

Experiment: A Statistical Test of Astrology

This experiment will span at least three class periods, including prep and review. Testing is not required, but there's 26 multiple-choice questions provided on the last pages (answer key in blue) if you want to use them as a review. The contents of this document are as follows:

Page 1: These instructions.

Page 2: Template for student handout (after teacher editing).

Page 3-4: Analysis sheet for student handout.

Page 5: Data for 13 years of this experiment (Brophy Prep, Phoenix, AZ, 1985-1999).

Page 6-8: Multiple-choice questions for optional test.

General Instructions:

1. This experiment will test the statistical validity of daily horoscopes for predicting events in the lives of student participants. Students will choose from 12 unlabelled horoscope predictions the 4 that best retroactively apply to yesterday.
2. The teacher will need to procure the daily horoscope from a local newspaper and cut/scan and paste the 12 individual horoscopes (sans Zodiac sign) into page 2.
3. On the day following the published horoscope, run the experiment using the prepared template and tabulate the results for your students to use in the Analysis.
4. A followup discussion can be useful. A surprisingly high number of students fail to question the statistical validity of daily horoscope predictions. A good question to ask is: Why do you believe that daily horoscopes provide useful information?

Experiment: A Statistical Test of Astrology

General Instructions:

1. Our objective is to statistically test the predictive accuracy of astrology.
2. Astrology is a system of rules for predicting the future. It is based on interpreting motions of the Moon, Sun and planets through the 12 constellations of the Zodiac.
3. Your own “astrological sign” is the constellation in which the Sun was located at the moment of your birth. It is the primary factor in predictions made by astrologers. For your reference ...

CAPRICORN: Dec 22 - Jan 19

AQUARIUS: Jan 20 - Feb 18

PISCES: Feb 19 - Mar 20

ARIES: Mar 21 - Apr 19

TAURUS: Apr 20 - May 20

GEMINI: May 21 - Jun 20

CANCER: Jun 21 - Jul 22

LEO: Jul 23 - Aug 22

VIRGO: Aug 23 - Sep 22

LIBRA: Sep 23 - Oct 22

SCORPIO: Oct 23 - Nov 21

SAGITTARIUS: Nov 22 - Dec 21

4. You were requested to not read your horoscope on the day before the experiment. If you did, then you may not participate in this experiment. You can, of course, still do the Analysis.

Procedure:

1. Spend a few minutes of quiet reflection reviewing the events in your life yesterday.
2. Yesterday’s Horoscope, minus the identifying dates, is provided below. Read them all at least once before making any choices.
3. Now ask yourself the question: Which of the predictions *best describes* or *is most relevant to* what happened in my life yesterday?
4. Select the 4 predictions that best apply by circling their letters.
5. When all participants have made their selections your instructor will provide you with the signs that correspond to each prediction. Write the signs in the spaces provided.
6. DATA: number of students in experiment = _____ number of correct predictions = _____

A CUT AND PASTE HOROSCOPES RANDOMLY INTO THESE SPACES WITH ASTROLOGICAL SIGNS OMITTED	G
B	H
C	I
D	J
E	K
F	L

Experiment: A Statistical Test of Astrology - Analysis

Scientists use the mathematics of statistics to guide them on their quest. Oftentimes the results of an experiment must be evaluated on the basis of probability. The question that must be asked is: Does this data indicate an actual correlation, or could the "signal" just be a random coincidence?

Scientists use the σ Rule to decide. The symbol σ represents one standard deviation in the data distribution. For data on the variable X:

68% of the data will be within the range $X_{ave} \pm \sigma$.

95% of the data will be within the range $X_{ave} \pm 2\sigma$.

99.7% of the data will be within the range $X_{ave} \pm 3\sigma$.

Data that consistently appears beyond the 2σ limits flags a potential discovery, and warrants further investigation. The probability of a 2σ event is 5%, or roughly 1/20 odds. The bar is raised higher in areas like particle physics, where a 3σ rule is the norm. Here's the equations you need:

The probability "P" of "k" successes out of "n" trials with each trial at probability "p" is:

$$P\{k\} = \binom{n}{k} p^k (1-p)^{n-k} \quad \text{where:} \quad \binom{n}{k} = \frac{n!}{k!(n-k)!}$$

1. Enter your data from this experiment: n = _____ k = _____ p = _____

2. Calculate the probability of obtaining the above value for "k". Show all values substituted into the P{k} equation:

P{k} =

3. Convert your answer into a fraction with a numerator of "1".

P{k} = 1/_____

Questions:

1. Does your analysis suggest that something other than random chance was responsible for your experimental result? Explain your reasoning.

2. In Analysis 3 you converted your value for $P\{k\}$ into a fraction with a numerator of "1". When expressed in this form, the probability is often more easily interpreted. What does it mean when we say that the probability of an event is $1/X$?

3. The author once ran an ESP experiment based on mentally "sending and receiving" the suits (clubs, spades, hearts, diamonds) of cards drawn from a shuffled deck. Out of a 52-card deck, an amazing 27 suits were called correctly. Many attempts to were made to repeat this remarkable level of performance, but none succeeded. Calculate the probability of getting 27 suits correct based on nothing more than dumb luck (which it appears, alas, that it was).

$$p = \underline{\hspace{2cm}}$$

$$n = \underline{\hspace{2cm}}$$

$$k = \underline{\hspace{2cm}}$$

$$P\{27\} = ?$$

A Statistical Test of Astrology (cumulative results)

<u>YEAR</u>	<u>n</u>	<u>k</u>	<u>P{k}</u>	<u>YEAR</u>	<u>n</u>	<u>k</u>	<u>P{k}</u>
1985:	29	14	0.037	1994:	20	9	0.099
	29	5	0.029		28	12	0.087
	27	6	0.075		25	5	0.066
	29	17	0.0031		21	11	0.035
	29	11	0.13		30	10	0.15
	29	13	0.065	1995:	24	6	0.12
1986:	28	7	0.11		32	12	0.13
	27	10	0.15		28	12	0.087
	30	11	0.14		25	10	0.13
	25	13	0.025		23	4	0.049
	27	10	0.15	1996:	30	8	0.12
	32	17	0.010		29	9	0.15
1987:	29	15	0.019		24	13	0.018
	32	15	0.040		14	6	0.16
	29	10	0.15		29	16	0.0081
	30	9	0.15	1997	18	3	0.069
	31	8	0.11		20	3	0.043
1988:	23	8	0.17		22	14	0.0026
	23	9	0.14		22	12	0.021
	26	9	0.16		22	10	0.084
	31	13	0.088	1998 ----- not run -----			
	26	12	0.062	1999	24	9	0.15
1989:	28	15	0.013		26	10	0.14
	28	13	0.054		24	9	0.15
	32	11	0.15		28	15	0.013
	29	6	0.058		29	9	0.15
	28	13	0.054				
1990:	25	12	0.050				
	30	10	0.15				
	27	11	0.11				
	30	11	0.14				
	23	9	0.14				
1991:	20	10	0.054				
	23	9	0.14				
	28	10	0.15				
	24	6	0.13				
	17	8	0.096				
1992:	22	7	0.18				
	18	7	0.17				
	14	6	0.16				
	26	9	0.16				
	19	7	0.18				
1993 ----- not run -----							

CUMULATIVE RESULTS OVER 67 RUNS:

$$\Sigma n = 1729 \Rightarrow \bar{n} = 25.8 \approx 26$$

$$\Sigma k = 669 \Rightarrow \bar{k} = 9.99 \approx 10$$

$$P\{10\} = 0.13$$

26 HOROSCOPE EXPERIMENT QUESTIONS:

Astrology attempts to predict the future based on

- how the constellations move with respect to the equator.
- random movements of the ecliptic to the north and south.
- the slow drift of Sun, Moon, and planets through the zodiac.
- geometric relationships between different coordinate systems.

Which of the following constellations is *not* near the ecliptic?

- Sagittarius
- Gemini
- Draco
- Leo

If you are a Capricorn, then the Sun

- will set immediately before that constellation.
- is at opposition to your "Moon sign".
- was located in that constellation at your birth.
- moves 15 degrees/hour faster than you.

Which of the following events is the least probable?

- 4 heads out of 5 coin flips
- 40 heads out of 50 coin flips
- 400 heads out of 500 coin flips
- 4000 heads out of 5000 coin flips

If $p = 0.25$ and $n = 40$, then the most probable value for "k" is

- 10.
- 20.
- 80.
- 160.

All real probabilities must have a value somewhere between

- 0 and 1.
- 1 and +1.
- zero and infinity.
- π and 42.

The objective of this experiment was to

- prove astrology does not really work.
- test whether astrology is accurate beyond random chance.
- use statistics to discover individual horoscopes.
- calculate the precision ratio of astrology.

What does it mean to say "event X has a probability of 0.5"?

- Around every 0.5 seconds X will occur.
- X happens about once every 5 trials.
- Other events are 5 times more likely to occur than is X.
- X happens, on average, every other event.

Which of the following constellations is misspelled?

- Sagittarius
- Capricorn
- Scorpeo
- Pisces

The typical "bell shaped curved" produced by data in experiments of this type imply that

- a. all values of "k" have an equal probability of occurrence.
- b. getting very few successful results is as rare as getting very many.
- c. the most likely events have the lowest probabilities.
- d. all data is within one standard deviation of the average.

Select the true statement:

- a. If astrology works, then about 600 million people are having the same kind of day as you.
- b. The number of astrologers on the planet must be greater than the number of people.
- c. About one out of every 6 billion people have the same birthday as you.
- d. The number of Geminis should be about twelve times the total population of the planet.

Which of the following is a true statement?

- a. If: $P\{a\} = P\{b\}$ then: $a = b$
- b. If: $k = p \times n$ then: $P\{k\}$ is at a maximum
- c. $P\{k\} > P\{k+1\}$
- d. $k = 1/p$

What is the probability of guessing the correct suit of a standard playing card?

- a. 0.25
- b. 0.5
- c. 0.4
- d. 0.52

What does it mean to say "the probability of an event is 0.14"?

- a. The event will happen 14 times out of every 10 trials.
- b. The event will happen 14 times out of every 100 trials.
- c. The event will happen 14 times out of every 1000 trials.
- d. The event will happen 14 times out of every 10000 trials.

The expression "7!" is equal to

- a. 49
- b. 120
- c. 5040
- d. 1234567

An observed event is not considered *evidence* of a law of nature unless it occurs, consistently, despite having a probability of less than

- a. 0.001.
- b. 0.05.
- c. 0.5.
- d. 1.

Given the number of people on this planet with the same astrological sign as you, one wonders

- a. how so many people could be having the same type of day.
- b. about the odds of that many people being born on the same date.
- c. why astrology isn't correct more than one-twelfth of the time.
- d. if all signs have an equal probability of occurrence.

What is the probability of predicting the roll of a single die?

- a. 0.12
- b. 0.17
- c. 0.5
- d. 0.6

The expression "8!" is equal to

- a. 64
- b. 5040
- c. 40320
- d. 12345678

Which of the following events is the *least* probable? Predicting correctly the

- a. total on a roll of a pair of dice.
- b. suit of a card drawn from a standard 52-card deck.
- c. flip of a coin.
- d. 12-digit serial number on a dollar bill.

About how many Geminis are there living on this planet?

- a. 6 hundred-thousand
- b. 6 million
- c. 60 million
- d. 600 million

What is the decimal value of this expression: $\binom{4}{2}$

- a. 2
- b. 4
- c. 6
- d. 8

All the constellations of the zodiac share the characteristic of

- a. consisting of the same number of stars.
- b. being near the zenith point.
- c. being named after astrological birth signs.
- d. straddling about 30 degrees along the ecliptic.

Which of the following objects does not figure prominently in the "theory" of astrology?

- a. Sun
- b. Polaris
- c. Moon
- d. Jupiter

What is the probability of rolling an odd number with 12-sided dodecahedral die?

- a. 0.067
- b. 0.250
- c. 0.500
- d. 0.666

Which of the following is not a criterion for scientific belief in the existence of a phenomenon?

- a. The probability that it happens by chance must be < 0.05 .
- b. One can make repeated and consistent predictions based on it.
- c. Established laws of nature provide an explanatory mechanism.
- d. It must agree with personal biases and predispositions.