Planning m l i 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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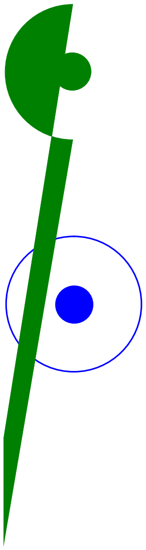
S.-W. Wu, M. F. Dal Martello, and L. T. Maloney (2009) evaluated subjects' performance in a visuo-motor task where subjects were asked to hit *two* targets in sequence within a fixed time limit. Hitting targets earned rewards and Wu et al. varied rewards associated with targets. They found that subjects 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 has a cost for motor accuracy. In a second experiment, we found that movements made under ex[illegible]its were [illegible] movement in our task and that subjects pursued different motor strategies with distinct speed–accuracy tradeoffs in different conditions.

Keywords: Bayesianecision theory, expected utility, op3Tality, Fitt 's Law, reaching, touching

Citation: Zhang, H., Wu, S.-W., & Maloney, L. T. (2010).



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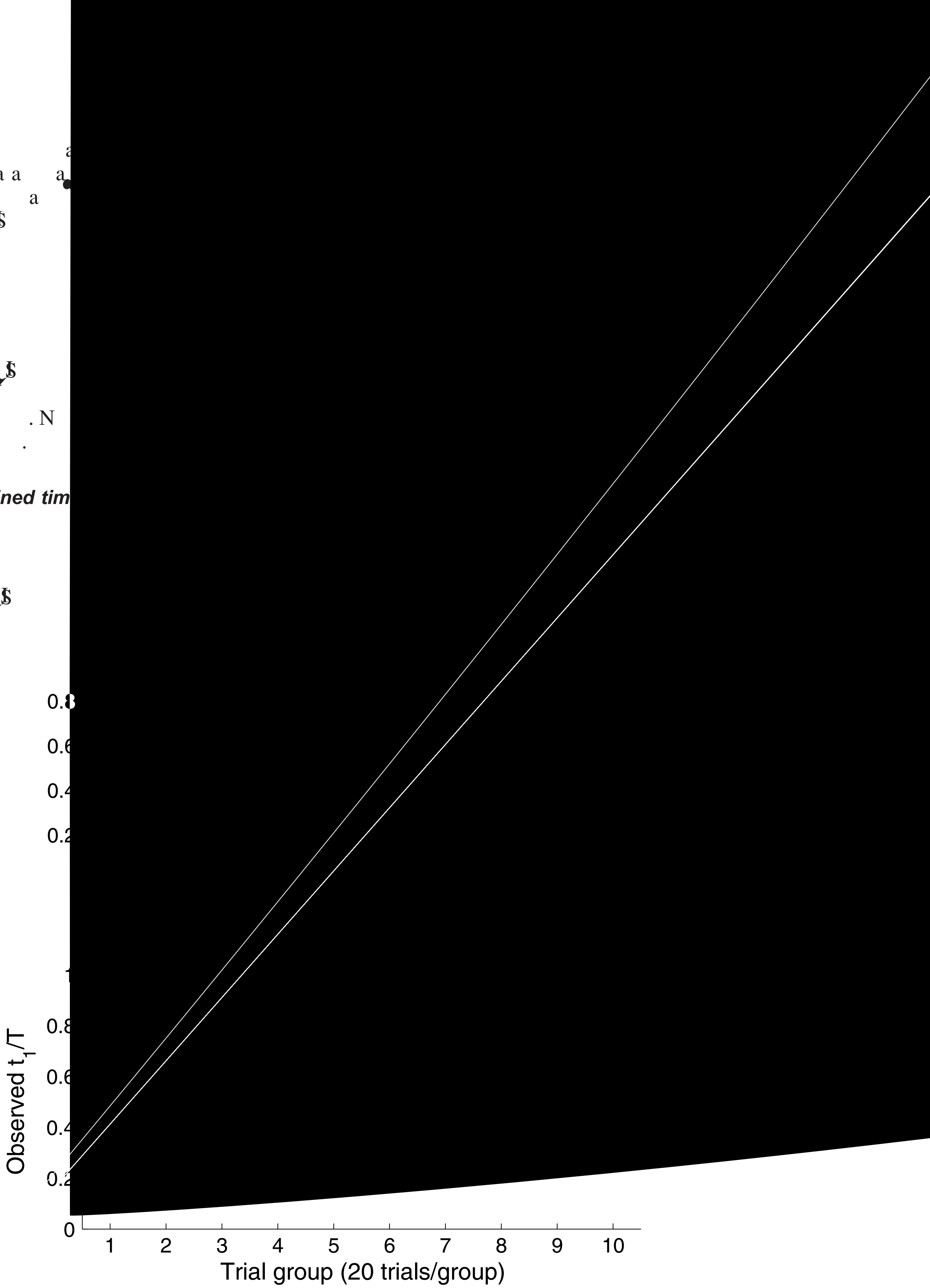

& T a , 1993), a a 10,000 . A 95% , a a a a a a a a - . H , a a , a a a preferred t_1/T ratio. T a a a 0.52. C a a a a , a , - a S , t- , a a a a , $t(7) = 5.72$, $p < .001$, a a a a , $t(7) = -5.20$, $p = .001$.

T a a , a 200 a a 10 20 a a a a t_1/T a t_1/T a a . W a a a a a a . T a a , a a , a a . T a . F 3C a t_1/T a a a a a . I - a a a a . A 95% (B), a a . N a a a S , t- a a a a a a 9 a a 10 . A a a 2 a 0.5 4 a a t_1/T 10 a t_1/T a a 9 a a 95% (B).

The independence of the two movements

F a , a a a a a a . F , a a a a a a a a . S , a a a . A 95% (B), a a . A , 0.75 7 a a a 0.63 7 a a a a a a , a , a (a 0.31).

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

Parameter estimation

W a a a (E a 3) a SAT (E a 5) a . T a a a a a a a a a a . T , a a a a . F 5A t_s /T − T/t_1 a a S01. T R^2 ( ) .95, .89, .86, .72, .67, .66, .64, a .61. T a a a .70.

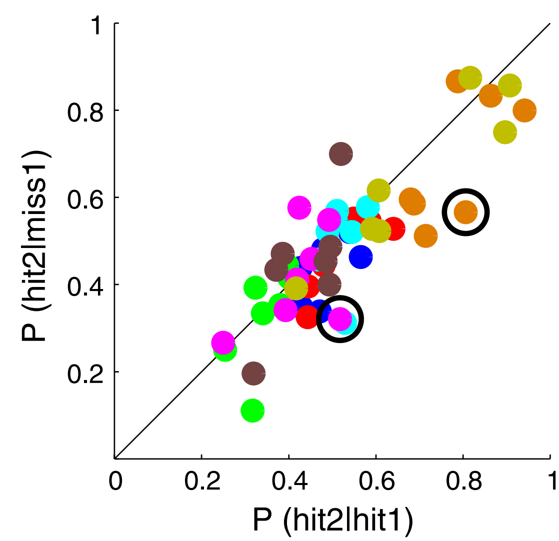

Figure 4. Movement independence. The probability of hitting the second target conditional on missing the first is plotted against the probability of hitting the second target conditional on hitting the first for each timing and value condition, for each subject. Each color denotes the results for one 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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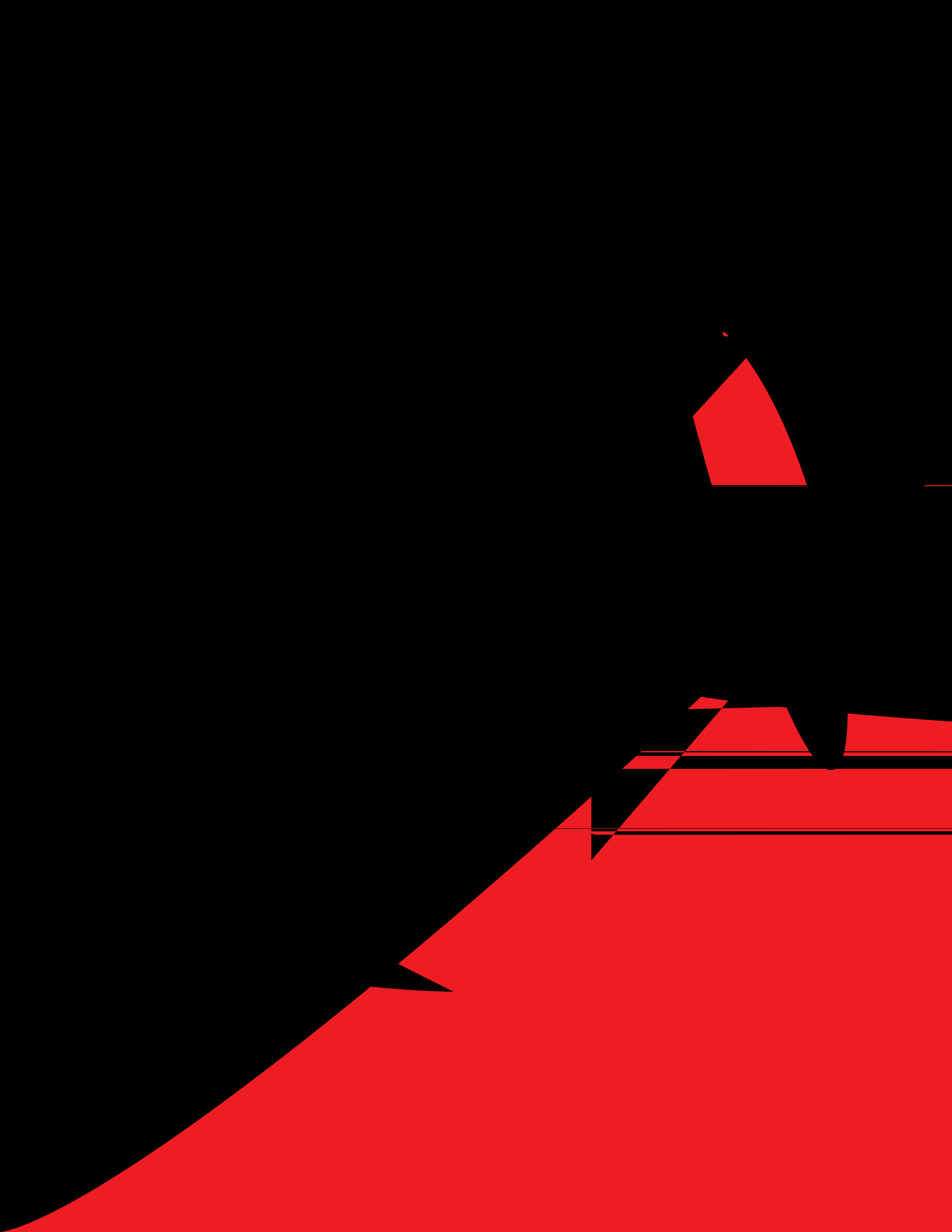

Figure 7. Efficiency E for subjects in the test session. The error bars mark 95% confidence intervals (Bonferroni corrected for three conditions).

timing task). T a a a a a a . H , a , a 800 a a , a a . H , a a a a a a a . A a a a , a a a a a a a a a . T a F 5C a a a a ( ) a a a a a a a 23%.

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Apparatus

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Stimuli

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Procedure

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A a , a a a , 50 a , a a .

Subjects

F , a a , a a. A a a a a a A a a . A - a a a a - - a . I a . T US$20 a a a - a . T a a , - a a , a a , US$28 US$34 a .

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The expected gain ratio of choice timing to constrained timing

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The practice/fatigue effect

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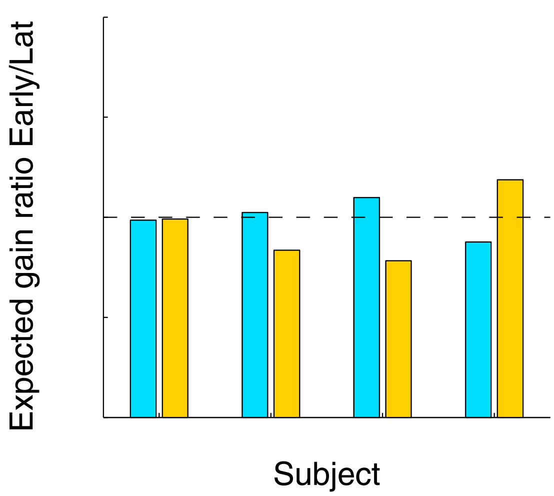

a . T a a a - a - a a a a , a a a a a a a . T a a / a , a a a a a a a . W a a (E & T a , 1993), a 10,000 a 95% a (B). F 10 . T a , a , a a a a a . A a , a a a a ; a a a . T - , a a a a a .

Di c ion

T a a a a . B a a a a a - - a , a a, , a a a a a a a . T a a a a a a a a a a (H , Ma , & La , 2008; T a , G , Ma , La , & Ba , 2005; T a , La , & Ma , 2006; T a , Ma , & La , 2003a, 2003). O a , a a a a a a a a a . C - , a , a a a W a . (2009) a . I a , a a a a a a a a a a a . S a a a a a a a a a . I a a , a a a a (Ba a a & S a , 2007; D a a ., 2007; H a ., 2008). I E 1, a a a a a a a . I , a a a a a a a , a a .

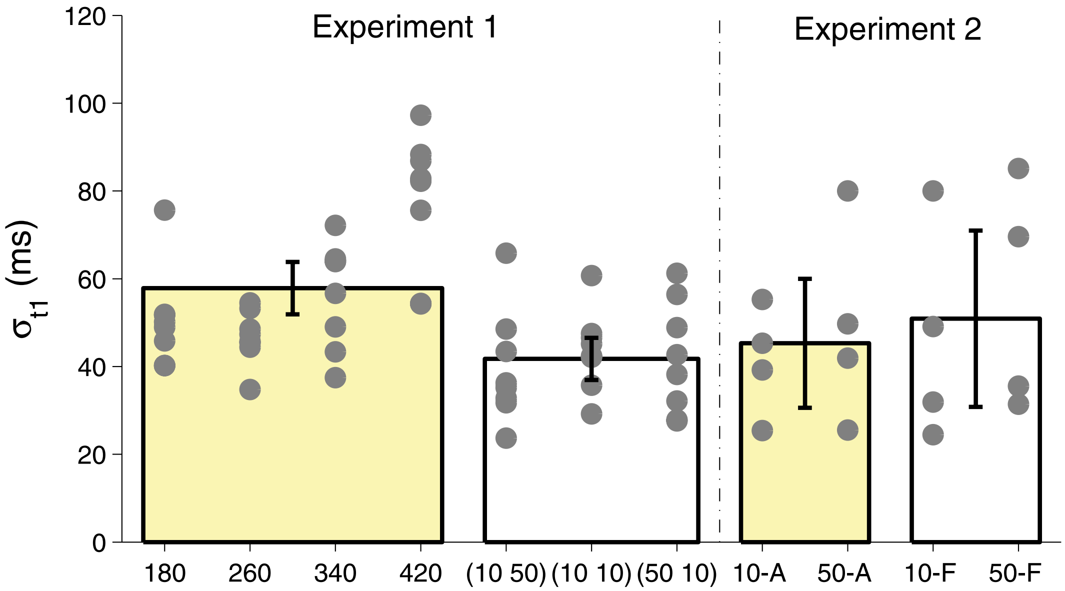

Figure 11. Temporal movement uncertainty. The standard deviation of t_1. The effort to constrain t_1 to a specified time window, as in the constrained timing conditions of Experiment 1 or 2, did not lead to a smaller standard deviation than when there was no need to control t_1. Each gray dot above a 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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Ackno ledgmen

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[2]T a , 4 32 (4 a 8).

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