# Do Younger and Older Adults Differentially Depend on an Automated System?

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Various factors, including trust, system reliability, and error type have been found to affect how people interact with automated systems. Another variable that is becoming increasingly important is the role of age in human-automation interaction. As automation continues to emerge in numerous domains, including the home, older adults will likely interact with these types of systems to a greater extent than ever before. Therefore, understanding if age-related changes in cognition, such as diminished working memory capacity or processing speed, affect how older adults use automated systems is critical to ensure these systems are designed and implemented effectively. This study examined the role of age in a simulated dual task environment using an automated aid. Younger adults outperformed older adults in both tasks. When the automation was incorrect, younger adults exhibited less dependence than older adults. Further, when older adults verified the automation's suggestion, they took significantly more time to do so than younger adults. Additionally, older adults reported greater trust in the automation and higher workload compared to younger adults.

## INTRODUCTION

The presence of automated systems has increased and spread to almost every aspect of everyday functioning. A weekend's errands may be punctuated by a stop at the ATM, purchasing groceries through a self-service kiosk, or paying an automated machine when leaving a parking garage. This abundance of automation has made many tasks safer, easier, and more convenient across a wide array of domains.

Automation may be especially beneficial in supporting the concurrent performance of multiple tasks. When a task becomes automated, some of the attention that was required to complete the task becomes available to focus on other tasks (Parasuraman & Mouloua, 1996). For example, consider the task of driving while simultaneously trying to follow directions or study a map to travel to an unfamiliar location. Doing both of these tasks concurrently is difficult, and usually performance in at least one task suffers as a result. Now imagine that the navigation task has been allocated to an automated device. This device tracks the vehicle's position and provides verbal commands telling the driver where to go, allowing the driver to focus attention solely on the task of driving.

Although this aspect of implementing automation certainly benefits most people, older adults may particularly benefit from automation if it reduces processing demands. Older adults tend to have more difficulties performing two tasks concurrently compared to younger adults (e.g., Kramer & Madden, 2008). Automating a task in these situations may allow older adults to reach higher performance levels because they are able to allocate their attention to a single task rather than dividing it between multiple tasks.

Although automation is intended to increase performance, decrease errors, and reduce workload, many factors can affect whether such benefits occur. These factors include the level of automation, reliability of the automation, and the degree to which users depend on the automation, that is, act in accordance with what the automation tells them to do. Previous research is mixed concerning whether there are age-related differences in automation dependence. Johnson (2004) and Mayer (2008) found that older adults typically displayed greater dependence on automation, which may not be desirable if the automation is prone to errors. Conversely, Ho, Wheatley, and Scialfa (2005) did not find age-related differences in dependence.

The goal of this study was to identify whether older and younger adults differ in the way they use automation as well as whether their subjective experiences of interacting with automation differ, as measured by trust and workload ratings. To accomplish this, older and younger adults participated in a dual-task scenario, in which one of the tasks was supported by an automated aid that was not perfectly reliable. This simulation was developed to represent characteristics of automated systems used in a variety of domains by different types of users. Understanding how interactions with an automated system may differ as a function of age is critical in ensuring that the systems are designed and implemented appropriately, as well as guaranteeing that older adults can reap the benefits automation may provide.

## METHOD

### Participants

Eighty four participants, 42 younger adults (M = 20.39, SD = 2.39) and 42 older adults (M = 70.17, SD = 2.8) participated in this study. The younger adults included 25 males and 17 females, and older adults included 19 males and 23 females.

### Materials

*Automated system.* This experiment employed a simulated dual-task environment in which the participant played the role of a warehouse manager charged with two tasks: 1) receiving packages into inventory and 2) dispatching fully loaded trucks. These two tasks occurred simultaneously, and participants were instructed to do as well as they could on both tasks; that is, they were encouraged not to neglect either task for the sake of the other[1].

In the dispatching trucks task, participants received help from an automated aid that provided a notification when it detected the truck to be full and ready to be dispatched. This automated aid was correct 70% of the time. When the automated aid erred, it either committed a false alarm (providing a notification before the truck was full) or a miss (failing to provide a notification when the truck was full). If participants failed to correct either of these errors, a message would appear stating that they had either dispatched the truck before it was full, or failed to dispatch it before it overloaded. Within each block, six misses and six false alarms occurred.

Because the automated aid was incorrect 30% of the time, participants were given the option of examining the interior of the truck themselves, to determine whether it was full. Participants could view the truck at any point in time, and for as long as desired. However, whenever participants viewed the truck, they were unable to work on the receiving packages task which could result in the loss of points.

*Workload assessment*. Participants completed a modified version of the NASA-TLX workload measure (Hart & Staveland, 1988) upon completion of each experimental block.

*Trust measure*. After each set of trials, participants were asked, "How much did you trust the automated system to correctly alert you when a truck was full and ready to be dispatched?" They responded on a 5 point Likert-type scale ranging from 1 – Very Little to 5 – Very Much.

### Procedure

Participants were first presented with an informed consent document. Next they completed the Snellen near and far visual acuity exam and had to demonstrate at least 20/40 visual acuity to continue in the study. Participants were then given specific information and instructions about the automated system. Next, seven practice blocks were completed to allow the participants to familiarize themselves with the receiving packages and dispatching trucks tasks. Participants completed three ability tests to evaluate verbal, memory, and speed of processing abilities. These data are not presented here.

Following completion of the practice trials, participants began the experiment trials. Participants were responsible for dispatching 20 trucks per block of trials, and they completed a total of 160 trials, or eight blocks. The eight blocks were completed over the course of two consecutive days. After each block of trials, the participant completed the workload assessment and trust measure and was given a break.

## RESULTS

Statistical tests were conducted using a two-way analysis of variance (ANOVA). The alpha level was set to .05 for all statistical tests. All error bars depicted in figures represent the standard error of the mean.

Performance was examined for both the Receiving Packages and Dispatching Trucks task (see Figure 1). In the Receiving Packages task, younger adults correctly matched significantly more barcodes than older adults, $F(1, 78) = 10.58$, $p < .01$. In the Dispatching Trucks task, younger adults had a significantly higher percentage of trucks that were dispatched correctly, $F(1, 78) = 14.29$, $p < .01$.

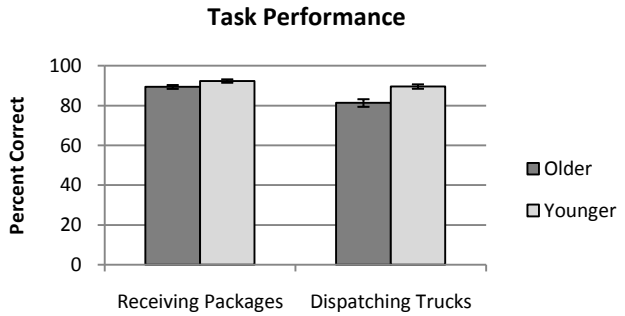


*Figure 1*. Percent correct on the Receiving Packages and Dispatching Trucks tasks.

[1] Workload in the Receiving Packages task was manipulated to create low, moderate, and high workload groups. This workload manipulation did not affect dependence; therefore, the data from the three groups are combined.

The following analyses were performed to examine how participants used the automated aid that was provided to them, including the extent to which they depended on the automation.

The dependence data were collected by recording whether participants viewed the truck on every trial. If participants viewed the truck, they were *not* depending on the automation; they were taking it upon themselves to determine whether the truck was full. But if they refrained from viewing the truck, they were depending on the automation to tell them when the truck was full. Therefore, dependence was calculated as the percentage of trials in which the truck was *not* viewed. There was not a main effect of age on dependence, $p$ = .11 (see Figure 2).

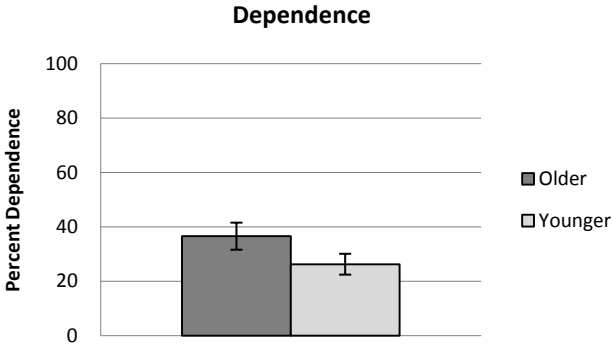


*Figure 2*. Dependence on the automation by age group.

Understanding dependence behavior in more depth is important because there are times when users should depend (i.e., when the automation is correct) and times when users should not depend (i.e., when the automation is incorrect). Therefore, another important component of understanding dependence behavior is identifying when individuals were depending. To this end, dependence was analyzed as a function of whether the automation was correct or incorrect. These data are presented in Figure 3.

There were no significant effects of age on dependence when the automation was correct, $p$ = .24. However, when the automation was incorrect, younger adults displayed lower dependence compared to older adults, $F(1,82) = 7.64$, $p < .01$. Younger adults may have been better at detecting when the automation was erring and decreased their dependence as a result, whereas older adults may not have detected the errors.

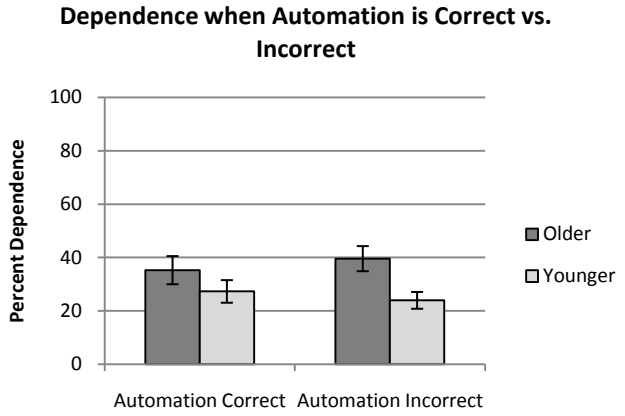


*Figure 3*. Dependence during automation correct vs. incorrect trials.

In addition to knowing how often participants depended on automation, another important question to answer was, when participants did not depend (i.e., viewed the truck), did they differ in the amount of time they spent viewing the truck? Time spent viewing the truck was time lost on the Receiving Packages task. In the navigation example presented earlier, this would be analogous to time spent staring at directions or a map rather than paying attention to the task of driving. More time spent viewing a map or directions is likely to result in substantial decreases in driving performance, a dangerous situation. Although the overall dependence data did not differ between younger and older adults, the average length of each truck view was significantly longer for older adults than younger adults, $F(1,69) = 39.38$, $p < .01$ (see Figure 4). Although older adults did not look at fewer trucks compared to younger adults, the nature of their views did differ in duration, suggesting that perhaps older adults required more time to process the information presented while viewing the truck. It could also be the case that older adults preferred to watch a truck fill until it was completely full, to ensure that they would dispatch it correctly.

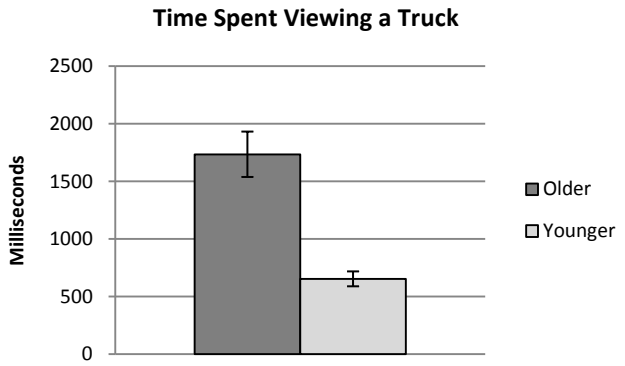


*Figure 4*. Length of truck views.

An examination of participants' trust in the automation is informative, as trust has historically been found to be positively related to dependence. Trust ratings are depicted in Figure 5. There was a main effect of age on trust rating, such that older adults rated their trust in the automated aid higher than younger adults, $F(1, 78) = 5.06$, $p = .03$. Although older adults reported trusting the automation more than younger adults, this did not lead to significantly greater overall dependence by older adults.

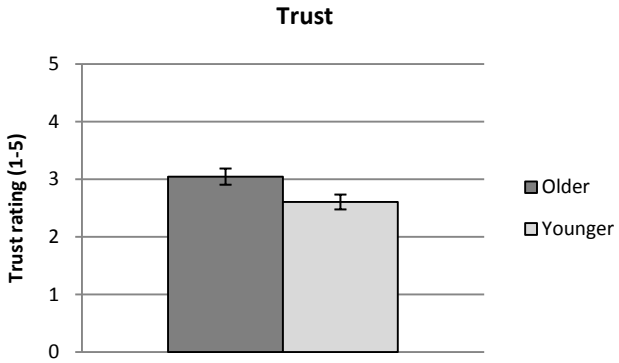


*Figure 5*. Self-reported trust in the automated system.

In addition to higher trust ratings, older adults also reported higher workload ratings on the NASA-TLX, $F(1, 77) = 9.49$, $p < .01$ (see Figure 6), which may result in part from the greater difficulties older adults typically experience in dual task settings.

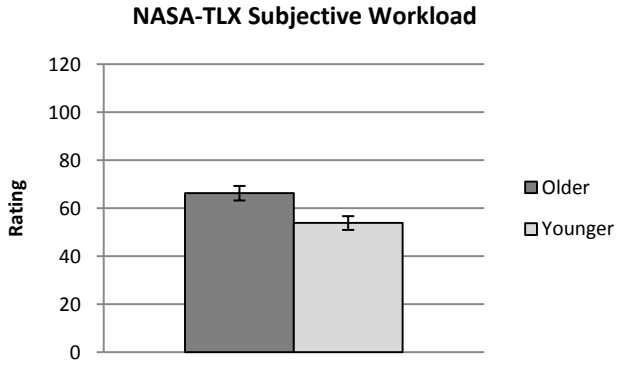


*Figure 6*. Self-reported workload rating. Rating could range from 0 to 120.

## DISCUSSION

Although older adults and younger adults did not display significantly different levels of overall dependence, when dependence was examined as a function of whether the automation was correct or incorrect, younger adults did depend appropriately less than older adults when the automation erred. These data suggest that older adults may not be as able as younger adults at identifying when the automation errs. This finding may have implications for the way that users of automated systems are trained. For example, training programs may need to consider that older adults need greater support to identify system errors, either from additional cues or feedback, or from more extensive practice.

There were also age-related differences in the amount of time spent looking at the truck to verify whether the automation was correct or not. Older adults may require more time viewing the trucks to process the presented information, or they may be more willing to forgo performance in the Receiving Packages task to ensure that a truck is dispatched correctly.

Additionally, older adults reported greater trust in the automated system. If older adults do not detect errors as well as younger adults, this may explain why they trust the system more. Additionally, older adults reported greater workload, suggesting that aspects of the system may need to be modified to reduce processing demands on older adults.

By understanding how older and younger adults use automation, designers will be better equipped to create automated systems that can be used by a wide range of users in varying domains. Issues that cannot be addressed through design can then be attended to in the training programs or instructions that users receive. Considering all potential users of a system and the varying abilities they possess will lead to more effective, efficient, and successful human-automation interactions.

## ACKNOWLEDGEMENTS

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