Electrophysiological correlates of instrumental learning

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The experimental investigation of instrumental learning has sought to describe how the outcome (O) of an action or response (R) brings about a change in the subsequent probability of the action. The conventional wisdom has been that the outcome simply strengthens an association between the discriminative stimulus (S) or context that is present when the action is reinforced, and the reinforced response. We employed a biconditional discrimination learning procedure: one discriminative stimulus S1D signaled that the emission of R1 would earn O+ while the emission of R2 would earn O–. Another stimulus, S2D, signaled that the outcomes for R1 and R2 were reversed. Written as a hierarchical associative structure, subjects had to encode S1D:(R1 > O+, R2/O–)/S2D:(R1 > O–, R2 > O+). In the double discrimination described here, two separate discriminative capacities may be involved; one is the discrimination of the exteroceptive stimulus, the other, the proprioceptive discrimination of the response (action monitoring).

We present data from 3 experiments. In all experiments, exteroceptive stimuli differed with respect to their brightness. In the first two experiments, the proprioceptive discrimination was based on the time that elapsed between two responses that had to be executed in rapid succession (inter-response intervals or IRIs). In order to explore the generalizability of our findings, the proprioceptive discrimination was based on response force rather than the time interval between two responses in the third experiment.

The behavioral results indicated that the acquisition of the double discrimination was distributed bimodally: about 50% of the subjects clearly acquired the contingency, whereas the remaining subjects did not (within 640 acquisition trials). The behavioral results revealed in addition that the criterion responses (IRI, response force) of learners adapted specifically to the contingencies of the double discrimination.

The ERPs of learners showed a prominent frontocentral positivity (FP) that was clearly absent in the ERPs of non-learners. FP in learners was apparent in the very early stages of the experiment, that is, long before the contingency was acquired. The early appearance of FP rules out the possibility that FP might be a consequence of learning. We infer that FP is a necessary prerequisite for the acquisition of our instrumental double discrimination task.

Our discussion focuses on the functional role of FP. We argue that FP was (a) response-synchronized and emerged (b) well before the execution of the response. We will discuss whether FP is related to the planning and/or the discrimination of the response or to the retrieval of stored regularities. In addition, we present a pre-movement "error-related negativity" and a sustained outcome-preceding negativity which appeared whenever the subject detected a response that did not obey the contingency so that an aversive outcome had to be expected.

Localization of task difficulties using ERPs: A difficulty we need to localize

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Increasing task difficulty usually leads to the increase of RT which poses the question at what level the difficulty is localized. The ERP technique has been broadly used to answer this question. A rule assumed in most studies is that the delay of the P3 latency indicates a problem located at the level of stimulus evaluation (e. g., the necessity to re-evaluate the stimulus once more), whereas an inappropriate lateralization of the premotor negativities (i. e., the motor cortex ipsilateral to the responding hand is more active than that contralateral to the responding hand) indicates that the difficulty is caused by response competition. However, when several ERP components are simultaneously used for locating the task difficulty in the same experimental paradigm, results are often contradictory. A common finding has been that ERP data "overexplain" the actual task difficulty. For example, ERP data indicate difficulties existing at both perceptual AND motor levels, whereas each of them alone would be enough to explain the observed RT delay.

This results in a difficulty which, in turn, should be localized by information processing researchers. It can be shown that the notion of processing stages being broadly overlapping in time (rather than strictly consecutive) may be necessary but not sufficient to solve this problem. Another approach is suggested which assumes that processing levels have to be taken into consideration instead of (or, maybe, in addition to) processing stages.

How attention modulates central odor processing

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The influence of attention on the processing of odors has rarely been addressed in olfactory research. Most studies have used rather indirect measures as performance data or measures of central arousal to assess the impact of non-attended odors on information processing. The recording of chemosensory event-related potentials (CSERPs), however, provides a direct measure of the time course of odor processing itself. The aim of the present studies was to investigate, with the aid of CSERPs, how the processing of olfactory stimuli is affected by the allocation of attention.

A classic paradigm for the investigation of attention in ERP research has been the presentation of two classes of stimuli, frequent and infrequent stimuli, under "ignore" and "attend" conditions. In the ignore

condition the subjects are always asked to ignore the stimuli and are, in most cases, also instructed to focus on a specified "distractor task." Under attend conditions subjects were required to discriminate frequent and infrequent stimuli, e. g., by showing a motor reaction in response to the infrequent stimulus.

In the first study the same dilution (1:50 v:v, diluted in propanediol) of linalool (lavender) and eugenol (clove) was presented to 6 healthy male subjects under "ignore" and "attend" conditions. In each condition each odor served once as the frequent and once as the infrequent stimulus. In the "ignore" condition the subjects were instructed to ignore the odors and to concentrate on an auditory distractor task. In the "attend" condition subjects were asked to lift their index finger every time they detected the infrequent odor. In each session subjects were presented with three series of 50 trials, and in each series the trials were delivered in blocks of five with an interstimulus interval of 8 s. The time interval between the blocks was 60 s. The infrequent odor was presented with a probability of 20%. A constant flow olfactometer was used for stimulus presentation.

The EEG was recorded from Fz, Cz, and Pz referred to linked mastoids. In order to control for ocular artifacts the EOG was measured with five facial electrodes.

The results show that the late positive complex seems to be most affected by the amount of attention invested in the processing of odors, suggesting that late evaluative processes are modulated by attention. However, in the attend condition all components showed significantly shorter latencies than in the ignore condition. This finding indicates that the investment of attention facilitates the processing of olfactory information already at an early processing stage.

In the second study 3 female and 3 male subjects were presented with their own odor and that of a foreign odor (axillary hair). In contrast to linalool and eugenol, body odor is a complex mixture which might have an inherent significance for the perceiver. The experimental set-up of both studies was identical except that in the second experiment the odors were presented in blocks of ten.

The results again show that the late positive complex is nearly absent when attention is diverted from the odors, independent of the complexity and significance of the odor presented.

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40 Hz ERD/ERS and automatic auditory word perception

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The ERD/ERS of 40 Hz EEG was studied in an auditory ignore task in 8 adults, using a passive auditory oddball paradigm with two types of stimuli: Finnish words (standard /tu:li/ "wind" and deviant /tuli/ "fire") and pseudowords (/tu:ni/ and deviant /tuni/). ERD/ERS, defined as the relative difference in 40 Hz EEG power between the presentation of standard and deviant stimuli was examined as a function of time separately for words and pseudowords. In this exploratory study, we examined whether the passive auditory oddball paradigm, based on automatic auditory perception, would be indexed by 40 Hz ERD/ERS. Further, we were interested in whether 40 Hz responses would differentiate between unattended verbal and nonverbal stimuli. The main effect for stimulus type failed to reach the level of significance. We observed a significant main effect for TIME and also a significant STIMULUS TYPE × TIME interaction indicating a 40 Hz enhancement, however, only for words. The results demonstrate that the 40 Hz EEG responses are modulated as a function of time and moreover, that the responses differentiate between verbal and nonverbal stimuli as a function of time. The differences in the ERD/ERS of 40 Hz EEG between verbal and nonverbal stimulus conditions suggest that the memory representation of the verbal standard stimuli are not merely based on the physical features of the auditory stimuli.

Organization of emotional perception in anhedonia: A psychophysiological analysis on a non-patient population

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Psychophysiological studies in anhedonic subjects, potentially at risk for psychopathology because of a deficient ability to experience pleasure, have demonstrated abnormalities in the ERP, i. e., in a tone discrimination paradigm, Miller and Giese-Davis reported enhanced N200 and possibly attenuated P300. These findings provided evidence of perceptual information processing difficulties, particularly a deficit in the use of memory template, in anhedonics. The data are consistent with Knight's model of early stimulus processing deficits in schizophrenia.

There has been very little work using ERP measures in emotion research. Nevertheless, one study of emotional face processing as a function of depression has shown a clear group difference in the so called N200. Another study of potentials related to the emotional valence for faces in normal subjects indicated that emotional face expression has clear effects on early stages of brain processing, prior to face identification or contextual integration.

In the present work, the organization of emotional perception was studied in an emotional rating task; evoked potentials were recorded from the scalp of anhedonic and non-anhedonic normal subjects in response to color slides of unfamiliar faces with happy, unhappy, or no expression.

The results showed that facial expressions had no