Abstract

Studies suggest that people's sensitivity to punishment may change from day to day, and such changes could impact mood and mental disorders. Of particular importance may be the sensitivity to primary aversive stimulation such as pain or loud noises (as opposed to secondary, conditioned punishment like monetary loss), since this is the most basic and natural form of punishment in animals and humans and can have a long-term impact on behavior. However, experimentally testing learning from primary aversive stimulation is difficult even in a single day lab experiment, let alone in an experiment that aims to assess and re-assess such learning over multiple days, which can be complicated by the problem of habituation to the experimental punishment. The goal of this project was to develop an experimental paradigm that can probe learning from primary punishment over multiple days. For this purpose, we developed a phone-based punishment learning task that administers punishment via headphones. The task allows quantifying both sensitivity and responsivity to punishment, with the former manifesting in the degree to which subjects tend to avoid experimental stimuli previously associated with punishment, and the latter in heartrate responses to punishment as measured through a wearable sensor. The experiment was conducted outside of the laboratory and was monitored remotely by the experimenter. 6 subjects performed an experimental session on their mobile phone twice a day, for 12 days. For comparison, another group of 6 subjects performed the experiment with secondary punishments, which consisted of monetary losses. On each session, subjects had to learn via trial-and-error the probabilities with which choices of different images (textured circles) led to punishment. Primary punishment consisted of a loud noise played through headphones put on during the sessions. To ensure that participants are receiving the punishments properly, an attention listening task was administered randomly between trials. On each session subjects learned about new stimuli. To assess how well learned information was remembered, on some trials subjects were asked to choose between images they had already learned about on previous days. To evaluate whether the experiment successfully probed learning from punishment over the 12 days of the experiment, we examined the degree to which subjects successfully avoided images that were associated with larger probability of punishment. As an implicit and more direct measure of the emotional impact of the punishment, we also measured subjects’ heartrate responses to outcomes in the learning task.

Results showed that subjects learned stimulus probabilities and remembered them even a few days after learning ended, which indicates good enduring conditioning to the aversive stimulus. Moreover, almost no decline in choices accuracy was observed during the progress of experiment days which suggest low habituation to the experimental punishment.  **Heartrate** analysis showed high responsivity to the loud white noise as well as the to the monetary loss punishment.

Due to the small pool of subjects we had, no conclusive analysis to the differences between groups was possible, although as a preliminary observation subjects of the primary punishment condition formed slightly stronger and more lasting learning.

These results confirms that the experiment procedure is a valid paradigm to produce reliable data for investigating sensitivity and responsivity to punishment over multiple days and the effect it has on instrumental learning mechanisms.