

REFLEX HABITUATION AND ATTENTIONAL PROCESSES

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The influence of cognitive events on the early processing of sensory information and the subjects' response habituation to such information were investigated through the use of reflex modification procedures. The research attempted to differentiate between early selective attention effects and generalized arousal effects; further, when early selective attention effects were evident, the research attempted to distinguish between perceptual facilitation and perceptual attenuation of information. The research employed a variable warning procedure, and in this procedure the subjects were presented with either no warning, onset warning, or onset plus valid or invalid modality warning of the startle-eliciting stimulus. The findings indicated that early selective attention effects were evident when the subjects' expectations about the modality of the stimulus were established; in particular, invalid information was associated with higher stimulus responding than was valid information. The pattern of findings suggests that selective attention effects, rather than generalized arousal effects, were responsible for subjects' responses. Further, the findings indicated that perceptual attenuation, rather than facilitation, of the relevant information occurred. The findings from the research are discussed in terms of their convergence with major theories of attention and habituation.

INTRODUCTION

This research addressed five questions: (1) can cognitive events, in particular expectations, influence early processing of sensory information, (2) can such effects be distinguished from general arousal effects, (3) when early selection is evident, does perceptual facilitation or perceptual attenuation occur, (4) what factors may influence the occurrence of early selective attention effects, and (5) do attentional processes influence the course of habituation.

Selective attention is the differential processing of simultaneous sources of information (Johnson & Dark, 1986), and

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evidence suggests that this differential processing may occur at both early and late stages of the information processing sequence (Hillyard, Hink, Schwent, & Picton, 1973; Parasuraman & Davies, 1984). Johnson and Dark (1982) have argued that during the early stages of information processing, both perceptual facilitation of relevant stimuli and perceptual attenuation of irrelevant stimuli may occur. In particular, they have argued that differential processing may occur because cognitive processes preset sensory channels to facilitate or to attenuate sensory information flow. In the current research a relatively simple psychophysiological paradigm, reflex modification, was employed in the investigation of the nature of selective attention and its effects on response elicitation and habituation.

Recent research has addressed the role of the allocation of attentional resources in habituation; for example, Öhman's (1979) model assumes that central processing resources are necessary for the occurrence of habituation. Predictions derived from Öhman's model include: (1) the more predictable the stimulus, the faster the rate of response habituation, and (2) the more attentional resources allocated to the stimulus, the faster the response habituation. These predictions were investigated in this research.

The paradigm used in this research was reflex modification, in particular, the modification of the amplitude and latency of the eyeblink startle response. There are three reasons for using this paradigm:

(1) The startle reflex is a robust but modifiable phenomenon that provides a baseline response against which both facilitation and attenuation can be measured (Hoffman & Ison, 1980).

(2) The short latency and the neural basis of the reflex excludes the possibility that higher cognitive processing of the stimulus can occur during the reflex (Davis, Gendelman, Tischler, & Gendelman, 1982).

(3) There is evidence that cognitions can influence the startle reflex through preset modulation of the afferent pathways that are involved in the reflex circuitry (Anthony & Graham, 1983; Del Pezzo & Hoffman, 1980).

For these reasons, the reflex modification paradigm allows the unambiguous interpretation of findings in terms of either early or late selective attention effects, and in terms of either perceptual facilitation or attenuation of early sensory information processing by cognitive factors. One particular reflex modification procedure, the variable warning procedure, has been developed to investigate attentional processes (Cohen, Cranney, & Hoffman, 1983). With this procedure, subjects may be given valid or invalid information about the onset and modality of impending reflex-eliciting stimuli (see Figure 1).

In applying the variable warning procedure, Cohen et al. (1983) gave subjects variable amounts of information about the reflex stimulus just prior to its presentation. The findings indicated that when subjects were told the modality (tactile or acoustic) of the stimulus to be presented (valid trials), the reflex amplitude was attenuated relative to the reflex amplitude that was displayed by subjects who were only told that a stimulus would occur (neutral trials). These data were interpreted in terms of a modality-specific early selection process; that is, a process that was acting on the sensory side of the reflex (Cohen et al., 1983).

An alternative explanation of these data, however, can be formulated in terms of the anxiety produced by a startle-eliciting stimulus perceived by the subjects as slightly aversive. Specifically, the more information subjects received about the impending stimulus, the less anxious and aroused they were, and this resulted in smaller responses to the startle stimulus. Thus, the finding of a greater eyeblink amplitude decrement following stimulus modality information (valid trials) can be explained in terms of modality information leading to either a greater decrease in anxiety-related arousal, or an early selective attenuation of sensory information. One way of obtaining data that would distinguish between these explanations would be to present subjects with misinformation about stimulus modality through the use of the valid versus invalid cue procedure (e.g., Posner & Snyder, 1975; see Figure 1). This procedure was employed in this series of studies.

The critical comparison for a test of the alternative explanations of Cohen et al.'s (1983) results is between valid and invalid trial responses. A finding of no difference in response to

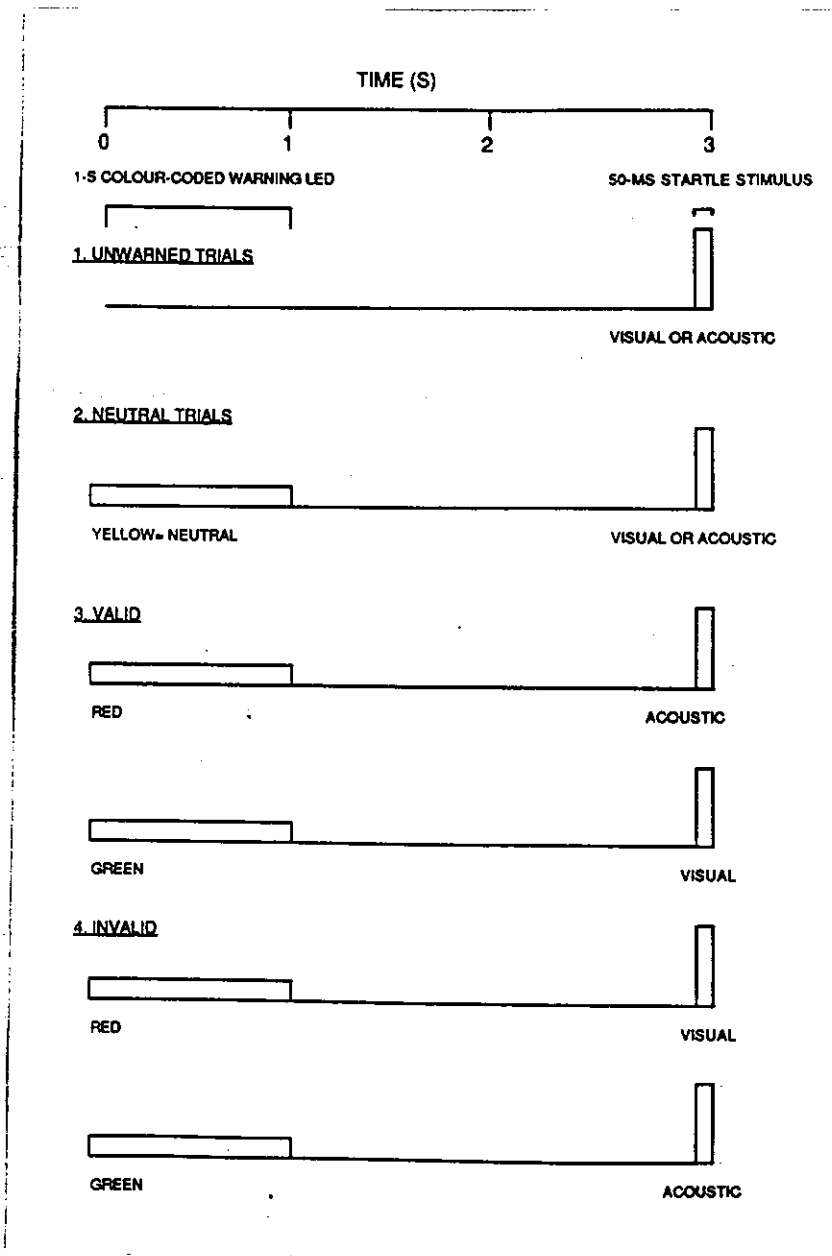


Figure 1. Schema of the types of valid and invalid trials employed in this series of experiments.

these two stimulus cue types would support the arousal explanation. In particular, if the responses to the validly cued and to the invalidly cued stimuli were no different from each other, but both were smaller than the response to the neutrally cued stimuli, then the arousal explanation would be supported. This is because modality information about the impending stimulus is assumed to lead to a decrease in responding; however, the validity of the stimulus modality information would not be registered by the subject until after the reflex has occurred, and therefore the validity information would not affect the reflex. In contrast, if the validly cued responses were smaller than the invalidly cued responses, then the selective attention explanation would be supported. This is because such differential responding reflects a modulation of sensory channels prior to stimulus presentation; such modulation would suggest preset, modality-specific cognitive influences on sensory channels. If the selective attention explanation is supported then the question remains as to whether perceptual attenuation of information processing in the relevant modality occurred, or whether perceptual facilitation of information processing in the irrelevant modality occurred. The attenuation explanation would be supported by a finding of larger responses to neutrally cued stimuli than to validly cued stimuli. The facilitation explanation would be supported by a finding of smaller responses to neutrally cued stimuli than to invalidly cued stimuli. Evidence for both facilitation and attenuation has been reported in evoked potential studies (Hillyard et al., 1973).

THE EXPERIMENT

In an early experiment, we attempted to establish a paradigm in which invalidly warned stimuli could be compared with validly warned stimuli. Unwarned, neutral, valid and invalid trials were randomly presented in a within-subjects manipulation, whereas the proportion of valid to invalid trials (i.e., the predictability of the stimulus) was manipulated between subjects. The results indicated no differences in responding to the different warned trial types. Stimulus predictability had no effect. In a further experiment, a number of methodological changes were made, including the substitution of the stimulus predictability factor with a task demand manipulation (RT response to the stimulus, no task). Although there were no differences in response amplitude amongst the trial types, the pattern of differences in response latencies were

suggestive of attenuation of sensory information processing in the relevant sensory channel (i.e., the valid trial response was slower than the neutral and unwarned trial responses). There was no effect of task demand.

A major difference between Cohen et al.'s (1983) procedures and the procedures employed in these two experiments is that the former did not include any invalid information about the nature of the RS. Thus, in the Cohen et al. study, subjects' confidence in the information would have been high, so that they should have developed strong expectations about the nature of the impending RS. It could be argued that such strong expectations are necessary for early selective attention effects to emerge. In a further experiment, then, the first 30 trials did not contain any invalid trials. Trial 31 was an invalid trial, and it was found that the response to that trial was greater than the response to the previous, validly-cued trial (see Figure 2).

This finding suggests that the subjects' expectations about the modality of the impending stimulus influenced the amplitude of the startle reflex through preset modulation of the afferent pathways that are involved in the reflex circuitry. That is, the results of this experiment supported the notion of early selective attention, and comparisons between the responses to neutral, valid and invalid trials suggest that the effect is inhibitory in nature. In particular, it seems that sensory processing of validly warned stimuli is attenuated, and this was reflected by the smaller startle response to those stimuli. A further experiment which controlled for trial order effects replicated these essential findings. The procedure employed in these last experiments does not allow any strong conclusions to be made about the comparison between neutral and valid/invalid trials, and hence about the directional nature of the early selective attention effect. An experiment which is currently being conducted is employing a slightly different procedure. In particular, the trial sequence more closely resembles that of Cohen et al. (1983); that is, it employs a mixture of valid, neutral, and unwarned trials, followed by a short series of test, including invalid, trials. This procedure should engender in subjects the appropriate expectations, and should also enable an unambiguous comparison of critical trial types, especially the neutral and valid/invalid trials. Early data suggest that the apparent perceptual attenuation of relevant stimuli in the last two experiments is confirmed.

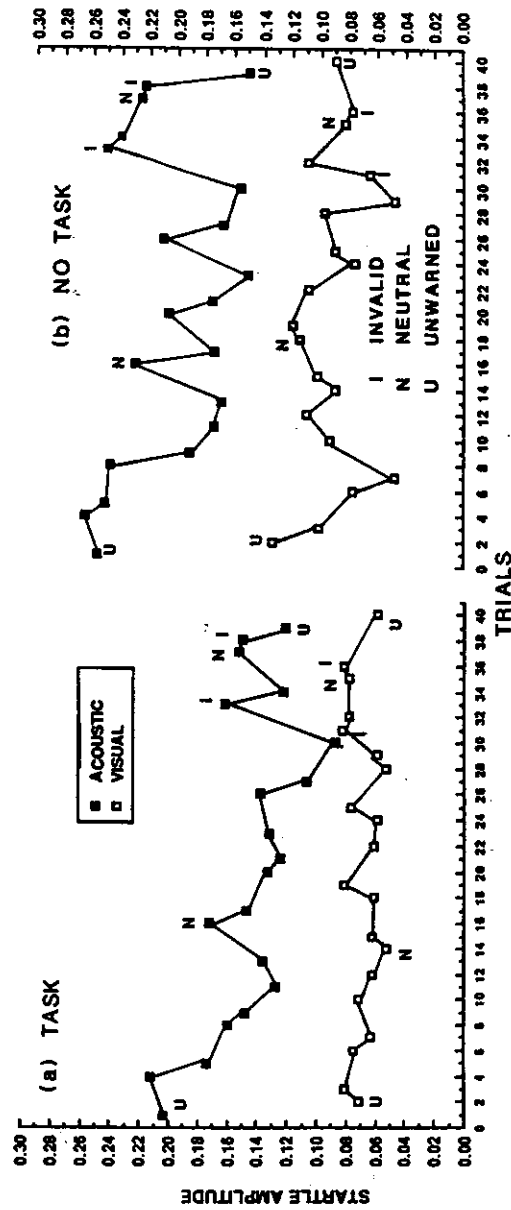


Figure 2. Mean integrated EMG eyeblink responses for (a) Task and (b) No-task groups, as a function of stimulus modality and trial. The Task group made a RT response to the startle stimulus, and the No-task group were only instructed to attend to the stimuli. All unmasked trials are valid trials. (I=invalid trial; N=neutral trial; U=unwarned trial)

DISCUSSION

The results of this research indicate that variations in responding to reflex-eliciting stimuli can reflect early, preset modulation of sensory pathways, and that this effect is not interpretable in terms of changes in arousal. The effect is dependent upon the careful establishment of subjects' expectations about the validity of the stimulus modality information. The results also suggest that the nature of the modulation is inhibitory; that is, information processing in the relevant sensory pathways is attenuated. This finding, in Johnson and Dark's (1982) terminology, suggests the operation of perceptual attenuation; in this case, however, perceptual attenuation of relevant, rather than irrelevant, information is occurring. Although Johnson and Dark did not seem to consider that possibility, it could be argued that when a stimulus has neutral or negative valence, attentional processes may lead to perceptual attenuation rather than facilitation. The salience of a stimulus may, then, influence the occurrence, and directional nature of, early selective attention effects. Overall, it appeared that task demands and more salient stimuli increased the overall level of responding above a putative threshold which allowed for the expression of early selective attention effects.

In all experiments, habituation occurred for the acoustic stimulus, but not for the visual stimulus. This lack of response decrement may be associated with the low response amplitudes elicited by the visual stimulus - there was a low level of responding to begin with, so less habituation occurred. Of interest is the general lack of effect of group differences on the amount of habituation. Neither the different levels of stimulus predictability in the first experiment, nor the different task demands in the later experiments, appeared to have any significant effect on habituation. This is contrary to the predictions derived from information-processing theories of habituation (Öhman, 1979; Wagner, 1976), in particular, that the more predictable the stimulus or the more attention directed toward a stimulus (as would occur with task demands), the greater would be the rate of habituation. Further research is required to check the alternate explanation that the current procedures did not provide a sensitive test of the predictions.

In conclusion, the findings from this research suggest that (1) cognitive events, in particular expectations, influenced early processing of sensory information, (2) these effects were distinguishable from general arousal effects, (3) when early selection was evident, perceptual attenuation of relevant information occurred, (4) factors which appeared to influence early selective attention effects included stimulus salience, and subjects' experience of the validity of warning information, and (5) attentional manipulations did not appear to influence the course of startle reflex habituation.

CORRESPONDENCE

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