was then characterized by a K concentration of 128 mmole per liter of cell water. During the incubation at 37°C, the cells took up K so that, at the end of a 15-minute period, the K concentration had risen to 212 mmole per liter of cell water, which approximates the K concentration in the unwashed harvested H^- cells. On the other hand, the initial K concentration in $H^-M^-\Phi^-_K$ had fallen to 60 mmole per liter of cell water, the lower value presumably arising because the mutant cell was unable to maintain its K concentration during the washing and centrifugation. In this case the cells lost so much K during incubation that no K could be detected in the cell by our analytical methods after 15 minutes at 37°C. Thus, it appears that $H^-M^-\Phi^-_K$ is unable to maintain the high K concentration ratios which can be attained by the parent strain.

It therefore appears that $H^-M^-\Phi^-_K$ is defective in its ability to concentrate K as well as in ability to synthesize methionine. In order to see whether these are expressions of a single defect, experiments were carried out on revertant clones. Thirteen such clones, selected at random from plate cultures on low-K medium which contained the 18 amino acids, were streaked on low-K medium plates, which lacked all amino acids but histidine. All 13 transport revertants had simultaneously reverted their biosynthetic defect since they grew well on these plates. Similarly four clones selected for reversion from their amino acid requirement were also transport revertants since they grew well on low-K medium supplemented with histidine. One amino acid revertant was isolated which retained its transport defect and would not grow on the low-K medium.

We also considered that all methionine-requiring auxotrophs might have defects in their K-transport system or that K might be necessary for methionine transport. Neither appeared to be the case. Several methionine-requiring auxotrophs of *E. coli* B (*9*) were investigated, including one that can grow in the presence of homocysteine but not cystathionine. All were able to grow on low-K medium, indicating that their methionine defects were unrelated to a K requirement.

In sum, we have observed a mutant with defective K transport and a methionine requirement. Although the possibility that we are dealing with two genetic defects has not been ruled out by our experiments, the indication is strong that only one genetic event is involved in the observed mutant and its revertants. If this is indeed the case, we would expect K transport in this organism to be metabolically related to methionine biosynthesis.

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Auditory Flutter-Driving of Visual Flicker

Abstract. *Changes in the physical flutter rate of a clicking sound induce simultaneous changes in the apparent flicker rate of a flashing light. For example, for one observer a flicker with a frequency of 10 cycles per second was driven downward to as low as 7 cycles per second and upward to as high as 22 cycles per second by changing the rate of initially synchronous auditory clicks. The reverse does not occur—changes in the flicker rate do not induce changes in apparent flutter rates.*

The sense of the lateral position of objects is mediated largely by vision. Moreover, sounds will be sensed as originating from the most reasonable visible sources perceived to be acting in synchrony with the sounds. The ear, on the other hand, is an organ of eminently superior temporal resolution. A healthy young ear has a critical flutter frequency (the frequency at which a clicking sound appears steady) which is much greater than the critical flicker frequency (the frequency at which a flashing light appears steady) of an eye in the same head. Thus it seemed reasonable to try to obtain an index of the perceived rate of visual flicker by asking the subject to match this to a perceived rate of auditory flutter.

Up to the present time, the critical flicker frequency is the only aspect of visual temporal resolution that has been studied in detail, primarily because phenomenal flicker rates are very difficult to measure.

Unfortunately, such flicker rates are not satisfactorily measured by rates of flutter either. The interesting intersensory fact, first noted by Gebhard and Mowbray, is that the flutter appears to "drive" the flicker (*1*). Suppose that a whitish light is set to flicker at 5 cy/sec and a whitish sound (approximately but not necessarily of the same waveform) is set to flutter (approximately but not necessarily in phase) at exactly the same rate. Then the flutter rate is gradually turned up or down in frequency. The perceived flutter rate will, of course, go up or down accordingly; but quite unexpectedly, so also will the apparent flicker rate. The reverse does not occur—we can drive the flicker by the flutter but we cannot drive the flutter by the flicker. Since this driving is compelling, auditory flutter rates cannot be used to measure visual flicker rates. On the other hand, though flicker rate changes do not drive the flutter frequencies, they nevertheless cannot be used to measure subjective flutter rates because, in the presence of a fixed flutter rate, the change of flicker rate is quite simply not seen. The flicker stays put, locked in apparent synchrony with the flutter.

An experiment was therefore conducted to determine, first, over what flicker-flutter ranges driving takes place, and, second, how far up and down a change in flutter can drive an initially synchronous flicker. The parallel dimensions of brightness—loudness, color—pitch, binocularity—binaurality, laterality—contralaterality, waveform, phase, on-off ratio, and modulation depth can be examined only after the basic phenomenon itself is described.

The effect of sound on the critical flicker frequency has been studied

(*1–3*), but the results are in general controversial: sometimes sound seems to increase the critical flicker frequency (especially if it flutters in phase with the flicker) and sometimes it seems to decrease the critical flicker frequency. This controversy has occurred, perhaps, because too much was attempted without proper control, or definition, of the numerous parameters involved. In any case, Maier *et al.* (*2*) conclude that the effects so far shown are very small; typically, a 2 to 4 percent change in critical flicker rates may be caused by sound, and never more than a 10 percent change.

The flutter driving effect, however, is of much greater magnitude (though quantitative measurements have not previously been reported).

The flicker source used was the Xenon lamp of the Grass model PS-2, reflected to the eye from a white cardboard surface. This has a blue-white color and a peaked wave of about 10 μsec duration. The room was otherwise dark, so that the modulation depth was effectively 100 percent. The screen was viewed from a distance of about 37 cm. The pupil of the eye was dilated with a 1 percent solution of mydriacyl (thus eliminating possible effects due to fluctuating pupil size), and viewing took place through a circular 5-mm artificial pupil placed as close to the natural pupil as comfortable, approximately 11 mm from the cornea. Thus the visual stimulus subtended 25 degrees of visual angle. The head was held by a chin rest. The steady-state luminance of the screen, measured with a Macbeth illuminometer, was 20.8 candles per square meter. The right eye was employed; the left eye was patched. (The critical flicker frequency was approximately 50 cy/sec under these conditions.)

The flutter source used was the discharge click obtained from a General Radio Strobotac, No. 1531A. This had a high-pitched tone and was unfortunately of much longer duration than the flash (*4*). The room was otherwise quiet, though definitely not anechoic, so that the modulation depth was only approximately 100 percent. The click was led into the right ear by means of a radio ear plug. The left ear was shielded. Only ipsilateral interaction (right eye and right ear) was studied. The sound pressure level was 69 db (ref. 0.0002 μbar) as measured on the C-scale of the Bruel and Kjaer No. 2203 precision sound pressure meter.

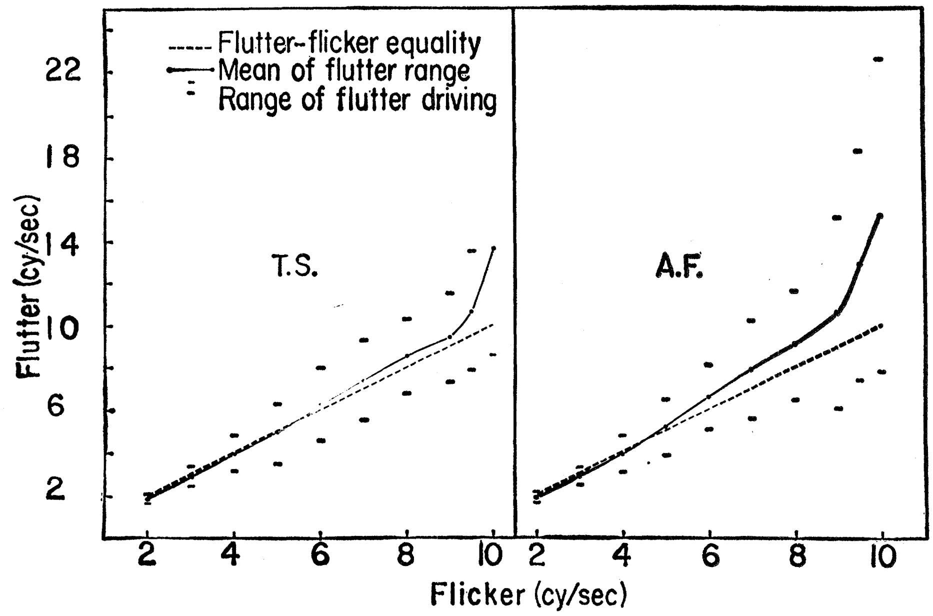

Fig. 1. The magnitude of auditory flutter-driving of visual flicker for two subjects, T.S. and A.F.

Most of this energy was confined to the 31.5 octave band. (The critical flutter frequency was approximately 100 cy/sec under these conditions.)

The experimenter set the flicker and flutter rates at the same random but predetermined frequency. The subject then turned the rate of flutter up or down very slowly (never changing direction) until the apparent synchrony disappeared. The experience can be described as follows: the light and sound were initially pulsating strongly together; as the flutter frequency changed, the apparent flicker frequency followed right along with it until some point was reached where an apparent asychrony intruded. It was seldom clear, except at the very low frequencies, which sensation, sight or sound, was going faster and which slower, but the rather sudden asynchrony was fairly definite. This point was taken as the limit of the driving range.

The results for two observers are presented in Fig. 1. The dotted line represents the line of physical equality. The solid line connects the midpoints of the range over which the flutter driving took place. The two horizontal bars, at each flicker rate, indicate the limits of the range of flutter driving. Each bar is a mean of at least five determinations.

The similarity of the curves for the two observers is quite good, suggesting that this technique may have some applicability in neurosensory work where reliable quantitative means for studying intersensory interaction are especially needed. The standard deviations at the higher frequencies, however, revealed partly by the suddenly widened range in the vicinity of 10 cy/sec are very great. Thus, for clinical use, these measurements might best be confined to frequencies of 3 cy/sec or less. Here, the reliability is excellent because the observer perceives the flicker rate clearly and perceives the asynchrony directly in terms of which sensation is leading which. He can actually "count" the two asynchronous events, a skill which he no longer possesses even at 4 cy/sec. It is important to note also that the curves for both observers cross the line of physical equality in the vicinity of 4 cy/sec.

Up to about 10 cy/sec the visual field pulsates somewhat in a unitary and organized fashion. Beyond that point, the field seems to break apart, and each section pulsates at a different and irregular rate. This end point is thus very tenuous, and the variability here is so great that reliable measurements could not be obtained at higher frequencies. Above 4 cy/sec the mean of the flutter range is just slightly higher than the corresponding flicker rate, and the relationship is fairly linear. But at 10 cy/sec the mean moves rather suddenly upwards, suggesting the abrupt participation of additional factors.

Finally, it is apparent that flutter driving upwards covers a wider range than flutter driving downwards. It is for this reason that it generally takes a faster flutter to match a given flicker; this is another way of observing that, except for the very low rates, auditory temporal resolution is better than the corresponding resolution by eye.

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4. The waveform was observed with an oscilloscope and was found to have three peaks and to be highly irregular, though it did not appear to change with frequency. Moreover, its full duration was at least 1 msec, with some trailing ripples. This difference in waveform could not be controlled by the apparatus at our disposal.
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Experimenter Bias in Hypnotist Performance

Abstract. *Eight hypnotist-experimenters administered a standardized suggestibility test to subjects under two separate experimental conditions. The experimenters understood the problem of experimenter bias, knew that they were being checked, and felt that they had treated both groups alike, yet judges were able to tell under which condition the subjects were tested by listening to the performances of the experimenters.*

The study reported here resulted from the finding, during a check of experimenter consistency, of significant bias among experimenters participating in an investigation of the effect of two conditions—hypnotic induction and lack of it—on responses to standardized tests of hypnotic suggestibility. The main study will be reported elsewhere (*1*); it is sufficient to know that the subjects in the experimental group of concern here were individually given one of two parallel versions of Form C of the Stanford Hypnotic Susceptibility Scales (SHSS) (*2*) on two successive days. Eight hypnotist-experimenters participated in the experiment, and no subject was tested by the same experimenter on both days. On the 1st day the subjects were told to imagine that the suggested items were true, and no hypnotic induction was given; on the 2nd day the standard eye-closure induction of the SHSS was given immediately prior to the suggestibility tests. One of the major comparisons to be made was between subjects' scores with and without hypnotic induction, the hypothesis being that the subjects would experience more hypnotic phenomena, and thus score higher, in the induction condition than in the imagination (no induction) condition.

Recent studies of experimenter bias (*3*) and Orne's recent discussions of the importance of implicit demands (*4*) on subject performance indicate that an experimenter may unknowingly influence subjects to perform in accordance with the experimenter's hypotheses. Hence, it seemed necessary to ascertain whether the experimenters were administering the suggestibility tests of the SHSS in the same manner in both conditions, especially in view of the report of one experimenter (C.T.T.) that he found it difficult to speak as "hypnotically" in the imagination condition as in the hypnosis condition (*5*). The problem was discussed with the experimenters (all of whom were graduate students or staff members in psychology, experienced in hypnotic work). They were urged to be as consistent as possible and were informed that practically all experimental sessions would be tape-recorded so that their performances could be judged.

Tape recordings were made with remote recorders, so that the experimenters were not aware of whether or not they were being recorded. After eliminating recordings which were unintelligible because of electrical and mechanical noise, 13 pairs of tapes were secured; in each pair the same experimenter was recorded with one subject in the imagination condition and another subject in the induction condition. The tapes in each pair were presented to the judges in random order. Only the experimenter's voice reading item 1 (hand will lower because it feels heavy) of the SHSS was transferred to the tapes which were to be judged. Item 1 was given immediately following instructions in the imagination condition, and immediately following induction in the hypnosis condition. The voices of the subjects never appeared on these tapes; only the voices of the experimenters reading from a standardized form were heard. Thus any inference as to which condition the subject was under would have to be made from the various paralinguistic features of the recording, such as amplitude, rhythm, pitch, and volume changes.

Seven judges (assistants and staff members of the Laboratory of Human Development) were asked to independently rate which half of each pair was more "hypnotic" in quality. Three of the seven judges (designated *C*, *F*, and *G*) had served as experimenters in the study, although none of the tapes recorded from judge *C* were included because of unintelligibility. All the judges were personally acquainted with all the experimenters.

The results for each judge are presented in Table 1. Probabilities were assessed on the null hypothesis that either half of a pair was equally likely to be judged as the "hypnotic" half. The binomial probabilities that the number of correct judgments would be as high as or higher than that obtained by chance alone were calculated directly from binomial tables (*6*) for each judge's results. As shown in Table 1, three of the judges (*B*, *D*, *E*) scored significantly higher than chance (p = .05), three others (*A*, *C*, *F*) came close to significance (p = .13), and one judge (*G*) scored at chance expectancy.

A judge judging his own performance had no advantage. Judge *F* did no better than five other judges, and judge *G* was the poorest judge of all. It is of interest that judge *G* was the only judge who felt that the study would show negative results.

The combined results for all seven judges are highly significant, according to the method of Jones and Fiske (*7*) (χ^2, 31.602; degrees of freedom, 14; $p < .005$).

The impressions of the judges as to what their judgments were based on are of some interest. They described the voices of the experimenters under the hypnosis condition as being relaxed, somnolent, solicitous, convinced, dramatic, insistent, coaxing, breathy, singsong, deeper, slower, soothing, sibilant, softer, droning, descriptive rather than