

Guessing Spreads Up-Down Estimates on the Stimulus Scale but Leaves Them Nearly Unchanged on the Proportion-Correct Scale

— in two-choice tasks the spread of estimates from the rule lowering after 2 correct in a row is 1.815195 times larger in stimulus strength and 3.294931 times the trials are needed for the same spread, but multiplying by the slope at the target leaves only a small difference —the separator is whether the spread is read multiplied by the slope of the psychometric function or not — [Paper 988]

Yuuki YAMAGISHI (山岸 勇輝)

Yamagishi Complexity Torus Lab, Japan

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YOI: <https://www.yamagishiyuuki.com/yoi/988>

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Abstract

Guessing shifts the level an up-down method tracks downward, and a one-down rule has no convergence point in two-choice tasks (Paper 954). The efficiency of estimation and the choice of the number of trials were not treated there. With the observer and rules of Paper 954, this paper runs 1000 simulated observers for up to 1200 trials and compares the spread of estimates by number of trials between a task without guessing and a two-choice task. No new theorem or law is claimed. First, in two-choice tasks estimates from the same rule spread widely in stimulus strength: the standard deviation of the 1200-trial estimate for the rule lowering after 2 correct in a row was 0.048149 with no guessing and 0.087400 for two choices, a ratio of **1.815195**. For the 3-in-a-row rule it was **1.536978** (Section 3). Second, many more trials are needed for the same spread: the squared ratio of standard deviations was **3.294931** for the 2-in-a-row rule and **2.362302** for the 3-in-a-row rule (Section 3). Third, on the proportion-correct scale the difference becomes small: the slope of the psychometric function at the target was 0.343893 with no guessing and 0.194841 for two choices (2-in-a-row rule), and the ratio of standard deviation times slope was **1.028445**, and 1.049098 for the 3-in-a-row rule (Section 4). Fourth, the standard deviation does not fully shrink with the square root of trials: standard deviation times the square root of trials rose as **2.245348**, **2.814447**, **2.919785** and **3.027628** for 150, 300, 600 and 1200 trials (two choices, 2-in-a-row). The mean estimate at 150 trials was -0.059690 , still toward the start from the target -0.216719 (Section 2). Fifth, the separator is whether the spread is read multiplied by the slope of the psychometric function or not: guessing multiplies the slope by one minus the guessing rate and also moves the target (slope at the target 0.194841 against 0.343893 for the 2-in-a-row rule). Read in stimulus strength the spread looks larger; multiplied by the slope and read as proportion correct, the values for the five combinations fell between 0.014060 and 0.017358 (Section 5). **Keywords:** up-down method, guessing, efficiency of estimation, number of trials, psychometric function, psychophysics.

Scope of this paper (scope note): No new theorem or law is claimed: up-down methods and their transformed versions (Levitt), comparing the efficiency of adaptive procedures by trials and spread (Taylor and Creelman), and that the slope of the psychometric function affects the spread of estimates, are known in psychophysics. These are set values: the observer given by a normal cumulative curve with guessing added, step 0.1 and start 2.0 are model values of Paper 935 and Paper 954; 1000 runs, 1200 trials and taking the estimate as the mean position over the last two thirds are set here. They correspond to no sense or experiment. No rule is judged, which rule or number of trials to use, and how to weigh bias against spread, are not stated. Spreads are only set out. No limit is stated: the number of trials at which standard deviation times the square root of trials becomes constant was not counted, and some combinations kept rising up to 1200 trials. Relation to earlier papers: Paper 935, in its scope note, did not say which rule is better, leaving out efficiency of estimation and the choice of number of trials, and Paper 954, in its scope note, also did not judge rules, leaving out efficiency of estimation, choice of number of trials and which rule to use; this paper sits in the seat of efficiency of estimation and number of trials (no earlier occupant; Paper 954 sat in the guessing seat of the scope note of Paper 935). Paper 954 showed that guessing shifts the level an up-down method tracks downward, and that a one-down rule has no convergence point in two-choice tasks. Here, for rules that do converge, how much guessing changes the spread of estimates is counted. What is added: finding the spread of estimates at four numbers of trials for five combinations of guessing and rule, giving the ratio of trials needed for the same spread, comparing on the proportion-correct scale by multiplying by the slope at the target, showing that with few trials a bias toward the start remains, and placing the separator on “read multiplied by the slope, or not”.

1. Notation and the Question

Observer and rules: as in Paper 954, the proportion correct at stimulus strength x is $p(x) = \gamma + (1 - \gamma)\Phi(x)$; after k correct in a row x is lowered by 0.1, and after any error raised by 0.1. The start is 2.0. The target is the solution of $p(x) = 0.5^{1/k}$: 0, 0.544952 and 0.819329 for $k = 1, 2, 3$ at $\gamma = 0$, and -0.216719 and 0.220865 for $k = 2, 3$ at $\gamma = 0.5$ (two choices; $\gamma = 0.5$, $k = 1$ has no convergence point, Paper 954).

Estimates: 1000 simulated observers were run for 1200 trials, and for $T = 150, 300, 600$ and 1200 the mean position from trial $T/3$ to trial T was taken as one estimate ($T = 600$ matches the last 400 trials of Paper 954). The standard deviation of estimates over the 1000 runs was found.

Proportion-correct scale: multiplying the standard deviation by the slope at the target, $p'(x^*) = (1 - \gamma)\phi(x^*)$, turns spread in strength into spread in proportion correct.

Question: how does guessing change the spread of up-down estimates and the number of trials needed for the same spread?

2. Trials and Estimates

Computation 2.1: mean estimate, standard deviation, and standard deviation times the square root of trials.

combination	trials	mean estimate	standard deviation	SD times root of trials
$\gamma = 0, k = 1$	150	0.010144	0.119503	1.463602
	1200	−0.001702	0.043510	1.507237
$\gamma = 0, k = 2$	150	0.591997	0.120770	1.479119
	1200	0.557779	0.048149	1.667936
$\gamma = 0, k = 3$	150	0.884030	0.131583	1.611562
	1200	0.835559	0.049300	1.707795
$\gamma = 0.5, k = 2$	150	−0.059690	0.183332	2.245348
	300	−0.209578	0.162492	2.814447
	600	−0.232855	0.119200	2.919785
	1200	−0.231187	0.087400	3.027628
$\gamma = 0.5, k = 3$	150	0.412196	0.167160	2.047280
	1200	0.229859	0.075773	2.624844

For all five combinations, going from 300 to 1200 trials reduced the standard deviation.

Observation 2.2

with few trials a bias toward the start remains, and for some combinations standard deviation times the square root of trials keeps rising. For two choices with $k = 2$ the mean estimate at 150 trials was −0.059690, still toward the start 2.0 from the target −0.216719: standard deviation times the square root of trials rose from 2.245348 to 3.027628 up to 1200 trials, not reaching the form that shrinks with the square root of trials. The difference between mean estimate and target at 1200 trials was −0.014468 to 0.016231 over the five combinations.

3. Guessing and Spread

Computation 3.1: ratios of standard deviations at 1200 trials and their squares (the ratio of trials needed for the same spread).

compared	ratio of SD	square
$\gamma = 0.5, k = 2$ over $\gamma = 0, k = 2$	1.815195	3.294931
$\gamma = 0.5, k = 3$ over $\gamma = 0, k = 3$	1.536978	2.362302
$\gamma = 0, k = 3$ over $\gamma = 0, k = 1$	1.133063	1.283833
$\gamma = 0, k = 2$ over $\gamma = 0, k = 1$	1.106618	1.224604

Observation 3.2

guessing has a larger effect than changing the rule’s k . With no guessing, changing k from 1 to 3 gave a ratio of 1.133063, while with the same $k = 2$ guessing of 0.5 gave 1.815195: reaching the same spread in two-choice tasks takes, by this count, 3.294931 times the trials of a task without guessing ($k = 2$).

4. The Proportion-Correct Scale

Computation 4.1: slope at the target and standard deviation times slope at 1200 trials.

combination	slope at target	SD times slope
$\gamma = 0, k = 1$	0.398942	0.017358
$\gamma = 0, k = 2$	0.343893	0.016558
$\gamma = 0, k = 3$	0.285193	0.014060
$\gamma = 0.5, k = 2$	0.194841	0.017029
$\gamma = 0.5, k = 3$	0.194665	0.014750

Comparing $\gamma = 0.5$ over $\gamma = 0$ at the same k , the ratio of standard deviation times slope was 1.028445 for $k = 2$ and 1.049098 for $k = 3$, closer to 1 than the ratios 1.815195 and 1.536978 on the strength scale.

5. The Separator

Observation 5.1

the separator is whether the spread is read multiplied by the slope of the psychometric function or not. Guessing multiplies the slope by $1 - \gamma$ and also moves the target (the slope at the target is 0.194841 for two choices with $k = 2$, against 0.343893 for $k = 2$ with no guessing): read in strength, two-choice estimates spread 1.815195 times as much; multiplied by the slope and read as proportion correct, the five combinations fell between 0.014060 and 0.017358, with a two-choice to no-guessing ratio of 1.028445. Why the slope-multiplied values fall in this range is not shown as a formula here.

Observation 5.2

what is not said. Which rule or number of trials to use, how to combine bias and spread, the number of trials at which standard deviation times the square root of trials becomes constant, other steps or starts, and real perception experiments are not treated. What is shown is that, for the same rule, guessing changes the spread of estimates greatly in stimulus strength and only a little when read as proportion correct.

6. Roll Call and Closing

1. estimates from 1000 runs of 1200 trials (Section 1): mean position over the last two thirds.
2. two-choice standard deviation **1.815195** times (Computation 3.1): large on the strength scale.
3. **3.294931** times the trials for the same spread (Computation 3.1): the 2-in-a-row rule.
4. multiplied by slope, ratio **1.028445** (Computation 4.1): nearly the same as proportion correct.
5. SD times root of trials rises to **3.027628** (Computation 2.1): a bias toward the start remains.
6. read multiplied by the slope, or not (Observation 5.1): the separator; the scope notes of Paper 935 and Paper 954.

Closing: Guessing spreads up-down estimates on the stimulus scale but leaves them nearly unchanged on the proportion-correct scale. Comparing 1200-trial estimates with the observer and rules of Paper 954, the standard deviation of the rule lowering after 2 correct in a row was 1.815195 times larger for two choices than with no guessing, and 3.294931 times the trials were needed for the same spread: multiplied by the slope at the target and read as proportion correct, the ratio was 1.028445 (1.049098 for the 3-in-a-row rule). The separator is whether the spread is read multiplied by the slope of the psychometric function or not. Placed among the earlier papers: to the up-down methods Paper 935 and Paper 954 counted by their convergence points, the efficiency of estimation and

number of trials that neither treated were added. To be honest. This sets out spreads of estimates for one observer model. On which scale and by how much guessing changes the spread, and no further.

References

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Yuuki YAMAGISHI (山岸 勇輝)

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