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Automation and Complacency: Insights from a Planning Task in the Transportation Domain

Eugénie Avril¹, Jordan Navarro², Liên Wioland³, Benoit Valéry¹, Virginie Govaere³,
Didier Gourc⁴, Koosha Khademi¹, Christos Dimopoulos⁵, Elisabeth Dargent⁶,
Nathalie Renaudeau⁷, and Julien Cegarra¹

¹ Science de la cognition, Technologie, Ergonomie (SCoTE), University of Toulouse, INU
Champollion, Albi, France.

{eugenie.avril, julien.cegarrar, koosha.khademi,
benoit.valery}@univ-jfc.fr

² Laboratoire d'Etude des Mécanismes Cognitifs, University Lyon 2, Bron, France.
jordan.navarro@univ-lyon2.fr

³ INRS working life department, Paris, France
{lien.wioland, virginie.govaere}@inrs.fr

⁴ University of Toulouse, IMT Mines Albi, France
didier.gourc@mines-albi.fr

⁵ Department of Computer Science & Engineering, European University Cyprus
C.Dimopoulos@euc.ac.cy

⁶ Deret, Saran
nrenaudeau@deret.com

⁷ Main Forte, Lille
elisabeth.dargent@main-forte.fr

Abstract. Automated systems are becoming increasingly prevalent in our environment. This leads to a new tasks repartition between the human operator and automation. Understanding human-machine cooperation including potential failures has become a hot topic. In this study we focus on a possible negative consequence of automation: the complacency phenomenon. This phenomenon has been repeatedly observed in dynamic situations in which automation execute an action in order to relieve the human operator from his/her activity. In static task, automation often serves to simplify/pre-process the data and not to directly make a decision. The goal of automation in a static task (like planning) is to optimize an external representation and allow the human operator to make his choices more easily. The Eye Tracker is used to understand human behaviors and their strategies in these static situations. The purpose of this study is therefore to compare complacency to “action execution” from complacency to “data simplification”. We confronted 96 participants to these two automation types on the Multi Attribute Task Battery. We also manipulated four levels of automation reliability (0%; 56.25%; 87.5%, 100%). In all these conditions we assessed complacency through the detection rate of automation failure. In addition, we used an eye tracker to assess a potential low level of suspicion regarding automation failure.

Keywords: Automation, Reliability, Complacency, Detection Failures, Trust.

1 Introduction

Automation might provide large differences in functioning when comparing dynamic situation such as aircraft piloting to static situation as the planning of delivery in the transportation domain. Since the 1970s, different decompositions of degrees of automation have been proposed in the literature [1, 2]. It also has been proposed to include human-human model of cooperation to human-machine activities [3]. According to Parasuraman [4], different failures in the cooperation between the human operator and the automated system can occur such as the complacency phenomenon. This phenomenon occurs when the human operator is not questioning the actions of the automated systems even if these were wrong. Automation is often considering in the ergonomic literature as an action execution intervening in a dynamic situation. The ecological interface design (EID) [5], allow extending this point of view by focusing on the importance of problem representation. Thus, the design of external representations has become central in this new type of automation [6, 7]. That is the case in the planning of delivery in the transportation domain where the human operator faces a large set of information. The automation is present through an interface where data is pre-processed, thus facilitating information seeking and finally decision making. The objective of the study is to demonstrate that the failures of the cooperation between the human operator and the automation can relate to “action execution” (automation of command) but also to “data simplification” (automation of signaling). We hypothesized an effect of the degree of reliability of the signaling automation and of the degree of reliability of the command automation on the error detection rate

2 Related Work

Many studies showed the emergence of complacency between human and automation [8, 9, 10]. This is particularly present in studies where the reliability of automation is modulated. Unability to detect automation failures is used to demonstrate the evidence of this phenomenon [8, 9, 10]. The study of eye movements also supports the hypothesis of the complacency through the attention allocation of the participant [11]. Bagheri and Jamieson [8] did compare different levels of automation reliability. They showed that when the reliability was constant and high, the mean time between fixations in the automated task was higher compared than the other reliability levels. These authors explained the importance of eye movement analysis to better understand the participant’s allocation strategies, in addition to the failure detection performance.

Trust of the human operator towards the system is also related to this phenomenon. Here the trust in the system is related to the automation performance [12]. All of these studies have in common to use the Multi Attribute Task Battery, a micro world of aircraft piloting that can present both “action execution” and “data simplification” automation [13].

In our study, we hypothesize that when automation reliability is high, the participant will tend to be "complacent" with the automated system and therefore will not neces-

sarily detect and react correctly to automation failures. Contrary, with a highly unreliable automated system, the participant will regain control (ie. a lower confidence) and will more easily detect errors (ie. a lower complacency). Indeed, when automation fails in the task, the participant does the task instead of automation and thus regain control.

3 Research Methodology

3.1 Design

We confronted 96 participants to 4 conditions of reliability of automation (24 in each condition).

The 4 levels of reliability of the automation were 0%; 56.25%; 87.5% and 100%. Two types of automation were used: an automation of command and an automation of signaling. The reliability of the command automation was an intra-subject variable; the participants performed the 4 levels of reliability. Conversely, the reliability of signaling automation was inter-subject; each condition corresponding to a level of reliability (and therefore the 4 levels of reliability "execution").

As the experiment is currently underway, only two conditions could be performed by the participants at the moment (0% and 56.25% of signaling automation).

3.2 The Multi Attribute Task Battery

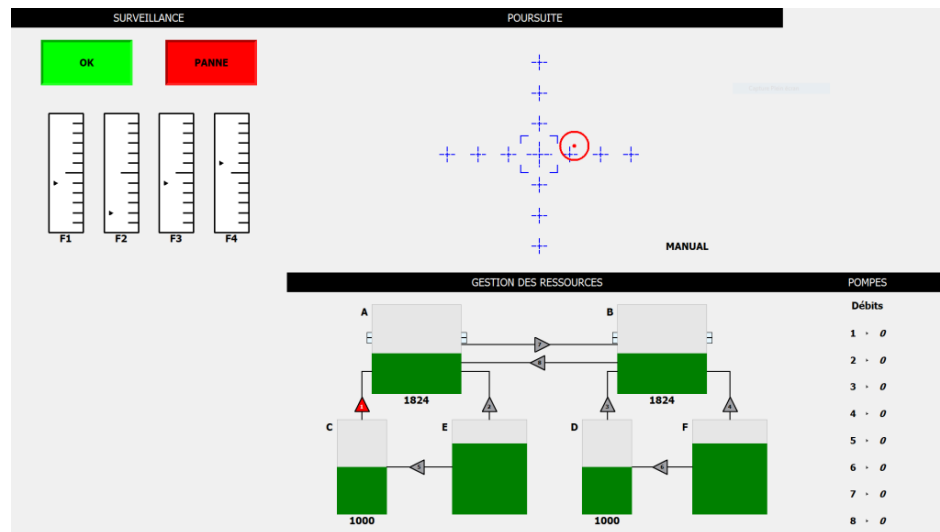


Fig. 1. The Multi Attribute Task Battery.

Each participant has to perform three tasks in parallel. The first task was a monitoring task (Fig 1. Top left). This task consisted of four columns. In a normal situation, the cursor fluctuated around the center of the column. In case of failure, the cursor

frozen in the lower part or the upper part of the column (and not in the center) and the "failure" light changed to red. When there was a failure, the participant had to press F1 (if the cursor was blocked in column 1), F2 (column 2), F3 (column 3) and F4 (column 4).

In our study, this task was automated. The cursor was automatically unblocked after 10 seconds when there was a failure. However, the automated system might dysfunction: sometimes, the cursor could not be unblocked (command automation) and the light did not change to red (signaling automation) while there was a failure. In these cases, the participant had to regain control by pressing the corresponding key. The participant was warned of "possible automation failures, in the release of cursor to nominal state or in the color signalling."

The resource management task consisted of several tanks (Figure 1 bottom). The goal is to maintain tanks A and B at 2500 units each (optimal value). However, the fuel emptied into these two tanks and the participant had to activate pumps to use the safety tanks and to keep the values in these tanks. The reserve tanks E and F were unlimited unlike other tanks whose liquid level was displayed under them. The different tanks did not have the same rate of fluctuation of the liquid. Thus, the pumps 1 and 2 had a flow rate of 800; pumps 3, 4, 5 and 6 had a flow rate of 600; pumps 7 and 8 had a flow rate of 400. When the participant activated a pump, the flow rate appeared on the right. To fill the main tanks, participants had to use the number located on their keyboard.

The last task is a compensatory tracking task and the subject's task is to keep the target in the center of the window with a Joystick (Figure 1 top right).

We used an SMI Eye Tracker to measure eye movements (at a 120Hz sampling rate).

4 Results

The results are not final because the experiment is still underway. Therefore only the first results on two conditions are described below (0% and 56.25% of signaling automation).

The effect of reliability of the automation signaling on the performance was analyzed. Condition 4 of reliability (100%) was excluded in calculating the performance of the monitoring task because there was no detection of automation failures and therefore no performance to measure. No overall effect of the command reliability was found (Figure 2). Concerning the signal reliability, participants perform better in the resource task than in the monitoring task and the tracking task.

The performance in the monitoring task is also better with a high reliability. More precisely, we can note an effect of the signal reliability on performance in the system monitoring task $F(1, 30) = 4.64, p < .05$.

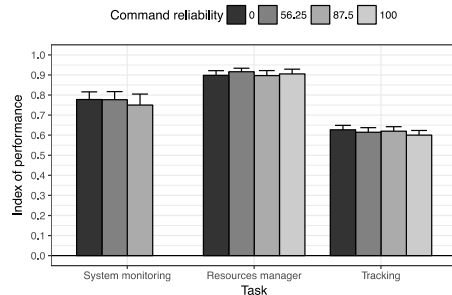


Fig. 2. Performance in each task and the four levels of command reliability. The higher the index the better is the performance.

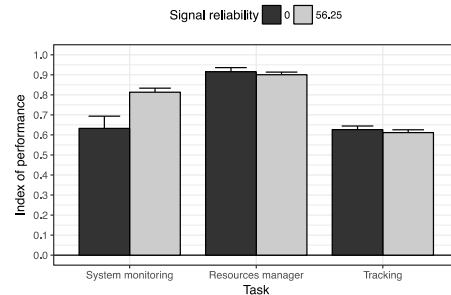


Fig. 3. Performance in each task and the two levels of signal reliability. The higher the index the better is the performance.

The analysis of eye movements showed no effect for the command reliability (Figure 4). However concerning the signal reliability (Figure 5) the dwell time proportion is more important in the tracking task than in the resource management task and last in the tracking task $F(2, 60) = 32.84, p < .05$.

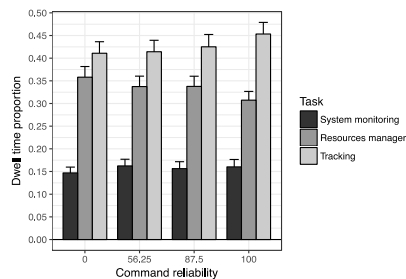


Fig. 4. Dwell time proportion for each task and the four levels of command reliability.

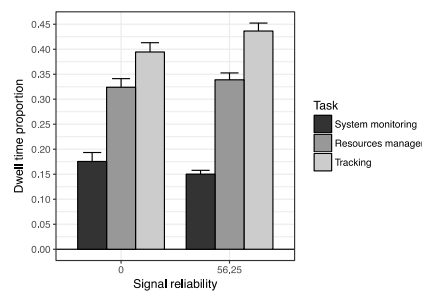


Fig. 5. Dwell time proportion for each task and the two levels of signal reliability.

Therefore, reliability of the automation signaling impacts the performance of the participants and their eye movements (task sampling). Full results (87.5% and 100%) are however necessary to confirm (or not) our hypothesis about a complacent behaviour. They will be discussed at the light of Bagheri and Jamieson's study on automation reliability [8, 10].

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