1 Two sample t-test example

1.1 Study Description

- Compare the effects of two soporific drugs
  - Optical isomers of hyoscyamine hydrobromide
- Each subject receives a placebo and then is randomly assigned to receive Drug 1 or Drug 2
- Dependent variable: Number of hours of increased sleep over control
- Drug 1 given to n_1 subjects, Drug 2 given to n_2 different subjects
- Study question: Is Drug 1 or Drug 2 more effective at increasing sleep?
  - $H_0 : \mu_1 = \mu_2$
  - $H_1 : \mu_1 \neq \mu_2$

1.2 Power and Sample Size

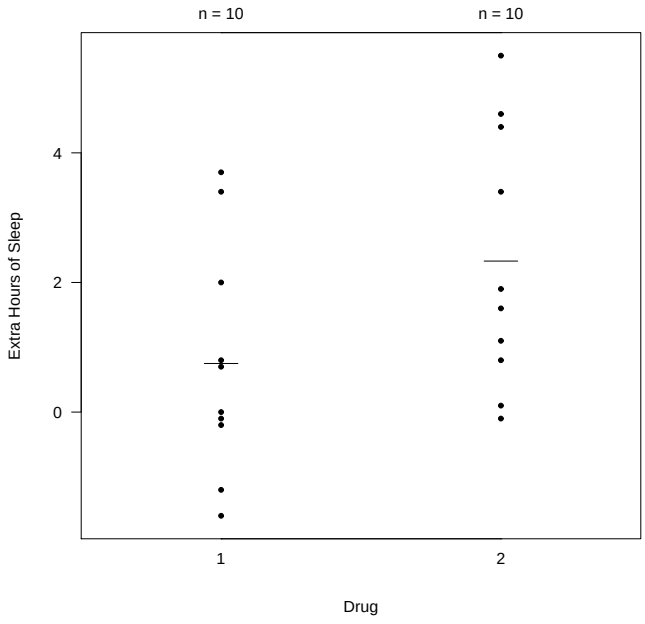
- Pilot study or previous published research shows $\sigma = 1.9$ hours
- Determine the number of subjects needed (in each group) for several value of effect size Δ ($\Delta = |\mu_1 - \mu_2|$) in order to have 90% power with $\alpha = 0.05$

Δ	1.0	1.5	2.0	2.5	3.0
n	77	35	20	14	10

- If Drug 1 (or 2) increases sleep by 3.0 hours more than Drug 2 (or 1), by enrolling 10 subjects in each group we will have 90% power to detect an association

1.3 Collected Data

Obs.	Drug 1	Drug 2
1	0.7	1.9
2	−1.6	0.8
3	−0.2	1.1
4	−1.2	0.1
5	−0.1	−0.1
6	3.4	4.4
7	3.7	5.5
8	0.8	1.6
9	0.0	4.6
10	2.0	3.4
Mean	0.75	2.33
SD	1.79	2.0



1.4 Statistical Test

- Stat program output

```
        Two Sample t-test

data:  extra by group
t = -1.8608, df = 18, p-value = 0.07919
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3.3638740  0.2038740
sample estimates:
mean in group 1 mean in group 2
           0.75            2.33
```

- Interpretation
  - Compare Drug 2 to Drug 1. The output compares 1 to 2
  - Subjects who take Drug 2 sleep on average 1.58 hours longer (95% CI: [-0.20, 3.36]) than subjects who take Drug 1

2 Paired t-test example

2.1 Study Description

- Compare the effects of two soporific drugs.
- Each subject receives placebo, Drug 1, and Drug 2
- Dependent variable: Number of hours of increased sleep
- Drug 1 given to n subjects, Drug 2 given to same n subjects
- Study question: Is Drug 1 or Drug 2 more effective at increasing sleep?
  - $H_0 : \mu_d = 0$ where $\mu_d = \mu_1 - \mu_2$
  - $H_1 : \mu_d \neq 0$

2.2 Power and Sample Size

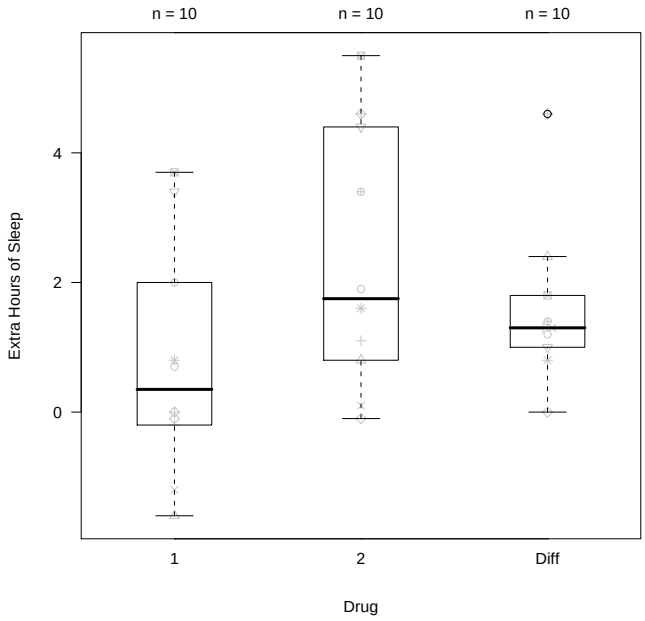
- Pilot study or previous published research shows the standard deviation of the difference (σ_d) is 1.2 hours
- Determine the number of subjects needed for several value of effect size Δ ($\Delta = |\mu_1 - \mu_2|$)with 90% power, $\alpha = 0.05$

Δ	0.5	1	1.5	2
n	62	16	8	5

- If Drug 1 (or 2) increases sleep by 1.5 hours more than Drug 2 (or 1), by enrolling 8 subjects we will have 90% power to detect an association.
- More powerful than the two sample test (need 10 subjects in each group for $\Delta = 3.0$ hours)

2.3 Collected Data

Subject	Drug 1	Drug 2	Diff (2-1)
1	0.7	1.9	1.2
2	−1.6	0.8	2.4
3	−0.2	1.1	1.3
4	−1.2	0.1	1.3
5	−0.1	−0.1	0.0
6	3.4	4.4	1.0
7	3.7	5.5	1.8
8	0.8	1.6	0.8
9	0.0	4.6	4.6
10	2.0	3.4	1.4
Mean	0.75	2.33	1.58
SD	1.79	2.0	1.2



2.4 Statistical Test

- Stat program output

```
        Paired t-test

data:  extra by group
t = -4.0621, df = 9, p-value = 0.002833
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.4598858 -0.7001142
sample estimates:
mean of the differences
                  -1.58
```

- Interpretation
  - A subject who takes Drug 2 sleeps on average 1.58 hours longer (95% CI: [0.70, 2.50]) than when he or she takes Drug 1
- Note: Same point estimate (1.58 hours), but more precise estimate (tighter CI) than the 2-sample t-test