Handedness Influences Intermanual Transfer in Chimpanzees (Pan troglodytes) but not Rhesus Monkeys (Macaca mulatta)

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Background

- Intermunal transfer refers to an effect whereby training one hand to perform a motor task improves performance in the opposite untrained hand (e.g., Schulze, 2002).
- We tested the hypothesis that handedness facilitates transfer in two nonhuman primate species: rhesus monkeys and chimpanzees.
- We chose these model species because (1) they differ in the motor control of the arms and (2) they differ in the distribution and direction of handedness.
- Rhesus monkeys have greater ipsilateral control of the upper arm and shoulder compared to chimpanzees (Brinkman & Kuyper, 1973; Kuyper, 1982).
- Handedness in rhesus monkeys has been equivocal (c.f., Bennett et al., 2006). By contrast, there is substantial evidence for population-level right-handedness in chimpanzees (e.g., Hopkins et al., 2011).

Subjects

- 13 adult rhesus monkeys housed at the University of Massachusetts Amherst (8 males; 5 females).
- 52 adult chimpanzees housed at the Yerkes National Primate Research Center (18 males; 34 females).

Handedness Groups

- The hand used for simple reaching was recorded for 50 trials. A Handedness Index (HI) was computed for each subject, HI = (# Right – # Left)/Total. Positive HI scores were considered right-handed and negative scores left-handed. See Table 1 for a distribution of subjects across handedness groups by species.

Methods

- Subjects were trained to remove a candy or a washer (exchanged for a treat) from three simple rods (Fig. 1).

Test of Transfer

- Transfer was measured by latency by comparing the average time taken to solve the task using a novel rod (Fig. 2) in the first session with the training hand compared to the first session with the untrained hand. Training was complete when subjects met a time criterion over two consecutive test sessions.

Figure 1. Rods used in monkey pre-training from left to right: S-shaped, straight, question-mark. Chimpanzees received the same three shapes in pre-training but rods were larger and presented horizontally.

Figure 2. Novel wave-shaped rod used in test of transfer. Picture depicts monkey setup with a Life Savers® candy. Chimpanzees removed a washer and exchanged it for a treat.

Results

- Rhesus Monkeys
  - Intermunal transfer (i.e., shorter latency in the untrained hand) occurred whether monkeys trained with the DOM or NDOM (Fig. 3), or whether monkeys were left-handed or right-handed.

Figure 3. Data from rhesus monkeys. The second (untrained) hand was significantly faster than the first hand regardless of whether training occurred with the DOM, t(5) = 3.110, p < .05, or the NDOM, t(6) = 4.867, p < .01.

- Chimpanzees
  - Intermunal transfer was unidirectional, occurring only when training occurred with the DOM in chimpanzees (Fig. 4).

Figure 4. Data from chimpanzees. The second (untrained) hand was significantly faster than the first hand regardless of whether training occurred with the DOM, t(5) = 3.110, p < .05, or the NDOM, t(6) = 4.867, p < .01.

Discussion

- Data from rhesus monkeys support the cross-activation model because a benefit occurred independent of which hand (DOM or NDOM) was trained. The untrained hand was always faster to solve the task.
- Data from chimpanzees partially support the proficiency model because a benefit occurred only when the DOM was trained. However, this pattern only held for right-handers when handedness subgroups were examined.
- The finding that there was transfer in both directions (DOM->NDOM and NDOM->DOM) regardless of handedness in rhesus monkeys but not in chimpanzees suggests that motor information may be transferred differently in the two species.
- Future work that utilizes imaging techniques is needed to characterize where motor programs are stored and accessed during learning, and to elucidate the mechanisms involved in intermanual transfer in primates.

Conclusion: As evidenced by transfer and handedness patterns, brain organization may differ between monkeys and chimpanzees. Perhaps only chimpanzees have hemispheric specialization of motor function.

References


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