ERROR MANAGEMENT

Combating omission errors through task analysis and good reminders

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Leaving out necessary task steps is the single most common human error type. Certain task steps possess characteristics that are more likely to provoke omissions than others, and can be identified in advance. The paper reports two studies. The first, involving a simple photocopier, established that failing to remove the last page of the original is the commonest omission. This step possesses four distinct error-provoking features that combine their effects in an additive fashion. The second study examined the degree to which everyday memory aids satisfy five features of a good reminder: conspicuity, contiguity, content, context, and countability. A close correspondence was found between the percentage use of strategies and the degree to which they satisfied these five criteria. A three stage omission management programme was outlined: task analysis (identifying discrete task steps) of some safety critical activity; assessing the omission likelihood of each step; and the choice and application of a suitable reminder. Such a programme is applicable to a variety of healthcare procedures.

Human error gets a bad press. A recent report to the President of the United States described the impact of health carers' errors upon patient safety as "a national problem of epidemic proportions".[1] Human error is portrayed as being in the same league as *Pasteurella pestis* or the AIDS virus. This is a misleading representation. Errors themselves are not intrinsically bad—indeed, they are often highly adaptive as in trial and error learning or the serendipitous discovery that can arise from error.[2] However, they can have damaging or even fatal consequences, particularly in the "hands on" often uncertain activities associated with delivering health care to vulnerable patients—although these injurious outcomes are probably far fewer than their contextual opportunities would warrant. Unlike some epidemics, there is no specific countermeasure for error. Rooted as it is in the human condition, fallibility cannot be eliminated—nor is that a sensible goal—but its adverse consequences can be moderated through targeted error management techniques. This paper will deal in a very practical fashion with one such technique: the reduction of omission errors through the use of task analysis and reminders.

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Error management is an ancient practice. Most hazardous endeavours developed tools for minimising the likelihood of error. Victorian railway signalmen, for example, inserted flagsticks into the spring catches of signal levers on line sections that were blocked by a stationary train to help them remember that a train is waiting to proceed and to avoid pulling off the signal prematurely. Pilots routinely use checklists prior to take off, descent, and landing to minimise the possibility of omitting important procedural steps. Scrub nurses count swabs and instruments before and after surgery to help ensure that none has been left in the patient.

Although of proven value, these evolved techniques tend to be piecemeal rather than planned, ad hoc rather than theoretically driven, and fail to take account of the developments that have occurred in understanding the nature, varieties, and affordances of human error. As a result, they focus upon the personal rather than the systemic causal factors; they rely heavily on exhortations and disciplinary sanctions; and they often fail to distinguish between the random and systematic error shaping factors. Perhaps the most serious barrier to progress is the essentially moral belief that responsible professionals should not make errors. There are two corollaries to such a view. Firstly, the errors of professionals will be rare but sufficient to cause adverse events and, secondly, errors with bad consequences must be negligent or even reckless and so deserve deterrent sanctions. The reality, however, is that responsible and highly trained professionals, being human, make frequent errors,[3 4] most of which are either detected and recovered or are simply inconsequential. It is also the case that such errors are only occasionally necessary to add the final ingredients to event scenarios that have often been simmering for lengthy periods within the system.

Error management has two components: (1) *error reduction* (measures designed to limit the occurrence of errors) and (2) *error containment* (measures designed to enhance the detection and recovery of errors, as well as seeking to minimise their adverse consequences). A broad spectrum of error management techniques has been discussed at length elsewhere[5]; our present concern is with the use of task analysis and reminders to combat dangerous omissions.

OMISSIONS AND THEIR AFFORDANCES

Omissions make a particularly worthwhile target since the failure to carry out necessary steps in the performance of a task is probably the single

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Table 1 Summary of the possible processes involved in omitting a necessary

Level of failure	Nature of failure	Failure type
Planning and intention formation	• A necessary item is unwittingly overlooked	Mistake
	• The item is deliberately left out of the action plan.	Violation
Intention storage in prospective memory	• The intention to carry out the action(s) is not recalled at the appropriate time	Lapse
Action execution	• The actions do not proceed as intended and a necessary item is unwittingly omitted from the sequence	Slip
Monitoring	• The actor neither detects nor corrects the prior omission	Slip or violation

most common human error.[6] Affordances in this context are situational factors—as distinct from personal factors—that promote the likelihood of an omission error. The predominance of omissions arises in large part from the variety of mental processes that are implicated in their occurrence. Action control involves at least four main stages—planning, intention storage, execution, and monitoring—and a glitch in any one or more of these processes can lead to an omission. These possible failures are shown in more detail in table 1. It is often very difficult to pinpoint the precise cognitive processes that were involved in omitting a crucial task step—even the error makers themselves find it difficult to identify the cause of the failure.

A more promising way forward is to focus not so much upon the underlying mental processes but upon those task characteristics most likely to afford omissions (termed "affordances"). Recent psychological research has identified a number of task properties that are likely to increase the probability that a particular step will be omitted. Some of the more important of these features are as follows:

- The greater the informational loading of a particular task step—that is, the higher the demands imposed upon short term memory—the more likely it is that items within that step will be omitted.[7]
- Procedural steps that are functionally isolated—that is, ones that are not obviously cued by preceding actions nor follow in a direct linear succession from them—are more likely to be left out.
- Recursive or repeated procedural steps are particularly prone to omission. In the case where two similar steps are required to achieve a particular goal, it is the second of these two steps that is most likely to be neglected.[8]
- Necessary steps that follow the achievement of the main goal of a task are likely to be omitted. This is an instance of a general principle: steps located near the end of a task sequence are more prone to omission. Such "premature exits" are due in part to the actor's preoccupation with the next task, particularly when the current activity involves largely routine actions.[2]
- Steps in which the item to be acted upon is concealed or lacking in conspicuity are liable to omission.
- Steps following unexpected interruptions are especially prone to omission. This can occur because the person loses her place in the action sequence and believes herself to be further along than she actually is, or because some unrelated action is unconsciously "counted in" as part of the task sequence.[2]
- Tasks that involve planned departures from standard operating procedures or from habitual action sequences are liable to strong habit intrusions in which the currently intended actions are supplanted by a more frequently used routine in that context, and thus omitted.
- Actions that are triggered by weak, noisy or ambiguous signals are likely to be omitted.

A number of these omission provoking properties can combine in a single task step. When this occurs, the effects are additive and the result is a recurrent error trap that predictably snares a large number of people. The everyday task of using a simple desk photocopier of the kind shown in fig 1 will both support this claim and illustrate the basic error management principles.

A STUDY OF PHOTOCOPYING ERRORS

Using a simple desk photocopier provides a convenient test bed for investigating the combinatorial potency of the omission provoking task features outlined above. It is commonplace, relatively stress free (at least while the machine is working), and is associated with a variety of possible errors.

A questionnaire was devised that asked 95 undergraduates, researchers, and academics how often they committed 15 distinct error types (table 2) while using such a photocopier.[6] The respondents were required to rate the frequency with which they committed each error type on a 7 point scale ranging from 0 = never to 6 = nearly all the time. The main prediction was that failure to remove the last page of the original would be the most frequent omission error because this step possesses the largest number of omission affording characteristics, as listed below:

- The emergence of the last copy page from the machine gives a strong but false completion signal. The main goal of the activity (copying) is achieved before all the necessary steps are complete.
- This false completion signal gains extra power from its closeness to the presumed end of the activity. As the end of this tedious task approaches, attention consuming preoccupation with the subsequent task increases.
- The emergence of the last sheet also indicates that it is no longer necessary to put in another original. This leaves the removal of the last sheet as a functionally isolated act. Throughout the copying process the removal of the preceding sheet has been cued by the need to place the next original sheet on the platen. To do this, it is first necessary to remove the preceding original. In the case of the last sheet this cueing is absent.

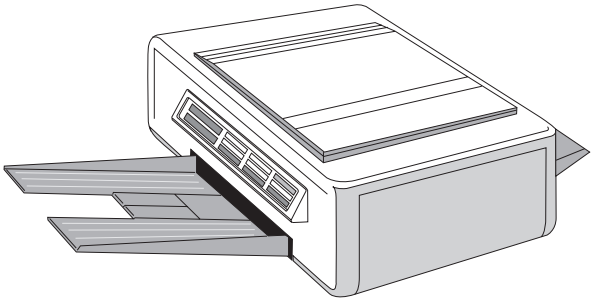

Figure 1 Type of simple photocopier discussed in the text.

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Table 2 Mean (SD) ratings for photocopying errors (in order of frequency)

Nature of error	Mean (SD) rating
Place original wrongly	3.06 (1.37)
Leave last page of original*	2.18 (1.56)
Copy page already copied	2.13 (1.36)
Fail to check copy quality*	1.98 (1.80)
Copy selector failures*	1.79 (1.18)
Fail to copy all pages*	1.72 (1.28)
Leave personal items behind*	1.69 (1.42)
Fail to log out or take card*	1.41 (1.38)
Lift lid at wrong time	1.36 (1.48)
Don't remove all copies, etc*	1.28 (1.14)
Fail to insert card at outset*	1.18 (1.14)
Fail to allow warm up*	1.09 (1.24)
Activate cycle without original*	1.05 (1.14)
Fail to switch on copier*	0.64 (0.90)
Switch off before completion	0.28 (0.71)

*Items involving omission errors

- The closed lid conceals the last sheet of the original, so no visible reminder of the need to remove is available.

Table 2 shows the mean ratings for the 15 error types set out in rank order of frequency. The omission errors are marked with an asterisk. As predicted, leaving the last page of the original was the most common omission. The main purpose of this exercise was to demonstrate that error traps likely to provoke frequent omissions can be established in advance by first breaking the task down into steps (task analysis), and then assessing the degree to which each step possesses error affording properties.

In contrast to higher order errors involving wrong diagnoses and bad decisions, the countermeasures for minimising the occurrence of omissions are fairly obvious. The provision of timely and suitably located reminders will make a substantial dent in the number of future omissions. A more effective solution would be to insert forcing functions—these are mechanical or electronic devices that block onward action until all of the prior steps have been satisfactorily completed. The problem with forcing functions, however, is that they usually involve the redesign of equipment and are thus likely to be both expensive and remote solutions. Reminders, on the other hand, are cheap and quick to apply. But what makes a good reminder?

THE FEATURES OF A GOOD REMINDER

The criteria for a good reminder were derived partly from the recent memory aid literature[9 10] and partly from a consideration of the factors promoting omissions (listed above). They fall into two groups:

- *Universal criteria*: characteristics that should apply to all reminders regardless of their form (see table 3).
- *Secondary criteria*: characteristics that could be useful in particular instances although are not applicable in all situations (see table 4).

A SURVEY OF EVERYDAY MEMORY AIDS

A first step in assessing the validity of these criteria was to survey the use of everyday memory aids.[6] One hundred and forty seven psychology undergraduates (128 women, 19 men) were asked to list the strategies they used to help them remember to carry out necessary tasks or activities. The strategies so obtained were grouped into 12 main categories listed below in order of popularity (numbers in parentheses indicate the percentage of subjects citing their use):

- *Notes and post-its* (65.1%): pieces of paper (with or without adhesive) upon which one or two actions are jotted down and either carried around or else attached to walls, doors, or pin boards in a readily visible location.
- *Diaries* (57.3%): including filofaxes, notebooks, or any single volume that could be carried around and in which items to be remembered are written down in some relatively organised fashion.
- *Lists* (55.5%): pieces of paper on which items to be remembered for that day are written down and checked off when done. These lists are either carried around or displayed in some prominent position.
- *Writing on hand* (43.8%): an item to be remembered is written on the hand with a ballpoint pen.
- *Object positioning* (41.8%): this entails locating objects requiring action in a prominent position within the person's living space. Sometimes they are deliberately placed where they might block an exit unless they are moved (a forcing function).
- *Getting others to remind them* (34.9%): friends or relatives are asked to remind the individual to do something.
- *Calendars and timetables* (31.5%): these are markings upon displayed charts organised by time.
- *Mental checking* (8.2%): this entails a routine that takes place either before sleeping or on waking in which the person runs through a mental list of the day's tasks.

Table 3 Universal criteria for good reminders—the five 'Cs'

Conspicuous	A good reminder must be able to catch the actor's attention at the critical time
Contiguous	A good reminder should be positioned as close as possible in time and space to the location of the necessary action
Context	A good reminder should provide information about the "when" and "where" of the item to be remembered
Content	A good reminder should provide sufficient information regarding what has to be done
Count	A good reminder should allow the actor to count off the number of discrete actions/tasks that need to be done

Table 4 Secondary criteria for good reminders

Comprehensive	A good reminder should be able to work effectively for a wide range of acts to be remembered acts
Compel	A good reminder should (when warranted or possible) compel the actor to perform a necessary task/act by blocking further progress until the act has been completed
Confirm	A good reminder should help the actor to check that the intended acts have been carried out as planned (i.e. it must continue to exist in a useful fashion after the time for action has passed)
Convenient	A good reminder should not cause unwanted or additional problems, particularly if these turn out to be worse than the omission
Conclude	A good reminder should be readily removable once the time for action and checking has passed

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- *Mental rehearsal* (6.8%): this involves the individual saying over and over to herself the action that has to be done. This was an exclusively female strategy in this sample.
- *Forming associations* (6.2%): this approximates to the method of loci in which the person links items to be remembered to images of familiar places or objects.
- *Visualising* (4.1%): the person simply visualises the performance of some act to be remembered.
- *Clocks and watch alarms* (3.4%): this involves setting an alarm clock or watch alarm to ring at the time when some action item has to be performed.

Although women far outnumbered men in this sample, there were a number of significant sex differences. On average, men listed only 3.4 strategies compared with 4.3 strategies by women ($p<0.01$). Women cited the use of diaries, lists, and mental rehearsal significantly more often than men ($p<0.01$). There were no significant sex differences in either self-rated memory ability or in the mean rated effectiveness of their employment of these various strategies.

HOW WELL DID THE STRATEGIES SATISFY THE "GOOD REMINDER" CRITERIA?

In a further study[6] 10 academic psychologists were presented with a list of the 12 main memory aid strategies and asked to rate how well each one satisfied the five universal criteria for a good reminder (table 4). They were required to use one of three ratings for each judgement: 0 = the strategy does not satisfy the criterion at all (or hardly at all); 1 = the strategy partially satisfies the criterion, at least under some circumstances; 2 = the strategy satisfies the criterion completely, or nearly completely. The results are summarised in table 5.

The Spearman's rank order correlation coefficient between percentage usage and mean criterion rating was 0.95 ($p<0.01$). This close correspondence confers a convincing degree of ecological validity upon the five universal criteria. Had criteria satisfaction not correlated highly with the relative popularity of strategy usage, there would have been little or no grounds for claiming that these characteristics were necessary features of good reminders. It seems reasonable to assume that people would not persist with these strategies if they failed to reduce the likelihood of everyday omissions. It must be noted, however, that undergraduates report relatively higher rates of omission slips and lapses than other groups.[2] We must conclude from this that the use of memory aid strategies does not guarantee the performance of all intended or necessary actions. However, we can only guess at how much worse they would be if they used no strategies at all.

Table 5 Comparison of mean criterion ratings with percentage usage of strategies to indicate how well each memory aid strategy satisfied the universal criteria for a good reminder

Strategy	Usage (%)	Mean criterion rating*
Notes and post-its	65.1	1.68
Diaries	57.3	1.46
Lists	55.5	1.48
Writing on hand	43.8	1.46
Object positioning	41.8	1.26
Ask others to remind	34.9	1.08
Calendars, timetables	31.5	1.28
Mental checking	8.2	0.92
Mental rehearsal	6.8	0.82
Forming associations	6.2	0.52
Visualising	4.1	0.72
Clocks and watch alarms	3.4	0.68

*The higher the value, the more closely the strategy satisfies the criteria.

Box 1 A hierarchical task analysis of the steps involved in copying a document on a simple desk photocopier

1. Prepare photocopier
   - 1.1. Switch on
   - 1.2. Wait for warm-up cycle to be completed
2. Select desired number of copies
3. Prepare first page of original for copying
   - 3.1. Raise lid
   - 3.2. Locate page in appropriate position on the glass
   - 3.3. Close lid
4. Activate copying cycle
   - 4.1. Press start switch
   - 4.2. Ensure that the original does not move
5. Check quality of photocopy
   - 5.1. If OK, go to step 6
   - 5.2. If not OK, select appropriate corrective action
   - 5.2.1. Put in more copy paper
   - 5.2.2. Remove paper jam
   - 5.2.3. Readjust position of original
   - 5.2.4. Adjust toner setting
6. Remove copied original and replace with next page
   - 6.1. Raise lid
   - 6.2. Remove copied original
   - 6.3. Replace with next page to be copied
   - 6.4. Close lid
7. Repeat steps 4–6 until all pages are copied
8. Remove last page of the original
9. Check that all pages have been copied satisfactorily
10. Switch off photocopier
11. Gather up all materials and depart

SUMMARISING THE MAIN STEPS IN MANAGING OMISSIONS

We began by identifying omissions as a suitable case for treatment. Not only can they arise from failures at many cognitive stages, they have also been shown to constitute the largest class of human performance problems in various hazardous operations, particularly aviation and nuclear power generation.[11 12] They are especially evident in maintenance related activities—hands on, complex, time pressured tasks that have much in common with a wide range of healthcare procedures.

While it is not always possible to identify which mental process failed in omitting a necessary step from a task, we can predict with some confidence which task elements are most likely to provoke such omissions. It has also been shown—using the photocopier example—that the likelihood of an omission is related to the number of omission provoking features associated with a particular task step. The more features present, the more probable the omission. How can we apply these observations in a healthcare context? There are three distinct stages: (1) task analysis, (2) assessing omission likelihood, and (3) choosing and attaching a reminder.

Task analysis

In order to identify these steps in advance it is necessary to carry out a task analysis—a process that decomposes an activity or procedure into a meaningful number of discrete steps. This is not particularly difficult but it can be labour intensive (an example of a hierarchical task analysis for the simple photocopier is shown in box 1). It is therefore necessary to be selective in choosing the procedures for omission management. The most obvious basis for selection is safety criticality. Would the omission of particular steps in the task have an injurious effect upon the patient? Should the consequences of such omissions be especially dangerous, this alone would warrant the use of suitable reminders—that is, skipping to

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stage 3 directly. If this were the case, then it is possible that useful data exist in the system's incident recording system. It may also be the case that the task already has a written stepwise protocol that would remove the need for task analysis.

Assessing omission likelihood

Because omission provoking features are not always intuitively obvious, it is necessary to review each task step for its omission affordances. A useful tool in this regard is a grid on A3 paper. Each task step could be briefly described on a row, and each of the eight omission provoking features (listed earlier) could occupy a column. The analyst could then mark the columns in which an omission provoking characteristic exists for each task step. At the end of this exercise it is easy to identify the most omission prone steps by summing the ticked features across the columns. Any step that possesses two or more features is a candidate for a reminder, although such judgements should also take into account both the safety criticality of the step and the ease or difficulty with which its omission could be detected before the task is complete. Again it pays to be selective since a great many reminders dotted around the task space are likely to be counterproductive.

Choosing and attaching a reminder

Experience in other domains indicates that those intimately engaged in the task are often the best people to design and apply a reminder. The study described above suggests that post-its or tie-on labels possess most of the characteristics of a good reminder. It must be recognised that all reminders have limits to their utility. Sooner or later they are likely to merge into the background. Reminders need to be renewed regularly and should be designed from the outset with that in mind.

CONCLUSIONS

The omission management programme described here addresses both aspects of error management—reduction and containment. The appropriate and sparing use of good reminders will achieve some reduction of safety critical errors. Understanding the omission affording features of a task will enhance the likelihood of error detection even when omissions still occur, since an expected slip is more likely to be spotted and corrected. Neither process, however, will be wholly successful. There is no single "magic bullet" solution for omissions. An essential prerequisite for effective safety management is the expectation that errors will always occur. Chronic unease along with continuous vigilance and adjustment are still the main weapons in the error management armoury.

Finally, think *kaizen*. *Kaizen* is a Japanese word meaning small continuing improvements achieved through a process of close monitoring and refinement. Error management is not like some electronic gadget that can be plugged in, switched on, and left to run on its own. Like religion—in which there are many prayers but few miracles—the process of managing error is as important as the product. Error will never be eliminated, but we can hope to improve the conditions under which people work so as to eliminate the more dangerous affordances for error and to increase their chances of detecting and recovering those errors that will inevitably still occur.

Key messages

- To set up an omission reduction programme, tasks and activities in which omissions are likely to have injurious consequences or which have a history of previous omissions should be identified.
- The task or activity should be broken down into a meaningful sequence of discrete steps using a task analysis technique similar to that shown in box 1.
- For each step the degree to which it possesses one or more of the omission affording characteristics listed in the text should be assessed.
- A customised reminder should be considered if any or more of the following features are present for that step: (a) two or more omission affording characteristics; (b) it is especially safety critical; (c) a history of previous omissions; and (d) omission of the step would be hard to detect later.
- A reminder that satisfies as many as possible of the universal criteria listed in table 3 should be designed.
- Reminders need regular renewal.

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