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A Study of the Training Possibilities of *Araneus diadematus* Cl.[1]

Though the behavior of spiders appears largely to be organized in rigid patterns which are innate, observations have been reported which show their ability to modify such behavior through experience. When the PECKHAMS[2] in 1887 'describe an attempt to teach a very interesting docile little female spider of the species *Cyclosa conica* Menge to listen composedly to the vibration of the tuning fork' they find it 'remarkable that one (spider) of them should have learned the sound of the vibrating fork so soon, and should have modified her action accordingly'. Recent observations on conditioning in a flatworm *Dugesia dorotocephala*[3] indicate too that invertebrates are more plastic in their behavior than expected. The description of the spider vibration receptor[4] and its electrophysiological analysis[5] point towards the ability of the spider to discriminate between different frequencies of vibration. It should be possible to measure this discriminatory ability in a spider's learned behavior.

For these experiments the spider *Araneus diadematus* Cl. was used. The adult female lives in the middle of its geometrical orb web and can be enticed to run to any part of that web if a vibrating tuning fork is held against it[6]. Five spiders were kept in individual aluminum frames with removable glass doors in the front and back (for details of method see[7]). They received a minimum diet of house flies and an 8% glucose water solution. In the first phase of the training period the spider was exposed to a dead fly which had been dipped first in AF type Anti-foam liquid emulsion and then in water containing 0.5% (w/v) quinine or 6% glucose. The dead quinine fly–presumed to carry an aversive taste–was thrown into the web first and made to vibrate through the touch of a C tuning fork. About 5 min later the glucose fly–presumably of agreeable taste to the spider–was presented together with a C[1] tuning fork. The spiders reacted in 4 different ways to the presentation which can be described as enwrapping, discarding, biting or no reaction. The experiment was repeated 48 times during

90 days according to the same pattern. After 15 trials all spiders regularly discarded and/or enwrapped the quinine-C fly and bit the glucose-C^1 fly. These results indicate that all spiders learned to distinguish between the first-quinine-C combination and the second-glucose-C^1 combination. In the second phase the sequence was switched for 4 trials. The spiders still bit the glucose-C^1 fly and discarded and/or enwrapped the other fly every time showing that the sequence did not affect the spiders' reaction. In a third phase the taste was paired with the opposite tone four times for each spider. Here they bit the glucose-C fly and discarded and/or enwrapped the other, obviously taking their clue from the taste. Consequently a fourth period of 16 trials was conducted in the same way as the first. The spiders, however, arrived at the originally learned pattern already after 5 trials. This seemed to indicate some retention on the spiders' part of the first learned behavior. In the last phase the flies were replaced by glass beads to which no taste was added. Supposedly the frequency of the tuning fork was now the sole clue for the spiders. The resulting constant behavior of discarding and/or enwrapping the C-bead and biting the C^1-bead indicates that the spiders could discriminate between these frequencies. This constitutes a quantitative behavioral proof for the postulate from Walcott's electrophysiological experiments[5], namely, that a spider can discriminate accurately two frequencies of vibration. The spiders, furthermore, associated each frequency with a previous experience as was shown in the last phase of the experiment. Such a learned behavior could be elicited soon again after several weeks, indicating good retention. These findings together with previous observations that some changes in the web with age depend on the spiders' change in body weight and leg length[8] and that food deprivation can change the mesh width of the web[9] point towards considerable plasticity which is superimposed on the innate patterns of behavior of the invertebrate spider.

Zusammenfassung: Kreuzspinnen verhielten sich verschieden, je nachdem ob eine tote Fliege mit Chininlösung, die durch eine vibrierende C-Stimmgabel in Bewegung gesetzt war, zuerst, oder eine Fliege in Glukoselösung, die durch eine C^1-Stimmgabel vibrierte, als zweite ins Netz gereicht wurde. Durch Vertauschen der Faktoren konnte gezeigt werden, dass der Geschmack den auslösenden Reiz bildet. Wenn hingegen geschmack-

lose Glasperlen mit den Tönen kombiniert wurden, richteten sich die Spinnen in ihrem Verhalten nach der Schwingungsfrequenz. Diese Ergebnisse zeigen die Fähigkeit der Spinnen, sowohl zwischen verschiedenen Schwingungsfrequenzen zu unterscheiden, als auch ihr Verhalten der Erfahrung anzupassen.

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