

# "How Good is Your Gut Number Sense?"

## INTRODUCTION

This is a unique output file generated for you that describes what your performance on the Panamath test reveals about the precision of your intuitive number sense. It also describes the number sense, and provides some rough comparison for how your precision stacks up against others who have taken the test.

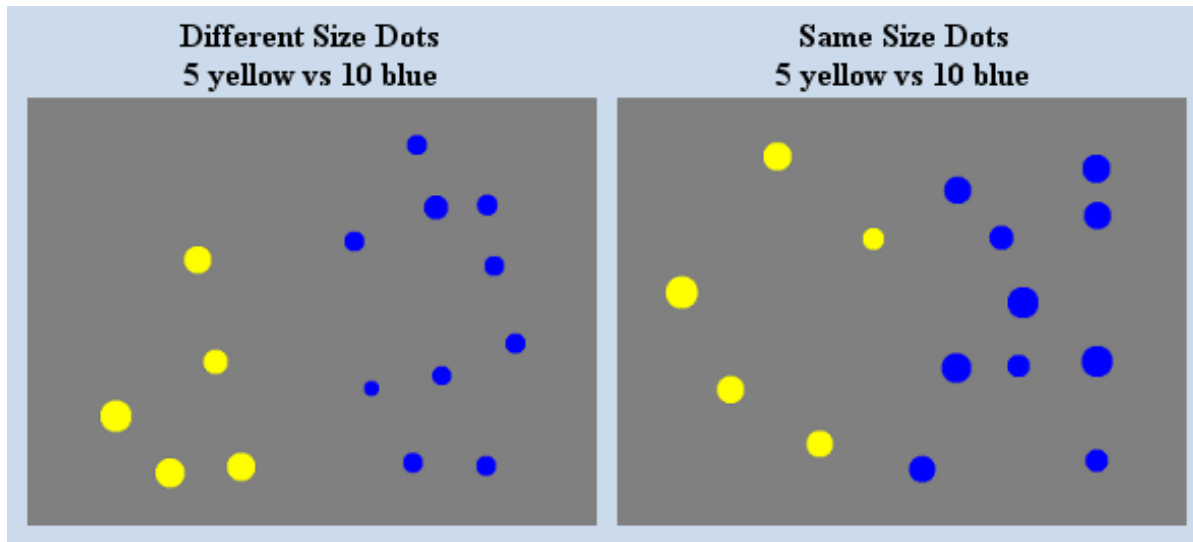
## DESCRIPTION OF WHAT PANAMATH DOES

### *How Does Panamath Measure My Number Sense?*

Panamath tracks two basic indices of your performance: your accuracy at judging which color had more dots and your reaction time to decide on your answer, both as a function of the ratio between the yellow and blue dots. It is the ratio that makes a trial harder or easier. On some trials, the number of yellow and the number of blue dots could be very close to one another, making that trial more difficult (e.g., 8 yellow and 10 blue), and on other trials you probably found that it was fairly easy to tell which color had more dots (e.g., 20 yellow and 10 blue).



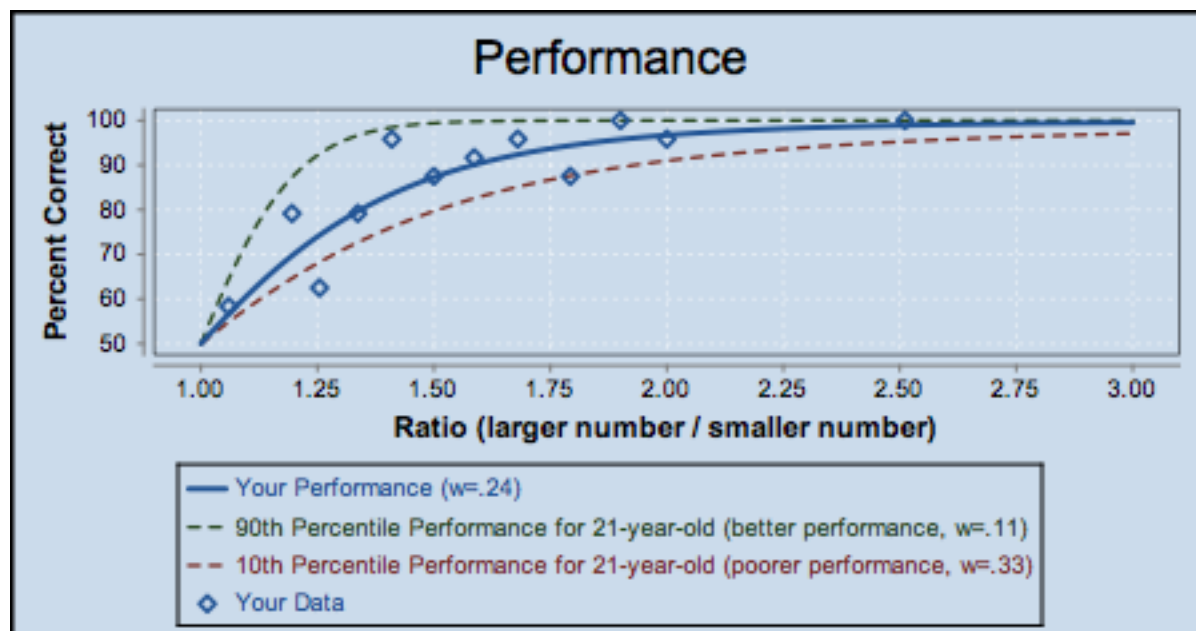
In some versions of the Panamath test, the sizes of the dots on each trial can change with the number of dots presented. For example, on some trials it may be that if yellow had more dots than blue, the yellow dot sizes were smaller than the blue dot sizes (note: Panamath varies many parameters and so this may not have occurred in the version of the test you took). We find that people perform equally well on these various trial types, but we include this mix to ensure that people are focusing on the number of the dots and not using the sizes of the dots or other such cues (e.g., total blue and yellow area, density of dots, etc).



## YOUR PERSONAL PERFORMANCE

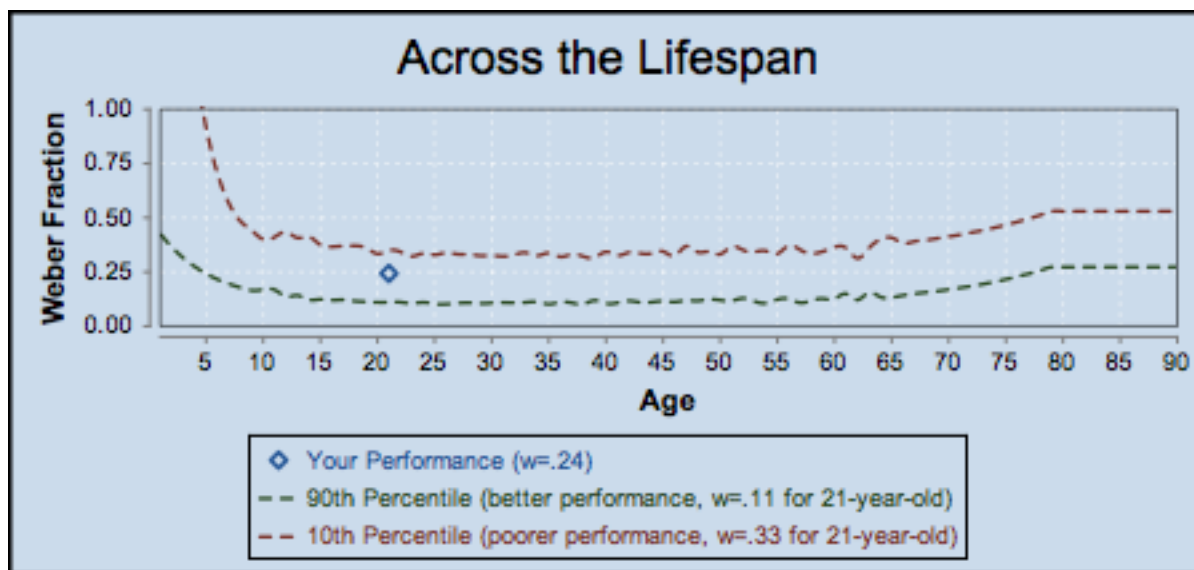
### *How Good Was My Panamath Performance?*

Panamath describes your performance in several ways. The figure titled "Performance" shows your percent correct across trials ranging from easy to hard ratios. The smooth line (blue) shows the Panamath estimate for your performance. The dashed green and red lines indicate the typical range of performance for 21-year-olds who have taken the Panamath test. The green line indicates better performance and the red line indicates less accurate performance. We have found a wide range of abilities, so do not worry if on a particular version of the test you scored above or below the typical range of performance (note: Panamath was not designed to professionally diagnose particular difficulties with mathematics; a school psychologist or education professional near your own home should be asked if you have concerns; your performance on Panamath can be better or worse for many reasons (e.g., trying to take the test very quickly) and so any one score may not accurately indicate your overall abilities).



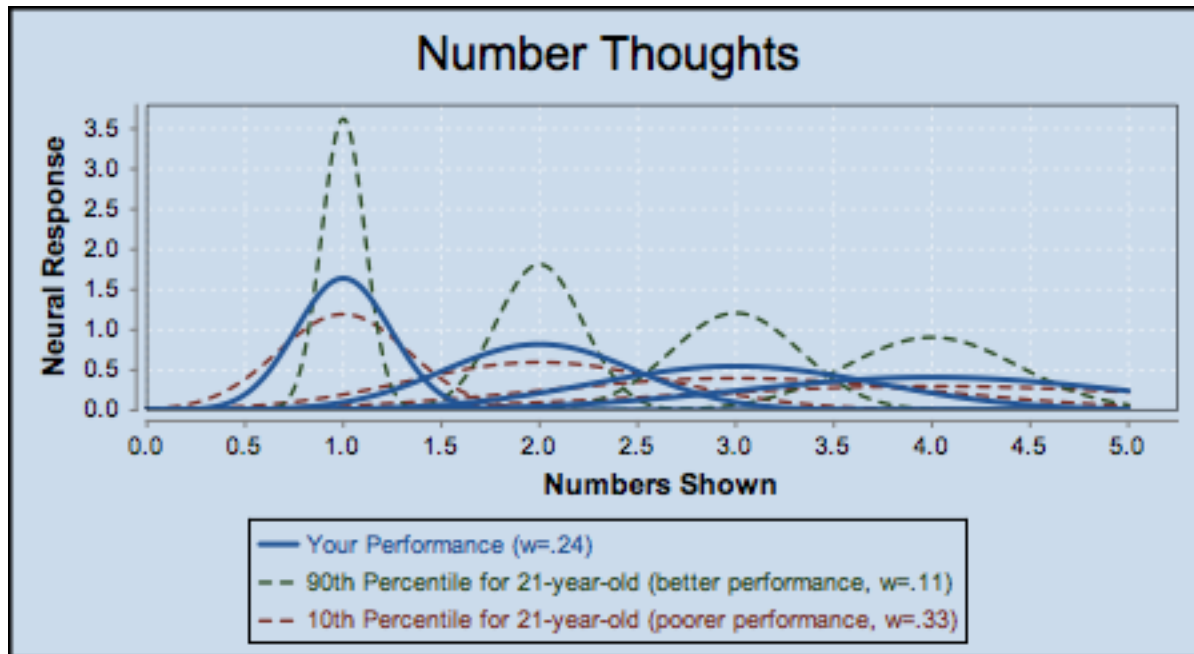
Your accuracy on the Panamath test can be described by a single parameter, the Weber fraction ( $w$ ), which indicates the level of "noisiness" in your underlying approximate number sense representations. No one can tell with perfect certainty exactly how many dots are flashed on a fast Panamath trial; everyone has some inaccuracy or "noise" in their estimates. The amount of noise varies from person to person and can change throughout your life (perhaps because of practice and learning). Noisier estimates make it harder for you to feel how many dots there are in the display and it is this noise that determines your accuracy. Noisier estimates are reflected in a larger Weber fraction ( $w$ ) and less noisy estimates are reflected in a smaller Weber fraction ( $w$ ).

In the figure titled "Across the Lifespan" you can see the range of typical values for the Weber fraction across the lifespan from birth through later adulthood. These estimates have been determined from looking at the performance of many people who have taken the Panamath test. A larger Weber fraction means more noise in a person's gut number sense. Babies have a noisier gut number sense than adults and your own level of noise will be different from your neighbor's. The BLUE diamond in this figure indicates the Panamath estimate of your personal Weber fraction.

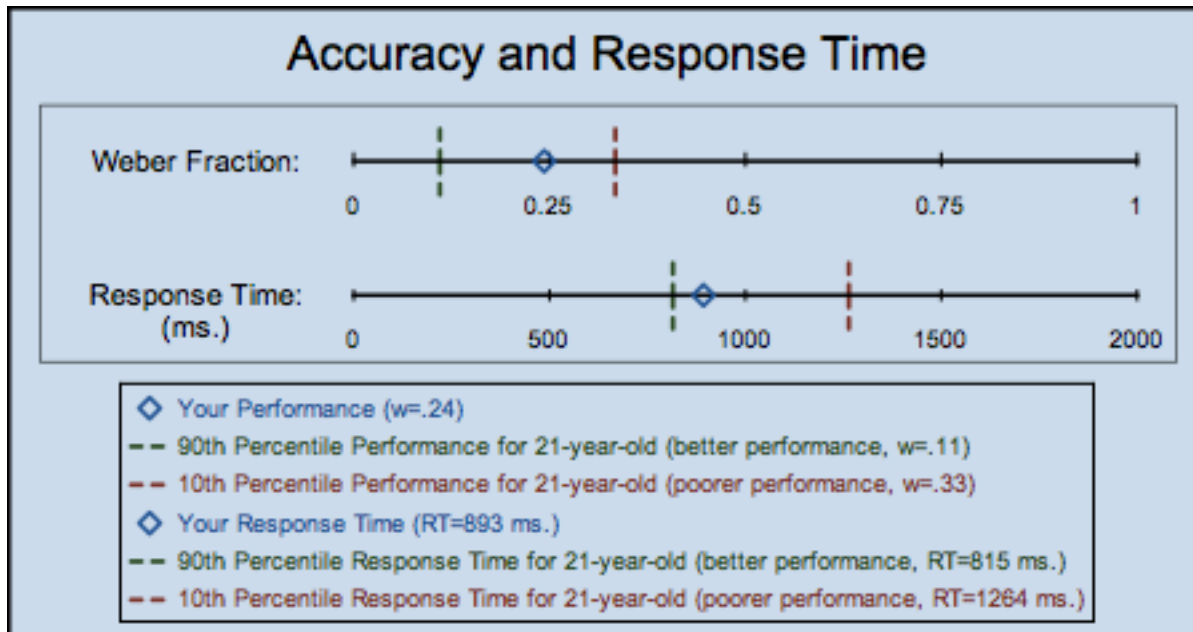


The noise in your gut number sense representations can be illustrated as "humps" around each number estimate. The wider the hump the more noise there is in the estimate. The figure titled "Number Thoughts" illustrates the Panamath estimate of the noise in your number sense representations in BLUE. Each BLUE hump is an estimate of the noise in your representation for that number with shorter, fatter humps indicating more noise and narrower, taller humps indicating less noise (i.e., more precise representations). Everyone's number representations get noisier as the numbers get bigger (i.e., the larger numbers in the figure have shorter and fatter humps indicating this increasing amount of noise as number increases). You can also experience this by looking at the images on the first page of this output; if you tried to guess how many dots there are of each color in the pictures, you likely feel more confident in your estimate when the number of dots is smaller (e.g., 8 yellow dots) than when the number of dots is larger (e.g., 18 yellow dots). Your lessening confidence with larger numbers is also a result of the noisier humps for these numbers as seen in the "Number Thoughts" figure. In the "Number Thoughts" figure, the

RED and GREEN lines indicate the typical range of noise for 21-year-olds who have taken the Panamath test.



To fully appreciate how well you did on the Panamath test we also need to consider your reaction time (how long it took you to make your decision on each trial). Some individuals prefer to take more time on each trial in order to be more accurate, while other individuals prefer to go faster in order to get through the test quickly. This is a personal choice and is independent of how precise your underlying number representations are. In the figures presented above, we have been focusing on your accuracy. Your performance in these figures may be better (if you chose to take more time on each trial) or worse (if you chose to be quicker on each trial). The figure titled "Accuracy and Response Time" displays an estimate of your Weber fraction and your average response time across all Panamath trials in BLUE. The RED and GREEN marks indicate the typical range for 21-year-olds who have taken the Panamath test. The best performance would be fast (i.e., low Response Time) and accurate (i.e., low Weber Fraction) while poorer performance would be slow (i.e., longer Response Time) and inaccurate (i.e., larger Weber fraction).



## CONCLUDING REMARKS

### *We all share a sense of number!*

To date, everyone who has taken the Panamath test has performed in a manner that is generally consistent with the above figures; everyone has a number sense. What varies across individuals (Halberda, Mazzocco & Feigenson, 2008) and across development (Halberda & Feigenson, 2008) is the precision of this underlying gut sense of numbers. We all use our number sense every day, oftentimes without even knowing it. Noticing that the corner market has a lot of new fresh fruit in today; deciding which check-out line will be the fastest based on the number of items already in the queue; choosing which lane of traffic has the fewest cars as we try to move ahead; all of these and more involve number decisions that may engage the number sense. The basic task in Panamath is discriminating which of two arrays of dots is larger in number. Practicing this kind of decision in everyday life may be one of the ways you can improve your number sense, and investigating ways of improving the number sense is an area of research that the Panamath project is currently focusing on.

Your performance on the Panamath test may reveal something about your performance in school mathematics, as differences in the precision of the number sense have been shown to correlate with performance in school mathematics (Halberda et al, 2008). But no one diagnostic tool is a "silver bullet" that can capture all of the interesting nuance that makes you - you. The estimates from Panamath should be used in combination with other tests and assessments that can be interpreted by a licensed professional should you have any concerns.

To learn more about the Panamath project and our research on the gut number sense and school mathematics, please visit <http://www.panamath.org> to explore some of our professional journal articles and popular press articles. If you have questions or concerns about your mathematics abilities, please contact a school psychologist or clinician near your own home. If you have questions or comments about the Panamath project, please see our FAQs page at <http://www.panamath.org/faqs.php> or contact us directly at [panamath@panamath.org](mailto:panamath@panamath.org).

Information on this page is used for Panamath tracking purposes.

#### Current Config:

```
{answer.ends.display = true, auto.next.trial.mode = false, avg.diameter.jitter = (25,19) (30,19) (35,19) (40,19) (45, 19) (50,19),
background.color = 128, 128, 128, backward.mask.on = true, backward.mask.time = 200, blank.mask.time = 250, block.by.trial.type =
true, break.time = 15, breaks.on = false, character.one = BigBird, character.two = Grover, check.dots.fit.in.window = true, customized =
true, debug.mode = false, display.between.trials = fixationcross, display.times = 200, dot.set.one.color = 255, 255, 0, dot.set.one.key =
70, dot.set.two.color = 0, 0, 255, dot.set.two.key = 74, generate.pdf = true, global.resize.ratio = 1, global.resize.ratio.decrement =
0.025, global.resize.ratio.rand.range = 0.3, interstimulus.interval = 3000, language = en_US, largest.dot.controlled = true,
left.right.margin = .16, local.config.file =
/Applications/Panamath/Panamath.app/Contents/Resources/config/last_used_settings.properties, log.mode = false, mask.dot.diameter
= 60, mask.num.dots.per.set = 1000, mask.setting = mask.random.pixels, max.kid.age = 7, max.rt.to.be.non.outlier = -1,
max.tries.to.place.dots = 200, min.rt.to.be.non.outlier = -1, next.trial.key = 32, num.dots.range = (10,30),
num.practice.trials.per.bin.type = 5, num.trials.between.breaks = 100, num.trials.per.bin.type = 2, numerosity.experiment = true,
numerosity.ratio.ranges = (1.049,1.067) (1.114,1.131) (1.187,1.201) (1.24,1.264) (1.317,1.353) (1.39,1.425) (1.49, 1.51) (1.57,1.601)
(1.65,1.701) (1.76,1.815) (1.85,1.92) (1.99,2.01) (2.41,2.61), passive.mode = false, pdf.dir = results, pdf.file =
/Applications/Panamath/results/results_4.pdf, practice.largest.dot.controlled = true, random.seed = 999, random.trial.type.order = true,
results.dir = results, results.file = /Applications/Panamath/results/results_4.xls, save.graphs.seperately = false, save.results = true,
screenshot.height = 600, screenshot.width = 800, screenshots.dir = /Applications/Panamath/screenshots/screenshots-20190327-
155724/, separate.dot.sets = true, show.instructions.in.test = true, show.kid.friendly.end.screen = false, show.progress.bar = true,
show.ss.characters = auto, show.window.rectangles = auto, size.controlled.exponent = .25, -1.25, skip.end.panel = false,
skip.instructions = false, skip.settings = false, sound.feedback = None, ss.character.width = .12, subject.id = 4, top.bottom.margin =
.14, use.custom.display.times = true, use.custom.ratios = true, use.jolicoeur.for.outlier.rt = true, user.age = 21, user.difficulty = 5,
user.time = 20, visual.feedback = None, visual.feedback.length = 600, warn.on.file.overwrite = true, warn.on.poor.performance = true,
window.rectangle.thickness = 7, window.width.separation = (45,100), windows.horizontally.separated = true; version number = 1.22,
task name = Panamath, operating system = Mac, license number = PMU009232, time = Wed Mar 27 16:09:06 EDT 2019, random
seed = 999, screen resolution = 1440x900, jvm version = 1.6.0_65}
```