

4. Patton, S., Lee, R. F., Benson, A. A.: *Biochim. Biophys. Acta* 270, 479 (1972)
5. Ackman, R. G., Linke, B. A., Hingley, J.: *J. Fish Res. Bd. Canada* (in the press)
6. Williams, P. M., Weiss, H. V.: *J. Fish Res. Bd. Can.* 30, 293 (1973)
7. Wong, C. S., Green, D. R., Cretney, S. J.: *Nature* 247, 30 (1974)
8. Williams, M. Y.: *Trans. Roy. Soc. Canada* 51, 13 (1957). — Adams, K. R., Bonnett, R.: *Nature* 223, 943 (1969). — Benson, A. A., Lee, R. F., Nevenzel, J. C., in: *Current Trends in the Biochemistry of Lipids*, p. 174 (ed. R. M. S. Smellie). London: Academic Press 1972

Futterverständnis bei Wespen der Gattung *Paravespula*

U. Maschwitz, W. Beier, I. Dietrich und W. Keidel

Fachbereich Biologie der Universität Frankfurt a.M.

Futterverständnis ist bei sozialen Hautflüglern weit verbreitet. Sie ermöglicht eine effektive Ausbeutung von Nahrungsquellen und findet sich schon bei Ameisenarten, deren Kolonien weniger als 100 Arbeiterinnen umfassen [1]. Die Angaben von Kalmus [2], nach denen die individuenreichen, oft mehrere tausend adulte Tiere umfassenden Kolonien der einheimischen *Paravespula germanica* und *Paravespula vulgaris* kein Futterverständnisssystem besitzen sollen, erschien uns daher fraglich. So griffen wir dieses Problem erneut auf.

Hierzu wurden Arbeiterinnen beider Arten auf 60 m vom Nest entfernte Futterplätze dressiert, wo wir eine 2-molare, beduftete Zuckerlösung boten. In Vorversuchen hatte sich gezeigt, daß Wespen ihren Futterplatz nicht wie die Honigbienen mit Duft markieren. Um zu verhindern, daß offen sitzende, fressende Tiere optisch oder olfaktorisch von suchenden Arbeiterinnen erkannt und angefliegen wurden, deckten wir die beflogene Futterschale sorgfältig zu und boten zudem in je ca. 4 m Entfernung zwei weitere, ebenfalls verdeckte Futterschalen mit demselben Duft. Je $\frac{1}{2}$ m neben diesen 3 Schalen wurde als Kontrolle Zuckerwasser mit einem anderen Duft aufgestellt. An allen 6 Schälchen wurden die Neulinge markiert und nach Überprüfung ihrer Zugehörigkeit zum Dressurnest möglichst rasch getötet. Tabelle 1 zeigt das Ergebnis von je 5 Versuchsreihen. Daraus geht hervor, daß sich Arbeiterinnen beider Arten aus Fremdnestern in etwa gleicher Zahl an den Kontroll- und den Dressurfutterschalen einfanden. Die Neulinge aus dem

Tabelle 1. Zahl der Neulinge von *Paravespula vulgaris* (21 Versuchstage) und *Paravespula germanica* (9 Versuchstage), die Dressurschalen, Versuchsschalen oder Kontrollschalen anfliegen. Dressurschale: Futterstelle, an der die markierte Sammelschar (3–4 Wespen) verkehrt; Versuchsschale: Duft wie Futterstelle, keine markierten Sammlerinnen; Kontrollschale: anders duftendes Zuckerwasser. Sowohl für Kontrolle als auch für Versuch verwendete Duftstoffe: Citral, Geraniol, Ionon, Isoamylacetat, Jasmin, Methylheptenon, Nelkenöl. Statistische Sicherung nach Pätou [3]: *P. vulgaris*: Unterschied zwischen Anflügen auf Kontrollschalen und Versuchsschalen $p < 0,0002$ (gut gesichert). *P. germanica*: Unterschied zwischen Anflügen auf Kontrollschalen und Versuchsschalen $p < 0,0002$ (gut gesichert).

	nesteigene Neulinge an:			
	Kontroll-Schalen	Dressur-Schalen	Versuchs-Schalen	
<i>P. vulgaris</i>	3	38	64	
<i>P. germanica</i>	6	35	34	
	Wespen aus fremden Nestern an:			
	Dressur- + Versuchsschalen		Kontrollschalen	
	<i>P. germ.</i>	<i>P. vulg.</i>	<i>P. germ.</i>	<i>P. vulg.</i>
<i>P. vulgaris</i>	22	0	24	0
<i>P. germanica</i>	6	8	11	0

Versuchsnest dagegen suchten fast ausschließlich das Dressur-zuckerwasser auf, wobei sie sich auf die drei entsprechend bedufteten Schalen verteilten. Die markierten Sammlerinnen hatten also Neulinge herbeigeholt, die gezielt den Dressurduft anfliegen. Bereits aus dem Verhalten der umherfliegenden Neulinge war klar zu erkennen, ob diese nach dem Dressurduft suchten. Kamen die in Suchschleifen dicht über dem Boden fliegenden Tiere in die Nähe der versteckten Dressurduftschalen, so begannen sie gezielt und intensiv nach der versteckten Futterquelle zu fahnden.

Besonders eindrucksvoll zeigte sich das Vorliegen einer Futterverständnis, als wir bei beiden Arten von einem Tag zum anderen Kontroll- und Dressurduft gegeneinander austauschten. Hierzu ein Beispiel: Am ersten Tag wurde der Dressurduft Geraniol von 12 *P. vulgaris*-Neulingen aufgesucht, während die citralbedufteten Kontrollfutterschälchen von keiner Wespe aus dem Versuchsnest angefliegen wurden. Am Morgen des zweiten Tages dressierten wir die FINDERinnen um, indem wir ihnen über eine Zeit von einer Stunde ausschließlich Citralfutter boten und während dieser Zeit keine anders bedufteten Schälchen ausstellten. Danach wurde Geraniol-Zuckerwasser als Kontrolle aufgestellt. Sämtliche 11 Neulinge dieses Tages flogen nun die Citral-Futterschalen an.

Damit ist bewiesen, daß die untersuchten Wespenarten über eine Futterverständnis verfügen, bei welcher der Futterduft als Signal dient. Weitere Untersuchungen sollen nun klären, ob zusätzliche Signale eingesetzt werden.

Mit Unterstützung der Deutschen Forschungsgemeinschaft.

Eingegangen am 26. August 1974

1. Maschwitz, U., Hölldobler, B., Möglich, M.: *Z. Tierpsychol.* (im Druck)
2. Kalmus, H.: *Brit. J. Anim. Behav.* 2, 139 (1954)
3. Pätou, K.: *Biol. Zbl.* 63, 152 (1943)



Age-dependent Hearing Loss in Normal Hearing Mice

G. Ehret

Fachbereich Biologie — Zoologie — der Techn. Hochschule Darmstadt

In systematic behavioral studies there is a lack of information about presbycusis in mammals. It is important, however, for the interpretation of studies in hearing to know the influence of age on the auditory thresholds of a species. Behavioral tests also provide the opportunity for a desirable comparison with data on hearing in man [1]. The laboratory mouse, *Mus musculus* (outbred strain NMRI), seems to be suitable for the tests because the thresholds for pure tones have been analyzed

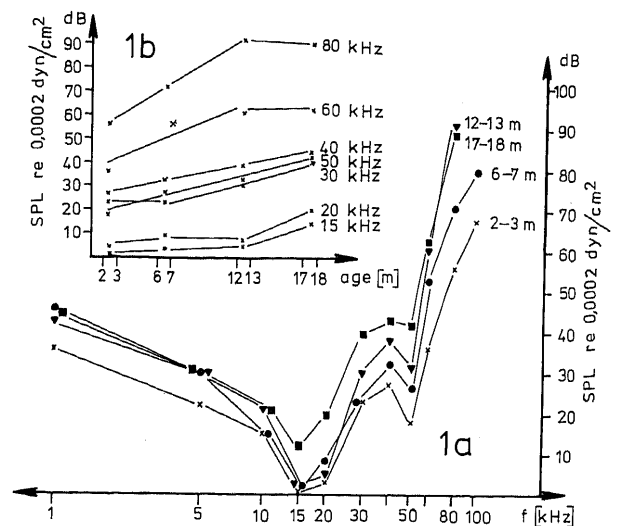


Fig. 1a and b. Age-dependent auditory thresholds in *Mus musculus*. (a) Variables: frequency and sound pressure level (SPL), parameter: age (in months: m); (b) Fig. (a) replotted with age and SPL as variables and frequency as parameter

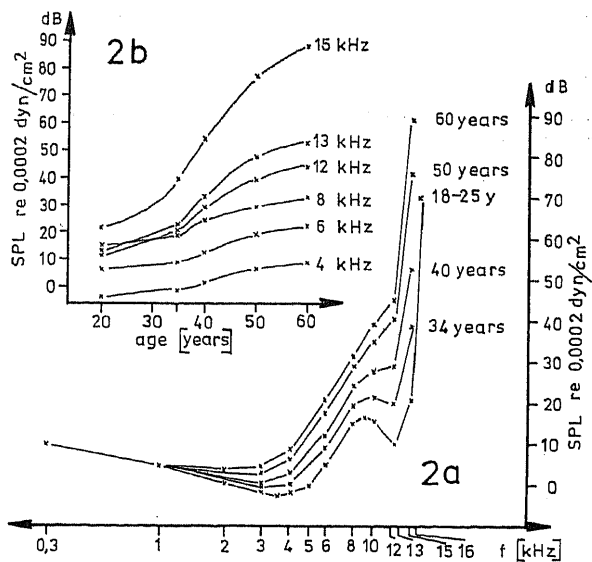


Fig. 2. Same as Fig. 1, but giving data for man (from [1])

in young adults by many different methods and the lowest thresholds result from behavioral experiments [2]. No pathologic abnormalities in the ear or in behaviour have been observed in NMRI mice. The age-dependent thresholds for pure tones were determined by means of the conditioned eyelid reflex and operant reward conditioning as described elsewhere [2] in mice of 2—3 (8♂♂, 5♀♀), 6—7 (2♂♂, 4♀♀), 12—13 (2♂♂, 4♀♀), and 17—18 (2♂♂, 4♀♀) months of age. Only animals with reliable and steady responses were used in the tests. The average life expectancy of laboratory mice is approximately 18 months; sexual maturity is reached by about 2 months of age [3].

The results are plotted in Fig. 1. All values which differ from each other by more than 5 dB (except at 10 kHz) are statistically significant ($p < 0.02$), especially at 30, 40, and 50 kHz. The comparison with human data (Fig. 2) calculated from [1] shows: 1. hearing loss in mice starts later with relatively low frequencies (unsystematic threshold shift below 10 kHz does not reflect auditory acuity), 2. mice are less affected at high frequencies, 3. the maxima of sensitivity exist for a relatively longer period, 4. hearing loss in mice does not follow S-shaped functions (2b) but shows linearity (1b) as soon as it starts at one frequency tested (exceptions must be made for old mice at high frequencies), 5. the overall shape of the curves (1a, 2a) is similar, especially the absolute hearing loss for old subjects and the relative hearing loss for comparable frequencies. Provided that the 2—3 months curve reproduces the absolute auditory threshold of *Mus musculus* fairly well, man and mouse show approximately the same amount of hearing loss during their lifetimes.

Supported by the Deutsche Forschungsgemeinschaft, grant to Prof. Dr. H. Markl (Ma 374/2,4), whom I thank for reading the manuscript.

Received July 18, 1974

1. ISO-Rec.: 226 —1961 (E)
2. Markl, H., Ehret, G.: *Z. Tierpsychol.* 33, 274 (1973)
3. Hagemann, E.: *Ratte und Maus. Versuchstiere in der Forschung.* Berlin: Walter de Gruyter & Co 1960

Forgetting: Length of Material, Motivation and Memory Span

Th. J. Thiekötter
Universität Heidelberg

W. F. Angermeier
Universität zu Köln

There are two major modern theories of forgetting: trace-decay and interference theory. The first of these theories holds that the memory trace formed during the presentation of the

material is degraded between that point in time and a later memory test. The interference theory states that the memory trace is not degraded as a function of time, but rather that forgetting occurs as a failure of retrieval at the time of the memory test. There are, however, today many theorists who assume that both, trace decay and interference, are involved in the process of forgetting.

The trace-decay theories assume that the degradation of the memory trace increases in the longer lists, since these lists contain a larger number of items preceding a given item to be remembered. The search theory of retrieval offers an alternative explanation to the effect of list length: the individual makes successive random draws according to a "search-set" defined by the appropriate instructions. When the available search time is gone or when the search proves fruitless, the individual stops the retrieval process. There have been a number of experiments which support this latter view [1]. It thus appears that both theories adequately predict the list-length effect.

In order to separate these two alternative explanations, Shiffrin [2] performed a number of experiments. These showed very clearly that memory was indeed dependent upon the length of the original list to be remembered and independent of the intervening list. In these experiments, Shiffrin instructed his Ss (subjects) to remember the list prior to the one just presented. He systematically varied the lengths of the lists, using lengths of 5 and 20 common English words. His Ss were not, however, particularly motivated to participate in the experiment. Furthermore, his choice of list lengths seemed to us rather unfortunate, since it did not permit any conclusions about list lengths between 5 and 20 (such as f.e. list lengths around the memory span 7 ± 2). Our own experiments may be considered an extension of Shiffrin's work, incorporating both the motivation and memory span variables.

Basically, our experiments followed those of Shiffrin as closely as possible. The Ss were students at the University of Heidelberg. In Experiment I ($N = 42$), the Ss were presented 24 lists (with words selected randomly from a list of 500 common German words constructed by Meier) as follows:

7-5-5-11-5-5-5-7-11-11-5-7-7-5-5-11-11-5-7-7-5-5-11-
or

5-5-11-5-7-7-5-11-11-7-7-5-11-11-5-5-5-7-11-5-5-7-5-5-

In Experiment II ($N = 40$), the Ss were presented 13 lists (with words selected as above) as follows:

7-5-20-20-11-7-7-20-7-11-20-5-7

The words were projected individually for each S with the aid of an automatically time-controlled slide projector. The Ss were instructed to write out their responses which they attempted to recall in any order from the list prior to the one just presented. These attempts at recall were made for all lists, except for the first list of each session. The words were projected for 1 sec; after a list had been presented in its entirety, a recall period of 1 min was allowed. The Ss knew that the list lengths varied, but did not know which list length to expect at any time during the experiments.

In order to investigate the effects of motivation upon memory processes, the Ss of our experiments were told that they were to receive money prizes. In each experiment, the ten Ss who did best on the memory test received prizes ranging from DM 10.— to DM 50.—.

The reason for dividing the Ss in Experiment I into two groups was to analyze any possible fatigue effects. The reason for conducting Experiment II was to afford direct comparison between our data and those by Shiffrin.

A comparison between the data of our Experiment II and those of Shiffrin is shown in Fig. 1.

Fig. 1 shows very clearly that the Ss of our Experiment II remembered more words than the Ss of the Shiffrin study. We attribute these differences to the difference in motivation between the Ss used in both studies. This Figure also points out another very important fact; the data from Shiffrin's experiments are deceptive since they show a linear progression between the two list lengths which actually does not exist. The slant of our own curve (T/A II), is very pronounced between list lengths of 5 and 7 words, less so between 7 and 11 words and very slight between 11 and 20 words. We interpret this to indicate that memory span is an important factor for the process of remembering the type of materials presented here.