



The incremental stimulus intensity effect in the habituation of the eyeblink response in humans



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ABSTRACT

Investigation of the eyeblink response of humans to auditory and tactile stimulation focused on the determinants of the so called incremental stimulus intensity effect. In Experiment 1, two groups of participants were exposed to 100 tones from 60 to 87-dB in intensity. In Group Incremental, the tones increased from 60- to 87-dB in 3-dB steps, whereas participants in Group Random received the same intensities in a pseudorandom order. The performance of the two groups was compared to Group Constant that received all 100 tones at 90-dB intensity and to a fourth group, named “Apparatus” that received no stimulation. In a subsequent testing block, the results indicated that there was less responding to a 90-dB tone in the Incremental than in the other three groups, which replicates the incremental stimulus intensity effect. The novel observation was that there was also significantly less responding in the Incremental than in the other three groups to an untrained tactile stimulus, suggesting that the differences between the conditions may have implicated differences in a more general sensitization, in addition to any differences in stimulus-specific habituation. Experiment 2 demonstrated that repetition of tones at a fixed intensity caused a decrease in responding to the tones, but also an increase in responding to a novel tactile stimulus, as compared to an untrained condition. These results are discussed in terms of the interpretation of the incremental stimulus intensity effect suggested by Davis and Wagner (1969) and the AESOP (Wagner & Brandon, 1989) treatment of habituation and sensitization.

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1. Introduction

There have been frequent reports demonstrating a so-called “incremental stimulus intensity effect” or ISIE (Groves & Thompson, 1970), consisting in a greater decrement in evoked responding to a repeatedly exposed stimulus when it is delivered at gradually increasing intensities than at a constant intensity. In one of the first of these studies, Church, Lolordo, Overmier, Solomon, and Turner (1966) showed that the cardiac acceleration response provoked by a shock decreased more in a group of dogs that had received a series of shocks in a sequence of increasing intensities (from 0.5- to 6-mA) than in a group that received the same number of repetitions at a constant intensity of 6-mA. Similar results have been obtained using the acoustic startle response of rats (Davis & Wagner, 1969), electrodermal response in humans (O’Gorman & Jamieson, 1975, 1978), hind limb flexion reflex of the acute spinal cat (Groves & Thompson, 1970), galvanic skin and cardiac responses

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to imagined phobic stimuli in humans (Grayson, 1982) and eyeblink response in humans (Ponce, Quintana, Philominraj, & Vogel, 2011).

Although all of the mentioned reports confirmed that exposure to an incremental sequence of stimulus intensities is accompanied by a greater reduction in the evoked response to that stimulus as compared to a sequence of constant intensities, they do not generally comment on whether the effect is due to the gradual nature of the incremental sequence or to alternative features, such as the lower overall intensities received within the sequence. The exception is the study by Davis and Wagner (1969), which evaluated the acoustic startle response to a 120-dB tone in a group of rats that had been exposed to 750 tones of gradually increasing intensities between 83- and 118-dB. It was contrasted not only with a group that received training with the 120-dB stimulus, but with groups exposed to either a like number and intensities of tones as in the incremental sequence but in a pseudorandom order, or to the same mean intensity of 100-dB on all occasions. The result was that there was substantially less responding to the tests with the common 120-dB tone in the group that had experienced the gradually increasing intensities than in any of the other three groups. The fact that evoked responding was less in the incremental group than in the groups that experienced equivalent stimulus intensities (i.e., random and constant 100-dB) suggests that the ISIE is indeed due to the incremental character of the sequence and not simply to the comparatively lower intensities received in this treatment.

In interpretation of the ISIE, both Davis and Wagner (1969) and Groves and Thompson (1970) noted the probable involvement of both a decremental process (habituation) reducing the response tendency to the stimulus and an incremental process (sensitization) increasing the response tendency, the balance of which must be concluded to be more-decremental/less-incremental following the gradually increasing intensity sequence than in the comparisons offered. According to this view, when a stimulus is repeated, both tendencies change their magnitude depending on various factors, such as the intensity of the stimulus and the number of repetitions. The overt behavioral change is supposed to be a reflection of the predominance of one tendency over the other.

Davis and Wagner (1969) speculated that in instances using aversive stimuli, such as intense tones, the ISIE may result from less sensitization being acquired to potentiate the measured response. They hypothesized that the degree of sensitization caused by a given stimulus may be a direct function of its intensity and an inverse function of its prior level of habituation. Since the gradual condition receives the highest intensities at a late stage of the exposure sequence, when considerable habituation to the stimulus has already presumably occurred, they argued that this could explain there being less sensitization in this group relative to the random and constant groups, where the highest intensities are distributed through the habituation session. We will return to this interpretation in the discussion.

According to Groves and Thompson (1970), the sensitization process dominates over the habituation process the more intense the stimulus, but decreases with the number of repetitions and the passage of time, while the habituation process is assumed to develop more easily with lower intensities and to increase with stimulus repetition. Following this logic, they explained part of the ISIE by suggesting that the constant group suffers from higher and longer-lasting sensitization and lower habituation than the incremental group, which receives less intense stimuli in each block. This interpretation does not provide an explanation for the different consequences produced by incremental and random sequences, and is difficult to reconcile with other data presented by Davis and Wagner (1968), demonstrating a greater response decrement with greater constant training intensities, when care is taken to test over the range of stimuli.

A common feature of the dual-process interpretations proposed by Davis and Wagner (1969) and Groves and Thompson (1970) is the supposition that of the two processes, habituation should be more restricted to the particular stimulus employed during the training sequence. In contrast, sensitization would be more likely to be seen not only in the evoked response to the training stimulus, but in the response to other equally potentiated stimuli. The purpose of the present research was to follow this reasoning in regard to the ISIE by employing two different stimuli, one acoustic and the other tactile, that have been demonstrated to have separable startle-producing features (Pilz, Arnold, Rischawy, & Plappert, 2014; Pilz, Carl, & Plappert, 2004; Simons-Weidenmaier, Weber, Plappert, Pilz, & Schmid, 2006; Vogel & Wagner, 2005). In Experiment 1, we examined whether the exposure to one of the stimuli in an incremental versus alternative fashion produced less test responding specific to the exposed stimulus (more likely reflecting differences in habituation to that stimulus) or equally to the two stimuli (more likely reflecting differences in a more general sensitization produced by the training). Experiment 2 was required to provide evidence disambiguating the observations.

2. Experiment 1

The first goal of this experiment was to demonstrate the incremental stimulus intensity effect with the exposure and test procedures employed. Four groups of participants were matched for their initial level of responding to a 90-dB tone. Two of the groups subsequently received 100 tone presentations, gradually increasing in intensity from 60- to 87-dB (Group Incremental), or of the same matched numbers and intensities but in pseudorandom order (Group Random). One additional group received 100 tones at the full intensity of 90-dB (Group Constant), whereas the final group was simply held in the experimental room for the same period of time without stimulation (Group Apparatus). It was anticipated that an ISIE would be seen in subsequent testing of the several groups' responding to the 90-dB tone, with the Incremental Group responding less than Group Random and Group Constant, all in relationship to the base-line responding of the relatively-unexposed Group Apparatus.

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