Planning m l le mo emen i hin a fi ed ime limi : The co of con ained ime alloca ion in a i o-mo o a k

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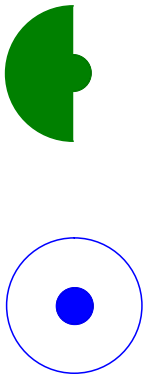
S.-W. Wu, M. F. Dal Martello, and L. T. Maloney (2009) evaluated subjects' performance in a visuo-motor task where subjects were asked to hit *two* targets in sequence within a fixed time limit. Hitting targets earned rewards and Wu et al. varied rewards associated with targets. They found that subjects failed to maximize expected gain; they failed to invest more time in the movement to the more valuable target. What could explain this lack of response to reward? We first considered the possibility that subjects require training in allocating time between two movements. In Experiment 1, we found that, after extensive training, subjects still failed: They did not vary time allocation with changes in payoff. However, their actual gains equaled or exceeded the expected gain of an ideal time allocator, indicating that constraining time itself



E e imen 1: The effec of aining

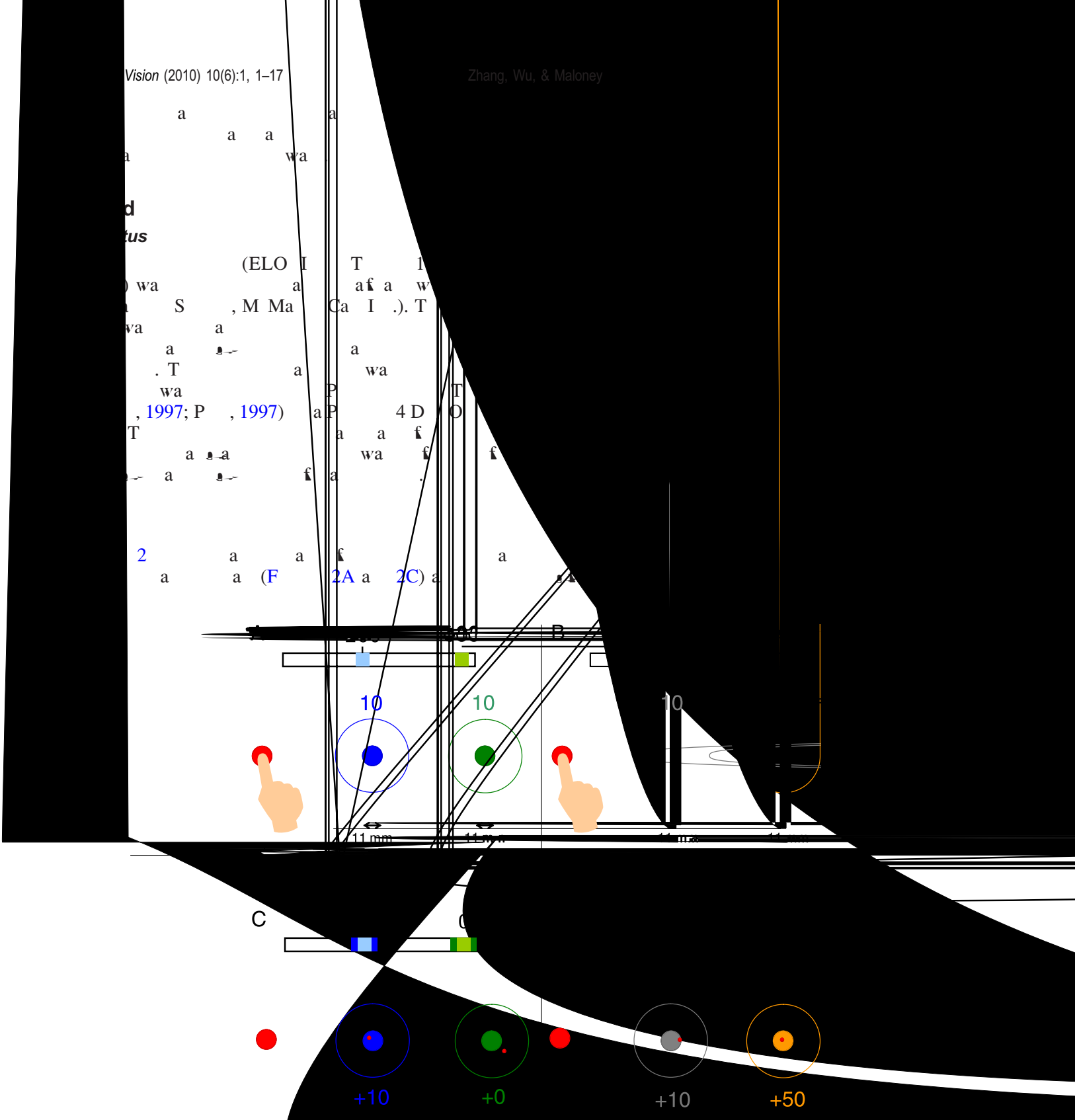


Figure 2. An illustration of the sequential movement tasks. (A) The constrained timing task in the training session. Time windows marked on a timing bar specified the required movement durations. The colors of the first and second time windows corresponded to the colors of the first and second targets. (B) The choice timing task in the test session. The first and second targets were silver and golden, respectively. Silver targets were worth 10 points. Golden targets were worth 50 points. (C) Feedback for the constrained timing task. Vertical lines on the time bar marked the times when the subject hit each target. Dots (shown here in red to improve visibility) marked the subjects' spatial endpoints. (D) Feedback for the choice timing task for the last four subjects, similar to feedback of the constrained timing task. Feedback for the first four subjects consisted of a report of total winnings or written messages specifying that they had violated one of the conditions for a reward (e.g. "You were too slow").

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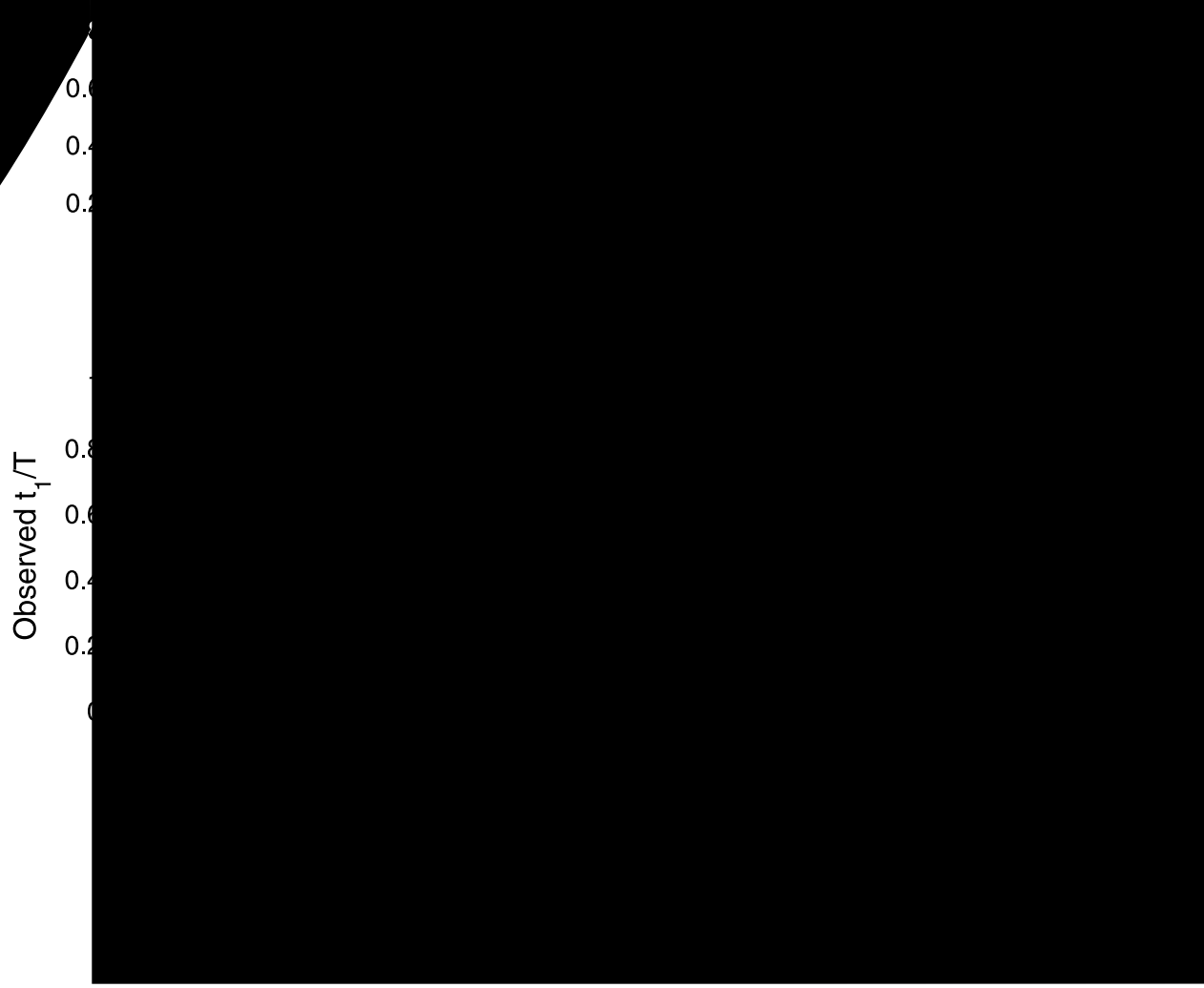

& T a , 1993), a f a w 10,000 . A 95% , a w a a f , a a w a a a - . H w , a w a , a a f a a a wa a 1/ . T a a wa 0.52. C w a a a , a , w - a S ' - , wa a a a , (7) = 5.72, < .001, a a a a , (7) = −5.20, = .001.

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The independence of the two movements

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F a a a , w a a f a wa . (2| 1) a a (2| 1) F 4 f a (a). A P a , χ^2 f , a 95% (B f f), (2| 1) f (2| 1) f w a a f w f w a (F 4). P , w a a a a w w a a a a , a w f W a . (2009).

Parameter estimation

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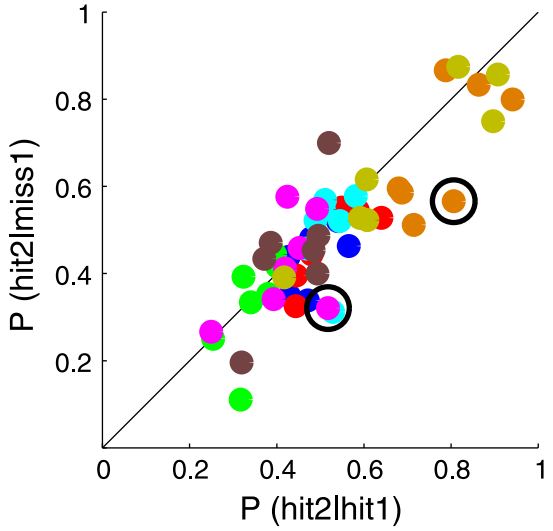

Figure 4. Movement independence. The probability of hitting the second target conditional on missing the first is plotted against the probability of hitting the second target conditional on hitting the first for each timing and value condition, for each subject. Each color denotes the results for one subject. If the two movements were independent, the data points should not depart significantly from the identity line. We tested equality of the two conditional probabilities using Pearson's χ^2 test with Bonferroni correction for seven conditions (overall .05 significance level corresponds to corrected level .0071). Only two differences proved to be significant (circled).

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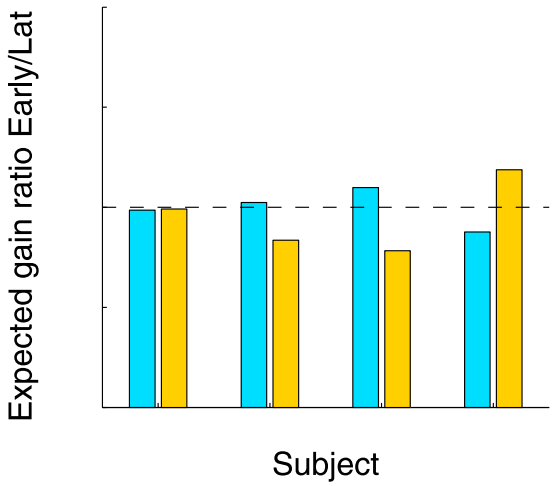

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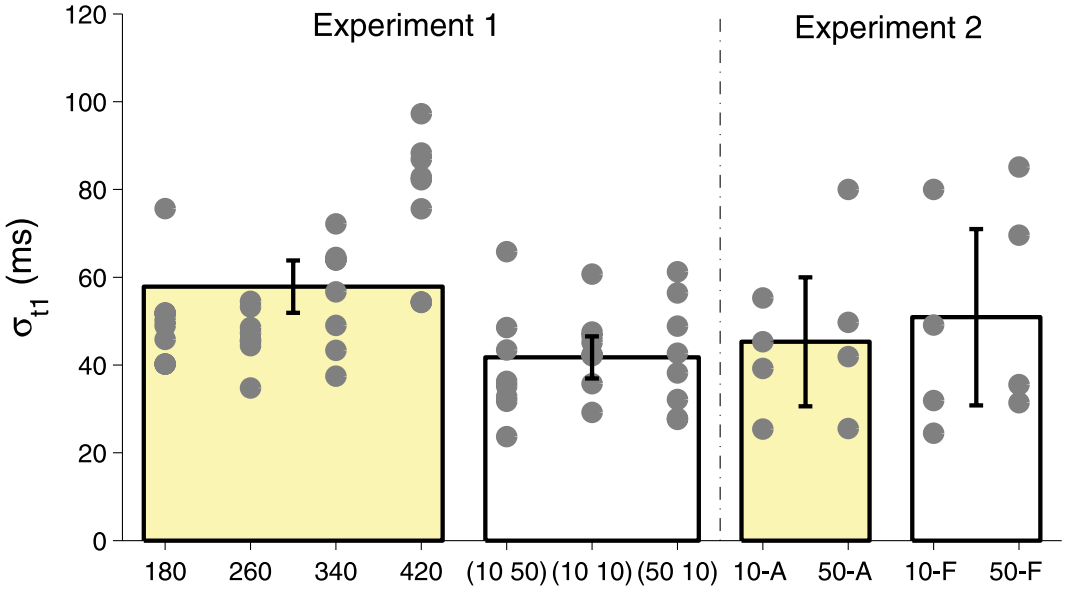

Figure 11. Temporal movement uncertainty. The standard deviation of t_1. The effort to constrain t_1 to a specified time window, as in the constrained timing conditions of Experiment 1 or 2, did not lead to a smaller standard deviation than when there was no need to control t_1. Each gray dot above a condition of Experiment 1 or 2 denotes the data of a subject under that condition. The bars shown serve to group conditions. The height of each bar is the mean across the conditions grouped. Yellow bars group the constrained timing conditions. White bars group the choice timing conditions. The error bars mark the 95% confidence intervals of the means.

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D , J., & G , S. (2009). R a f a a f a w a a a . 283 288. [P M]

D a , N. R., & S , H. (1998). (3 .). N w Y : W -I .

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G a a a , R., & W , M. B. (1968). P a a f a a f a a. 1 17. [P M]

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M , D., S , J., & W , C. (1982). M f a a a f a . 449 482. [P M]

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S , R. A., Z a , H., Haw , B., F a , J. S., & Q , J. T. (1979). M - a a : A f a a f a a . 415 451. [P M]

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