**\section{Study 5: Interleaving between data entry tasks}**

**\subsection{Introduction}**

Study 4 showed that people group subtasks of looking up information according to the information's IAC: if all information sources were equally easy to access, participants looked up and entered information for a task in sequential order. However, if some sources were more costly to retrieve, people first retrieved and entered all low IAC items, before they retrieved high IAC items.

If people deal with multiple data entry tasks, would this also make people more likely to look up and enter low IAC items across tasks, rather than completing one task at a time?

In Study 2, participants saved up data entry tasks to do in one session and occasionally had multiple data entry tasks open at the same time. Multitasking between data entry tasks is a common occurrence, but this strategy can be prone to errors.

The aim of the current follow-up study is to see if differences in IAC between information sources makes people more likely to interleave between data entry tasks.

The following question will be addressed:

What is the influence of IAC on interleaving between data entry tasks?

**\subsection{Method}**

**\subsubsection{Participants}**

Fourty-two participants (32 female), ranging from 18-46 years (M = 25, SD= 8) took part in the experiment. They were recruited from a university subject pool and received $\pounds$4 for their participation.

**\subsubsection{Materials}**

The task was similar to the one used in Study 4 but differed in one aspect. Instead of filling in one data entry form per trial, participants had to complete two forms per trial, which were shown on two different pages (see Figure \ref{fig:ch34\_5-tasklayout}.Each data entry sheet contained one expense, and participants completed the trial by entering the amount and account code for each sheet. The aim of this follow-up study was to investigate if differences in IAC of the two sources makes people more likely to interleave between two separate data entry tasks.

\begin{figure}

**\includegraphics**[width=\textwidth]{images/ch34/ch34-5\_Tasksequence.pdf}

\caption{Participants had to enter two data entry forms per trial, each containing two items. Each trial started by showing the first data entry form. As in Study 4, the data items for both forms were retrieved from a separate Amounts page (Step 1) and an Accounts page (Step 2). Participants had to enter the items for the first form (Step 3) and second form (Step 4) before submitting the data entries and moving on to the next trial.}**\label{fig:ch34\_5-tasklayout}**

\end{figure}

**\subsubsection{Design}**

The experiment was a between-participants design with the presence of a delay as the independent variable. As in Study 4, in the Control condition there were no delays in opening the pages. In the High-Amount condition, there was a delay in opening the page with amounts. In the High-Account condition, there was a delay in opening the page with account codes. The main dependent variable was whether participants interleaved between sheets or not: did participants enter the data items in sequential order, or did they interleave between the two sheets? If participants entered the amount and account code of one sheet before entering the other sheet, this was considered a sequential order. If participants entered amounts of each sheet first, followed by entering the account codes or vice versa, this was considered interleaving. All key presses were recorded to determine in which order data was entered. Page switches were recorded to capture when and how often a participant looked up the data items. Other dependent variables were trial completion time, data entry error rate, and type of errors.

**\subsubsection{Procedure}**

The experimental setup was similar to Study 4. For each experimental trial, participants had to enter four data items: they had to complete two forms with two entries each, an account code and an amount. For each experimental trial, participants had to enter four data items, two for each sheet. It was explained that they could use any strategy they wanted, but that it was important to complete both sheets before continuing to the next trial. Participants first completed two practice trials to familiarise themselves with the task, and data from the practice trials were excluded from the analysis. The experiment took approximately 30 minutes.

**\subsection{Results}**

Three participants were removed from the data due to extreme values on performance measures.

P28 and P23 made at least one error on every trial. They made 118 and 153 errors out of 200 error opportunities, respectively. P26's session was terminated before the end had been reached, as 45 minutes had passed. This participant spent on average 65 seconds per trial, which is twice as long as the mean trial time of other participants.

These three participants were considered outliers and removed from the data. Data of the remaining 39 participants was taken into the data analysis.

Table \ref{tbl:ch34\_5-means} shows a summary of the results of all three conditions for the dependent variables. Kruskal-Wallis tests were carried out to test if there were significant differences between the conditions.

\begin{table}

**\includegraphics**[width=\textwidth]{images/ch34/ch34\_5-means.pdf}

\caption{The means (and standard deviations) of all dependent measures for each condition. The rates are calculated by dividing the number of occurrences to the number of opportunities, e.g. an interleaving rate of 50 percent means participants interleaved on 50 percent of trials.}

**\label{tbl:ch34\_5-means}**

\end{table}

**\subsubsection{Interleaving strategies}**

A trial was labelled as 'interleaving' if the participant started entering one data entry sheet, but interleaved to entering items on the other sheet before completing the first one. The interleaving rate for each condition was calculated by dividing the number of trials where people interleaved by the number of total trials.

The boxplots in Figure 4 show the variability of interleaving rates across conditions. Participants interleaved most often between data entry sheets in the High-Account (M = 73.4\%, SD = 32.1\%) and High Amount (M = 83.8\%, SD = 21.6\% ) conditions compared to the Control (M = 30.5\%, SD = 37.7\%) condition, $\chi^2$(2) = 11.13, p = 0.004. A post-hoc comparison showed there was a differnece between the Control and the High-Amount (p<.01) and High-Account (p = 0.01) conditions, and no difference between the High-Account condition and the High-Amount (W = 22, p = 0.4) conditions.

As can be seen in Figure x, which shows the distribution of interleaving rates, all participants in the High-IAC conditions interleaved on at least a part of the trials. This is illustrated by the left side of the graph: the lines of the High-IAC conditions have a frequency of 0 participants at an interleaving rate of 0\%. The Control condition line has no obvious peak, indicating that interleaving rates in this condition were evenly distributed: participants interleaved on zero, a portion, as well as all of the trials.

As in Study 1, participants made on average four visits per trial, i.e. one visit per data entry. There was no difference in the number of visits, $\chi^2$(2) = 1.59, p = 0.5. Participants made significantly shorter visits in the Control (M = 2.00s, SD = 0.68s) condition compared to the High-Account condition (M = 2.25s, SD = 0.67s) compared to the High-Amount (M = 2.61s, SD = 0.85s) and $\chi^2$(2) = 6.14, p= 0.04. Post-hoc comparisons found a significant difference between the High-Amount and the Control (p=.02) conditions, but not between High-Account and Control conditions (p = 0.2) or the High-Account and the High-Amount (p = 0.2).

%Participants' data entry strategies were categorised in one of two categories: they either interleaved between the two data entry forms (e.g. entering amount on Form1, followed by entering the amount in Form 2), or they filled the forms in sequential order (entering amount and account code on Form1, followed by entering the amount and account code on Form2).

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%Table \ref{table:ch34\_Study5interleavingfreqtbl} shows the frequency of strategies per condition. In total, the strategy was chosen on 333 trials in the High-Account condition, 427 trials in the High-Amount condition, and 184 trials in the Control condition. In other words, the strategy was chosen on 66.6\%, 85.4\% and 40.88\% of the trials, respectively. There was a significant difference in interleaving behaviour,

%F(2,30) = 4.41, p = .02. A post-hoc comparison showed people interleaved significantly more often in the High-IAC conditions than the Control condition (p = 0.02) . There was no significant difference between the High-Account and High-Amount condition (p = 0.18).

%A Kruskal-Wallis test shows there is a significant difference between the different conditions, $\chi^2$ (2, N = 29) = 6.68, p = 0.035. Mann-Whitney U tests were used to get further insight in pairwise differences between conditions. Participants interleaved significantly more often in the High-IAC conditions than the Control condition (U = 138, p = 0.02) . There is no significant difference between the High-Account and High-Amount condition (U = 32, p = 0.18).

%A chi-square test shows that the frequency of interleaving strategy was significantly associated with the condition, $\chi^2$ (2) = 207.29, p= < 0.05.

**\subsubsection{Errors and trial completion time}**

There were 200 data entries, so in total there were 200 opportunities for a participant to make a data entry error. The error rates were calculated as the number of errors divided by the number of entries.

There was a marginal though not significant effect of IAC on error rate, $\chi^2$(2) = 5.37, p = 0.06. The mean error rate was marginally higher in the High-Account condition (M= 8.42\%, SD=9.08\%) compared with the High-Amount (M=7.54\%, SD=4.33\%) and Control (M=3.88\%, SD=4.13\%) conditions. When comparing the actual completion time including lockouts, participants were significantly faster in the Control condition (M=27.39, SD = 3.49s) than the High-Account (M = 33.83s, SD = 6.08s) or High-Amount (M = 33.11s, SD = 8.16s) conditions, $\chi^2$(2) = 8.52, p= 0.01. With the lockout times removed, the difference is no longer significant, $\chi^2$(2) = 1.61, p = 0.4.

The type of errors can be seen in Figure. The most common error type was when a data entry was skipped: this happened 243 times. Table 1 shows the number of skipped errors for each condition. It can be seen that in the Control condition this type of error occurred 16 times. The error happened more frequently in the High-IAC conditions: in the High-Account condition it happened 114 times, and in the High-Amount condition it happened 116 times.

Typing the correct number but in the wrong field happened 78 times. This happened 18 times in the Control condition, 14 times in the High-Account and 46 times in the High-Amount condition.

When comparing across conditions, these types of errors happened on a significantly higher proportion of data entries in the High-Account (M = 4.58\%, SD = 3.6\%) and High-Amount (M=6.54\%, SD=5.01\%) compared with the Control condition (M = 1.23\%, SD = 1.82\%), $\chi^2$(2) = 11.29, p = 0.004. A post-hoc comparison showed there was a difference between the Control and the High-Amount (p<.01) and High-Account (p = 0.01) conditions, and no difference between the High-Account condition and the High-Amount (W = 22, p = 0.4) conditions.

**\subsection{Discussion}**

The aim of this study was to see if an increase in IAC makes people interleave more between data entry tasks. In contrast with \citet{Back2012}, who found that an increase in IAC made people less likely to interleave between two data entry tasks, participants in the current experiment interleaved more as IAC increased.

This may be due to the presentation of the information. In \citet{Back2012}'s study, people had to retrieve all information for both data entry tasks from one sheet. If the sheet was nearby, participants read one item at a time, and interleaved between tasks on 59\% of the trials. As the cost to access this source increased, they chunked the data items associated with one task, and then after completing this task, returned to the source to chunk data items for the second task.

However, in many situations, such as the office setting of Chapter 3, information is not in one location, but different information sources have to be consulted for different types of information. For an expenses task, amounts and account codes are not on one sheet, but people have to consult one spreadsheet for account codes, and another source to retrieve the amounts. The current study looked at people's interleaving behaviour when retrieving items from multiple sources. If there were no delays in accessing these sources, participants completed one task at a time on 59\% of the trials. If there was a delay in accessing either one of these sources, people tried to enter all information from this source after one visit, so they did not have to open it again. They chunked the data items associated with one source, rather than task. They first entered either Amount1 for Form1, Amount2 for Form2, and then the accounts, or first entered Account1 for Form1, Account2 for Form2, and then the amounts.

Whereas in Study 4 people became more accurate by chunking data items according to IAC, there no longer was a difference in errors in the current study. Chunking by data items in this set-up meant people interleaved between tasks and started a second task before completing the first task, a strategy which can be prone to errors \citep{}. People may forget steps, or enter correct information in the wrong fields.

It can be argued that the design of the materials encouraged participants to always group per source, regardless of the condition. However, in the Control condition there was an almost even distribution of strategies, and participants interleaved 40\% of the trials. The majority of the time participants still chose to complete one task at a time.

**\subsection{Conclusion}**

People have to regularly switch between looking up information for a data entry task and entering it. The three studies described in this chapter showed how strategies to look up and enter information are influenced by the time cost to access information sources. It also showed that certain strategies are more accurate or efficient than others.

The main effect of an increased IAC is that people try to minimise (re)visits. If the time to access a source increases, people will try to copy over more information after one visit. If they do not memorise it well, errors increase (Study 3). If information is spread across different sources and the IAC differs between these sources, people group visits and first look up and enter low IAC items, before entering high IAC items. This not only made them more efficient, but it also reduced errors (Study 4). However, if they have to manage multiple data entry tasks, this strategy means that they will interleave between tasks (Study 5).

These results are partly in line with observations from the first two studies. Whereas people would look at the physical receipts while typing it in, they would hold other items in memory and barely used tools to offload memory. They would first enter all items on the physical receipts. For digital information however, they would look it up as they needed it, even if IAC differed between these sources, and it could sometimes take a while before they had retrieved the information.

It seems that it is better to be able to reduce IAC and have task information ready at hand, so people do not need to switch back and forth to a source that takes time to access. There are solutions, such as increased screen space, multiple screens, or having a physical copy and placing it nearby. It was interesting to see in the first two studies that people did decrease IAC for physical items, but not for digital ones. People had a second screen, but used their primary screen to look up information because they perceived it as quicker. In this case, the cost to decrease IAC by placing information on a second screen, outweighed the cost to look it up, hold it in memory, and go back to the primary screen. However, they often did not know the associated time cost to access it, so could be away from the screen for a longer time than anticipated.

There is a need to better support people in decreasing IAC without tasking them with the added responsibility of re-arranging different tasks, information sources, devices and screens.

They should be able to do their job and have task information at hand more seamlessly.