# Consequences of shifting from one level of automation to another: main effects and their stability

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**Abstract**

A simulated space operations environment was used to investigate the effect of changes in the distance between levels of automation (LOA) on operator telerobotic performance. Participants were assigned to four experimental conditions corresponding to four different LOAs. During the simulation they both switched and did not switch between these LOAs. Participants performed three tasks: *i*) rover task: controlling the rover's cruise and picking up (by means of a mechanical arm) samples of rocks from the terrain; *ii*) fault detection task: detecting the occurrence of a fault; and *iii*) recovery task: remembering the location of each of the simulated operators within the station, in order to recover from the fault. No performance costs were observed when two successive trials involved the same LOA. On the contrary, upward and downward shifts in LOA led to performance costs that were modulated by stage of processing and workload. Particularly, when workload was high, performance was primarily negatively affected when shifting from decision support to manual control (LOA 2 and 0 respectively) in a detection task, whereas the same shift led to a better performance in a working memory task. Finally, moderate LOA seems not to be suited for supporting working memory tasks.

**Introduction**

Automation is being introduced into various systems in various domains of work and everyday life, part of the move towards "ubiquitous computing". Automated sub-systems now provide the human operator valuable support in such domains as air, ground, space, and maritime transportation, military command and control, health care, and other areas. These types of computer support can be considered to define different levels of automation (LOA) between the extremes of full manual and full automation control (Sheridan, 2002). Between these two extremes a variety of intermediate LOA can be identified, and each one could be conceptualized as a compromise between human and machine responsibilities.

A given system could be designed for a particular LOA on the basis of criteria such as system safety and efficiency, as well as human performance criteria such as the

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