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The effect that rounding to prototypical values has on expected duration estimation accuracy

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ABSTRACT

The scheduling component of the time management process was used as a ‘paradigm’ to investigate the estimation of duration of future tasks. Two experiments looked at the effect that the tendency to provide estimates in the form of rounded close approximations had on estimation accuracy. Additionally, the two experiments investigated whether grouping tasks together prior to scheduling would decrease duration estimation error. The majority of estimates provided in both experiments were categorised as rounded close approximations, and were overestimates of the actual time required to complete the experimental tasks. The grouping together of the relatively short tasks used in Experiment 1 resulted in a significant increase in estimation accuracy. A similar result was found in Experiment 2 for relatively long tasks. The results are discussed in relation to the basic processes used to estimate the duration of future tasks, and means by which these scheduling activities can be improved.

Everyday individuals make estimates of the ‘time required’ for future work and life tasks. Two research literatures address this type of estimation process. The time management literature considers the estimation of future tasks within the broader frame-work of planning and prioritizing tasks (see Claessens, Van Eeerde, Rutte, & Roe (2004) and Macan 1994). In contrast, there is research literature focusing specifically on temporal aspects of memory, which tends to consider just the estimation process (see Block & Zakay, 1997; Roy, Christenfeld, & McKenzie, 2005 for recent reviews). Both under- and over-estimation of task completion time can have negative consequences. In the case of overestimation, an individual’s time may not be being used efficiently, whereas in the case of underestimation the individual may be stressed by the realisation that they have not scheduled enough time to complete a task. Roy et al. (2005) claim that underestimation of future task duration is more common than overestimation, and offers a model of the processes by which this occurs. We examine the research they cited to support the claim that individuals typically underestimate the duration of future task, and offer an alternative model of the processes involved in estimating duration, which we test with two experiments.

Roy et al’s. (2005) review cites fourteen published studies (see their Table 1) which have examined individual’s estimates of future task duration, and which also collected data on the actual duration of these tasks, thus allowing a determination of whether the estimates were on average an under- or over-estimation of actual task duration. A number of these studies included more than one task, thus overall there were 35 specific comparisons of estimated and actual task duration. If we do as Roy et al. (2005) did, and simply consider all 35 comparisons it is evident that individuals underestimated duration for 25 (71.4%) of the comparisons, justifiying their claim that individuals typically underestimate future task duration. However, a closer inspection of the 35 tasks examined in Roy et al. (2005) indicates that 18 of them lasted less than one hour (*short* tasks), 4 were for tasks which had actual durations between 2.4 and 16.8 hours (*intermediate* tasks), and the remaining 13 tasks had actual durations of between 1 and 55.5 days (*long* tasks). Examination of these 3 types (*short, intermediate* and *long* tasks) indicates that 10 (55%) of the short task, 3 (75%) of the intermediate tasks, and 11 (84.6%) of the long tasks produced underestimation. Thus underestimation seems more likely as actual duration gets longer. Particularly in relation to short tasks, the claim that individual typically underestimate duration is not overwhelmingly supported by the data/studies Roy et al. (2005) reviewed.

Our focus in the experiments reported in this paper is on short duration tasks, and the processes by which individuals allocate time to these tasks. In order to understand those processes a further examination of the data reported by Roy et al. (2005) for the short (less than one hour) duration tasks is warranted. Our principle argument is that individuals tend to given estimates for future short duration events/tasks which are in units of 5 (e.g., 5 minutes, 10 minutes, 15 minutes etc). We explain later why we think this occurs, and how this can result in very predictable tendencies towards under- and over-estimation. Mean estimated duration can mask such tendencies, and we argue that median and modal estimates give a better indication of a group's estimation tendency. Thus one of the first things to note is that the data reported by Roy et al. (2005) for the 18 comparisons of actual and estimated duration for short tasks, while stated as all being means, are a mixture of means and medians (and in the case of the studies by Konecni & Ebbesen, (1976) and Buehler, Griffin and MacDonald, (1997) are values calculated on other data presented).

The 18 comparisons of actual estimated duration which Roy et al. 2005 reviewed came from a total of 6 different published papers, which they examined in chorological order, as we do. Konecni and Ebbecen (1976) asked 89 individuals to estimate how long they would have to wait in line to buy petrol. Participants estimated the number of cars ahead of them in the line and how long they thought they would be waiting. While the average waiting time was 28.8 minutes, participants estimated they would wait around 19 minutes on average (an underestimation). But from their data it appears that no one participant actually estimated they would wait 19 minutes, rather only 5 different estimates were given: 14.1 % of the participants estimated 10 minutes, 53.9 % estimated 20 minutes, 18 % estimated 23 minutes, 6.3 % estimated 24 minutes and 7.7% estimated 25 minutes. Thus overall, 75.7% of all these estimates were in multiples of five, and the modal estimate was 20 minutes. The next study examined by Roy et al. (2005) was Burt and Kemp 1994. This study examined estimated and actual duration for 10 different tasks, median estimated duration for the 10 tasks were 2, 10, 5, 3, 2.2, 15, 15, 14, 10, and 7 minutes. Thus at the task level, 50% of the tasks examined produced median estimates that were multiples of 5, (note also that for 7 of the 10 tasks the median estimated duration was an overestimation). Next Experiment 2 of Buehler et al. (1997) was reported. This involved participants completing a series of anagram-like word puzzles performed under a speed incentive or an accuracy incentive manipulation. Buehler et al. report mean estimated and mean actual duration for each experimental condition, and Roy et al. (2005) averaged the means across conditions (averaged the estimated duration for the experimental and control group) when reporting the overall mean actual and mean estimated duration for this experiment. Perhaps a more appropriate consideration of these data is to just examine the control conditions – in which case average estimated time to complete the task was an overestimation. Roy et al. report data for two tasks from Byram (1997). For the first task, which involved building a computer stand, they reported an overall mean actual duration of 70.5 minutes and overall mean estimated duration of 45 minutes. However, a closer reading of Byram's paper shows estimated duration was obtained, and medians reported, for sub-components of the whole task: median estimated duration of 60 minutes for assembly of the stand, 25 minutes for the table, 15 minutes for the keyboard tray, and 15 minutes for the monitor stand. Data for the second task from Byram's work relate to making origami. Roy et al. reported these as averages, while they are in fact medians (median actual duration of 8 minutes and median estimated duration of 6 minutes), but they do show underestimation. Next, data from Francis-Smythe and Robertson (1999) were reported for proofreading of an essay (mean estimated duration was 5 minutes and actual 5.8 minutes). Finally, data from two samples from Hinds (1999) were reported. In one sample relating to a cell phone task the mean estimated duration was 18.5 minutes and in the other sample relating to a Lego task mean estimated duration was 10.7 minutes – unfortunately medians (which might well have been 20 and 10 minutes respectively) were not given. Overall, the data which Roy et al. (2005) report in relation to short duration tasks does not consistently indicate underestimation, and they fail to note the tendency for participants to give estimates in multiples of 5 minutes.

We turn now to the *memory bias account* which Roy et al. (2005) offer to explain the assumption that estimates are often under-estimations. They propose that "people remember tasks as taking less time than they actually did and, therefore, underestimate how long similar tasks will take in the future' (P. 738). However, literature on retrospective duration estimation indicates that individuals are often relatively good at estimating the duration of past events. For example, Burt, Kemp and Conway (2001) tested individual's ability to estimate duration for autobiographical events on two occasions with a 10 year interval, and found that the duration estimates were highly accurate and extremely stable over time. This study, and a number of previous studies (e.g., Burt 1992, 1993, 1999; Burt & Kemp, 1991; Burt & Popple, 1996), concluded that retrospective duration estimation involves considerable reconstructive processing which is suggested to begin with the classification of the target event as belonging to a particular category. This classification provides access to general knowledge regarding the typical duration of such events (e.g., it typically takes 10 minutes to go to the shop for milk). Thus, in contrast to Roy et. al's., (2005) *memory bias model,* we do not assume that memory for duration is stored for individual events, rather we propose it is associated with general knowledge of event categories. Thus, Burt and Kemp (1991) showed that increased experience with event categories reduced the between-subject variation in duration estimates. Furthermore, Burt (1993) found that the accuracy of an individuals duration estimate when based primarily on an event category's typical duration, was influenced by the typicality of the actual duration of the target event, and by the individuals ability to use his or her memory of the target event to adjust their estimate for atypical event characteristics. We have argued that similar processes occur when individuals estimate the duration of future events (e.g., Burt & Kemp, 1994). Here the target event is classified into a category, and memory for that category of event is examined. For example, you are asked how long it will take you to proof read an essay – and this prompts access to your general knowledge of proof reading documents – essays, research proposal, grant applications etc. Your general knowledge of how long such tasks have taken in the past is then used to make an estimate. Because the event has not occurred yet, you can not adjust for atypicality (e.g., to give a longer estimate because you know a particular essay contains many spelling mistakes), and the estimate given is often a *rounded close approximation*. For short duration events we suggest that these rounded close approximations are often in 5 minute intervals. For example, you know it takes approximately 10 minutes to go to the shop to get milk – sometimes more, sometimes less, but in round terms about 10 minutes. As discussed above, studies on short duration tasks, which Roy et al. (2005) reviewed, show considerable evidence of these rounded close approximation estimates.

Francis-Smythe and Robertson (1999) have also discussed how 'rounding' may effect task duration estimation. Likewise, this process has been suggested by Zakay (1990) who points out that any verbal estimate of a duration is prone to error arising from the response bias of reporting durations in round numbers. Consistent with this view, Hornik (1981) noted that participants in his study tended to report duration estimates in multiples of five minutes. Furthermore, many of the rounded values found in duration estimation studies may represent temporal categories (Smith & Medin, 1981; Oden, 1987). The tendency to use rounded close approximations may also be enhanced by the design of diaries and daily planners, which typically provide 15 minute, 30 minute or 1 hour segments in which to schedule tasks (see Burt & Forsyth (1999) for studies on schedule design). Finally, in relation to much longer intervals, Huttenlocher, Hedges, Bradburn (1990) found that participants over-reported temporal values like 7, 14, 30, 60 (week, fortnight, month, and two months respectively) when asked how many days had elapsed since various personal (autobiographical) events.

How then does our reconstructive model explain why individuals under- or over-estimate the duration of future events? Roy et al. (2005) argue it is because we incorrectly recall the duration of past events as shorter than they actually were (resulting in a general tendency to under-estimate). In contrast, we argue that two different factors determine under- or over-estimation. The first relates to experience with the event type. As we experience more instances of a specific type of event our knowledge of approximately how long it will last for becomes more exact (recall that Burt & Kemp, 1991 found experience with event categories reduced between-subject variance in estimated duration). The inverse of this is that, with little experience with a task we may not be certain as to which rounded close approximation to use. For example, a task which we feel might last between 5 to 10 minutes can either be allocated 5 or 10 minutes as a rounded close approximation of its required time. If this task actually lasts 7 minutes, a 10 minute estimate would have been an over-estimation, and a 5 minute estimate an under-estimation. The second factor that we suggest is important is how close our general idea of a task's required duration is to a particular rounded close approximation unit. For example, if we think it generally takes 8 to 9 minutes to go to the staff room to get coffee – we might put a note on the office door saying 'back in 10 minutes' – rather than 'back in 5 minutes' because 8 or 9 minutes is closer to 10 minutes than it is to 5 minutes. This could result in consistent overestimation. In contrast, a task which we think might take about 6 to 7 minutes (which is closer to 5 minutes than 10 minutes) might occasion an estimate of 5 minutes – resulting in underestimation if the task lasted say 6.5 minutes.

Finally it is important to remember that the estimation of duration of future tasks is often within a context where the accuracy of the estimate has consequences. These consequences relate to how others perceive us, for example how reliable they perceive we are, how much pressure we put on ourselves. Burt and Kemp (1994) argued that overestimating task time maybe a 'safe estimation' strategy which helps ensure tasks are completed on time (thus others see the individual as reliable), and which helps avoid the stress of not completing a task in the allocated. Therefore we argue that individuals are perhaps more inclined to use a rounded close approximation which results in overestimation, as opposed to giving a rounded close approximation which results in an underestimation.

Experiment 1 and 2 investigated the effect that using rounded close approximations has on estimation accuracy. It was predicted that when asked to estimate the duration of a to-be-completed task participants will be more likely to provide an estimate which is in the form of a rounded close approximation (e.g., five-minute 'chunks'). Secondly, although the predicted over-reliance on rounded close approximations will tend to lead to inaccuracies for almost all duration estimates of future tasks, it is argued that this tendency to estimate in five-minute segments will result in proportionally more overestimations for very short tasks (less than 5 minute tasks as used in Experiment 1) because the closest rounded close approximation is larger than the event's actual duration. Furthermore, given that the use of rounded close approximations has the potential to create estimation error every time an estimate is given for a future task, if the number of estimates is reduced it may be possible to reduce estimation error. If, for example, three tasks are grouped together and a single estimate of their required time is requested, this estimate should be more accurate than the sum of three individual estimates (one for each of the three tasks). To examine this prediction we included a 'task grouping' manipulation into both experiments. This simply requested participants to estimate completion time for half the tasks as a group (i.e. one segment of time scheduled for the completion of 3 tasks which individually were designed to require less than 5 minutes to complete). It was predicted that grouping relatively short duration tasks together, and requesting one duration estimate for the completion of all these tasks, will result in greater task duration estimation accuracy when compared to estimates (summed estimates) given for each of the tasks individually.

EXPERIMENT 1

Method

The experiment contained two participant conditions, both involving the scheduling and completion of the same six office-type tasks. In condition one, three of the tasks were grouped together to form one set of activities to be scheduled, and the other three tasks were scheduled as separate tasks. In condition two, the three tasks scheduled as one set of activities in condition 1 were scheduled as individual tasks, and the remaining three tasks scheduled as a task set. These manipulations resulted in both groups providing 4 duration estimates, three relating to individual tasks and one relating to a set of tasks.

Participants

Twenty male and 20 female students, with a mean age of 22.5 years, participated in the experiment. Participants received NZ$20 remuneration and were debriefed after the experiment.

Materials

Scheduling Planner

The scheduling planner consisted of an A4 sheet of paper with a plain border.

Tasks

Two criteria were used in the development of the six experimental tasks. Firstly, a balance was sought between re-creating an office environment, and having tasks that all participants would find at least somewhat familiar. Secondly, the individual tasks were designed, based on previous research (e.g., Burt & Kemp, 1994) and informal pilot studies, so as to have relatively short average completion times of between three and eight minutes.

Participants received the following task descriptions. ***Task 1*** *A three-page document, typed (double spaced) on A4 paper is provided. Your task is to proof read it for spelling mistakes. Circle each spelling mistake that you find.* ***Task 2*** *Deliver eight letters to their respective pigeonholes. The addressee's pigeonholes are located in Room 209 of the psychology building (i.e., the Resource room). This room is two floors directly below your present location (opposite the secretaries' office).* ***Task 3*** *Obtain the current river conditions (water colour & fish-ability) for the following four Canterbury rivers: Waimakariri river, Rakaia river, Hurunui river, and Waiau river. To obtain this information you will need to phone Fish and Game North Canterbury's automated river report. The phone number should be looked up in the telephone book provided.* ***Task 4*** *Five 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator).* ***Task 5*** *Buy a candy bar (or similar) from the vending machine just inside the law café (if you look out the window you will see the new law building – the café is located near the main entrance on the* *ground floor). One dollar is in the appropriate folder.* ***Task 6*** *Arrange 20 job applications in alphabetic order with respect to the applicants' surnames (i.e. 'A' in the front, through to 'Z' at the back).*

Procedure

Participants were randomly assigned to one of two conditions. In the first condition (group 1) tasks one, two, and three were scheduled separately, and tasks four, five, and six were grouped together and scheduled as a task set. In condition two (group 2) tasks one, two, and three were grouped together and scheduled as a task set, while tasks four, five, and six were scheduled separately.

Participants were seated individually at a cubicle which contained: a table, experimental instructions, task descriptions, a scheduling planner, folders containing task materials, a telephone and directory, and a 'Completed Task' tray. Each participant was instructed to read the following instructions: "This experiment examines job satisfaction in office work. You are required to complete six tasks. These tasks can be carried out in any order you choose, however you must complete one task before you move on to the next one. Try to imagine that you are working in an office situation and the completion of these tasks is part of your duties. Specifically you are required to: Read the accompanying sheet that describes the tasks – this sheet listed 3 tasks separately and three as a group of tasks. Schedule the completion of the tasks by entering onto the scheduling planner the order you propose to complete the tasks, along with the time you expect to need for completion of each (participants were not constrained to provide duration estimates in any particular scale (i.e., minutes versus seconds). The participants then completed the tasks. The researcher, who was partitioned off from the participant, discretely recorded the time taken for the participant to complete each task.

Results And Discussion

Table 1 shows the mean actual duration, mean, median and modal estimated duration, and mean signed error (estimated minus actual duration) for each task. Inspection of Table 1 indicates that the mean signed errors are positive for all six tasks (when scheduled as separate tasks), meaning that participants tended to overestimate the amount of time they actually needed to complete each task.

Insert Table 1 about here

Rounding and Overestimation

The 40 participants' supplied a total of 160 estimates, and the majority of these (73%) were rounded close approximations (e.g., multiples of five minutes), with 51 percent of all estimates being either five- or 10-minutes. This is also shown in the modal estimated durations shown in Table 1. Table 1 also shows the proportion of participants that overestimated. The three tasks (letter delivery, river conditions, and document ordering) with the shortest average actual durations (around three to four minutes) had the highest proportions of participants providing overestimates (100, 90, and 95% respectively). Conversely, the two tasks with the longest average actual duration (proofreading and balancing bills) of around seven minutes had the lowest proportions of participants providing overestimates (60 and 45% respectively). In the case of these two tasks, participants who used rounded close approximations had a choice between allotting five (an underestimation) or 10 (an overestimation). The modal estimates for these two tasks indicate that the participants tended to give a 5 minute estimate - a choice which is reflected in the proportion of over- and under-estimates for these two tasks.

Actual Task Duration

A 2x2 mixed design ANOVA, with group being the between subject variable and whether the tasks were scheduled together or separately being the within subject variable, was conducted for the actual task durations. It revealed no main effect for group ($F(1, 38) = 1.53$, $p=.22$), confirming that the two groups do not differ significantly in the overall time to complete the tasks. In addition, it revealed no main effect for the scheduling variable ($F(1, 38) = 1.46$, $p=.23$). Likewise, there was no significant interaction between the group and scheduling variables ($F(1, 38) = .15$, $p=.70$). This balancing actual task duration for the three tasks scheduled together and three scheduled separately was successful, and these results mean that analysis of the effect of scheduling tasks together could be undertaken both within and across the two groups of participants. Furthermore, these findings indicate that grouping relatively short duration tasks together at the time of scheduling has no significant positive (or negative) effect on actual completion duration.

Grouping Tasks and Scheduling

The median estimated duration for the tasks which were scheduled as a group, and the median summed estimated duration for the three tasks scheduled separately are shown in Table 1, and comparison of these results indicates less time was allocated when the tasks were grouped. This is further indicated by the mean signed errors. For example the mean summed signed error for the three tasks scheduled separately by group 1 was +8.9 minutes, while the mean signed error for the same three tasks scheduled as a group of tasks by group 2 is +1.5 minutes. A 2x2 mixed design ANOVA, with group the between-subject variable and whether the tasks were scheduled together or separately the within-subject variable, was conducted for estimated task durations. The ANOVA revealed a significant interaction between the group and scheduling variables ($F(1,38) = 17.91$, $p=.0001$). Significant differences were found between the two groups on their duration estimates for tasks one, two, and three ($F(1,38) = 12.27$, $p=.001$), group one's estimation of tasks one, two, and three and tasks four, five, and six ($F(1,38) = 9.15$, $p=.004$), and similarly group two's estimation of tasks one, two, and three, and tasks four, five, and six ($F(1,38) = 8.76$, $p=.005$). Although in the right direction, the only comparison where a significant difference was not found was between the two groups and tasks four, five, and six ($F(1,38) = 1.39$, $p= .25$). These results support our prediction that grouping relatively short duration tasks together results in less time being allocated to them, and thus the generation of more accurate estimates.

EXPERIMENT 2

Experiment 2 attempted to replicate the findings from Experiment 1 by assessing the effect of scheduling grouped tasks and the influence of using prototypical temporal values when actual task time was substantially longer (i.e. 20-40 minutes). The experimental design was the same as used in Experiment1, except that different tasks that required longer to complete were used. The following four prediction were made: (1) on average participants will tend to overestimate the time required for task completion, (2) participants will be more likely to provide an estimates which is in the form of a rounded close approximations (e.g., five-minute 'chunks'), (3) grouping tasks together for scheduling purposes will result in less time being allocated for their completion, than when the same task were scheduled separately. However, although Experiment 1 appears to provide evidence that grouping relatively short duration tasks together for scheduling purposes results in less time being allocated for their completion and more accurate estimates, it is likely that this effect will have relatively less value for longer tasks. For instance, it seems likely that people will change the 'scale' (rounded close approximations) of their estimation as the actual task duration increases. For example, if asked to estimate how long it will take to read a 300-page manuscript it would seem unlikely that the predisposition towards estimates of multiples of five minutes would prevail. This being the case, the effectiveness of grouping tasks together in order to increase accuracy may be dependent on the association between the actual duration of the task and the prominent rounded close approximation chosen.

Method

Participants

Forty participants, 19 males and 21 females students, with a mean age of 22.4 years, participated in the experiment (none had participated in Experiment 1). Participants were remunerated for taking part, and debriefed at the end of experiment.

Materials

Scheduling Planner

The task schedule planner consisted of an A4 sheet of paper.

Tasks

Two criteria were used in the design of tasks. As with Experiment 1, a balance was sought between re-creating an office environment, and having tasks that all participants would find somewhat familiar. Secondly, individual tasks were designed so as to have a significantly longer average completion time (between 20-40 minutes) than those used in Experiment 1. This was achieved by increasing the magnitude of three of the tasks used in Experiment 1, and by designing three new tasks that were trialled by volunteers and adjusted accordingly. The six tasks were: ***TASK 1*** *A 13-page company report, typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find.* ***TASK 2*** *The consumer research company you work for is currently interested in how people spend their holiday time. As part of this information gathering process you are required to write a two-page document describing what you did during the Christmas holidays.* ***TASK 3*** *The company you work for is thinking of building or renting a new office. As part of this process they want to get quotes from relevant providers. Using the telephone book (yellow pages) provided look-up and record the names and phone numbers (response forms provided) of 10 Builders, Plumbers, Real Estate Agents, Concrete contractors, Civil Engineers, Interior Decorators, Roofing Contractors and Architects.* ***TASK 4*** *Twenty 'bills'* *(e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator).* ***TASK 5*** *The company you work for has many job application letters, which it has received over the past five years. These need to be ordered and filed. The folder contains 100 job application letters. Firstly, you need to sort the letters with respect to the year they were sent. This will result in five groups of letters. For each of these five groups you are required to arrange the job applications in alphabetic order with respect to the applicant's surname (i.e. 'A' in the front, through to 'Z' at the back). The paper clips provided should be used to keep each group together.* ***Task 6*** *The company you work for is thinking of subscribing to various academic journals. Your task is to gather subscription information on these journals (normally found on the inside front or back cover). Go to the current periodicals section of the main library and record the annual institutional subscription rate (non-airmail where applicable) and the subscription address for the following 10 journals* (titles and call numbers were provided).

Procedure

Participants were randomly assigned to one of two conditions. In the first condition (group 1) tasks 1, 2, and 3 were scheduled separately and task 4, 5, and 6 were grouped together and scheduled as a task set. In condition two (group 2) tasks 1, 2, and 3 were grouped together and scheduled as a task set, and tasks 4, 5, and 6 were scheduled as separate tasks.

Participants were seated individually at a table, given the experimental instructions (identical to Experiment 1), task activity descriptions, a scheduling planner, folders containing the task materials, a telephone directory, a 'Completed Task' tray, and directed to read the instructions. Participants scheduled the completion of the tasks, and completed the tasks in the order they had chosen. The researcher discretely recorded the time taken for the participant to complete each task.

Results and Discussion

Table 2 show the mean actual duration, mean, median and modal estimated duration, and mean signed error (estimated minus actual duration) for each task. In contrast to Experiment 1, the mean signed errors are not positive for all six tasks. For two of the tasks the actual duration tended to be underestimated (*proofreading* & *contact detail look-up*). Table 2 also shows the proportion of participants who overestimated completion durations, and these are generally smaller than those obtained in Experiment 1.

Insert Table 2 about here

Rounding and Overestimation

Examination of the duration estimates indicated that 83% of the participants gave values of 10, 15, 30, 40, 45, 50, 60 or 90 minutes which might be considered to be rounded close approximations. This tendency is also reflected in the median and modal estimates shown in Table 2.

Actual Task Duration

Table 2 shows the mean actual time it took participants to complete the tasks. A 2x2 mixed design ANOVA, with group the between-subject variable, and whether the tasks were scheduled together or separate the within-subject variable, was conducted for actual task durations. It revealed no main effect for group ($F(1, 38) = 2.91$, $p=.10$). This result confirms that the two groups did not differ significantly in the actual duration it took to complete the tasks. Likewise, the ANOVA revealed no significant interaction between the group and scheduling variables ($F(1, 38) = .40$, $p=.54$). However, it did reveal a main effect for the scheduling variable ($F(1, 38) = 9.49$, $p=.004$). Although this is not the ideal outcome, it does not affect any of the important analyses concerning duration estimation (the difference in actual duration is between tasks that have been scheduled together for both groups). Overall these results confirm that the important parts of balancing actual task duration for the three tasks scheduled together and three scheduled separately was successful. These results mean that analysis of the effect that scheduling tasks together had on duration estimates could be undertaken both within and across the two groups of participants. This finding also confirms that grouping tasks together has no significant positive (or negative) effects on actual completion duration.

Grouping Tasks and Scheduling

Table 2 shows the median estimated duration for the tasks which were scheduled as a group and the median summed estimated duration for the three tasks scheduled separately. A 2x2 mixed design ANOVA, with group the between-subject variable and whether the tasks were scheduled together or separately the within-subject variable, was conducted for estimated task durations. The results of the ANOVA revealed no main effect for group (F (1, 38) = .42, p=.52). This result confirms that the two groups did not differ significantly as far as overall duration estimated to complete all six tasks. In addition, there was no main effect for the scheduling variable (F (1, 38) = .88, p=.36). However, as expected, the ANOVA revealed a significant interaction between the group and scheduling variables (F (1, 38) = 36.16, p=.0000). Significant differences were found between the two groups on their duration estimates for tasks one, two, and three (F (1, 38) = 5.44, p=.03), tasks four, five, and six (F (1,38) = 14.5, p= .000), group one's estimation of tasks one, two, and three, and tasks four, five, and six (F (1, 38) = 12.89, p=.001), and similarly group two's estimation of tasks one, two, and three and tasks four, five, and six (F (1, 38) = 24.15, p=.000). These findings replicate the findings of Experiment 1 whereby grouping tasks together had a significant effect on duration estimates.

However, in contrast to Experiment 1, the reduction in estimated duration did not result in an increased accuracy of the estimations. In fact when presented separately the somewhat longer tasks used in this experiment were estimated with a relatively high degree of accuracy. Whereas, scheduling tasks together resulted in greater estimation error, specifically underestimation of actual duration.

GENERAL DISCUSSION

The results from Experiments 1 and 2 suggest that people often tend to report rounded close approximations when estimating the duration of future *short* tasks. This bias tends to lend to overestimation for tasks with actual durations less than 5 minutes. Grouping tasks into small clusters prior to scheduling was shown in both experiments to reduce the amount of time allocated for task completion, and this strategy may provide one means though which the influence of using rounded close approximations can be decreased. However, it is important to note that overestimation of required task time may not always be a negative behaviour. As Burt and Kemp (1994) noted, this could be a 'safe estimation strategy', a strategy which results in tasks being completed within the allocated time. The stragety may well increase the individual's feeling of control over time and result in less time management related stress.

While our results show considerable use of rounded close approximations, which is consistent with our constructive account of the estimation of future task duration, they are inconsistent with Roy et al. (2005) *memory bias account*. None of the tasks we used was particularly novel or unusual, and our participants might have been expected to have had some experience with such tasks. Given this, if they were using specific memories (albeit erroneous ones) of the duration of such tasks to give estimates, in the way Roy et al., suggest, we might have expected to find much more variance in the estimates, rather than the tendency towards estimates rounded in 5 minute units. The *memory bias account* appears to have much in common with Ornstein's (1969) *storage size hypothesis* which proposed that estimated duration is proportional to the information stored in memory about the event or interval at the time of estimation. This hypothesis was the dominant explanation of retrospective duration estimation for many years, and numerous laboratory based studies supported it (see Fraisse, 1984 for a review of this work). Basically, as an individual forgets information (often stimuli like burst of tone or light) presented during an interval their estimate of its duration shortens. However, Ornstein's modal does not appear to generalise to more complex real world events. Burt and Kemp (1991) tested the model with real world events and failed to support it. For example, it does not seem to be the case that because you now can recall less about a holiday you had 10 years ago, that you now think the holiday lasted less time. Thus the direct relationship between memory for past durations and estimates of the duration of future similar events/tasks may not be as strong as Roy et al. suggest.

While our results show considerable evidence of rounded close approximations in short duration tasks, and evidence that these can lend to overestimation for such tasks, what of longer tasks? As noted in the introduction, there was more evidence of underestimation for the longer tasks examined by Roy et al., (2005). Roy et al. cited Kahneman and Tversky's (1979) work on the *planning fallacy* in support of their model, and as an explanation for underestimation. Kahneman and Tversky suggested a person can use two types of information to make a time prediction. *Singular* information relates to the target task, and *distributional* information relates to completion times of similar tasks in the past. Our constructive model suggests that *distributional* information of past events/tasks duration is developed into general knowledge structures for event categories (Kahneman & Lovallo, 1993 also discuss such knowledge of the average time tasks have taken) and these structures plays an important part in the estimation process, whereas Roy et al. argue that while distributional knowledge is important, that these memories of past duration are generally wrong – we tend to remember that events/tasks in the past actually took less time than they really did. In contrast, we argue that the reason why the required time of future longer tasks is sometimes underestimated is that individuals find it difficult to use *singular* information when estimating.

As noted singular information relates to the target task. Several factors may influence how we can use singular information when trying to estimate how long a future task will take. First, what information is available about the specific task? Take, for example, the task of reviewing a paper for a journal. When the day arrives on which you might have to begin this task (schedule it in) the reviewer may or may not know the authors, basically what the paper is about (having read the abstract or title when accepting it for review), and approximately how long it is (having printed it). However, the specific content of the paper remain unknown at this point. The reviewer may be able to make some adjustments to their constructed estimate of the review time (based on singular information) because they know the authors do typically do good work (which *might* occasion less need for critical comment) or the paper seems atypically short or long. Such adjustments may or may not result in a more accurate allocation of time, and they may result in either over- or under-estimation. Thus use of singular information about the task may not produce specific estimation tendencies.

Often there is also *singular* information about *when* we have scheduled the tasks, for example the day of the week, time of the year. Arguably there is an interaction between accuracy (under- or over-estimation) of the scheduled time and just when that time is used. Let us take the review process as an example again. If a review is scheduled to be completed during the working week, the probability of interruptions (colleagues and students arriving unexpectedly) is perhaps greater then if the review is completed at home on the weekend. Furthermore, as the actual time allocated to any task increases, the probability of an interruption undoubtedly increases. For example, in a one hour period the phone might go once or twice, someone might knock on the office door, and in combination these interruptions have a time cost to whatever is being done. However, this time cost potentially increases as the task's actual duration increases. In other words, the longer a task takes the less likely an individual will be to complete it on time because the potential number of interruptions increases. Being able to apply this logic (singular information) when constructing the duration of future events/tasks is probably extremely difficult. Thus perhaps the only way to avoid underestimating the duration of longer tasks is to schedule their completion at a time when there is absolutely no possibility of interruptions. Of course such time rarely exists.

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Table 1. Summary of actual and estimated task duration for Experiment 1.

Group	Task	Mean Actual Time (&SDs) to Complete (Minutes)	Mean Estimated Time (&SDs) (Minutes)	Median Estimated Time (Minutes)	Mode Estimated Time (Minutes)	Mean Signed Error (Minutes)	Percentage of Participants Who Overestimated
Group 1	Proof Reading	7 (1.6)	8.3 (4.9)	6.5	5.0	+1.3	60%
	Deliver letters	4.2 (1.2)	6.7 (2.2)	6.0	5.0	+2.5	100%
	River reports	3.9 (1.1)	9.1 (4.7)	9.0	M*	+5.2	90%
	Scheduled separately: Summed Proofreading, Deliver Letters & River Reports	15.1 (1.7)	24.1 (8.2)	24.0	35.0	+8.9	
	Scheduled as Group: Balance Sheet, Candy Bar & Order Documents	12.8 (2.2)	17.9 (7.3)	15.0	15.0	+5.1	45%
Group 2	Balance Sheet	7.0 (2.4)	8.0 (6.4)	5.0	5.0	+.83	45%
	Candy Bar	4.7 (1.0)	7.5 (4.8)	5.5	5.0	+2.7	75%
	Order Documents	3.1 (.9)	6.5 (4.2)	5.0	5.0	+3.4	95%
	Scheduled separately: Summed Balance Sheet, Candy Bar & Order Documents	12.1 (2.5)	22.1 (14.0)	19.5	20.0	+10	
	Scheduled as Group: Proofreading, Deliver Letters & River Reports	14.5 (3.0)	16.1 (6.0)	15.0	M*	+1.5	55%

* Multiple modes evident in data

Table 2. Summary of actual and estimated task duration in Experiment 2.

Group	Task	Mean Actual Time (&SDs) to Complete (Minutes)	Mean Estimated (&SD) Time (Minutes)	Median Estimated Time (Minutes)	Mode Estimated Time (Minutes)	Mean Signed Error (Minutes)	Percentage of Participants who Overestimated
Group 1	Proofreading	24.5 (9.2)	23.7 (9.9)	20.0	20.0	-.78	50%
	Written Report	22.3 (5.0)	28.2 (14.0)	30.0	30.0	+5.9	60%
	Contact Detail Look-up	30.6 (7.1)	25.3 (11.3)	30.0	30.0	-5.3	40%
	Scheduled separately: Summed Proofreading, Written Report & Contact Detail Look-up	77.5 (14.3)	77.3 (26.3)	72.5	65.0	+.25	
	Scheduled as Group: Balance Sheet, Order Documents & Library Subscription Details	71.6 (10.1)	59.0 (22.4)	60.0	60.0	-12.6	20%
Group 2	Balance Sheet	22.2 (10.3)	22.6 (9.8)	20.0	20.0	+.4	50%
	Order Documents	18.7 (3.1)	25.8 (10.3)	20.0	20.0	+7.1	80%
	Library Subscription Details	35.7 (6.9)	36.2 (9.4)	35.0	30.0	+.55	60%
	Scheduled separately: Summed Balance Sheet, Order Documents & Library Subscription Details	76.6 (15.2)	84.7 (20.1)	85.0	70.0	+8.05	
	Scheduled as Group: Proofreading, Written Report & Contact Detail Look-up	85.5 (16.4)	59.6 (21.2)	60.0	60.0	-25.9	5%

The effect that rounding to prototypical values has on expected duration estimation accuracy

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