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A Review of the Effects of Colds and Influenza on Human Performance*

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Summary
Results from our research on the effects of colds and influenza on performance have led to the following conclusions. First, these illnesses have significant effects on performance efficiency, although the nature of the impairment depends on the type of virus and the task being performed. For instance, influenza slows reactions to stimuli appearing at irregular intervals, or in unknown locations, whereas colds impair hand-eye co-ordination. Performance impairments have also been found with sub-clinicial infections, during the incubation period of the illness, and after the symptoms have gone. These results have important implications for occupational safety and efficiency.

Introduction

There has been little research on the effects of illness on performance efficiency and safety. This is partly because many illnesses are so severe that the person can no longer continue to work and, therefore, the problem of reduced efficiency and safety does not arise. However, some illnesses, such as the common cold, often do not prevent people from working. It is, therefore, important to examine whether such illnesses impair performance efficiency.

Many people believe that when you are ill everything is performed less efficiently than usual. Others suggest that illnesses like the common cold are too slight or transitory to produce any significant effect on performance. Yet another possibility is that the change in performance will depend on the clinical pattern of the illness, which means that an illness which produces systemic effects (e.g. influenza) will have a different effect to one where the symptoms are largely local (e.g. an increase in nasal secretion, as is observed with the common cold).

Despite the frequency with which respiratory virus illnesses occur there has been no research on their effects on the efficiency of performance. This has largely been due to the difficulties involved in carrying out such studies. Naturally occurring colds and influenza are difficult to predict, and it is often unclear which virus produced the illness (there are over 200 viruses that produce colds). The study of such illnesses only enables one to examine effects when clinical symptoms are observable. It is possible that sub-clinical infections may also influence behaviour and these can only be identified by using the appropriate virological techniques.

These problems were overcome here by examining the effects of experimentally induced colds and influenza at the MRC Common Cold Unit, Salisbury, England. The methodology employed here overcomes the above problems and the main features of the Unit's procedure are described below.

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The procedures of the MRC Common Cold Unit, Salisbury

1. The volunteers are screened during the application period to exclude pregnant women and those with chronic illness.
2. At the onset of the trial all volunteers have a medical examination and chest X-ray. Any who fail these are excluded from the trial.
3. Volunteers stay there for a period of 10 days, being housed in groups of two or three and isolated from outside contacts.
4. There is a quarantine period of 3 days prior to virus challenge. Any volunteers who develop colds in this period are excluded from the trial.
5. Every volunteer is assessed daily by the unit's clinician who assigns a score based on objective measures such as temperature and number of tissues used, and on the presence of other symptoms (see Beare and Reed, 1977, for full details of the scoring system).
6. Nasal washings are taken so that virus shedding can be measured. Pre- and post-challenge antibody status can be measured from blood samples taken at these times.
7. All procedures of the Common Cold Unit are approved by the Northwick Park Ethical Committee and carried out with the informed consent of the volunteers.

Assessment of performance

The data described in this article were collected during clinical trials which had other specific aims. This imposed certain limitations on the type of task that could be used. Portable tests had to be used because the volunteers were in isolation and could only be tested in their flats. Two main methods have been used, the first consisting of paper and pencil tests and the second involving automated performance assessment.

Paper and pencil tests

In these experiments the volunteers carried out paper and pencil tests 4 times a day (at 08.00, 12.00, 17.00 and 22.00 h) on all the days of the trial. It was important to examine performance at several times of day for two reasons. First, it has been shown that performance varies over the day (see Colquhoun, 1971). There is also diurnal variation in the severity of symptoms of colds and influenza (see Smith et al., 1988c), with increases in nasal secretion and temperature being greatest in the early morning.

Performance tests were selected which have been used in studies of other occupational health hazards (e.g. noise and nightwork). The following tests were used.

A logical reasoning test

The subject was shown 32 sentences describing the order of the letters A and B, each sentence being followed by the letters AB or BA. The subject had to read the sentence, look at the pair of letters, and then decide whether the sentence was a true or false description of the order of the letters. For example, the sentence 'A follows B' BA requires a 'true' response, whereas 'A follows B' AB requires a false one. The sentences ranged in syntactic complexity from simple, active (e.g. A follows B) to passive, negative (e.g. A is not followed by B). The time taken to complete the 32 sentences was recorded, as was the accuracy of responding.

Visual search tasks with varying memory loads

The low-memory load search task involved searching through 24 lines of 60 single spaced capital letters looking for the occurrence of a target letter defined at the beginning of each line. There were 0–3 targets per line and the subjects had to complete a 24 line block. Subjects were instructed to scan each line in a left to right direction and to cross out any targets they detected. They were told to search each line only once and not to re-check any lines. The time taken to complete the test and the number of targets detected was recorded.

In the high memory load version of the test the subjects had to search for the presence of any of the five target letters defined at the start of the line. The time taken to complete a 12 line block and the number of targets detected were recorded.

Semantic processing test

This test measures the speed of retrieval of information from general knowledge. Subjects were given a list of 50 statements (e.g. a canary has wings, or dogs can fly) and had to decide whether each one was true or false. The time taken to complete the test was recorded.

The pegboard test

A portable test of manual dexterity and movement time was included in the paper and pencil battery. The subject had to transfer pegs as quickly as possible from one pocket solitaire set to another using the dominant hand. Each peg had to be placed in the corresponding position in the empty set. The time to complete the task was recorded.

The subjects carried out these tests on every day of the trial. The scores obtained prior to virus challenge were used as covariates in analyses of covariance with the scores in the incubation period and days when symptoms were present being the dependent variables. This statistical technique takes account of baseline differences when assessing the effects of the illness. On average about one-third of the volunteers challenged with the virus develop significant clinical symptoms (the significance of the illness being assessed by the unit's clinician), another third have no significant symptoms but are infected with the virus (as shown by virus shedding and/or changes in antibody level), and the remaining group are uninfected (the virus cannot be detected in the body).

Results from studies using the paper and pencil tasks

These experiments are reported in detail in Smith et al. (1988a), and the reader is referred to this paper for details of the trials, subject characteristics, levels of statistical significance, etc. The main results may be briefly summarized as follows.

Influenza B illnesses impaired performance on a visual search task but had no effect on a test of manual dexterity. The impaired performance on the search task was observed in the incubation period prior to the onset of clinical symptoms, and also in volunteers with sub-clinical infections. These effects are shown in *Fig.* 1.

Volunteers who developed colds following challenge with respiratory syncytial virus were impaired on the motor task but not the search task. In contrast to influenza, the effects of colds were restricted to volunteers who had significant clinical symptoms and were only observed when symptoms were apparent. This is shown in *Fig.* 2.

Neither influenza nor colds impaired the speed or accuracy of logical reasoning or semantic processing.

Automated performance testing

The second method of assessing the effects of respiratory illnesses on performance efficiency used computerized performance tasks, with the volunteers being tested once

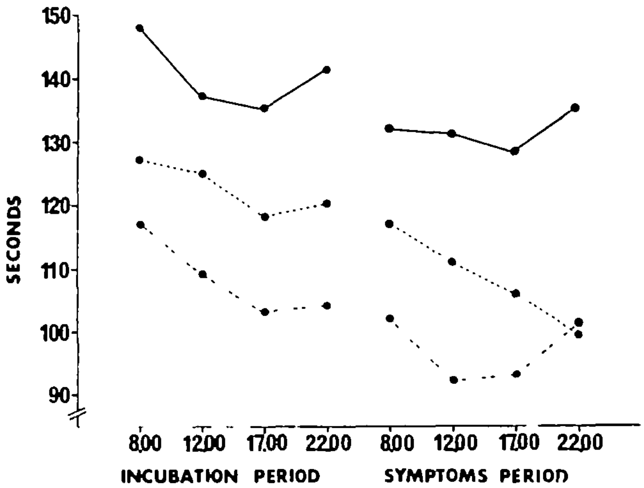

Fig. 1. Effects of influenza on the speed of performing the search and memory task at four times of day (after Smith et al., 1988a). (——, clinical illness; -----, sub-clinical illness; – – –, uninfected)

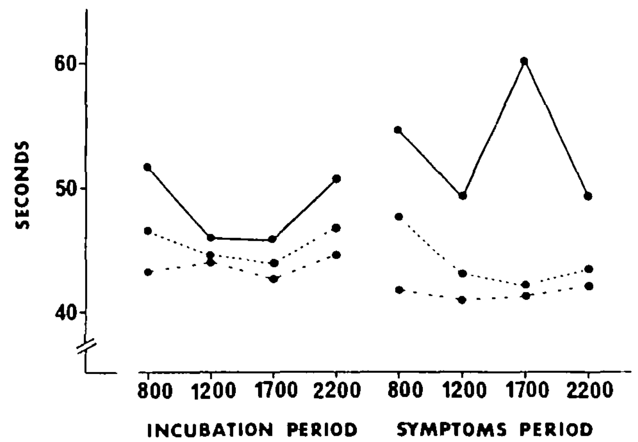

Fig. 2. Effects of colds on the speed of performing the pegboard task at four times of day (after Smith et al., 1988a). (——, clinical illness; -----, sub-clinical illness; – – –, uninfected) during the pre-challenge period, once when symptoms were apparent in some volunteers, and in some trials during the incubation period. Subjects were always tested at the same time of day on all occasions (although some were tested in the morning and some in the afternoon, which meant that diurnal variation in the effects of the illnesses could be examined). These computerized tests have all been widely used to study the effects of stressors and drugs, and they were selected to assess a range of functions such as attention, memory and motor skills.

Smith et al. (1987b) confirmed that colds and influenza have selective effects on performance. In one task (the variable fore-period simple reaction time task) subjects heard a warning tone and a black spot appeared on the screen at varying intervals after this tone. The subjects had to press a key as soon as the spot was detected. The reaction times of those with influenza were much slower than those of uninfected volunteers. The effects of having influenza on performance of the variable fore-period simple reaction time task are shown in *Table I*.

In another task a black spot moved in a square pattern around the screen. Also on the screen was a cross which the subject could move by means of a joystick. The aim of the experiment was to keep the cross in contact with the square. Influenza had no significant effect on performance of this type of task. In contrast to this, colds impaired tracking but had no effect on the variable fore-period reaction time task. The effects of having a cold on the tracking tasks are shown in *Table II*.

Our studies show that there are real effects of these illnesses, but that the functions affected depend on the nature of the illness and type of task being carried out. Many types of behaviour, such as driving a car, involve both attentional and motor skills, which suggests that such activities will be vulnerable to the effects of both colds and influenza. The size of the effects of these illnesses on performance should also be noted. Volunteers with influenza showed a 57 per cent impairment compared with their baseline level. This is a very large effect compared with other factors known to reduce performance (e.g. alcohol usually impairs such tasks by about 5–10 per cent, and working at night impairs performance of the variable fore-period simple reaction time task by 5 per cent, Smith and Miles, 1985).

Table I. Mean reaction times (in ms) in the variable fore-period simple reaction time task for volunteers who developed influenza and those who remained uninfected (low scores = good performance) (after Smith et al., 1987b)

	Influenza (n = 3)	*Uninfected (n = 7)*
Pre-virus challenge	320	348
Post-challenge (when symptoms apparent)	503	325

Table II. Mean scores (number of contacts) on the pursuit tracking task for subjects with colds and those who remained uninfected (high scores = good performance) (after Smith et al., 1987b)

	Colds	*Uninfected*
Pre-challenge	13·8	13·3
Post-challenge (symptoms apparent)	12·6	21·5

Other experiments used the five-choice serial reaction time task. The subject was shown five boxes in a row across the middle of the computer screen. A black square appeared in one of the boxes and the subject had to press the key on the keyboard which corresponded to the box number. As soon as the subject responded another square appeared and the subject had to make another response. This task is meant to mimic the serial self-paced tasks which are found in certain jobs.

Results from studies using this task have confirmed that activities involving movement of the hands are impaired by colds (Smith et al., 1987a). In one experiment volunteers who developed colds following challenge with a coronavirus were significantly slower than uninfected volunteers. This result has been replicated in a study using respiratory syncytial viruses, and here the impairment was also found in the incubation period and in volunteers with sub-clinical infections.

Another experiment (Smith et al., 1989) has examined performance on choice reaction time tasks after the clinical symptoms have gone. The results showed that volunteers who developed a cold were significantly slower on choice reaction time tasks than those with no illness, and this effect was still apparent a week after the clinical symptoms have gone. After-effects of real-life influenza illnesses have also been observed in workers carrying out a range of activities (Grant, 1972).

Mechanisms underlying the effects of respiratory virus infections on performance

One must now ask what mechanisms are responsible for the behavioural effects of these respiratory illnesses. It has been suggested that the deficits produced by influenza reflect the systemic effects of the illness. It is known that interferon is endogenously produced following infection with influenza viruses, and that interferon produces systemic effects which could be responsible for the attentional deficits. If this is the case, then similar impairments should occur when volunteers are given an injection of interferon but no virus challenge. Preliminary studies have provided support for this view (Smith et al., 1988b).

It is harder to explain the effects of colds on performance. One possibility is that some other lymphokine, such as interleukin 1 or 2 is responsible. Indeed, there is evidence that interleukin 1 not only influences the hypothalamus but has a direct effect on skeletal muscle. This could explain the slower reaction times when the person has a cold. Alternatively, the impairments could reflect changes in sensory stimulation via the trigeminal nerves in the nose.

Recent results

The results from other experiments are as yet not published but may be summarized as follows.

Drugs, colds and performance

Many trials at the Common Cold Unit are designed to assess prophylactic and therapeutic drugs. It is of major interest, therefore, to examine whether these not only reduce clinical symptoms but also remove performance impairments. One compound which has been shown to reduce the severity of colds is zinc. A recent trial at the Common Cold Unit confirmed the therapeutic efficacy of zinc gluconate in a carefully controlled trial, and showed that volunteers with a cold who were given a placebo were slower than healthy subjects on a choice reaction time task. However, those who began to develop colds and were given the zinc showed comparable levels of performance to the healthy subjects. Unfortunately, it is unclear how zinc produces this beneficial effect, so this study does not help us understand which mechanisms underlie the effect of colds on performance.

Effects of colds on cognitive performance

Most of the early studies used simple psycho-motor tasks. In recent trials we have examined the effects of colds on memory and cognition. Many aspects of memory (e.g. the ability to recall a list of words, or a string of digits) are unaffected by colds. However, colds do seem to impair the learning and recall of more complex material (e.g. stories), although recall of material learned before the illness is not reduced. Indeed, reminiscence, the ability to recall subsequently information which the person could not recall immediately after learning, may actually be enhanced when the person has a cold.

Prediction of susceptibility to illness

We have shown that performance impairments may be observed in the incubation period before symptoms develop. Results from other trials have shown that volunteers who subsequently develop colds have worse levels of performance prior to virus challenge than those who remain symptom free. In other words, measures of performance may be used to predict vulnerability to illness.

Conclusions

Overall, our research programme has shown that minor illnesses do have significant effects on performance efficiency. The exact effect depends on the task being performed and the type of virus. Viral infection, unaccompanied by clinical symptoms, can also impair performances although these effects again depend on the virus and the nature of the task. These results have strong implications for occupational safety and efficiency, and suggest that detailed studies of the impact of these illnesses in real-life should now be carried out. We also usually consider the effects of occupational hazards on the performance of healthy individuals. It is possible that having a respiratory illness not only has a direct effect on performance but may make the person more vulnerable to the deleterious effects of other stressors, such as noise and nightwork. This issue also requires investigation.

Acknowledgements

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