Understanding how people look up and enter information for a data entry task in financial office settings

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Third, the measured short visits in the Medium IAC conditions may have confounded the results. In future studies, the setup of the experiment should be designed so that participants do not accidentally access the source when they do not intend to.

Lastly, for each dependent variable, the same consistent measure should be used to compare across conditions. This could be data provided by an eyetracker, or interaction measures such as mouse clicks, key presses or interkey intervals.

The next study will try to more closely simulate the expenses task observed in the financial office setting of Study 1 and 2. People will have to enter and collect information from multiple sources with different IACs. The aim is to see how these differences in IAC influence people's switching strategies between entering and looking up data when copying from multiple sources.

4.2 Study 4: Copying data from multiple sources

4.2.1 Introduction

Study 3 showed that as it takes longer to access an information source needed for a copying task, people spend a longer time looking at that source. They try to group and memorise as much information, in order to minimise the number of revisits to this source. Though people copied over more items after one visit using this strategy, they also made more errors overall. In the experiment, all information was to be found on a single source. People may have tried to memorise too much items in one visit, and upon entry relied on incorrectly memorised information in the head.

Data entry in office workplaces often does not involve a single source, but information can be spread over various sources. These sources are often not all equally easy or hard to access. How do people prioritise how they enter and look up information from these different sources? Do they enter the easy items first? And will they still try to group and memorise as many items? Or will they look up and enter items from one source at a time? In order to support people in looking up information for data entry work, it is important to first understand how people currently manage these information tasks.

In the contextual inquiry of Study 2, participants started data entry by first collecting all physical sources first and placing these on their desk. They then entered this information, which was nearby, first. They postponed accessing other sources until they needed to enter it during the task. If information took too long to access, they would set aside the task and continue with other tasks. One of the factors that influenced the different strategies appeared to be the time cost to retrieve the information.

This study tests the assumption that observed strategies from Study 2 are influenced by the time costs to access information sources. Whilst prior studies have demonstrated that various tasks can involve the use of multiple information sources (Cangiano & Hollan, 2009; Murphy, Chen, & Cossutta, 2016; Su, Brdiczka, & Begole, 2013), there are limited studies that measure how people use these sources, and to what extent the time cost to access a source influences these decisions.

The following questions will be addressed:

RQ1. *How does IAC affect the number of visits to look up information from multiple sources with different IACs?*

RQ2. *How does IAC affect the order of visits to look up information from multiple sources with different IACs?*

RQ3. *Do the number and order of visits affect data entry accuracy and speed?*

The soft constraints hypothesis predicts that people choose and adapt their task strategies in order to minimise time (Gray et al., 2006). Study 3 found that the longer it takes to access information, the more items people try to memorise in one visit. Based on these findings, the following hypothesis is made:

H1. As IAC increases, people will try to group and memorise multiple items to minimise visits.

In O'Hara & Payne (1998)'s study on the effect of IAC on problem solving tasks, participants in Low-IAC and High-IAC conditions initially performed the same type of strategies. However, over time participants in a High-IAC condition learnt more efficient strategies, whilst participants in a Low-IAC condition continued to use the same strategy. Prior work has also shown that people who are exposed to High-IAC situations will continue to use the strategy they learnt to be the most efficient, even in situations where the cost to access information is no longer high (Patrick, Morgan, Tiley, Smy, & Seeby, 2014). It is therefore expected that once participants learn it is more efficient to group High-IAC items, they may adopt this strategy for Low-IAC items as well. In Study 2 of this thesis, people tried to enter items that were nearby in the environment first, and postponed looking up other information until later. Based on these findings, the following hypothesis is made:

H2. As the experiment progresses and people become aware how costly it is to access certain sources, they will learn and choose to enter all the Low-IAC items first, in a batch, and then the High-IAC items second, also in a batch, rather than looking up each item as they need it.

Lastly, if people group items and spend a longer time looking up information, this means they will be interrupted from their data entry task for a longer time. The longer people are interrupted from a primary task, the slower they are to resume that task after the interruption (Monk, Trafton, & Boehm-Davis, 2008), and the more likely they are to make resumption errors (e.g. Brumby, Cox, Back, & Gould, 2013). Based on this, the following hypothesis is made:

H3. As IAC increases, people will be slower and make more errors.

4.2.2 Method

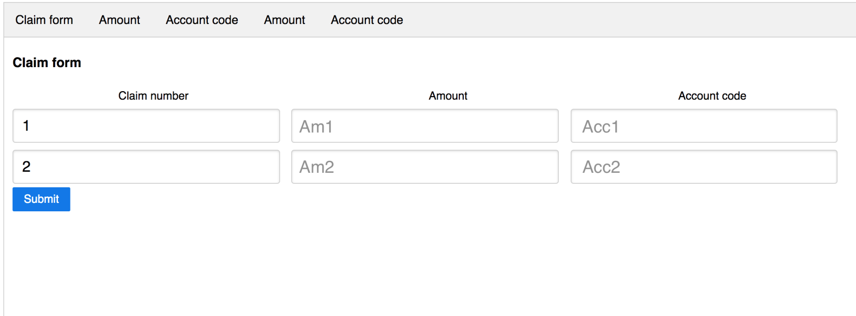
Participants

Thirty-three participants (12 male) with a mean age of 26 years (SD= 8) took part in the experiment. They were recruited from a university subject pool and received £4 for their participation.

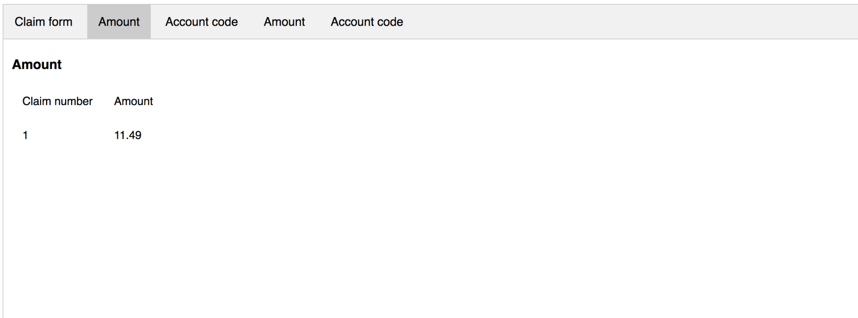
Task

The experimental data entry task was framed around the expenses task from Studies 1 and 2. For this task, the user has to complete a number of data entries regarding incurred expenses in order to claim back the money. They enter this into a claim form, which looks similar to a spreadsheet. Users can choose to either fill in multiple expenses in one sheet, in which each row corresponds to one expense, or have separate spreadsheets for each expense. The current experiment will use the scenario where users enter multiple expenses in one sheet.

The experimental task can be viewed in Figure 4.6. Participants had to switch between five web pages on the computer screen. One page contained the data entry form, in which



(a)



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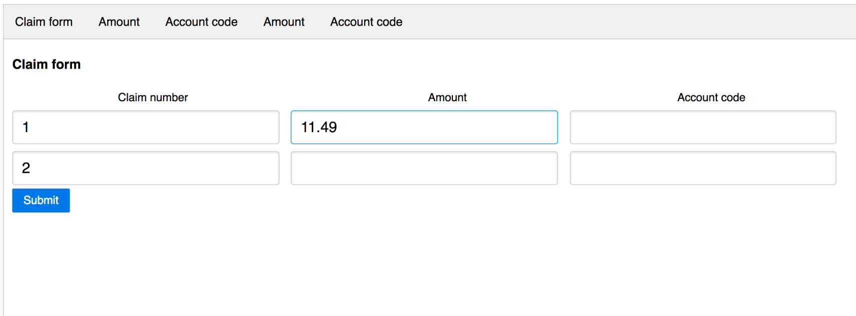


(c)

Figure 4.6: Participants had to enter four data items in a data entry form (a). Each item had to be retrieved from a separate window (b) and entered into the form (c).

the data for two expenses had to be entered (see Figure 4.6a). One row in the form corresponded to one expense. For each expense, they had to enter a financial amount (Am1) to specify the expense that was made, and an account code (Acc1) to determine from which account to claim back the expense. The four data items had to be retrieved from four separate pages (see Figure 4.6b), and entered in the corresponding fields on the data entry form (see Figure 4.6c). The participant could go to a page by clicking on the corresponding name in the horizontal menu at the top of the screen. Only one page could be viewed at a time and covered the full screen.

Materials

The data items were designed to look similar to the numbers seen in Studies 1 and 2. Office workers in these studies usually worked with the same 20 or 30 account codes. They were aware they worked with the same set of codes, but still had to look a code up each time they needed to enter it. The codes had a length of six digits, and the string was random with no pattern.

An experimental session consisted of 50 trials, divided into 5 blocks of 10 trials. Each trial consisted of four data entries, so in total a participant made 200 entries. For each block, a set of 20 different amounts and 20 different account codes were used. These sets were re-used for every block, so in total, each number was presented five times throughout a session. There were two practice trials before the experiment began. The numbers used in the practice trials were not used for the experimental trials. The data items always had the same length: the amounts consisted of two digits on the integer part and two digits on the fraction part (e.g. 11.94), and the account codes were six digits (e.g. 654273).

The experiment was conducted in a web browser, on a desktop computer with a 24-inch monitor with a resolution of 2048 x 1152 pixels. People used a computer mouse and number pad, and the option to copy and paste information was disabled. If the participant switched from the data entry form to another page and back, the cursor stayed in the same cell of the data entry form. The task interface was developed in HTML, CSS, Javascript and PHP. The browser window was maximised to avoid distractions. All mouse clicks, keypresses and their timestamps were recorded using Javascript.

Design

The experiment was a between-subjects design with one independent variable, the IAC of the four information source pages. In the control condition, there were no delays in opening the pages. In the other two conditions, there was a two-second delay before two of the four pages were revealed. In the High-Account condition, there was a delay for viewing the two account codes, whereas in the High-Amount condition there was a delay for viewing the two amounts. All page switches and key presses were logged to determine the order and grouping strategies of visits and entries. Other dependent variables were trial completion time, number of visits to information sources, and data entry errors.

Procedure

The experiment took place in a closed quiet room. Participants were welcomed and briefed verbally about the study. They were instructed to complete the task as fast and accurately as possible, but other than this instruction, it was emphasised they were free to use whichever strategy they wished. Examples of possible strategies were demonstrated: they could enter it per row, per column, and could go back to the information sources as often as they wished. After reading an information sheet and signing a consent form, participants completed two practice trials. After this they completed 50 experimental trials. After every 10 trials, there was the opportunity to take a break. A prompt appeared on the computer screen and time stopped. Participants were free to choose the length of each break, and continued the experiment by pressing a 'Next' button on the screen. The experiment took approximately 30 minutes.

Pilot study

Two pilot studies were conducted with colleagues of the researcher to test the experimental design. In particular, the pilot studies aimed to see if the length of the experiment was long enough for participants to learn and develop strategies, but not too long to tire the participant.

During the pilot studies, there was a scheduled break after every 5 trials. Both participants mentioned the break prompts happened too frequently, and experienced them as disruptive. They did not find the experiment too long. One participant could not remember which computer tabs had an increased IAC. As a result, he did not adapt his strategies according to anticipated IACs and entered the numbers row by row. The second participant mentioned that the increased IACs definitely made her more careful in checking the numbers were correct. The participants were aware some of the numbers occurred more than once, but the numbers did not occur often enough to be able to memorise them.

For the real experiments, the breaks were reduced to happen after every 10 trials. In addition, the names of information sources with an increased IAC were underlined in the horizontal menu. This visual feature was added to help users see which windows had an increased time cost to open.

Analysis

In order to analyse if there was a significant difference in ordering and grouping strategies, a bottom-up approach was taken to manually code people's strategies.

All mouse click events to switch to a different page and key press events to enter data were recorded and saved in a spreadsheet. For each trial, the order of actions was considered and the trial was either grouped under a new strategy group for this order, or the trial was grouped under an existing strategy group. There were eight different possible actions: viewing the first amount (V-Am1), viewing the second amount (V-Am2), viewing the first account code (V-Acc1), viewing the second account code (V-Acc2), entering the first amount (E-Am1), entering the second amount (E-Am2), entering the first account code (E-Acc1), and entering the second account code (E-Acc2).

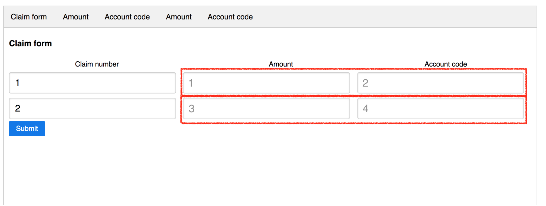
The first iteration of grouping the trials resulted in 17 different strategy groups. For the second iteration, the strategy groups were categorised into two larger Ordering categories, according to the order in which items were entered: per row or per column. This categorisation was to determine whether people entered data per type of data item (Amount and Account code), and if they entered items in the order of IAC (Low-IAC and High-IAC), or if they entered data in the sequence in which it was presented on the form (Claim1 and Claim2). The 17 strategy groups were also categorised into two Grouping categories. For this categorisation, it was considered whether a participant grouped multiple data items in one visit, or if data items were viewed and then entered one by one.

For each participant, the number of trials on which a particular strategy was done was calculated and saved in a spreadsheet. One-way ANOVAs were used to determine if there were significant differences between conditions in frequency of strategies, number of visits to the information sources, trial completion time, and errors.

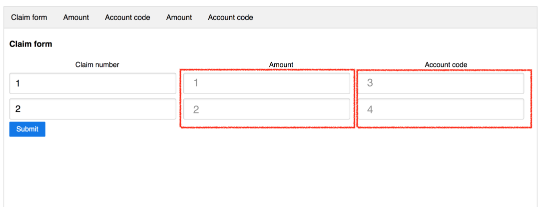
4.2.3 Results

Ordering strategies

Table 4.3 shows the number of trials where people grouped per row, per column and where they had another order. The Row strategy meant that the participant first entered Amount1 and Account1, and then Amount2 and Account2, or the other way around (Figure 4.7a). The Column strategy meant that the participant first entered Amount1 and Amount2, and then Account1 and Account2, or the other way around (Figure 4.7b). There were seventeen trials in total that did not fall into either one of these categories. An example is a trial where the participant first entered Amount1, then Account2, and then submitted the trial before completing all entries.



(a)



(b)

Figure 4.7: The order strategies. (a) If people entered Amount1 and then Account1 (or Amount2 and then Account2), this was categorised as a 'Row' strategy. (b) If people entered Amount 1 and then Amount2 (or Account1 and then Account2), this was categorised as a 'Column' strategy.

Condition	Row	Column	Other	Total
High-Account	33.27% (183)	66.55% (366)	0.18% (1)	100% (550)
High-Amount	64.73% (356)	34.18% (188)	1.09% (6)	100% (550)
Control	64.18% (353)	34.00% (187)	1.82% (10)	100% (550)
Total	54.06% (892)	44.91% (741)	1.03% (17)	100% (1650)

Table 4.3: The rates (and frequencies) of ordering strategies per condition.

There was a significant difference in choice of Ordering strategy, $F(2,30) = 3.32$, $p = 0.04$. People most often entered data in the order in which they were presented, per row. In the High-Amount and Control condition, this strategy was chosen on 64.73% and 64.18% of the trials, respectively. In the High-Account condition, the strategy was chosen 33.27% of the time, and people more often entered items per column. In the 741 trials where people adopted a Column strategy, they predominantly entered the amounts first, even in the High-Amounts condition. There were only fifteen trials where account codes were entered first, and these were by the same person in the High-Amounts condition.

Grouping strategies

Condition	Grouped	One-by-one	Other	Total
High-Account	37.52% (206)	62.48% (343)	0.18% (1)	100% (550)
High-Amount	55.70%(303)	44.30% (241)	1.09% (6)	100% (550)
Control	67.78% (366)	32.22% (174)	1.82% (10)	100% (550)
Total	53.58% (875)	46.42% (758)	1.03% (17)	100% (1650)

Table 4.4: The rates (and frequencies) of grouping strategies per condition.

Condition	Grouped	One-by-one	Total
High-Account	24.32% (89)	75.68% (277)	100 (366)
High-Amount	65.43% (123)	34.57% (65)	100 (188)
Control	50.80% (95)	49.20% (92)	100 (187)
Total	41.43% (307)	58.57% (434)	100 (741)

Table 4.5: The rates (and frequencies) of grouping strategies for trials where people entered items in column order.

To see if people tried to reduce number of visits by viewing multiple data items before entering them, strategies were categorised into so-called 'Grouped' and 'One-by-one' strategies. If participants grouped visits and made multiple visits before entering them, they were placed in the 'Grouped' category. If they visited and then entered each item one by one, they were placed in the 'One-by-one' category.

Overall, there was an even distribution of trials where participants tried to group items (53.58%) and trials where they entered them one by one (46.42%) and this did not differ significantly between conditions, F(2,30) = 0.39, p = 0.68. (see Table 4.4). There was also no significant difference between conditions on mean number of visits to information sources, F(2,30) = 2.71, p = 0.08. On average people made five visits per trial.

However, looking at the trials where people entered items per column, in Table 4.5 it can be seen that in the High-Amount condition, people more often tried to group items. A chi-square test showed that looking at trials where people ordered per column, grouping strategy was significantly associated with condition, χ^2 (2) = 95.55, p < 0.05.

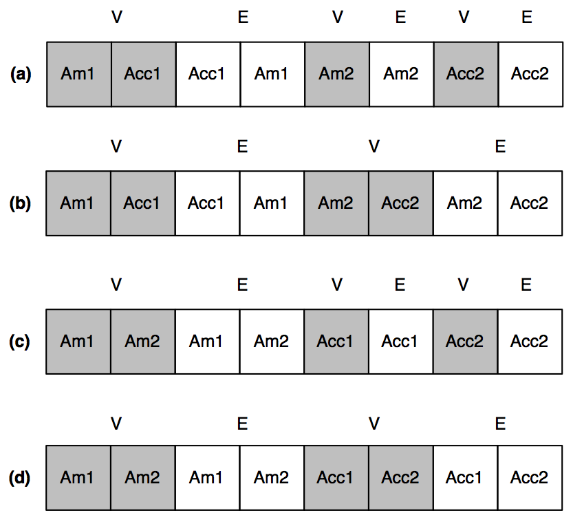


Figure 4.8: The sequence of the most common grouping strategies. V = visit to the data source, E = entry of the data item. For example, in Strategy (a) a participant first viewed Amount1 and Account1, and then entered Amount1 and Account1. He/she then viewed Amount2 and entered it, and then viewed Account2 and entered it.

Figure 4.8 illustrates the most common Grouping strategies. People most often chunked items into three groups (Strategies (a) and (c) in Figure 4.8). For example, they first visited Amount1 and Amount2, and then entered Amount1 and Amount2. They then viewed Account1 and entered it, before they viewed Account2 and entered it. Table 4.6 shows the frequency with which these strategies were chosen per condition.

still to do: double-check frequencies in Table 4.6, do not seem to add up with other tables.

	Row		Column			
Condition	First row (a)	First & Second row (b)	Amounts (c)	Amounts & Accounts (d)	Other	Total
High-Account	34% (48)	4% (6)	57% (80)	2% (3)	3% (4)	100 (141)
High-Amount	20.99% (44)	16.57% (35)	49.72% (104)	9.39% (20)	3.31% (7)	100 (210)
Control	11.2% (16)	21.6% (32)	54.4 (81)	12% (18)	0.8% (1)	100 (148)
Total	21.18% (190)	15.02% (73)	52.96% (265)	8.37% (41)	2.46% (12)	100 (499)

Table 4.6: The most common grouping strategy was to chunk the items into three groups. The strategies are shown graphically in Figure 4.8.

Performance measures: errors and speed

There was no significant difference in the time it took to complete a trial, F(2, 30) = 0.05, p =0.9). On average, participants took about 29 seconds per trial across conditions.

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. In total, 114 errors were made in the High-Account condition, 83 in the High-Amount condition, and 191 errors in the Control condition. The mean error rates were 5.7%, 4.15 %, and 9.55%, respectively. Despite the differences in means, due to high sample variance no significant difference was found in errors, F(2,30) = 1.47, p = 0.25.

An alternative error rate was calculated based on the number of erroneous trials. If a participant made a mistake on all four entries of a trial, this rate would consider it as one error, rather than four errors. Looking at the number of trials on which an error was made, there was no significant difference either, F(2, 30) = 1.61, p = 0.22. In total, there were 79 erroneous trials in the High-Account condition, 53 trials in the High-Amount condition, and 117 trials in the Control condition. In other words, errors were made on 14.36%, 9.64% and 21.27% of the trials, respectively.

Qualitative findings

After the experiment had ended, participants were debriefed and the purpose of the study was explained. Some participants recalled their strategies and gave additional explanations behind them.

Condition	Error rate M (SD)	Trial completion time (s) M (SD)
High-Account	4.82% (3.56)	29.23 (7.44)
High-Amount	3.68% (2.73)	28.88 (6.92)
Control	7.75% (9.81)	29.99 (10.94)

Table 4.7: The means (and standard deviations) of error rate and trial completion time the three conditions. Error rates were calculated as the number of errors divided by the number of entries.

x participants adapted their strategy several times throughout the experiment, in order to find the quickest way to complete the task. Because amounts were shorter and easier to remember, several participants mentioned they tried to first view all amounts before entering them. They tried this strategy with account codes as well, but these were longer and therefore it was more difficult to memorise two at a time. As. a result, most participants ended up viewing and entering each account code one by one.

Several participants noticed that numbers re-occurred throughout the experiment. They felt it was easier to memorise a number that had already occurred earlier in the experiment, so when a trial contained a number they had entered before, they would use the 'Grouped' strategy: they viewed another window and item before returning to the entry form. Furthermore, some participants started a trial by not viewing any other windows, but re-entering the data items of the previous trial in the data entry form. They would then visit the information source windows to check if the items were the same, or if they needed to change some of the items.

4.2.4 Discussion

The aim of this study was to investigate the effect of IAC on how people manage subtasks to look up information from multiple information sources with varying IACs. IAC influenced the order in which people entered data and whether and how they chunked data items.

Ordering strategies

IAC had an effect on people's ordering strategies, but only in the condition where the IAC was increased for accessing account codes. People first looked up and entered the low IAC items, the amounts, before they entered the high IAC items, the account codes. However, if the cost to access the amounts was increased, people entered items row by row, as participants did in the control condition.

In O'Hara & Payne (1998)'s study on the effect of IAC on problem solving tasks, participants in Low-IAC and High-IAC conditions initially performed the same type of strategies. However, over time participants in a High-IAC condition learnt more efficient strategies, whilst participants in a Low-IAC condition continued to use the same strategy. Prior work has also shown that people who are exposed to High-IAC situations will adopt and continue to use a certain strategy, even in situations where the cost to access information is no longer high (Patrick et al., 2014). It is therefore expected that once participants learn it is more efficient to group high-IAC items, they may adopt this strategy for low-IAC items as well. In Study 2 of this thesis, people tried to enter items that were nearby in the environment first, and postponed looking up other information until later. Based on these findings, the following hypothesis is made:

In previous studies, people would postpone or not address information needs if there was a high time cost associated with it (Sohn, Li, Griswold, & Hollan, 2008). This was also found in Study 2. People initially tried to do tasks as they needed it, but if it took too long, they would put it aside.

In the current study, this was also found but the cost to memorise an item overrode the cost to access it: people would first enter the amounts, even if the cost to access them was higher. If the cost was high, they would try and memorise them both before entering them. This shows people try to minimise interleaving between viewing and entering information.

Grouping strategies

The soft constraints hypothesis predicts that people choose and adapt their task strategies in order to minimise time (Gray et al., 2006). Study 3 found that the longer it takes to access information, the more items people try to memorise in one visit. Based on these findings, the following hypothesis is made:

Performance

Grouping strategies

IAC also had an effect on how often people switched between visiting and entering information. In the conditions where the amounts were low, people often visited multiple items before returning to the entry interface. Though there was no difference in errors in the current study, it can be imagined this strategy is more risky as people are away for longer so resuming a task is more difficult, and they are storing more information in memory, so people may misremember information.

In the condition where the IAC for amounts was high, this strategy was not used as frequently. IAC thus does not have to be bad if the information is easy enough to briefly hold in memory (condition amounts high).

IAC made people changes strategies even if only two of the four information sources had an increased IAC. This is in accordance with (**?**), who showed that a more memory-based strategy can be trained for future situations. When people were exposed to an interface with an increased access cost, they adopted a memory-based strategy and retained this strategy, even when they then interacted with an interface with lower access costs.

Conclusion

This study investigated the effect of IAC on looking up information from multiple sources, and showed that, if all information has the same IAC it is better if this is low, differences in IAC between sources can make people schedule their subtasks more efficiently and effectively. People needed less visits and made fewer errors. However, for this study people only had one data entry task at a time to focus on, and the sources only contained information for this single task. In Study 1 and 2, people often batched and saved up multiple data entry tasks, and sources included more than just the information for one task: for example, if people had to look up an account code, this was often retrieved from a spreadsheet with all account codes. They thus not only had to manage subtasks of one data entry task, but had to coordinate multiple data entry tasks. In order to save visits, people may therefore look up information for several tasks and interleave. One of the participants from Study 1 shared that this did occur and said she and colleagues had to be very careful to not input information in the wrong form. If people group information subtasks per IAC for a single task, would they also group these subtasks per IAC when dealing with multiple tasks? In order to answer this question, a follow-up study was run to see the effect of IAC on interleaving behaviour between two claim forms.

4.3 Study 5: Interleaving between data entry tasks

4.3.1 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?

4.3.2 Method

Participants

Thirty-two participants (seven male) with a mean age of 25 years (SD= 8) took part in the experiment. They were recruited from a university subject pool and received £4 for their participation.

Materials

The task was similar to the one used in Study 4 but differed in two aspects. Instead of filling in one data entry form per trial, people filled in two forms per trial. Furthermore, instead of four sources, participants in the current study had to retrieve information from two sources: one source to retrieve amounts, and a second source to retrieve account codes. 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 data entry tasks.

Design

The experiment was a between-subjects design with the IAC of the information source windows as the independent variable. In the control condition, there were no delays in opening the windows. In the second condition, there was a delay for opening the window that contained the account codes. In the third condition there was a delay for viewing the amounts. All window switches and key presses were logged to determine the order in which participants accessed the windows and entered the data items. In addition, the number of errors and trial completion time were measured.

Procedure

The experimental setup was similar to Study 4. For each experimental trial, participants had to complete two forms with two entries each, an account code and an amount. They

Figure 4.9: Participants had to enter two data entry forms per trial, each containing two items. (a). The amounts for both forms had to be retrieved from one window (b) and entered into the form (c), while the account codes had to be retrieved from a second window (d) and entered (e).

were instructed to complete it as fast and accurately as possible. It was explained that they could use any strategy they wanted, but that they had to complete both forms, before continuing to the next trial. The experiment took approximately 30 minutes.

4.3.3 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 29 participants was taken into the data analysis.

Table **??** shows a summary of the results of all three conditions for the dependent variables. One-way ANOVAs were carried out to test if there were significant differences between the conditions.

Interleaving strategies

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).

Condition	Interleaving rate	Error rate	Trial completion time (s)
	M (SD)	M (SD)	M (SD)
High-Accounts	66.6 (3.39)	6.5 (1.04)	33.96 (5.08)
High-Amounts	85.4 (2.17)	2.9 (0.25)	33.67 (8.68)
Control	40.88 (4.03)	4.9 (0.45)	27.66 (3.40)

Table 4.8: Results of the dependent variables for the three conditions. The rates are percentages calculated as the ratio of occurrences to the number of opportunities.

Condition	Interleaving	No interleaving	Total
High-Account	66.6% (333)	33.4%(167)	100% (500)
High-Amount	85.4% 427	14.6% (73)	100% (500)
Control	40.88% (184)	59.12% (266)	100% (450)
Total	65.1% (944)	34.9% (506)	100% (1450)

Table 4.9: The number of trials in which participants interleaved for the three conditions.

Table 4.9 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 ($p = 0.18$).

Speed and errors

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.

In total, 130 errors were made in the High-Account condition, 58 in the High-Amount condition, and 88 errors in the Control condition. The mean error rate was 6.5%, 2.9% and 4.9%, respectively. Looking at the total number of data entries, there was no significant difference in errors, $F(2,30) = 0.93$, $p = 0.41$.

An alternative error rate was calculated based on the number of erroneous trials. If a participant made a mistake on all four entries of a trial, this rate would consider it as one error, rather than four errors. Looking at the number of trials on which an error was made, there was no significant difference either, $F(2,30) = 0.87$, $p = 0.43$. In total, there were 87 erroneous trials in the High-Account condition, 41 trials in the High-Amount condition, and 65 trials in the Control condition. In other words, errors were made on 17.4%, 8.2% and 14.4% of the trials, respectively.

There was a significant difference in the time it took participants to complete a trial, $F(2,30) = 3.05$, p-value = 0.03. Participants took longer in the High-IAC conditions than the control condition ($p = 0.008$) . There is no significant difference between the High-Account and High-Amount conditions ($p = 0.63$).

4.3.4 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 Back, Cox, & Brumby (2012), 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 Back et al. (2012)'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 (). 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.

4.3.5 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.

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