PROPRIOCEPTION VERSUS MOTOR OUTFLOW IN TIMING:
A REPLY TO JONES

RICHARD A. SCHMIDT
University of Michigan

Jones' point that the motor outflow hypothesis should be considered a rival to the proprioceptive feedback interpretation of the motor response timing data reviewed by Schmidt has potential merit. However, with no data ruling in favor of motor outflow over proprioceptive feedback for timing, and with other peripheral feedback channels (e.g., vision) known to be mechanisms for timing, the proprioceptive feedback explanation is favored over motor outflow.

Rather than the proprioceptive feedback interpretation for some of the data I reviewed in my paper (Schmidt, 1971), Jones (1973) prefers an interpretation wherein motor outflow to the muscles provides a basis for the timing of future responses. Jones' point is that the data discussed in terms of the proprioceptive feedback input hypothesis did not rule out the possibility of motor outflow, and that, therefore, the motor outflow view was also deserving of attention as a possible explanation for that body of data. Strictly speaking, he is correct.

While space does not permit an extensive comparison of the motor outflow and proprioceptive feedback hypotheses for movement control, it should be pointed out that, using motor responses, there seem to be two lines of evidence for the outflow hypothesis which cannot be handled by other theories. First is the evidence by Angel, Garland, and Fischler (1971) who showed that subjects could correct errors in step tracking without peripheral feedback. Second, the evidence by Taub and Berman (1968) that monkeys could learn motor responses after deafferentation may indicate that some form of feedback was mediating learning. These studies point to the possibility of internal monitoring of the motor outflow to the muscles via a rapid feedback loop as a mechanism in motor learning and performance. To the contrary, that a subject can execute movement in the absence of any peripheral feedback (e.g., Lashley, 1917) and that the accuracy of duplication is a function of active versus passive presentation (e.g., Jones, 1972) can be handled easily by the notion of the motor program (see Keele, 1968; Schmidt, 1972; Schmidt & Russell, 1972). The problem with all this evidence for the present question is that it deals with the spatial aspects of movement production and error correction, whereas the present issue concerns mechanisms for determining the time of initiation of these sequences (e.g., the time to initiate a swing so as to hit a pitched ball). Of course, the possibility of internal monitoring for one class of behavior does not provide assurance that internal monitoring is involved in timing.

In sharp contrast to the suggestion that outflow is involved, there is strong evidence that peripheral information plays a powerful role in timing. Consider vision, for example, in a situation where the subject must respond exactly 2.0 seconds after a starting signal while either watching or not watching a clock. Some of our unpublished evidence shows that with vision, subjects make absolute errors of only a few milliseconds, while without vision (e.g., Quesada & Schmidt, 1970) the mean absolute error is about 100 milliseconds. Clearly inflow from the periphery can aid timing. Since there is no logical necessity to assume any fundamental difference between proprioceptive feedback and the other senses (other than, of course, those differences involving the specific receptors or the types of physical stimuli detected), it would seem that Jones' (1973, p. 5) suggestion that the proprioceptive feedback hypothesis could be ruled out if passive movements had been employed in the Schmidt-Christina (1969) experiment.

---

1 Reprint requests should be sent to Richard A. Schmidt, Department of Physical Education, University of Michigan, Ann Arbor, Michigan 48104.
would be certain to support the proprioceptive feedback hypothesis. What is the difference between having a subject watch a clock or having his limb moved predictably for 2.0 seconds? Both provide reliable sensory information about the passage of time, and proprioceptive feedback would almost certainly be superior to no feedback at all. In fact, we (Schmidt & Christina, 1969) did not use passive movements because we wanted to rule out this explanation, as we were interested not in whether the subject could use proprioceptive feedback to time (which seemed obvious) but whether, in fact, he did use the feedback. Our findings indicated that he did, although we must admit the possibility that they could have been using motor outflow information.

Therefore, since there is the possibility that a motor outflow mechanism may be involved in timing as it may be with motor control situations, and since the timing data do not strictly rule out this view, Jones' point that it should be considered a rival to the proprioceptive feedback hypothesis is well taken. However, because there is support that peripheral information is strongly involved in timing, and there is no direct support that a motor outflow mechanism is involved, I naturally prefer to interpret the timing data in proprioceptive feedback terms. The answer to Jones's question, "Is there any proprioceptive feedback?" seems to be "Yes" for timing. We now anxiously await solid data which answer affirmatively the question, "Is there any outflow in timing?"

REFERENCES


JONES, B. Outflow and inflow in movement duplication. Perception and Psychophysics, 1972, 12, 95-96.


(Received June 7, 1972)