RELATIONSHIP BETWEEN PHYSICAL NOISE LEVEL, EXPERIENCED ANNOYANCE, AND PHYSIOLOGICAL REACTION

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ABSTRACT

Do psychological annoyance and physiological reaction to a sound or to a noisy event depend, apart from the sound level, also on prior experiences of a person with the sound under concern? In an experiment, subjects (Ss) were exposed in a classical conditioning paradigm first to a sound and then either to a neutral (control group, CG) or to a provoking anger inducing instruction (experimental group, EG). Thereafter, the Ss were exposed to the sound without an instruction. Now, the Ss of the EG experienced psychologically the sound more annoying and reacted physiologically with higher arousal than the Ss of the CG. Furthermore, the Ss of the EG exhibited a tendency to adapt to the sound events slower than the Ss of the CG, and hence seem to develop a non-adapting physiological defensive reaction.

Results suggest that annoyance is the output of a PLOF-detector (possible loss of fitness detector) and that this detector is also capable of learning, such that originally neutral sounds can become annoying and, if they trigger physiological stress reactions, possibly even health-impairing in the long run.

INTRODUCTION

One aim of noise research is to predict (psychological) annoyance or other reactions to noise from (physical) noise measurements. At present, the favourite measurement procedure is the energy equivalent sound pressure level (Leq). In order to answer the question, how precise the prediction is, the concepts of 'reliability' and 'validity' defined in the 'theory of psychological testing' can be applied (Kalveram 1995, 1997c). Thereby, the noise measurement procedure is regarded as 'test' and the related annoyance ratings as 'criterion'. The coefficient of correlation between these two
variables then is the validity of the measurement procedure indicating its prediction power, and the coefficient of correlation between two successive series of measurements of the same sound sources represents its reliability. The reliability of the Leq (and derived measurement procedures) is, as often is the case of physical measurements, close to its maximum value 1, its validity, however, turns out to be only moderate (about 0.5). This means that the Leq misses a good deal of the factors influencing personal annoyance ratings, but suffices to predict the average reactions to noise of groups of persons exposed to the same physical noise level.

Whereas traditional noise research focusses strongly on the psycho-physics of auditory perception with the Leq being the pillar, the present paper is dealing with the question, what else - apart from the Leq - causes people's noise annoyance? Or, expressed more precisely, what is the mechanism making people experience annoyance? Recent theories based originally on Gibson's "affordances" (Gibson 1979) emphasize that acoustical signals have a psychological function, e.g. they convey information about the environmental state, or provide feedback of the individual's actions, or are used for communication or environmental monitoring (e.g. Guski 1991, Cutting 1982, Kaminski 1989). Annoyance then originates from acoustical signals not compatible with, or even severely disturbing, these psychological functions. In these theories, therefore, interference with current activities is the primary effect of noise exposure, followed by annoyance as the psychological reaction.

In the present paper, this functional approach is extended implying also the biological function. In this approach, annoyance following noise exposure is considered to convey a "possible loss of fitness signal" (PLOF-signal) indicating, that the individual's Darwinian fitness will decrease if she or he continues to stay in that situation (Kalveram 1997a, 1997b). Especially, non familiar conspecifics appearing in the habitat diminish fitness of the inhabitants because they are going to exploit the same but restricted resources. Therefore, sounds carrying the information that they are men made are likely to evoke more annoyance than other sounds of equal level and spectral density. That means that annoyance is the primary effect of noise exposure, distracting attention from the current activity in order to enable either retreat, aggress, stand by or coping behavior with respect to the source of the sound.

In an experiment (Kalveram et al. 1999), this hypothesis was tested. Subjects were exposed to recorded sounds of ocean surf and party murmur. Both sounds were carefully equalized regarding spectral energy and overall level (Leq =52 dBA). In the "man made" sound condition, subjects felt significantly more annoyed and were significantly more impaired in a free recall memory test. However, physiological stress indices (potassium/sodium measured in saliva) didn't discriminate significantly between the conditions. The results support the hypothesis, that, considered biologically, the main function of noise annoyance is to warn a person that fitness may diminish, but not to induce actual stress. This additionally explains the frequently reported finding that moderate noise, though annoying, causes only little or even no physiological stress reactions.

The purpose of the present paper is to give further evidence to the PLOF hypothesis of annoyance. The PLOF approach implies that the related detector should have the ability to learn to assign an alert to a previously neutral acoustical stimulus. The outlined experiment shows, though data processing is not yet completely finished, how - in a Pavlovian conditioning paradigm - an annoyance reaction can be acquired only by
connecting a click sound to a noxious social experience, without any introduction of interference with current activity.

METHOD

The experimental procedure consisted of an accommodation phase of 15 minutes, a conditioning phase of 20 minutes, and a test phase again of 20 minutes (s. fig. 1). In the conditioning phase, totally 16 subjects (Ss) where exposed to a sequence of 16 sounds, each with a duration of 10s and transmitted through loudspeakers. The sounds were composed of a short click simulating switching on of an intercom, followed by a verbal instruction prepared by the experimenter, and ended with a noise trail indicating the end of the message. The sounds were spaced randomly over 20 minutes with a minimum distance of 1 minute. The Leq measured over the conditioning period was about 55 dB(A). Before the session, all Ss were urged by the experimenter to sit as quiet and calm as possible in order to get undisturbed records. The control group (CG, N=8) got a neutral instruction, whereas the instruction of the experimental group (EG, remaining Ss) was an anger inducing one, by which the experimenter complained about an alleged misbehavior using tape recorded shoutings like "Seems you are unable to keep quiet!!" Because the Ss of the EG really behaved well, these statements were supposed to be offending to them and thus generating anger. The conditioning phase then was followed by a test phase of 20 minutes, where all Ss had to perform mental arithmetics (KLT) while exposed to the same 16 klicks, but now without any instruction. In the test phase, the Leq was about 45 dB(A). Fig. 1 visualizes how the experimental procedure was arranged over time. During the test phase, blood flow through the tip of the left middle finger was recorded. After the experiment, the Ss had to fill in a questionnaire containing questions about how they experienced the sounds, for instance as annoying, disturbing or hindering to relax. From blood flow, pulse volume amplitude (PVA) was computed as the difference between maximum and minimum flow referring to one heart beat. PVA indicates sympathetic activation: The smaller the PVA is, the higher is the activation. Baseline values were defined as the mean PVA taken over the last five minutes of the accommodation phase. To indicate the reactions of the Ss to the clicks in the test phase, the PVAs first were averaged over 10 seconds after the onset of a click for each S, and then the baseline values were subtracted. The more these values go negative, the greater is the increase of activation (cmp. also Jansen 1959).

![Figure 1: Timing of the experimental procedure](image-url)
RESULTS

Fig. 2 shows the PVA reactions to the clicks in the experimental group (EG) and control group (CG) after anger conditioning. Results are preliminary in the sense, that at present only 10 of 16 reactions have been extracted from the rough data. Both curves differ significantly (p<5%). The thin dashed lines represent the linear trend, the slope of which seems to be lower in the experimental group than in the control group, however, the difference is statistically not significant.

![Graph showing PVA reactions to clicks in EG and CG](image)

**Figure 2**: PVA reactions to clicks 1 to 10 in the experimental group (EG) and control group (CG) after anger conditioning. Negative going values indicate higher sympathetic activation. Both curves differ significantly (p<5%). The thin dashed lines represent the linear trend, the slope of which tends to be lower in the experimental group.

Table 1 refers to the questionnaire items and the mental arithmetic task. The experimental group's annoyance and disturbance ratings of the verbal instructions as well as of the clicks ranged on average significantly higher than those of the control group. Referring to the mental arithmetic task, there was no significant difference between the groups, indicating that considerable interference with the current task didn't occur.
Table 1: Results regarding questionnaire statements and mental arithmetics in the control (CG) and experimental group (EG).
"<" means that the EG got significant higher ratings, and "=" that there was no significant difference.

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<td>Verbal instructions are annoying</td>
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<td>Clicks are annoying</td>
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<td>Self rating of sensitivity against noise</td>
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<td>Clicks interfere with thinking</td>
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<td>EG</td>
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<td>Clicks prevent to fall asleep</td>
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<td>Performance of mental arithmetics</td>
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DISCUSSION

Taken together, results suggest that "anger conditioning" indeed took place, making originally neutral sounds provoke annoyance. Furthermore, the physiological reactions to the anger conditioned stimuli as described by the PVA were obviously stronger than to the unconditioned ones. Therefore, recovery from sympathetic activation caused by the anger conditioned stimuli obviously needs more time, or, in other words, habituation phase to these stimuli is prolonged. Recovery from sympathetic activation caused by the click noise might further be hindered if it will prove true that the activation level in the EG diminishes slower than in the CG, or even is held constant on a high level of activation. This may be regarded as the beginning of a non-habituating defensive reaction (Sokolov 1963, Jansen 1959).

Remarkable is the fact, that the overall noise exposure of both groups during the whole experiment was the same. The different reactions in the second part of the experiment are due to different personal experiences of the Ss with the previously applied noise. Sympathetic activation commonly is considered as a stress reaction possibly having consequences also for health, and the present experiment shows that and how a stimulus could acquire the property to trigger such a stress reaction. But whether stress reactions acquired in this manner persist over time or even can cause health problems, remains an open question. These reactions must be related to all the stress reactions the organism is prone to in daily life. However, the present experiment shows that psychological and physiological reactions to noise can be determined by personal history, triggered by low level sounds, and rapidly change over time. This should be taken into account in political decisions concerning noise producing plants.
REFERENCES


