

In another calculation Brillouin derives a formula for the transmission of information in the presence of thermal noise². He uses the negentropy assumption twice: first, to give the proper appearance of order where information is concerned; second, to convert information into physical terms. This double use of the assumption restores the correct sign to the result. By using entropy instead of negentropy, the same result is reached in fewer steps. The revised argument is as follows.

It is required to find the capacity C of the channel/unit of time in the presence of thermal noise at temperature T . (T is assumed constant, hence the result is a simplified approximation for C .)

The noise power at temperature T within the bandwidth W is given by $P_n = kTW$. The signal has power P and duration τ , and thus has energy $P\tau$. As the cable is at temperature T , the increase in entropy when the signal is introduced is given by $\Delta S = P\tau/T$. It follows that $\Delta S = kW P\tau/P_n$. (In Brillouin's argument the signal is introduced as information, hence negentropy; this is converted to entropy as the energy of the signal is dissipated to heat.)

The entropy ΔS (Brillouin uses negentropy) represents information flowing at the rate of $\Delta S/\tau$ units per s, and hence the channel capacity per s is $C = \Delta S/\tau = kW P/P_n$, which is the required result.

In these two examples, the correct conclusions have been reached, but the simplicity of the argument has been obscured by the use of the negentropy assumption. We should reject that assumption and assume simply that Brillouin's bound information is to be identified with entropy.

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¹ Woolhouse, H. W., *Nature*, **216**, 200 (1967).

² Brillouin, L., *Science and Information Theory*, second ed. (Academic Press, New York, 1962).

Absence and Attendance under Non-continuous Three-shift Systems of Work

INDUSTRIAL interest in the use of multiple shifts has been growing in recent years, but little is known about the effects of different shifts and shift systems on work performance. This communication discusses variations in attendance at work under a 5 day, three shift system. The investigation is part of a wider attempt to examine behavioural differences under various arrangements of working hours.

The factory was a metal-working unit in the north-east. It was continuously manned over fifteen shifts a week from 0800 h on Monday to 0800 h on Saturday. Each 24 h period was divided into three 8 h turns of duty—0800 h to 1600 h, 1600 h to 2400 h, 2400 h to 0800 h—and the men changed shifts weekly in this sequence. A basic working week of 37½ h (allowing for a lunch break of half an hour) was paid for at the rate of 44 h on day and evening shifts, and 48 h on night shift. The work, involving high volume production of a single product, was constant throughout.

The absence and attendance records of 206 hourly paid male operatives were examined for 1966, and 265 for 1967. Only men who had remained with the same shift team throughout these periods, and had thus adhered to the same sequence of shifts, were included. Discounting holiday periods, fifteen complete shift cycles were covered for each man in each year. The amount of lost shifts on the different shift periods is summarized in Table 1.

Table 1. LOST SHIFTS 1966 AND 1967

	1962	Days	Evenings	Nights
Certified sickness absence	554 (31%)	587 (32%)	664 (37%)	
"Other reasons" absence	114 (23%)	170 (35%)	209 (42%)	
Single-shift "other reasons" absence	90 (28%)	105 (32%)	181 (40%)	
	1967	Days	Evenings	Nights
Certified sickness absence	746 (32%)	764 (33%)	808 (35%)	
"Other reasons" absence	113 (24%)	173 (37%)	184 (39%)	
Single-shift "other reasons" absence	83 (25%)	118 (35%)	136 (40%)	

In both years there is a tendency for most absence to occur on the night shift and least on the day shift, with evening shift absence occupying an intermediate position. As would be expected, this trend is least marked in the case of certified sickness absence. There is no reason why genuine illness or injury which prevents a man from attending work should occur on one shift rather than another.

In the case of absence for reasons other than certified sickness (consisting chiefly of single shift absence without permission) a greater element of personal choice is presumably involved, and, in consequence, liking for or antipathy towards particular shift periods becomes more clearly shown in the variable amounts of absence taken on days, evenings and nights.

Permitted absence is taken at this factory largely in the form of single, additional "rest days" (for which men qualify with increasing length of service). Preference for daytime work is confirmed by the much greater extent to which such rest days are taken on the evening and night shifts (Table 2).

Table 2. SHIFTS TAKEN AS REST DAYS

	Days	Evenings	Nights
1966	74 (13%)	228 (42%)	247 (45%)
1967	140 (16%)	385 (43%)	360 (41%)

An interesting feature of these results is that they differ from previous findings. In the steel industry, under both a seventeen and a twenty-one shift cycle, Shepherd and Walker¹ found that three-quarters of single shift absence without permission occurred on the day shift (0600 h–1400 h). They attributed this to the early morning start. Single shift absence with permission was distributed more evenly over the morning, afternoon and night shifts.

In the present case, the payment of a differential of four hours may be thought of as an incentive to maintain attendance on the night shift. But this effect is outweighed by the greater opportunities for overtime on the day shift and to a lesser extent on evenings. These unequal opportunities are reflected in the annual amounts of overtime hours worked by the men in these two samples (Table 3).

Table 3. OVERTIME HOURS WORKED ON DAY, EVENING AND NIGHT SHIFTS

	Days	Evenings	Nights
1966	21,972 (43%)	19,407 (38%)	9,920 (19%)
1967	32,780 (44%)	26,947 (37%)	14,140 (19%)

On this evidence it is impossible to determine the extent to which better day shift attendance is due to the attractions of overtime, and how far it results from a dislike for work during night-time hours. To examine the question further, this investigation is being pursued in a second factory working on a three shift, 5 day basis, where little or no overtime was available during the period in question, and where a common allowance of 20 per cent was paid on all three shifts. In such circumstances, it is argued, any differences in time lost between the three shift periods will be attributable directly to varying degrees of preference for day, evening and night work.

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¹ Shepherd, R. D., and Walker, J., *Occupational Psychology*, **30**, 2 (1956).