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Avoidance of acoustic stimuli by the herring

by

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Introduction

In summer 1964 it was possible to make recordings of herring sounds (HERING 1964). From these circumstances there were induced investigations about the possibility of influencing herring shoals by sound.

Statements about sound production and influencing commercial fish by sound are directly important to the fishing technics. It is not only possible to locate the sound producing species acoustically, but also they can systematically by acoustical substitutes be attracted or scared.

The investigations were made on herring, spawning in autumn in the Greifswalder Bodden (Isle of Rügen, Baltic Sea). The experimental fish was catched by baskets. They were enclosed in a net aquarium, 4 x 4 m large and about 2,5 m deep. The sound transmission was made with some underwater loud-speakers, of small acoustical power (about 5 W electrical power consumption).

The original problem tended to test the reaction of enclosed small herring shoals with regard to the whistles of herring. The tape recordings were made in earlier experiments (HERING 1964). However, these tape recordings caused no reactions of the enclosed fish, probably due to the insufficient quality of recordings. It was necessary to use technical sound structures. Initially such patterns of stimuli were provided for control only. Fish is able to hear within the range of their capacity of hearing any given sound stimulus, but only responds such stimuli which have a direct biological signification. For instance a pure sine tone of 100 c.p.s. has small or no information content for a fish. It is not to be expected that such a tone causes definite pattern of behaviour. For instance the negative results of the experiments by BURNER and MOORE (1953) and MOORE and NEWMAN (1956) also might attributed to this cirsumstance. However, our experiments demonstrated that also technical sound structures can influence the behaviour of herring. This fact is corresponding to the observations in the commercial fisheries.

Primary reactions on acoustical stimuli

Reactions on acoustical stimuli could observed only, when more than 100 herrings (in our experiments about 150 - 200 fish) were enclosed in the net aquarium.

When the herrings are not influenced, they were equally distributed in the whole net aquarium or in a part of it. They were swimming confusedly, forming no shoal, but only a not compact group.

Acoustical stimuli caused a more or less significant aggregating and forming of a shoal. This aggregating tendence was in course of time more and more hazy. It was no more demonstrable during the last experiments. The acoustical stimuli caused not only aggregating, but also typical taxes. The fish is responding to v i g o r o u s acoustical stimuli, by turning off as quick as lightning from the sound source ("Turning on the place") and swimming in to the range of less acoustic intensities ("Swimming away"). When the fish is swimming away, simultaneous aggregating always occurs.

Several w e a k e r acoustical stimuli sum up in their effect and result in the same reactions as one vigorous stimulus.

A special structure of the escape reaction in the two phases "Turning" and "Swimming away" appears by a slow sequence of weaker stimuli. The first weak stimulus stops the movement of the fish swimming around in the sonic field. The first medium- strong stimulus causes not only an inhibition of the movement, but also a clear turning away from the sound source. The second weak or medium strong stimulus is based on the reaction, produced by the first stimulus. The stimulus tends direct to swimming away from the sound source and leads to an aggregating.

Both phases of the taxis can be decreased or prevented by additional noises.

An escaping shoal of fish shows no further taxes on sound processes. The shoal preserves the once chosen direction of movement, even when it is swimming directly in to a very intensive sonic field.

Sound frequency and structures of rhythm

The intensity of the scaring effect is dependent on the structures of frequency and rhythm of the scaring sound process, when it is measured as a free scared room around the sound source.

The investigated sound processes are shown in Fig, 1. The motivation on noises was very different during the individual experiments. In order to compare all the single measurements, together the scaring effect of the 100 c.p.s. tone in any experiment was equated with one. On this basis the relative scaring degree of any noises was calculated. 273 single measurements were taken as a basis for the calculations.

The relative scaring graduations of all the sound structures, which are not assembled, are shown in Fig. 1. Four statements are possible:

1. The scaring effect is dependent on the time behaviour. Pure sine tones, which are disconnected rhythmically, can scare much stronger than continuous sine tones (Fig. 1). (The difference is really greater than according to the here informed values, because in our experiments the continuous tones were presented always beginning immediatly. The scaring effect was estimated also in the moment of switching-on).

Uncontinuously interrupted noises (speaking, puffing to a microphon membrane) are scaring stronger than the continuously interrupted noises described above.

2. The scaring effect is dependent on the frequency. A continuous 100 c.p.s. tone for instance is scaring stronger than a continuous 7.000 c.p.s. tone.

3. The component frequency of the scaring effect can cover the component rhythm. A continuously transmitted noise of a merine engine even can scare a little stronger than the same noise, when it was interrupted rhythmically.

The human speaking and that noise originated by puffing on a microphone membrane are most efficient for scaring. It seems that a wide band width of the noise (so when puffing) would increase the scaring effect, compared to the change of frequency (so when speaking), which would effect scaring decreasey (puffing is more efficient than speaking. A sequence of tones 100 c.p.s./ 320 c.p.s. is scaring less than a sequence of 100 c.p.s./rest in the same rhythm).

Acoustical scaring stop

The scaring stop by acoustical additional stimuli, as described above, was complete in the first days of experiments only. In the later experiments described here the scaring stop mostly could not be clearly noticed by the observer. However, the calculation of the relative scaring graduations makes obvious the scaring decrease by addidtional noises also in these experiments.

For the reduction of the scaring effect always continuously transmitted sine tones were used. The statements are as follows:

1. A scaring sine tone of low frequency (100 c.p.s., intermitted) can be "covered" by tones of a highes frequency. The scaring decrease is obviously dependent on frequency. The optimum lies under 5.000 c.p.s. (Fig. 2).

2. The scaring effect of a sound process with wide band width (noise of marine engine) can be decreased by sine tones, too.

   The optimum of the scaring decrease lies here near or under 100 c.p.s. The "covering" also takes place when the noises with wide band width are interrupred.

3. The dependence of frequency of the relative scaring decrease is current for all experiments (Fig. 3). The variation of the values is clear, when the variety of the "covered" noises and the small numbers of measurements will be taken into consideration. Because of these circumstances the Fig. 3 can show a tendence only, but this is very clear.

Discussion

The described here results are founded on preliminary experiments of limited extent. Therefore some factors could not be measured:

1. The samll volume of the net aquarium caused the escaping shoal to swim back in to the scaring room resulting in absolutely and relatively unexactly messured scaring ranges.

2. It was impossible to separately measure the coefficients "taxis", "escape" and "swimming back into the scaring range". These statements, which are very important for the commercial fishery, must be made in later experiments.

3. Even the "motivation" of the herrings could not be measured. The experimental fish were spawning herrings and spent herrings.

The experiments will be continued.

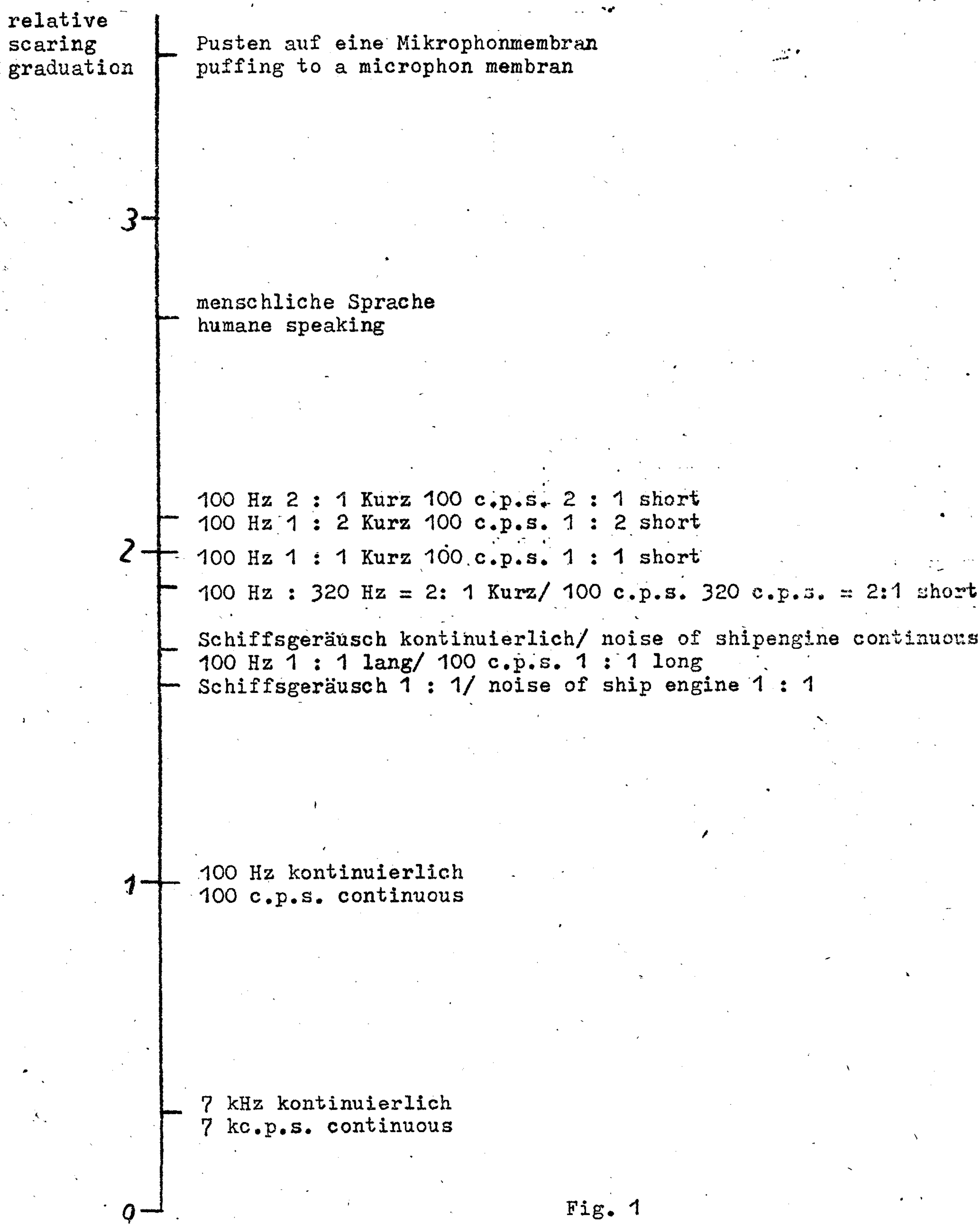

relative scaring graduation
Pusten auf eine Mikrophonmembran
puffing to a microphon membran
3
menschliche Sprache
humane speaking
100 Hz 2 : 1 Kurz 100 c.p.s. 2 : 1 short
100 Hz 1 : 2 Kurz 100 c.p.s. 1 : 2 short
2
100 Hz 1 : 1 Kurz 100 c.p.s. 1 : 1 short
100 Hz : 320 Hz = 2: 1 Kurz/ 100 c.p.s. 320 c.p.s. = 2:1 short
Schiffsgeräusch kontinuierlich/ noise of shipengine continuous
100 Hz 1 : 1 lang/ 100 c.p.s. 1 : 1 long
Schiffsgeräusch 1 : 1/ noise of ship engine 1 : 1
1
100 Hz kontinuierlich
100 c.p.s. continuous
7 kHz kontinuierlich
7 kc.p.s. continuous
0

Fig. 1

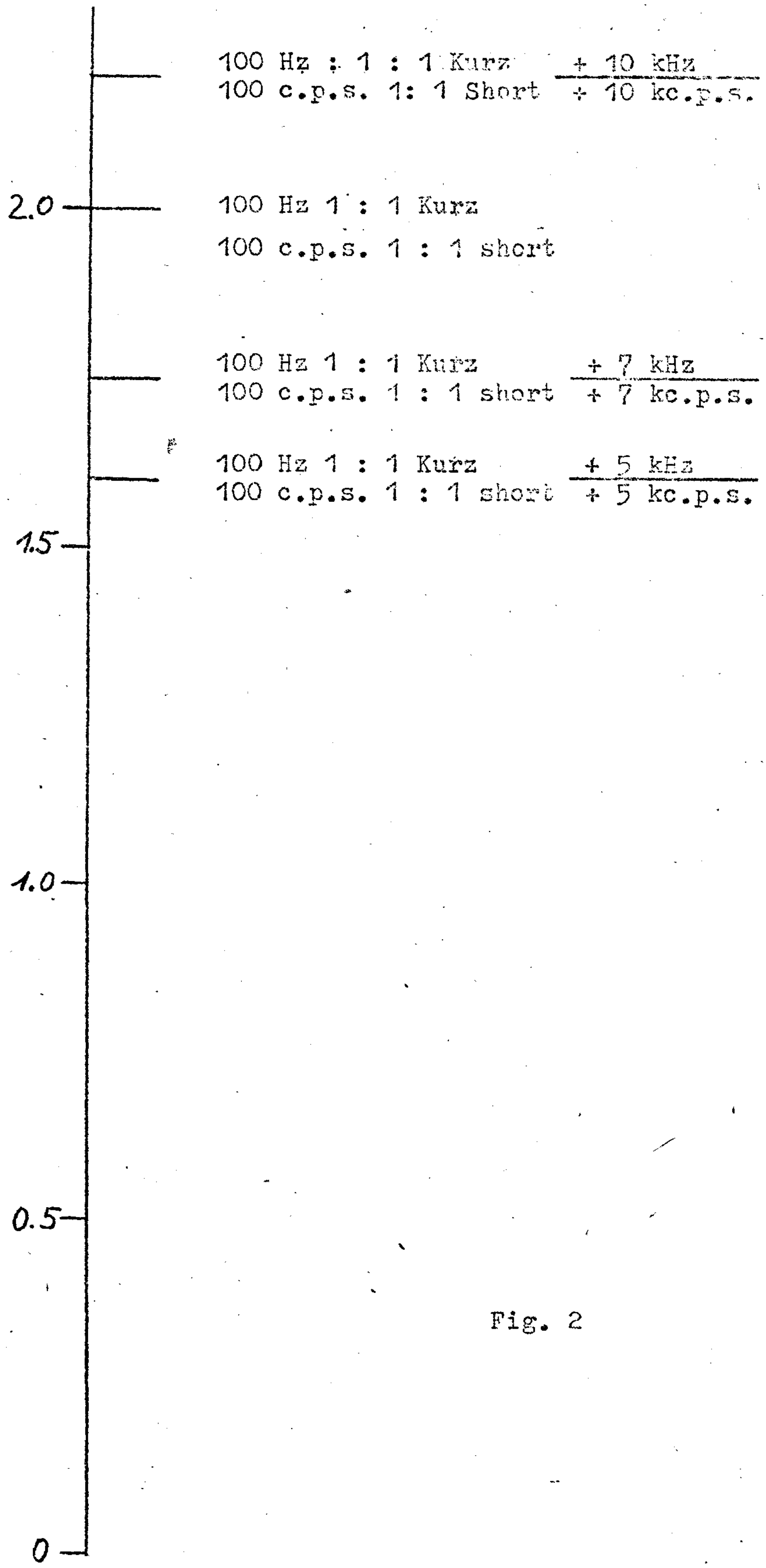
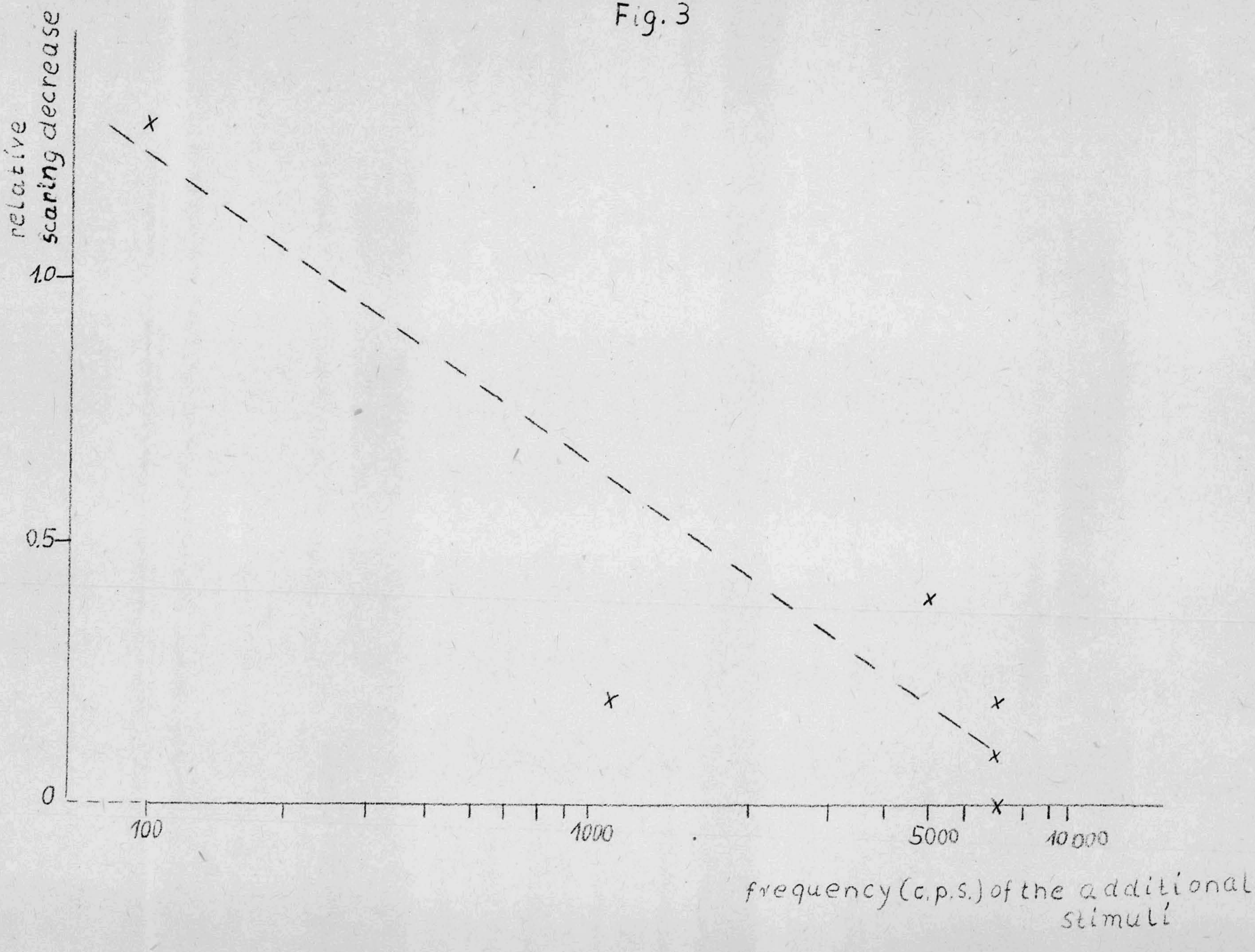

100 Hz 1 : 1 Kurz + 10 kHz
100 c.p.s. 1: 1 Short + 10 kc.p.s.
2.0
100 Hz 1 : 1 Kurz
100 c.p.s. 1 : 1 short
100 Hz 1 : 1 Kurz + 7 kHz
100 c.p.s. 1 : 1 short + 7 kc.p.s.
100 Hz 1 : 1 Kurz + 5 kHz
100 c.p.s. 1 : 1 short + 5 kc.p.s.
1.5
1.0
0.5
0

Fig. 2

Fig. 3


relative scaring decrease
1.0
0.5
0
100
1000
5000
10 000
frequency (c.p.s.) of the additional stimuli