Fig. 1 Plot of the logarithm of the reciprocal of the period time (log k_ω) against $1/T$ ($T = 288,298$ and 308 K). The chemical systems containing malonic acid (0.4 M), potassium bromate (0.1 M), sulphuric acid (1 M) and catalyst (0.0005 M). $\bigcirc$, Ce^{3+}; $\times$ Mn^{2+}; $\blacktriangle$, Ru $(dipy)_3^{+2}$.

with the two systems. (In system 1 $k_\omega = 0.053$ and in system 2 $k_\omega = 0.015$ at 25° C.) E_ω—at least within certain concentration ranges—is independent of the composition of the oscillating system the probability of 'bursts', however, is a function of the composition.

Are there any characteristics of the oscillating reactions which manifest themselves when one catalyst is replaced by another? An exhaustive answer cannot be given yet.

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Memory for words

LISTENERS do not ordinarily retain the syntax of a sentence for longer than is necessary to grasp its meaning; they rapidly forget both superficial 'surface structure' and underlying 'deep structure'[1-3]. What they retain is the sense of the sentence, evidently divorced from its syntax. It has been argued that this sense might consist of an associative structure linking representations of the words in the sentence[4]. Yet, if meaning is divorced from syntax, it might also be divorced from words. Indeed, we shall argue that a semantic representation need not incorporate any direct information about the lexical categories of words; it merely appears to do so because they can often be reconstructed from the meaning of a sentence. It follows, of course, that the specific wording of a sentence should ordinarily be

rapidly forgotten[5]. One simple test of this hypothesis, avoiding the predictability of words from meaning, is to examine a person's ability to recollect whether a certain element of meaning was conveyed by a noun or a verb. (Does the reader recollect with any confidence whether, for example, we wrote earlier, "the divorce of meaning from syntax", or "meaning is divorced from syntax"?) We predicted that information about lexical categories would tend to be forgotten if subjects were unaware that their memory for a sentence was to be tested, but that it would tend to be remembered if subjects expected their memory to be tested.

Two independent groups of subjects were told that their task was to make up two sentences continuing the theme of a short spoken passage. The members of the 'memory' group (M) were also told that they would be given a memory test for the passage; the members of the 'incidental' group (I) were given no such instruction. After listening to the tape recorded passage, which described a brief incident in a science-fiction story, both groups were given recognition tests for two of the sentences in the passage.

To test the hypothesis, we obviously had to use sentences whose meanings do not allow the lexical categories of their constituent words to be easily reconstructed. The third sentence of the spoken passage was therefore one of the following items:

(1) The owner of the magic staff dispatched the ship.
(2) The dispatcher of the ship owned the magic staff.
(3) The owner of the ship dispatched the magic staff.
(4) The dispatcher of the magic staff owned the ship.

The first pair of sentences are very similar in meaning—what one presupposes the other asserts—yet they convey their meanings by way of totally dissimilar lexical categories, for example, the information conveyed by the verb 'dispatched' in sentence (1) is conveyed by the noun 'dispatcher' in sentence (2). The second pair of sentences stand in a similar relation to one another, but their meanings are quite different to the meanings of the first pair of sentences: in the first pair it is the ship that is dispatched, in the second pair it is the magic staff that is dispatched. The fifth and final sentence of the spoken passage was selected from the following set of sentences constructed according to the same principles:

(5) On earth, the interrogator of the Martians advised the President.
(6) On earth, the adviser of the President interrogated the Martians.
(7) On earth, the interrogator of the President advised the Martians.
(8) On earth, the adviser of the Martians interrogated the President.

The sense of the remaining sentences in the passage was sufficiently flexible to accommodate any combination of the different versions of the third and fifth sentences. Thus, four different variations of the passage were recorded involving the following combinations of sentences: (1) and (6), (2) and (8), (3) and (7), and (4) and (5).

After listening to the passage, each subject was given a recognition test for the third sentence followed by a recognition test for the fifth sentence. These tests involved presenting the four versions of each sentence, together with their equivalents in the passive voice; both of the two sets of eight sentences were presented in different randomised orders. The subjects, 16 students at Sussex University, were assigned in rotation to a group and to one of the four passages. They were tested individually; and they were allowed, if necessary, to make three attempts in each test to select the actual sentence that had occurred in the passage.

There was no reliable difference between the groups in their ability to retain the correct meanings of the sentences: two subjects out of eight made semantic errors in group M, and four subjects out of eight made semantic

errors in group I. The crucial distinction between the groups concerned those syntactic errors that reveal an inability to remember the lexical categories of the original sentence even though its correct meaning has been retained, for example, the selection of sentence (2) where the original was, in fact, sentence (1). Only one such error was made by a subject in group M, whereas six subjects produced a total of eleven such errors in group I; the difference in the number of subjects making errors in the two groups was reliable ($P=0.02$, Fisher Yates exact test). When a subject makes two semantic errors his other attempt is likely to be a guess even if it is correct in meaning, so we excluded the data of two such trials from the totals although their inclusion does not alter the basic pattern of the results.

A second experiment with a similar design but different materials examined the ability of a further twenty-four subjects to remember such sentences as:

(9) The borrower of the money purchased the car and the seller of the fridge bought the lawn-mower.

(10) The purchaser of the car borrowed the money and the buyer of the lawn-mower sold the fridge.

This task proved to be more difficult than remembering the sentences of the first experiment. The subjects in group I made a total of twenty-two semantic errors and the subjects in group M made a total of eight semantic errors; and the difference between the groups was reliable ($S_c=73.25$, $P<0.015$, Mann-Whitney test). Yet every subject made at least one error symptomatic of a failure to retain lexical categories, for example, confusing sentence (9) with sentence (10).

The results of the experiment suggest that even when listeners successfully recall the meaning of a sentence they can only remember whether an element of this meaning was conveyed by a noun or a verb if they know that they are to receive a memory test. They are then liable to implement a method for retaining verbatim information. Otherwise, lexical categories appear to be rapidly forgotten along with the superficial and underlying syntax of the sentence. One could defend the thesis that sentences are remembered by forming an associative structure linking representations of their nouns and verbs by arguing that the associative machinery deals with nominals derived from verbs in a very similar way to verbs themselves. But this argument runs the risk of rendering the thesis untestable. It is precisely such items that prevent the automatic reconstruction of lexical categories from the meaning of a sentence. One could also defend the thesis that at least word stems are remembered, since it was only the suffixes of words which were manipulated (together with the syntax of the sentence). But this view is incompatible with the results of previous experiments[2,3]. We prefer to think that meaning is something that can be put into words with a suitable syntactic structure rather than a direct representation of the structured set of words itself. The words and their structure can be thrown away as soon as their meaning has been grasped. If this thesis is correct, it is misleading to talk of a memory for the nouns and verbs of a sentence unless one is concerned with a deliberate attempt to memorise them. It is similarly misleading to talk of a memory for the underlying subject and object of a sentence, or for its underlying cases. Such terminology is tied to the words that occur in a sentence and, as we have shown, it can be misleading to talk of a memory for words.

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Genotype interaction with undernutrition and external environment in early life

IN spite of the well documented effect of early undernutrition on body and brain size in adult animals[1-3], its reported influence on behaviour has been less consistent. Changes in performance in learning tasks and activity tests have been found following undernutrition in early life[4-7]. Several studies, however, have shown little or no effect of such a manipulation[8-10]. Here we consider two factors which may contribute to variability in later behavioural response to early life undernutrition.

Recent work indicates that the type of environment in which animals are reared may modify the behavioural consequences of undernutrition[11-13]. Subtle changes in rearing conditions in different laboratories might account for the apparent lack of effect of undernutrition in some cases and its significant influence in others. Another important variable which could account for variability in results is the genetic background upon which nutritional treatments are imposed. Thus, the effects of undernutrition during the period of rapid development may differ according to the particular genotype selected for study.

We examined the interaction of genetic background with both early life undernutrition and differential environmental conditions. The C57BL/6J and DBA/2J mouse strains were selected for our experiments because they differ genetically in the control of a large number of behavioural, biochemical and physiological characteristics[14].

Mice were raised in three different environments and two levels of dietary protein. Five males and five females from each mouse strain were exposed to each of the above conditions.

Litters from dams of the C57BL/6J and DBA/2J mouse strains which had been previously mated in our laboratory were reared after parturition in *ad libitum* or undernourished nutritional conditions in either enriched, normal or impoverished environments. The enriched condition consisted of a large, clear, lucite box ($75 \times 40 \times 20$ cm high) divided diagonally in two, containing various manipulanda; the normal condition was represented by opaque, plastic home-cages ($30 \times 13 \times 12$ cm); the impoverished group was reared in sound-deadened, ventilated chambers in normal home-cages but with sensory input restricted by covering the top of the cages with a white painted, fitted metal sheet. Control or undernourished animals were fed a 27% or 8% casein diet respectively, containing 10% fat with minerals and vitamins added. The diets were made isocaloric by the addition of dextrose and contained 0.2% saccharin to improve palatability. The litters were culled to four animals on day 4 of life. After removal of the mother at 21 d, the weanlings remained in the appropriate environmental and nutritional treatment groups until 42 d after birth. At this age, they were separated by sex and maintained in normal laboratory conditions with food and water available *ad libitum* until behavioural tests were carried out 90–124 d of age.

At this time, animals were exposed to an illuminated (30 foot candles) Lehigh Valley photactometer, 45 cm in diameter, with a solid wood floor painted white, for 2 min on three consecutive days. The frequency with which animals intersected the light sources activating the photocells was recorded automatically every 30 s. Rearing and defaecation frequency were scored by an observer for each daily trial. Two days after the final open-field test, animals were exposed to a 'novel-object' test in the same apparatus. The number of visits to,