors and processing time. Individual performance was also based on the neurodiverse worker's experience and was measured with qualitative measures such as job satisfaction and the understandability of the instruction.

The experiment was performed based on the General Assembly Task Model by Funk, Kosch, Greenwald, and Schmidt (2015). In this experiment, neurodivergent workers are asked to complete various LEGO® assemblies with different types of work instructions. In partnership with a similar study conducted in parallel to this research, the relative complexity capability levels, and individual needs for personalised work instructions of the neurodivergent participants were discovered prior to the experiment.

First, a sequence of events (SoE) was defined for each of the variables of the model of Funk et al. (2015), being: part locating, picking, locating position, and assembly. An overview of the SoE of assembling one part is found in *Table 3.1*.

Table 3.1 – The sequence of events (SoE) for assembling 1 part

Main Event	***Sub-Event***
Locate Part	Identify part
	Locate part
Pick	Move hand to container
	Pick part
	Move hand back to the assembly
Locate Position)	Identify the positioning of the part
	Count spots to identify the position
Assemble	Move hand with part to the identified position
	Assemble part on the baseplate

Based on the SoE, two different types of instructions were constructed: traditional and personalised. A traditional work instruction is a standard work instruction, similar to the average instruction of the case companies (*Appendix A*), which contains a basic level of detail, number of steps, additional information and ratio between text and images. A personalised work instruction is an adjusted work instruction with alterations in content and presentation based on the individual needs for work instructions. Here, the traditional work instruction was created on the forehand (*Appendix B*), whereas the personalised work instruction was created (alteration on traditional instruction) during experimentation. An outline is found in *Table 3.2*.

Table 3.2 – The information in the instructions based on the sequence of events

Main Event	***Traditional***	***Personalised***
Locate Part(s)	Show Parts	Adapted to individual needs
	Highlight location	
	Mainly textual instructions	
Pick	No instruction	No instruction
Locate Position(s)	Highlight position	Adapted to individual needs
	Mainly textual instructions	
Assemble	No instruction	No instruction

During the determination of the needs for work instructions, assemblies of the same complexity were offered that match the current level of the participant. Furthermore, a variety of assembly types were established for experimentation at higher levels of assembly complexity. Therefore, four different assembly complexity levels were defined and altered in the process (number of individual mounts) and product (material characteristics) related factors, following Alkan et al. (2016). A level 1 complexity assembly contains 4 parts with the same shape. A level 2 complexity assembly contains 8 parts with little variety in shape. A level 3 complexity assembly contains 16 parts with a variety in shape. A level 4 complexity assembly contains 32 parts with a high variety in shape.

To make sure that the learning curve effect does not affect the results of the experiment, a different assembly of similar complexity was given for each of the two instruction types. Therefore, a total of 8 assemblies were constructed, which can be found in *Appendix C*. Every participant performed a total of two experiments, both being performed one time and at the same level of complexity. A preview of the experimental setting is displayed in *Appendix D*.

Throughout the experiments, quantitative performance was measured by recording the average and standard deviation of *t_pick* (locate part and pick part) and *t_assemble* (locate position and assemble part) of an experiment and the average and standard deviation of the number of errors made throughout the experiment. The number of measurements per complete assembly depended on the level of complexity, as *t_pick* and *t_assemble* were measured per activity rather than per job. Therefore, at the lowest complexity, the number of measures equals four for *t_pick* and *t_assemble* each, with the highest complexity having a total of 32 measures for *t_pick* and *t_assemble* each.

Furthermore, in between the experiments, a discussion was held with the participants on how work instructions should be communicated. This discussion was done after each experiment and addressed 2 questions: *"What did you like about the instruction?"* and *"What could be better in the instruction?"*. Additionally, for qualitative performance, in every two experiments an additional question *"What did you think about this job?"* was addressed to the participants. Following this discussion, possible adjustments to the tasks themselves, visual instructions or level of details could have been made.

3.4 Data Analysis

In the current-state analysis, the raw interview data was organised before exploring the data for relationships. A primary interpretation logic was developed to define patterns in the data that relate to aspects of the conceptual model: the assembly complexity, personalisation of a work instruction, and the technology used. In the experimental study, the qualitative and quantitative data were explored for patterns that relate to specific challenges and benefits of using work instructions for a neurodivergent workforce in relation to assembly complexity.

After analysing the data, the findings were interpreted in the context of the needs of neurodivergent workers, and how the application of personalised work instructions can accommodate the needs to achieve individual performance in relation to assembly complexity. This was done by identifying patterns, trends, and relationships in the data.

3.5 Ethical Considerations

Research involving neurodiverse people requires careful consideration of ethical issues to ensure that participants are protected and their rights are respected. Neurodiverse people may have difficulties understanding information, making informed decisions, and understanding the implications of sharing personal information. Some considerations to tackle these issues were mentioned before, however, a summary of the considerations is stated below:

- Ensure that participants fully understand the interview and have the capacity to provide informed consent.
- Ensure that privacy and confidentiality protections are appropriate for the population being studied and, if needed, involve caregivers in discussions about privacy and confidentiality.
- Be aware of personal sensitivities and take steps to minimise any discomfort or distress that may be caused by the research environment.

4. Case Description

4.1 Current-state Analysis

The current-state analysis was executed at nine organisations that perform assembly work using work instructions and have neurodiverse workers. These organisations all have a low volume of production, with the exception of one, and all have a high product variety. The size of these organisations and their products vary from each other. Therefore, the relevant information and characteristics of the organisation are summarised in *Table 4.1*.

Table 4.1 – Case characteristics summary

Case	Product Variety	Production Volume	FTE	Description
A	High	High	3,500	Sheltered employment with a wide variety of assembled products
B	High	Low	225	Assembly of elevators. Customers can customise their orders in an order configurator
C	High	Low	350	Production of lace tools and machines. Wide variety of products made
D	High	Low	250	Sheltered employment with a wide variety of assembled products
E	High	Low	700	Assembly of large (port) lift structures. International company with two different production lines
F	High	Low	120	Production of semi-manufactured products in preparation for final assembly at their customers
G	High	Low	180	Production of air suspension systems with a high degree of variation in products
H	High	Low	450	Production of truck trailers, largely custom made
I	High	Low	100	Sheltered employment with a wide variety of assembled products

4.2 Experimental Study

Scalabor B.V., founded in 2018, is a sheltered employment located in Arnhem, the Netherlands. Scalabor operates as a sheltered employment in collaboration with the Municipality of Arnhem, UWV (Employee Insurance Agency), and various local businesses. Scalabor focuses on providing vocational training, work experience, and employment support to individuals facing challenges such as disabilities, long-term unemployment, or social disadvantages.

At their production facility in Arnhem, Scalabor employs around 250 full-time equivalents (including staff departments). Here, multiple production lines and work groups can be distinguished, where a high variety of products (and accompanying complexity) and a low production volume is present. Scalabor makes products with work instructions provided mainly by an external client. As a result, the content, form, and level of detail in the work instructions vary greatly from product to product.

During the experiments, the focus at Scalabor was on a work group within the hand packaging department, consisting of 5 neurodivergent employees. This workgroup normally assembles products with relatively low complexity. During the study, new assemblies were introduced with relatively higher complexity.

5. Findings

5.1 Current-state Analysis

The results of the current-state analysis mainly provide findings for three aspects of the conceptual model (the assembly complexity, personalisation of a work instruction, and the technology used). Below, these findings are grouped for each of the three aspects of the conceptual model.

5.1.1 Assembly Complexity

The insights gathered through the interviews with the organisations (hereinafter named as participants) have revealed an important observation: currently, due to various reasons, the organisations face a shortage of individuals who can perform relatively complex tasks. Moreover, the insights from sheltered employment within this group of participants (case A, D & I) emphasised that engaging employees in relatively complex tasks can have a positive impact on their job satisfaction. This is particularly relevant for a specific group within the workforce that is currently involved in relatively less complex and repetitive jobs, which can result in boredom. It is expected by these participants that when introducing more relatively complex jobs to individuals with a distance to the labour market, both employees and employers may potentially benefit through enhanced job satisfaction and filling vacant job positions. However, the problem of resolving the difference between supply and demand lies in the inadequate accommodation of this target group.

5.1.2 Personalisation of Work Instructions

In the current situation among the participants, limited forms of personal work instructions were identified. Three different forms were distinguished:

1. Adjustments have been made to the work instructions over time for workers with a distance to the labour market by implementing less text, simple descriptions, more pictures, and more comprehensive descriptions (case G).
2. Employees can create their own instructions or make comments and minor modifications to the instructions themselves (case F & H).
3. The work supervisor gives different instructions to employees through personal guidance (case D & I).

In general, the management of work instructions in particular is perceived as complicated by almost all participants. Making specific adjustments to individual instructions or implementing changes across all instructions requires significant time and resources. Thus, organisations find it unfavourable to implement personalised work instructions from a work instruction management perspective, as this personalisation puts further pressure on the time and resources required for the management of work instructions

Furthermore, from the interview with the expert in the field of neurodiversity at work, it became clear that individual personalisation of work instructions for neurodiverse workers is very difficult due to the great variety in characteristics and needs of this group. Neurodiversity is in itself a broad spectrum, but the degree of neurodiversity also affects the needs. In addition, two-thirds of neurodiverse individuals have a double neurodiverse diagnosis (e.g., dyslexic and dyspraxic), which creates even more variations in characteristics and needs.

5.1.3 Technology

Currently, only less than half of the participants present the work instructions paperless (case B, C, F & H). These participants use various hardware for the presentation of work instructions such as computer screens at workstations and laptops and tablets for flexibility and mobility. Regarding software, none of the participants has any experience with (semi-) automatic generation of work instructions. However, two participants have commissioned a system which is compatible with the adjustment and maintenance of work instructions on an individual level, nevertheless, the participants do not use the system (yet) in that manner (case B & G). Implementing such a system may alleviate the time and resource constraints associated with work instruction management when personalising work instructions.

Apart from work instruction generation and customisation software, the majority of the participants have either conducted (case B, D, F & G) or are currently running (case A, E & H) pilot programs to explore the application of modern technologies for work instruction presentation, whereas one participant (case I) has fully implemented five smart beamer setups for the projection of instructions. The pilot programs generally involve visual systems, including augmented reality combined with 3D objects and exploded views, guidance through beamer projection, and virtual reality. Participants have responded positively to these pilot programs, but they also have questions: *"What kind of maintenance is involved in these technologies, what expertise is needed for this, and how much time does it take?"*.

To summarise, the interviews revealed a supply and demand difference in individuals capable of handling complex tasks. Implementing personalised instructions is perceived as complicated and resource-intensive and individualising instructions for neurodiverse workers is difficult due to diverse characteristics and needs. Also, currently, personalised work instructions are observed limited among participants. Furthermore, few participants have adopted paperless instructions, while exploring technology applications like augmented reality and virtual reality shows promise but raises questions about maintenance, expertise, and time requirements.

5.2 Experimental Study

The results of the experimental study mainly provide findings for four aspects of the conceptual model (needs for instructions, the extent of fit between needs and instruction, complexity, and performance). Below, these findings are grouped for each of the four aspects of the conceptual model, whereas each time the qualitative results are addressed before the quantitative results.

5.2.1 Needs for work instructions

Addressing the needs of neurodivergent workers for work instructions was not a straightforward process. It should be noted that the researcher and the worker themselves were not aware of the needs for work instructions tailored to the neurodivergent worker beforehand. Therefore, the black-box approach was ultimately mainly adopted, where various examples of work instructions were presented and discussions were held to determine the needs. The emphasis was placed on what aspects of the different types of instructions worked best, with qualitative (satisfaction) and quantitative performance (time and errors) being the primary consideration.

First of all, it was found that the neurodivergent workers have varying levels of information processing capacity. Excessive stimuli and information overload have been shown to lead to confusion and difficulties in understanding instructions. Furthermore, while very detailed step-by-step instructions may set the slowest pace to comprehend the instructions for assembly tasks, it appears they do not provide sufficient context for neurodivergent workers to grasp the interconnections between different components. Therefore, without understanding the bigger picture, neurodivergent workers may struggle to comprehend the purpose and importance of each step. Lastly, to minimise confusion, it is important to ensure the accuracy and clarity of work instructions. This became clear due to an accidental mistake in the experimental work instructions itself where ambiguity or inconsistencies in the work instructions led to errors and confusion among the neurodivergent workers.

In terms of the presentation of the instruction, text-heavy instructions posed challenges for the neurodivergent workers. Instead, visual aids such as pictures or illustrations were more effective. It was found that visual instructions provide clear and concise information, reducing the cognitive load associated with reading and understanding text-based instructions. Furthermore, neurodivergent workers often face motor skill challenges, which can make handling paper instructions complicated, especially when dealing with extensive instructions containing numerous steps. In these cases, some of the neurodivergent workers were spending more time browsing the work instruction instead of executing the work instruction.

5.2.2 Extent of fit between needs and instruction

To confirm the results provided in '*5.2.1 Needs for work instructions'*, three types of work instructions (varying in the level of detail, number of steps, and usage of additional information) were constructed and presented in partnership with a similar study conducted in parallel to this research. Here, instruction type 1 is the most detailed, step-by-step, instruction with additional information and instruction type 3 is the least detailed instruction containing steps on sub-assembly level rather than part level. These three types of instructions were presented to the participants in combination with three assemblies of the same complexity level. The work instructions were offered to the participants in a fixed order, starting with instruction type 1 and finishing with instruction type 3. An overview of the partnership experiments for defining the needs is found in *Table 5.1*.

Table 5.1 – Overview of the partnership experiments for defining the needs

Experiment	***Participant***	***Instruction type***	***Assembly complexity***
1	A	1	Level 1
2		2	
3		3	
4	B	1	Level 2
5		2	
6		3	
7	C	1	Level 2
8		2	
9		3	
10	D	1	Level 3
11		2	
12		3	
13	E	1	Level 3
14		2	
15		3	

The quantitative results are given in *Table 5.2* and *Figure 5.1* (t_pick), *Table 5.3* and *Figure 5.2* (t_assemble), and *Table 5.4* (number of errors).

Table 5.2 – Average time in seconds for t_pick per instruction type and participant (STDEV)

Participant	Instruction 1	Instruction 2	Instruction 3
A	5.38 (2.87)	4.35 (1.21)	4.63 (0.29)
B	4.33 (0.72)	3.10 (0.33)	4.05 (0.24)
C	3.41 (0.97)	2.95 (1.42)	2.35 (0.69)
D	6.24 (0.69)	3.22 (1.35)	3.33 (0.73)
E	3.18 (0.36)	2.54 (0.89)	1.34 (0.24)

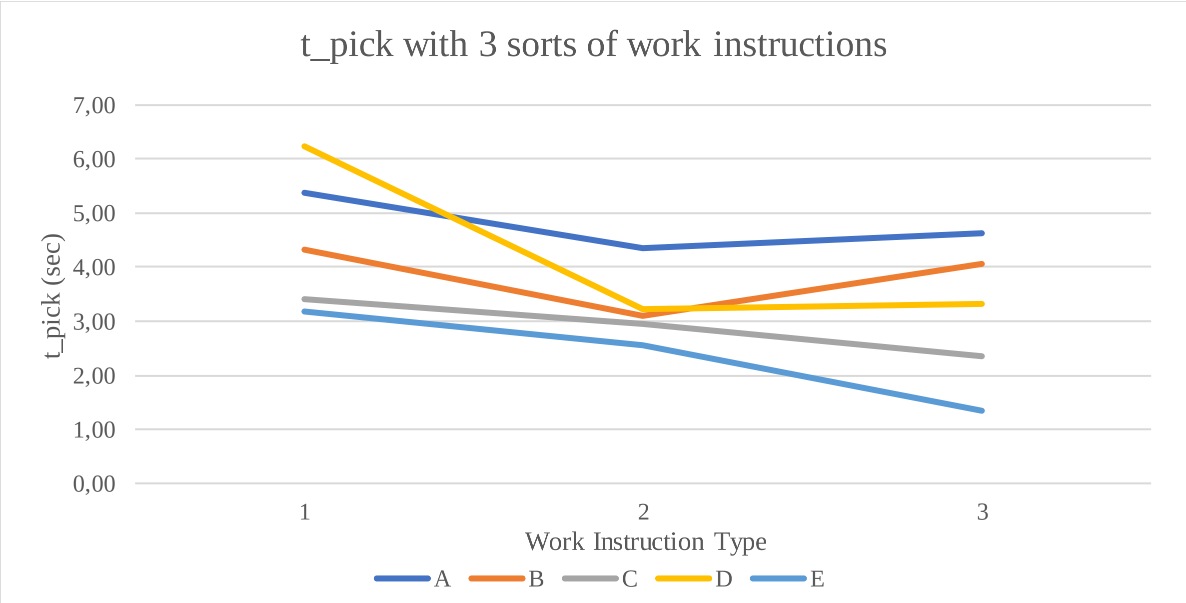

Figure 5.1 – Average time in seconds for t_pick per instruction type and participant

Following *Table 5.2* and *Figure 5.1*, there is a pattern to be recognised in the execution time of the picking process and the type of instruction. Here, the most detailed instruction (instruction type 1) has the longest average processing time, whereas the optimal instruction differs between instruction types 2 and 3. It can be noted that the variation in processing times is the lowest for instruction type 3, which is probably related to picking at assembly level, rather than part level.

Table 5.3 – Average time in seconds for t_assemble per instruction type and participant (STDEV)

Participant	Instruction 1	Instruction 2	Instruction 3
A	8.31 (6.60)	6.39 (2.05)	6.31 (0.70)
B	8.91 (2.00)	13.08 (7.31)	13.11 (1.15)
C	5.51 (1.71)	5.25 (1.94)	3.52 (0.74)
D	10.71 (6.97)	5.12 (1.48)	5.20 (2.12)
E	6.59 (3.76)	4.23 (1.60)	1.91 (0.28)

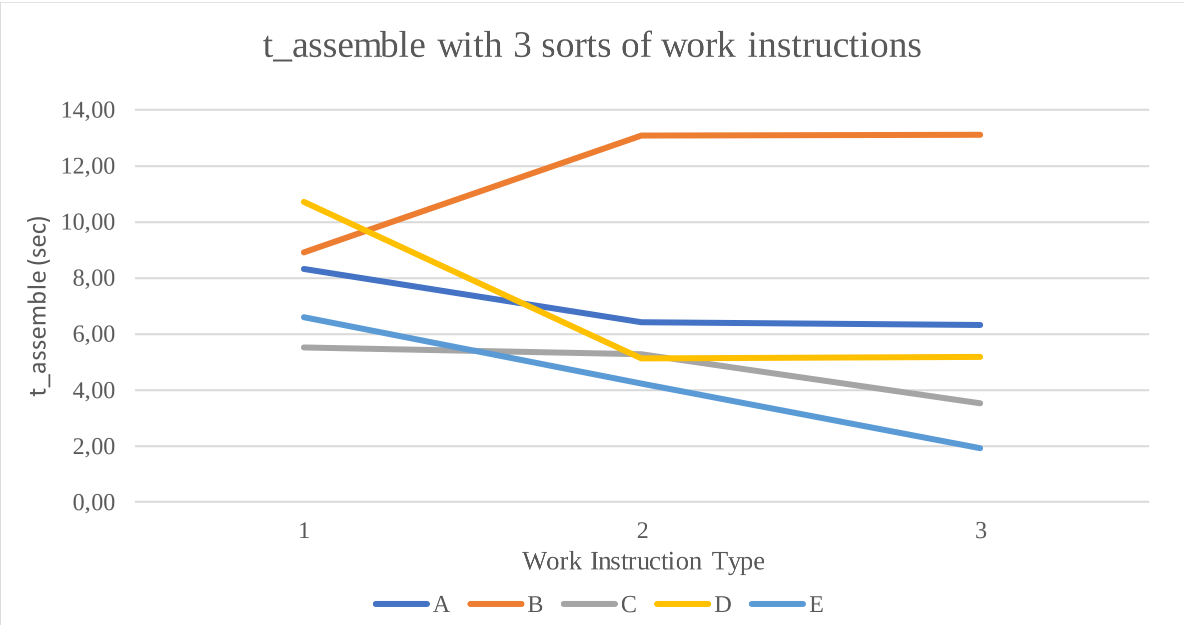

Figure 5.2 – Average time in seconds for t_assemble per instruction type and participant

Following *Table 5.3* and *Figure 5.2*, the same patterns as previously can be recognised in the execution time of the assembly process and the type of instruction, except for Participant B. The number of errors, displayed in *Table 5.4*, does not show significant values for the difference in instruction types, only that the errors were made exclusively in instruction type 2.

Table 5.4 – Average number of errors in steps per instruction type and participant (STDEV)

Participant	Instruction 1	Instruction 2	Instruction 3
A	0	0	0
B	0	0.25 (0.44)	0
C	0	0.13 (0.35)	0
D	0	0	0
E	0	0	0

5.2.3 Assembly Complexity and Performance

In the experimental study, the plan was to construct and present two additional types of work instructions (traditional and personalised based on previous results) to the neurodivergent workers in combination with an introduction of a task with higher complexity than previously. However, the neurodivergent workers found the introduction of more complex tasks to be a source of anxiety, especially when the task was accompanied by a traditional work instruction. This sample group exhibited resistance and frustration when errors occurred during the assembly with the traditional work instructions, whereas participant B was no longer willing to cooperate with the experiment. However, when provided with personalised work instructions, the neurodivergent workers were better able to handle relatively complex tasks and often reported enjoyment of the challenge and satisfaction that come with more complex tasks. Therefore, the experiment was continued, however without the usage of traditional work instructions and participant B. An overview of the adjusted follow-up experiments for defining the performance in relation to assembly complexity is found in *Table 5.5*.

Table 5.5 – Overview of the follow-up experiments for defining the needs

Experiment	***Participant***	***Instruction type***	***Relative assembly complexity capability level***	***Introduced higher assembly complexity level***
1	A	4 (Personalised)	Level 1	Level 3
2	C	4 (Personalised)	Level 2	Level 3
3	D	4 (Personalised)	Level 3	Level 4
4	E	4 (Personalised)	Level 3	Level 4

During the experiments, neurodivergent workers expressed a strong preference for the sense of independence that comes from following instructions. This sample group appreciated the clarity and structure provided by well-defined work instructions, as it allows them to work autonomously. Additionally, when given the option, the neurodivergent workers preferred to rely on the work instructions, rather than solely observing and imitating others, as this type of work instruction is also offered at the case company.

The quantitative performance of the tasks is compared to the previous results to see if there is an increase or decrease. The quantitative results are given in *Table 5.6* and *Figure 5.3* (t_pick), *Table 5.7* and *Figure 5.4* (t_assemble), and *Table 5.8* (number of errors) on the next pages.

Table 5.6 – Average time in seconds for t_pick per instruction type and participant (STDEV)

Participant	Relative assembly complexity capability level			Higher complexity
	Instruction 1	**Instruction 2**	**Instruction 3**	**Instruction 4 (Personalised)**
A	5.38 (2.87)	4.35 (1.21)	4.63 (0.29)	1.92 (0.45)
C	3.41 (0.97)	2.95 (1.42)	2.35 (0.69)	2.09 (0.71)
D	6.24 (0.69)	3.22 (1.35)	3.33 (0.73)	2.23 (0.52)
E	3.18 (0.36)	2.54 (0.89)	1.34 (0.24)	2.39 (0.60)

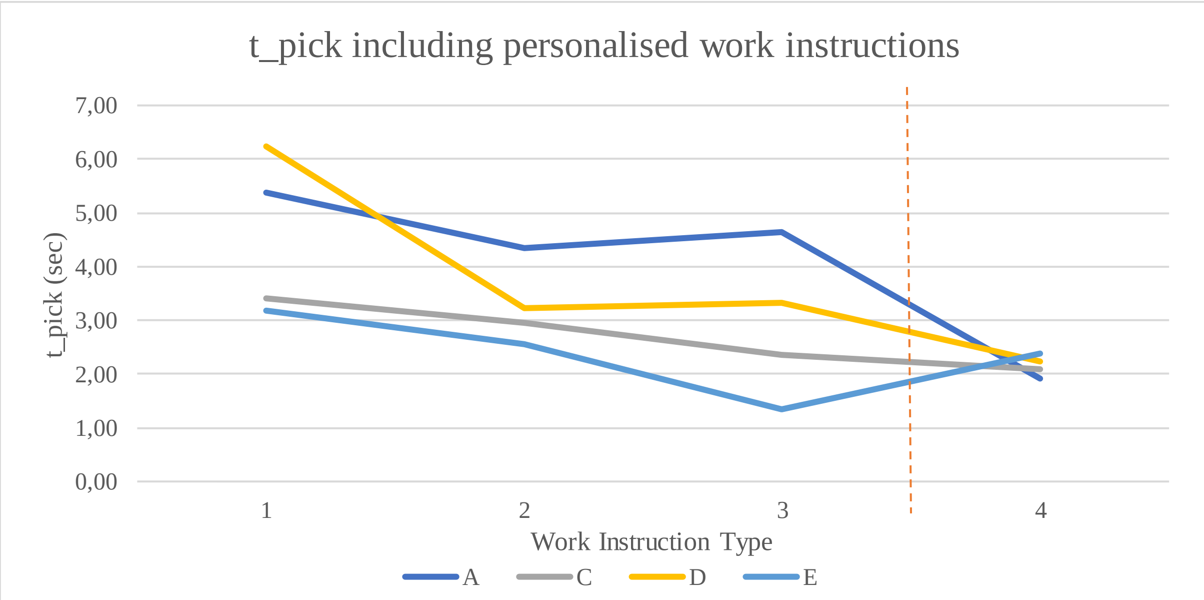

Figure 5.3 – Average time in seconds for t_pick per instruction type and participant

Following *Table 10* and *Figure 4*, there is a pattern to be recognised in the execution time of the picking process for tasks on the level of the relative assembly complexity capability in relation to tasks with a relatively higher complexity (and accompanying work instruction types). Here, the personalised work instruction (instruction type 4) ensures an equal or sometimes even faster execution of the picking process, even though the complexity of the assembly has increased.

Table 5.7 – Average time in seconds for t_assemble per instruction type and participant (STDEV)

Participant	Relative assembly complexity capability level			Higher complexity
	Instruction 1	**Instruction 2**	**Instruction 3**	**Instruction 4 (Personalised)**
A	8.31 (6.60)	6.39 (2.05)	6.31 (0.70)	3.24 (0.98)
C	5.51 (1.71)	5.25 (1.94)	3.52 (0.74)	3.76 (0.66)
D	10.71 (6.97)	5.12 (1.48)	5.20 (2.12)	4.14 (0.86)
E	6.59 (3.76)	4.23 (1.60)	1.91 (0.28)	3.08 (1.08)

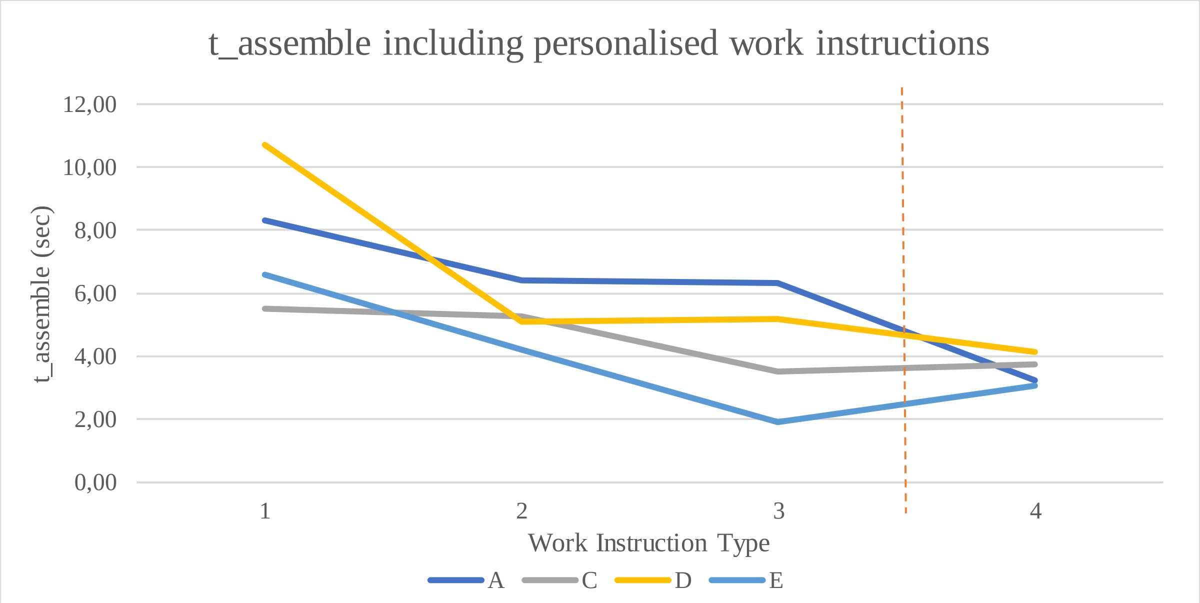

Figure 5.4 – Average time in seconds for t_assemble per instruction type and participant

Following *Table 11* and *Figure 5*, the same patterns as previously can be recognised in the execution time of the assembly process and the type of instruction. The number of errors, displayed in *Table 12*, does not show significant values for the difference in instruction types, only that the errors were made exclusively in instruction types 2 and 4.

Table 5.8 – Average number of errors in steps per instruction type and participant (STDEV)

	Relative assembly complexity capability level			**Higher complexity**
Participant	**Instruction 1**	**Instruction 2**	**Instruction 3**	**Instruction 4 (Personalised)**
A	0	0	0	0.06 (0.25)
C	0	0.13 (0.35)	0	0
D	0	0	0	0
E	0	0	0	0.06 (0.25)

6. Discussion

The findings from the current-state analysis provide insights into the assembly complexity, personalisation of work instructions, and the use of technology in relation to neurodivergent workers. Whereas the experimental study focuses on the needs for work instructions, the extent of fit between needs and instructions, and the performance of neurodivergent workers.

Regarding assembly complexity, the current-state analysis reveals that organisations are experiencing a shortage of individuals who can perform relatively complex tasks. On the other hand, neurodiverse workers, particularly those in sheltered employment, are engaged in less complex and repetitive jobs that can lead to boredom, which corresponds to the challenges neurodiverse workers face due to a lack of understanding and accommodation in previous research. Introducing more complex tasks, along with the correct accommodation, to individuals with a distance to the labour market can be seen as a potential solution to enhance job satisfaction and fill vacant positions. This finding highlights the importance of providing meaningful and engaging work for neurodivergent workers, as it can have a positive impact on their overall job satisfaction.

The current-state analysis also explores the personalisation of work instructions for neurodivergent workers. While limited forms of personal work instructions currently exist at the case companies, the management of work instructions is generally perceived as complicated by participants. Making specific adjustments or implementing changes across all instructions requires significant time and resources. This poses a challenge for organisations considering the implementation of personalised work instructions from a management perspective. Additionally, the diverse characteristics and needs within the neurodiverse population make individual personalisation of work instructions difficult. With a broad spectrum of neurodiversity and the occurrence of double neurodiverse diagnoses, there are variations in the characteristics and needs of neurodivergent workers. These findings suggest that developing personalised work instructions for each individual may be a complex and time-consuming task.

The use of technology in work instructions is another aspect explored in the current-state analysis. Currently, only half of the participants have adopted paperless work instructions, with various hardware, such as computer screens and laptops, being used for instruction presentation. However, none of the participants has experience with (semi-)automatic generation of work instructions. Some pilot programs involving visual systems, augmented reality, and virtual reality have been initiated by participants, but the participants are reluctant to this technology when it comes to maintenance and expertise. The potential benefits of implementing technology for work instruction generation and customisation are acknowledged, as it may alleviate some of the time and resource constraints associated with the manual management of instructions, which can be an important enabler for developing personalised work instructions.

Regarding the needs of neurodivergent workers for work instructions, it became clear that the neurodivergent workers lacked a clear understanding of their own needs. As a result, examples of work instruction had to be presented to determine preferences, which is in line with the 3-step plan from previous research in which the responses to different types of instructions are measured. Neurodivergent workers exhibited varying levels of information processing capacity, with excessive stimuli and information overload leading to confusion and difficulties in understanding instructions. Detailed step-by-step instructions, while providing clarity, may not offer sufficient context for understanding the interconnections between components. Clear and concise visual instructions were found to be more effective in reducing cognitive load and improving comprehension. Motor skill challenges among neurodivergent workers made handling paper instructions time-consuming and complex, highlighting the importance of considering alternative formats for instruction presentation.

The extent of fit between the needs and instructions was explored through the construction of different types of work instructions. It was observed that the level of detail, number of steps, and usage of additional information impacted the execution time of the picking and assembly processes. The most detailed instruction had the longest average processing time, while instruction type 3, which contained steps at the sub-assembly level, exhibited the lowest variation in processing times. This reaffirms the significance of understandability and readability as crucial factors for a well-crafted work instruction, as highlighted in earlier research. These findings further indicate that while there exists a somewhat general preference towards certain presentation options, it is important to acknowledge that the needs of neurodivergent workers do not fully align with those of each other, which is also in line with previous research.

Regarding performance, neurodivergent workers expressed a preference for following work instructions, as it provided them with a sense of independence and structure. Traditional work instructions were found to be challenging, particularly when presented with more complex tasks, leading to resistance and frustration among the workers. However, when provided with personalised work instructions, neurodivergent workers were better able to handle complex assemblies and reported enjoyment and satisfaction. This corresponds to previous literature that mentions the importance of personalised work instructions that take into account individual preferences, as well as literature that highlights the enhancement of motivation by increasing job complexity. Personalised work instructions appeared to support neurodivergent workers in understanding and executing tasks efficiently, even when the complexity increased.

Overall, the findings suggest that personalised work instructions have the potential to improve accommodation for neurodiverse workers. While challenges exist in terms of managing and implementing personalised instructions, technology can play a role in alleviating some of these difficulties. As a result, the immediate cost-effectiveness of personalised work instructions may seem unfavourable. Nevertheless, in the long term, personalised work instructions provide a structured approach to training and supporting neurodivergent workers based on their individual needs. The experimental study further highlights the importance of considering the specific needs of neurodivergent workers, such as reducing cognitive load through visual instructions and providing clarity and structure. By tailoring work instructions to the individual characteristics and needs of neurodivergent workers, organisations can enhance their job satisfaction, performance, and overall inclusion in the workforce.

7. Conclusion

This research aimed to investigate the role of personalised work instructions in improving inclusive accommodation for the neurodiverse workforce, specifically in relation to assembly complexity. By addressing the existing knowledge gap (lack of understanding of the needs of neurodiverse workers, and how these needs can impact individual performance in the workplace) and exploring the cognitive characteristics of neurodivergent workers, this research has made contributions to the field of operations management. The research consisted of two parts: a current-state analysis and an experimental study. The current-state analysis involved interviews with nine organisations employing neurodiverse workers to understand their experiences and challenges with work instructions. An interview with an expert in neurodiversity at work provided additional insights into the variety of characteristics and needs of neurodiverse workers. The experimental study explored personalised work instructions in relation to the assembly complexity, addressing the needs of neurodivergent workers and evaluating the effectiveness of the work instruction.

The current-state analysis provided insights into the assembly complexity, personalisation of work instructions, and the use of technology. It revealed the importance of providing meaningful and engaging work for neurodivergent workers, as well as the challenges associated with implementing work instructions. The study also highlighted the potential benefits of using technology for work instruction generation and customisation. Furthermore, the experimental study explored the needs of neurodivergent workers for work instructions and the extent of fit between those needs and the instructions provided. It revealed the varying levels of information processing capacity among neurodivergent workers and the effectiveness of clear and concise visual instructions in reducing cognitive load. The experimental study also demonstrated the positive impact of personalised work instructions on performance, indicating that neurodivergent workers were better able to handle complex tasks and reported higher levels of satisfaction when provided with personalised work instructions.

Based on the findings, it can be concluded that personalised work instructions have the potential to improve accommodation for neurodiverse workers. While challenges exist in terms of implementation and management, technology can play a crucial role in overcoming these difficulties. Although the immediate cost-effectiveness of personalised work instructions may be a concern, the long-term benefits, such as enhanced job satisfaction, improved performance, and increased inclusion in the workforce, make personalised instructions a valuable investment.

However, it is important to acknowledge the limitations of this study. Firstly, the research focused primarily on assembly work, limiting its generalisability to other types of work. Secondly, subjective data collection methods introduce potential bias, particularly in qualitative data analysis. Furthermore, using LEGO® assemblies as products may not fully capture real-world work complexities. Also, presenting the different instruction types in the same order (instruction type 1, instruction type 2, instruction type 3, instruction type 4) cannot completely exclude the learning effect from the findings. Lastly, a group-based approach to personalised work instructions may overlook specific individual needs, potentially affecting the outcomes. Future research can explore the effectiveness of technology-based work instruction systems in improving the performance and inclusion of neurodivergent workers. Other potential topics are to investigate the transferability of personalised work instructions to different types of work, evaluate their long-term effects on neurodivergent employees' retention, career progression, and well-being, or to compare individual-based and group-based approaches for optimal customisation in terms of efficiency and scalability. Assessing the economic implications, including cost-benefit analysis and potential savings associated with improved productivity and employee well-being, may also be an interesting topic for future research.

In conclusion, personalised work instructions offer a promising approach to accommodate the unique needs of neurodivergent workers. By tailoring instructions to needs, organisations can enhance the performance and job satisfaction of neurodiverse employees. The integration of technology can further support the implementation and management of personalised work instructions. This research contributes to the understanding of how work instructions can be a valuable tool in improving accommodation for neurodiverse workers, ultimately promoting inclusiveness and diversity in the workforce.

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Appendix A – Two examples of traditional work instructions at the case companies

4 OMDOOS INPAKKEN

4.1 Instructie

a. Elke omdoos bevat 2 lagen van 7 displays.
b. Vul de eerste laag met 7 displays (zie de foto). NB: de foto laat een andere kleur display zien.

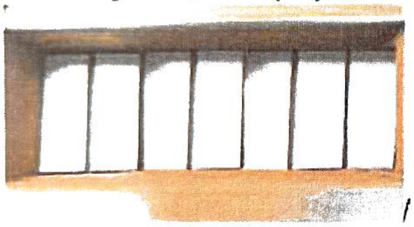


Foto 9

c. Zet daar nog een keer 7 displays bovenop.
d. In totaal gaan er 14 displays in de omdoos.
e. Sluit de omdoos met plakband.

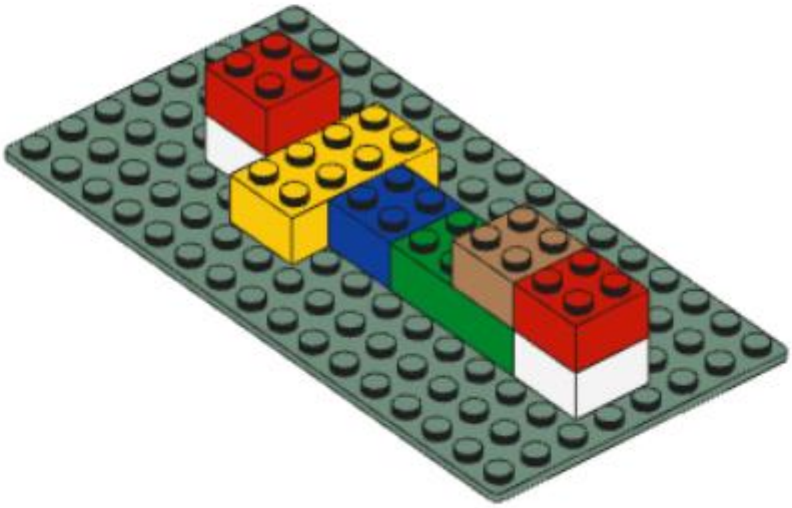
Stap 5

3 x 800504 bandenlichter simson lang (in elkaar geklikt) in het doosje leggen

Stap 6

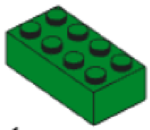
1 x 500205 Plastic wegwerp handschoenen in het doosje leggen

Appendix B – Translated version of traditional work instruction #2

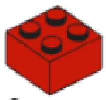


Work Instruction #2

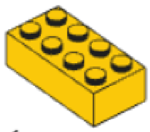
Part list



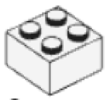
x1



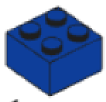
x2



x1

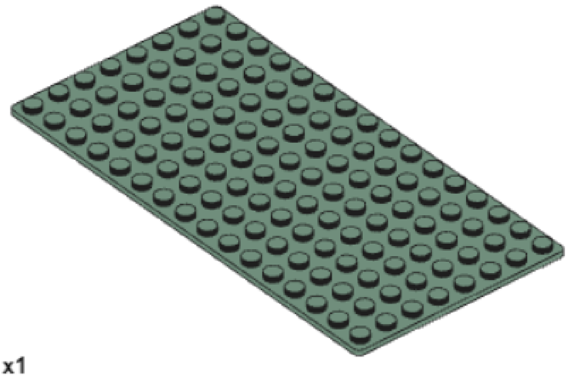


x2



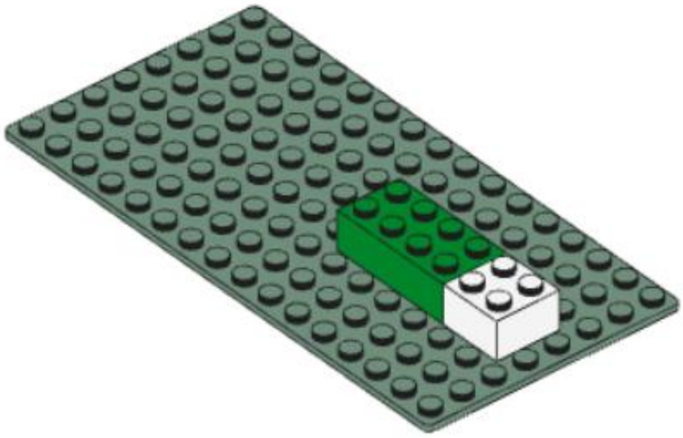
x1

x1

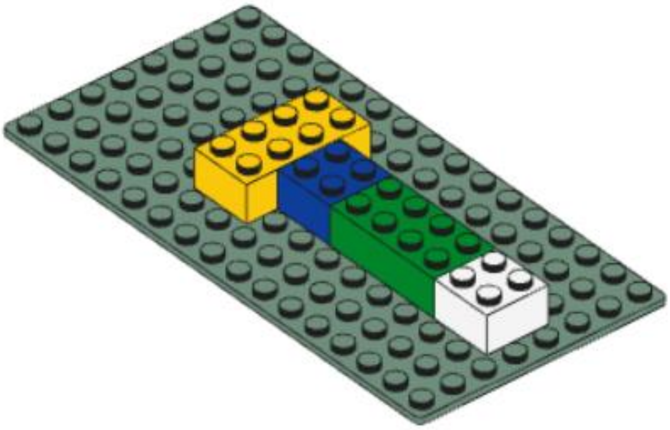


x1

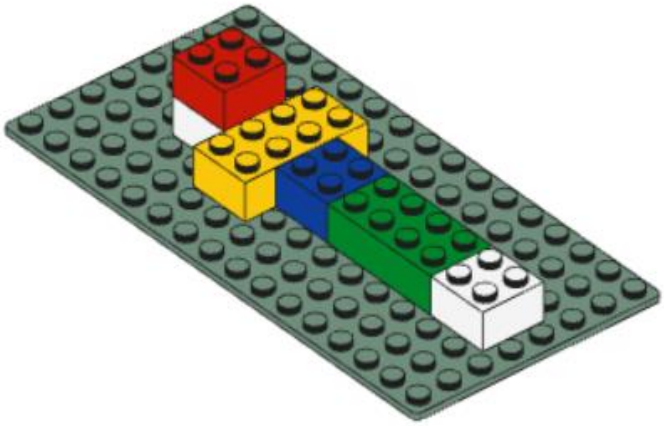
Step 1

1. Take a white 2x2 block and assemble it at the location addressed in the picture 2. Take a green 4x2 block and assemble it next to the white 2x2 block at the location addressed in the picture	

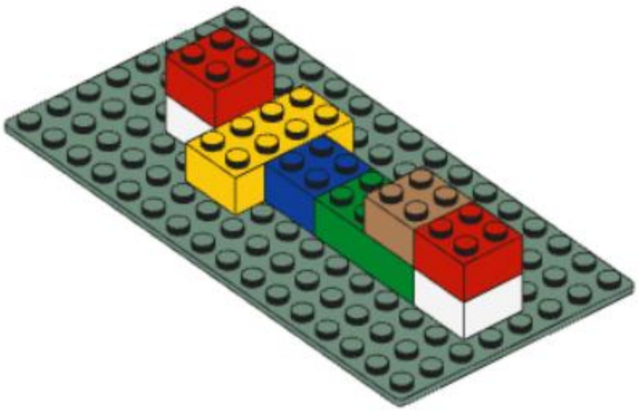
Step 2

1. Take a blue 2x2 block and assemble it next to the green 2x2 block at the location addressed in the picture 2. Take a yellow 4x2 block and assemble it next to the blue 2x2 block at the location addressed in the picture	

Step 3

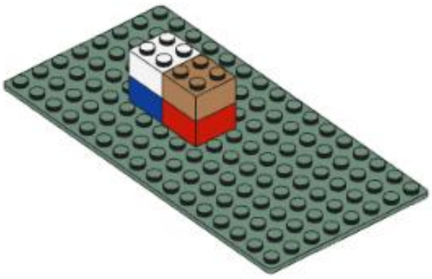
1. Take a white 2x2 block and assemble it next to the yellow 4x2 block at the location addressed in the picture 2. Take a red 2x2 block and assemble it on top of the white 2x2 block at the location addressed in the picture	

Step 4

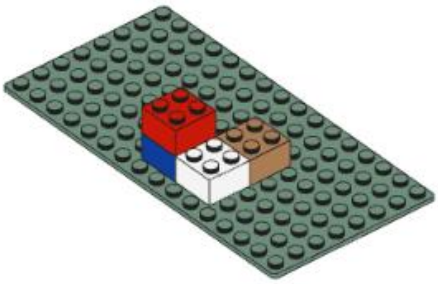
1. Take a red 2x2 block and assemble it on top of the white 2x2 block at the location addressed in the picture 2. Take a brown 2x2 block and assemble it next to the red 2x2 / on top of the green 4x2 block at the location addressed in the picture	

Appendix C – Assemblies of the experiment at different complexity levels

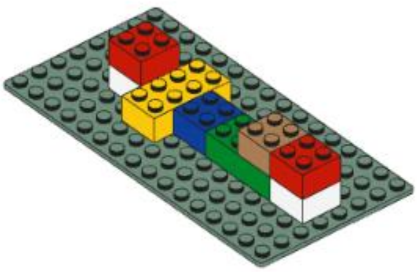
1. *Complexity level 1 - Assembly 1*



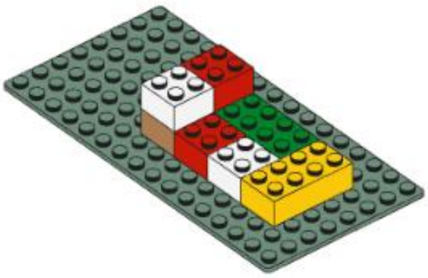
2. *Complexity level 1 - Assembly 2*



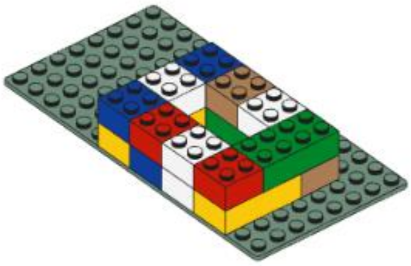
3. *Complexity level 2 - Assembly 3*



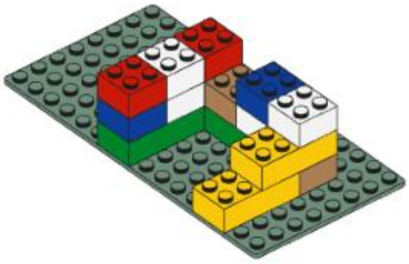
4. *Complexity level 2 - Assembly 4*



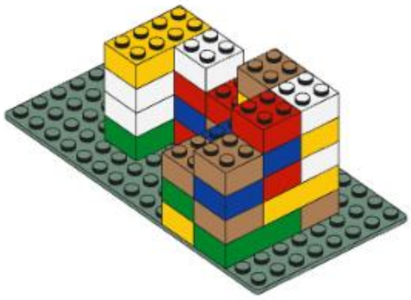
5. *Complexity level 3 - Assembly 5*



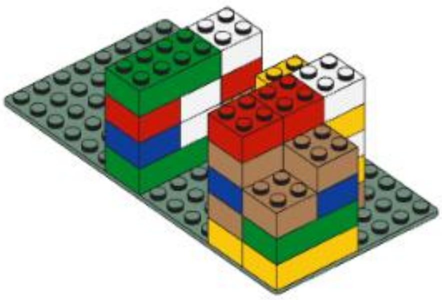
6. *Complexity level 3 - Assembly 6*



7. *Complexity level 4 - Assembly 7*



8. *Complexity level 4 - Assembly 8*



Appendix D – Preview of the experimental setting

The participant of the experiment has their own workplace, which is located on the work floor to simulate normal work conditions.