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INADEQUATELY DESIGNED INFORMATION AND ITS EFFECT ON THE COGNITIVE WORKLOAD

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ABSTRACT

The design and handling of information in manual assembly is becoming increasingly important in achieving effective and competitive assembly. However, the information provided to the assembly personnel in the automotive industry is usually poorly designed and presented, which can cause unnecessary mental stress and increase cognitive workload. Due to inadequate information, the original goals are placed aside and the workers are forced to figure out where the right information is located and how to access it within the system. One way of supporting the assembler could be to use kitting, which is a material supply principle where the assembler is provided with a kit of components that together support one or more assembly operations. The kit can also be considered as a carrier of information that complements or even replaces conventional assembly instructions. The aim of this paper is to initiate a theoretical exploration of the relationship between the assembler’s information needs and the kitting box, by investigating the kitting box and its potential to provide enough information for the assembler to fulfil the assembly task.

KEYWORDS: Inadequate information, Manual assembly, Kitting

1. INTRODUCTION

The information systems used in today’s assembly are lacking in usability in many ways [1]. One of the reasons is that the assembler is provided with too much information rather than the appropriate information. As a result, the operators not only fail to assemble the correct and required parts in spite of available information, but also they suffer unnecessary mental workload which ultimately results in a further increase in assembly errors. However, information that is presented at the right time, with the right content, in the right layout and in a perceivable way will ease the workload for the assembler [2, 3].
2. THEORETICAL FRAMEWORK

To support the assembler, several information systems are necessary. If assemblers are faced with poorly presented information, their workload increases due to the fact that they must concentrate on mental sorting and searching for the appropriate information. Since the original goals are then placed aside, the workers are forced to figure out where information is located and how to access it in the system. Therefore poorly constructed interfaces place demands on resources such as memory and attention [4].

2.1 The information search process

Information behaviour and the information search process are used, in this paper, as a foundation when considering how the construction and presentation of information affect the performance of an assembly task. Byström et al. [5] identify the stages of the information search process as:

- Perceive the need for information
- Receive information
- Interpret information
- Sort information
- Process information
- Act

A projection of this process onto manual assembly is illustrated in figure 1. Here the assembler first searches for information about the assembly object. Then the assembler perceives what type of variant of the assembly object is of concern. Afterwards, the assembler has to search for the right components to complete the assembly task. This is usually the most time demanding part of the process since the information provided to the assembler is often unfavourable and each part number is generally presented in a separate container. In the example illustrated in figure 1, the assembler at this particular workstation will assemble three components: one turbo, one manifold and one gasket. It is not uncommon for these components to exist in various variants (five of each in this example). This means that the assembler has 125 combinations to choose from, which illustrates the complexity of the task. However, when the three correct components are chosen the assembler is ready to complete the task. This entire information search process represents an enormous risk of losses in for instance time and quality. It also shows that the assembler, contrary to common perception, is subjected to information overload rather than receiving too little information.
2.2 Attention

According to Endsley [6], attention to information is prioritised depending on the importance of the perceived information. Through examples it was inferred that experienced operators deployed their attention in ways that are consistent with operational goals. Further, attention can be divided into two situations [7]:

- **Passive attention**: a salient event happens (e.g. loud noise) and automatically triggers the attention of an agent.
- **Active attention**: an agent is involved in an intentionally directed oriented process (for instance climbing a mountain) and must actively selecting particular features of its environment.

Yantis [8] argues that attention is both goal-driven and stimulus-driven. This indicates that assembly personnel are faced with top-down (goal driven) attention or bottom-up (stimulus driven) attention. Yantis further states that:

- **Goal-driven** (active attention) is recognised when it is controlled by the observer’s deliberate strategies and intentions, such as searching for a specific marker connected to a product.
Stimulus-driven (active or passive attention) is recognised when it is controlled by some salient attribute of the image that is not necessarily relevant to the observer’s perceptual goals. For example, an assembler may be searching for components but all components look similar or the same, except one that seems to “pop-out of the background and draw attention automatically”.

Bäckstrand et al. [9] claim that there is a connection between active information seeking behaviour and assembly errors (i.e. incorrect assembled engines). They also suggest that it does not matter how much information the assembler acquires if the active information seeking behaviour is not supported or triggered in any way. Bäckstrand [2] further elaborates on the possibility of passive attention drawing less energy from a “strictly limited pool”, which according to Wickens [10] is used as storage of working energy. Further, Endsley [6] discusses that limited working memory imposes a constraint on situation awareness. This leads to novice decision makers and those in novel situations having a harder time of combining information, interpreting it and later striving to make projections. This is very interesting since, as stated before, the aim of information is to support the assembly personnel in fulfilling their assembly task. Then the goal must be to support the assemblers in a way that makes it possible to continue working in a passive attention mode which might result in reduced cognitive workload [2].

Based on this assumption it is interesting to further study the potential consequences of active and passive attention. In figure 2, two possible scenarios are illustrated, in which an attempt to identify the possible consequences of inadequately designed information and well-designed information is considered. An assembler receiving inadequately designed information probably has to search more actively for information, which is time consuming and affects the mental workload. This in turn increases the stress level, which has the possibility to result in greater risk of a decrease in working conditions, assembly errors and productivity. In the alternative scenario an assembler receives well designed information, which means that the assembler passively can perceive and process information. This results in a simplified work situation, and the likeliness of improved working conditions and increased quality and productivity.
2.3 Information support systems

As mentioned earlier, to ease the cognitive workload for the assembler at the assembly line, several information support systems are necessary. One method that has potential in decreasing the cognitive workload is the principle of kitting. This material feeding principle is often discussed and compared to the common alternative of continuous supply (also known as line-stocking) [1]. In contrast to continuous supply, kitting means that parts are delivered and presented to the assembly operations in pre-sorted kits, where each kitting box containing parts for one assembly object [11]. Within the literature, kitting has been stated to be associated with a number of effects such as quality, productivity, man-hour consumption and space requirements near the final assembly line [11, 12].

However, a kit can also be regarded as a carrier of information that complements, supports or even replaces conventional assembly instructions. Medbo [13] argues that, correctly structured, a kit can support assembly by functioning as a work instruction. If the parts are placed in the kit in a manner that reflects the assembly operations, kitting can facilitate learning and, consequently, reduce learning times and improve product quality [14]. The benefit, from an ergonomics perspective, is that the assembler only has to focus on the assembly process, i.e. how to assemble,
and does not need to be concerned with what parts to assemble, which ultimately can result in high support of product quality [2].

As discussed earlier, the conventional way of searching and receiving information for the assembler in manual assembly, such as continuous supply, leads to stress and a significantly increased cognitive workload for the assembler. If one instead uses a kit and therefore replaces the need for perceiving what type of assembly object that will be assembled as well as the search for component variants and fetching parts, the possible combinations are reduced to one (see figure 3). This will not only reduce the stress level for the assembler but will possibly also reduce the cognitive workload.

![Figure 3. Information search process when using a kit.](image)

Accordingly, kitting will be able to entirely eliminate the assembler’s risk of picking the wrong variant of component. However, quality must be assured in the preparation of kits, otherwise the potential quality gains associated with kitting will not be realised.

When using kitting as a material supply system and information carrier, the decision of what variants of components the kitting box will contain is only forwarded to the personnel that prepare the kitting box. This means that the preparer is in need of an information support system that is able to handle the decisions concerning the component variants that should be in the box.

### 2.4 Semiotics

If one presumes that the use of kitting will ease the cognitive workload for the assembler by acting as a carrier of information, then the design of the box should be of outmost importance and support the assembler in the best way possible. It also means that the components themselves contain and convey information, signs, to the assembler of how to fulfil the assembly task. By studying semiotics, also known as the study of signs [15] (figure 4) it is possible to learn more about, for instance, alternative ways of triggering information and how the assembler perceives, searches and sorts information. Further knowledge regarding this issue could lead to an optimised design of the kitting box resulting in reduced cognitive workload for the assembler.
Semiotics studies the signs in everyday use, such as traffic signs, symbols and pictures. Text is an assemblage of signs (such as words), constructed and interpreted with reference to the conventions of a particular genre and medium of communication.

Semiotics is most commonly studied within the research fields of product design and human-computer interaction, and then mainly through the use of semantics [16]. Very little research has been conducted connecting semiotics to manual assembly, or in an industrial environment at all for that matter. Bäckstrand et al. [17] experimented in manual assembly by using colours as a trigger which had a positive effect on assembly errors.

3. CONCLUSION

The little research that has been done within the field of manual assembly usually concerns semantics. However, the authors believe that it is important to gain a broader perspective and therefore also study how an assembler interprets and uses signs/information and how the message of the signs can be perceived differently. Studying semiotics further increases the possibilities for understanding and affecting the assembler’s information search process. Future studies will therefore include studying different aspects of semiotics and its impact on the information process as well as its application onto the kitting principles.

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5. REFERENCES


