Scientists Identify Transition Between Easy and Difficult Tasks

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Scientists have found that the nervous system uses different control mechanisms for easy and difficult aiming tasks, in order to optimize motor performance. Hand drawn by Hans Holbein the Younger around year 1523.

(PhysOrg.com) -- One of the primary ways in which we as humans can manipulate our environment involves working with our hands, using them to point, reach, and handle tools such as pens, needles, and screwdrivers. While it's clear from everyday observation that it takes longer to perform difficult aiming tasks (those that require precise, detailed movements) than easy ones, scientists have long thought that performance time increases linearly with task difficulty. However, a new study shows that the human nervous system is more complicated than this theory suggests.

In their study, Raoul Huys, Laure Fernandez, Reinoud Bootsma, and Viktor Jirsa from the University of the Mediterranean in Marseille, France, have investigated the relationship between task difficulty and movement speed. Until now, this relationship has been thought to be continuous, as expressed by Fitts' law. Proposed in 1954 by Paul Fitts, the law states that the time needed to successfully perform an aiming movement increases linearly with task difficulty.

However, Huys and his coauthors found something different: that the relationship between task difficulty and movement speed is discontinuous. The researchers identified a specific level of task difficulty at which a transition occurs, where the human nervous system abruptly engages a different control mechanism for difficult tasks. Specifically, humans seem to use faster rhythmic movements when performing easy tasks, and slower discrete movements when performing difficult tasks.

“Of greatest significance is the finding that two control mechanisms are involved in reciprocal precision aiming and that each of them adheres to its own particular speed-accuracy trade-off,” Huys told *PhysOrg.com*. “This puts the well-known speed-accuracy trade-off in a completely different light than previously held. It also tells us that evolution has endowed us with different functional modules that each adhere to its own merits and limitations, and that we can use them in order to optimize motor performance given certain task constraints.”

The scientists arrived at these conclusions after performing experiments in which participants moved a cursor back and forth between two targets on a screen as quickly and accurately as possible. There were 12 different versions of the test, with 12 different target widths to represent varying levels of task difficulty. The researchers measured each participant’s total movement time, as well as its constituents, acceleration time and deceleration time, which were defined as the duration prior to and following peak velocity, respectively. The scientists found that total time and deceleration time always increased as task difficulty increased. However, acceleration time stopped increasing at a certain degree of difficulty, revealing a discontinuity between easy and difficult tasks.

This transition seems to mark the point at which a different control mechanism becomes engaged, evoking a change from rhythmic to discrete movements. The results suggest that, when moving rhythmically, both acceleration time and deceleration time increas with increasing task difficulty. But after the transition to discrete movements, only the deceleration time increased. Thus, acceleration time is not a continuous function of the degree of difficulty, implying that Fitts' law is discontinuous due to a change in the control mechanism. The researchers think that this discontinuity has not been observed before because most experiments have focused primarily on the more difficult discrete movement tasks while overlooking easier rhythmic tasks. As Huys explained, the discovery of the two control mechanisms could have applications in man-machine interfaces, robotics, and sensorimotor rehabilitation.

"In robotics, the two control mechanisms have sometimes been implemented," Huys said. "Our result indicates that which mechanism should be indicated depends on the speed and accuracy requirements of the task to be fulfilled. In addition, clinicians are still seeking for easy to be implemented clinical assessment tools in the context of sensorimotor rehabilitation and neurological and motor pathology evaluation. We hope that our result may help their development."

In the future, the scientists hope to further explore how neurological and motor pathologies affect the utilization of the control mechanisms.

"The first population that we will investigate is patients suffering from Parkinson's disease," Huys said. "Thereto, one of my coauthors, Laure

Fernandez, has recently initiated a collaboration with the La Timone Hospital here in Marseille. Another future avenue that we would like to pursue is to investigate how the nervous system of (healthy) humans implements the two motor control mechanisms."

More information: Raoul Huys, Laure Fernandez, Reinoud J. Bootsma, and Viktor K. Jirsa. "Fitts' law is not continuous in reciprocal aiming." *Proceedings of the Royal Society B*. doi:10.1098/rspb.2009.1954