205 Experimental Simulation

Psychological theories are ways of organizing observable phenomena in terms of a limited number of unobservable constructs. In addition to describing known phenomena, theories allow for prediction of as yet unobserved phenomena. Theories may be stated as informal descriptions, or may be stated in formal propositional logic or in mathematical equations. Complex theories that involve many variables may be stated as dynamic processes that change over time and that can best be captured in computer simulations.

This experiment simulates the complexity of a real research program by simulating the complex relationships between a set of observed characteristics of individuals, how they react to situations in terms of their motivational state, and how motivational state, in turn, affects cognitive performance. Prior work in the Personality, Motivation, and Cognition Laboratory at Northwestern has allowed us to formulate a complex model of human cognition in response to stress (Anderson and Revelle, 1994; Revelle, 1992; Revelle and Anderson, 1989; Revelle, Amaral and Turriff, 1976; Revelle, Humphreys, Simon and Gilliland, 1984). This simulation is based upon that work. In a sense, the simulation is a theory of the relationship between these four sets of variables (person characteristics, situational characteristics, intervening motivational states, and cognitive performance). The parameters of the model have been set to reflect empirical estimates of the strength of various relationships. Several nuisance variables have been added to more properly simulate the problems of experimental design.

This simulation of the theory may be used as a test of the theory as well as a tool for understanding the complexity of research. That is, although one may want to study the full model, because of the limitations one's time and energy, one may study only a limited aspect of the model. The student's objective is two fold: to better understand a limited aspect of a particular psychological theory, and to try to understand what are the relationships that have been specified in the model.

What are the variables in this simulation?

Independent variables that are under control of the experimenter may be categorized as <u>experimental</u> variables and <u>subject</u> variables. Experimental variables may be manipulated by the experimenter. Subject variables are characteristics of the subjects that may be measured but not manipulated.

In this experiment the Experimental Variables include **Drug** condition (placebo or caffeine), and **Time of Day.** Given the realities of volunteer subjects, Time of Day is assumed to only vary between 8 am and 10 PM (22.00 hours). The subject variables that are "assessed" in this study include **Impulsivity**, **Trait Anxiety**, **Sex**, and when the subject appears during the quarter (**Subject Number**).

The **Dependent Variables** are measures of motivational state (**Energetic** and **Tense** Arousal) as well as accuracy of **Performance** on a simple cognitive task (letter scanning). Energetic Arousal may be seen as reflecting how active and alert rather than sleepy and drowsy a subject reports being. Tense Arousal reflects how Tense and Frustrated rather than Calm and Relaxed a person reports being (Thayer, 1988). Both of these scales are reported in units ranging from 0-100.

<u>Subject Number</u> increases for every subject run in a particular experiment.

The values of the remaining variables may be specified by the experimenter for each subject, or may be allowed to vary randomly. If allowed to vary randomly, the experimental variables will be assigned values in a uniform random distribution. The subject variables may either be specified (this simulates choosing particular subjects based upon a pretest) or may be allowed to vary randomly. If varying, they will be assigned values based upon samples from a normal distribution. If subjects are selected for particular personality types, this is the same as rejecting many potential subjects and thus the Subject Number grows more rapidly than the simple number of subjects who participate.

Drug has two levels (0=Placebo or 1=Caffeine). Caffeine is known to act as a central nervous system stimulant although it has some side effects such as tremor (Revelle, et al., 1976).

Time of Day has 15 levels (8 AM ... 10 PM or 8 ...22). Although most cognitive psychologists do not examine the effects of time of day on cognitive performance, there is a fairly extensive literature suggesting that performance does vary systematically across the day (Revelle, et al., 1980).

Impulsivity is a stable personality trait associated with making up one's mind rapidly and doing and saying things with out stopping to think. It has been shown in prior work to relate to an inability to sustain performance. Theories of impulsivity have also suggested that impulsivity is related to a general sensitivity to cues for reward and to a greater propensity towards positive affect (Gray, 1991). In this simulation, impulsivity can take on values from 0-10.

Trait anxiety is a stable personality trait associated with feelings of tension, worry, and somatic distress. Trait anxious individuals are more sensitive to cues for punishment and non-reward and are also more likely to experience negative affect than are less trait anxious individuals (Gray, 1991). In this simulation, anxiety can take on values from 0-10.

Sex of subject sometimes interacts with characteristics of the experiment (sex of experimenter, stress of experiment, type of task) and has sometimes been associated with levels of anxiety. In this study, Sex varies randomly taking on the values of 1 or 2. (Using the mnemonic of the number of X chromosomes, that is 1=M and 2=F)

Energetic arousal reflects self reports of feelings of energy, activity, and alertness. EA has been shown to increase with exercise and to decrease with sleep deprivation (Thayer, 1988). EA is also associated with feelings of positive affect (Watson and Tellegen, 1985).

Tense arousal reflects feelings of tension, frustration, and fear (Thayer, 1989) and is moderately associated with feelings of negative affect (Watson and Tellegen, 1985).

Performance in this simulation reflects accuracy on a simple decision task. A perfect score is 100, and performance deteriorates from that as a function of condition and motivational state. Abstractly, this may be thought of as accuracy on a vigilance task, or the ability to make accurate judgments on some sustained processing task.

What should you test?

Any experiment pits power against practicality. That is, the more subjects that are studied, the more statistical power that one has to detect an effect. However, subjects are not an unlimited resource. They are hard to recruit and they are time consuming to run. In addition, for a particular number of subjects, as the number of variables that are examined increases, the potential number of higher order relationships (interactions) increases dramatically at the same time that the power to detect these interaction decreases because of the limited number of subjects in any one condition.

A reasonable approach is do have some theoretical reason to believe that a certain relationship exists, and then perhaps conduct a series of "pilot" studies to determine the sensitivity of certain parameter values.

The goal of this project is to try to determine at least some of the relationships that have been built into the model. You will be evaluated on principles of experimental design, not on the significance of the results.

References

Anderson, K. J. & Revelle, W. (1994) Impulsivity and time of day: is impulsivity related to the decay of arousal? *Journal of Personality and Social Psychology.*, 67,334-344.

Eysenck, H. J. (1967).*The biological basis of personality*. Springfield: Thomas.

Gray, JA. (1991). The neuropsychology of temperament. In J Strelau & A Angleitner (Eds.), Explorations in temperament: international perspectives on theory and measurement (pp. 105-28). London: Plenum.

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Revelle, W., & Anderson, KJ. (1992). Models for the testing of theory. In A Gale & MW Eysenck (Eds.), *Handbook of individual differences: biological perspectives* Chichester: Wiley.

Revelle, W., Amaral, P. and Turriff, S. (1976) Introversion-extroversion, time stress, and caffeine: the effect on verbal performance. *Science*,*192*, 149-150.

Revelle, W., Humphreys, M.S., Simon, L., & Gilliland, K. (1980) The interactive effect of personality, time of day, and caffeine: a test of the arousal model. Journal of Experimental Psychology: General, 109, 1-31.

Thayer, R. E. (1989). *The biopsychology of mood and arousal.* New York.Oxford.

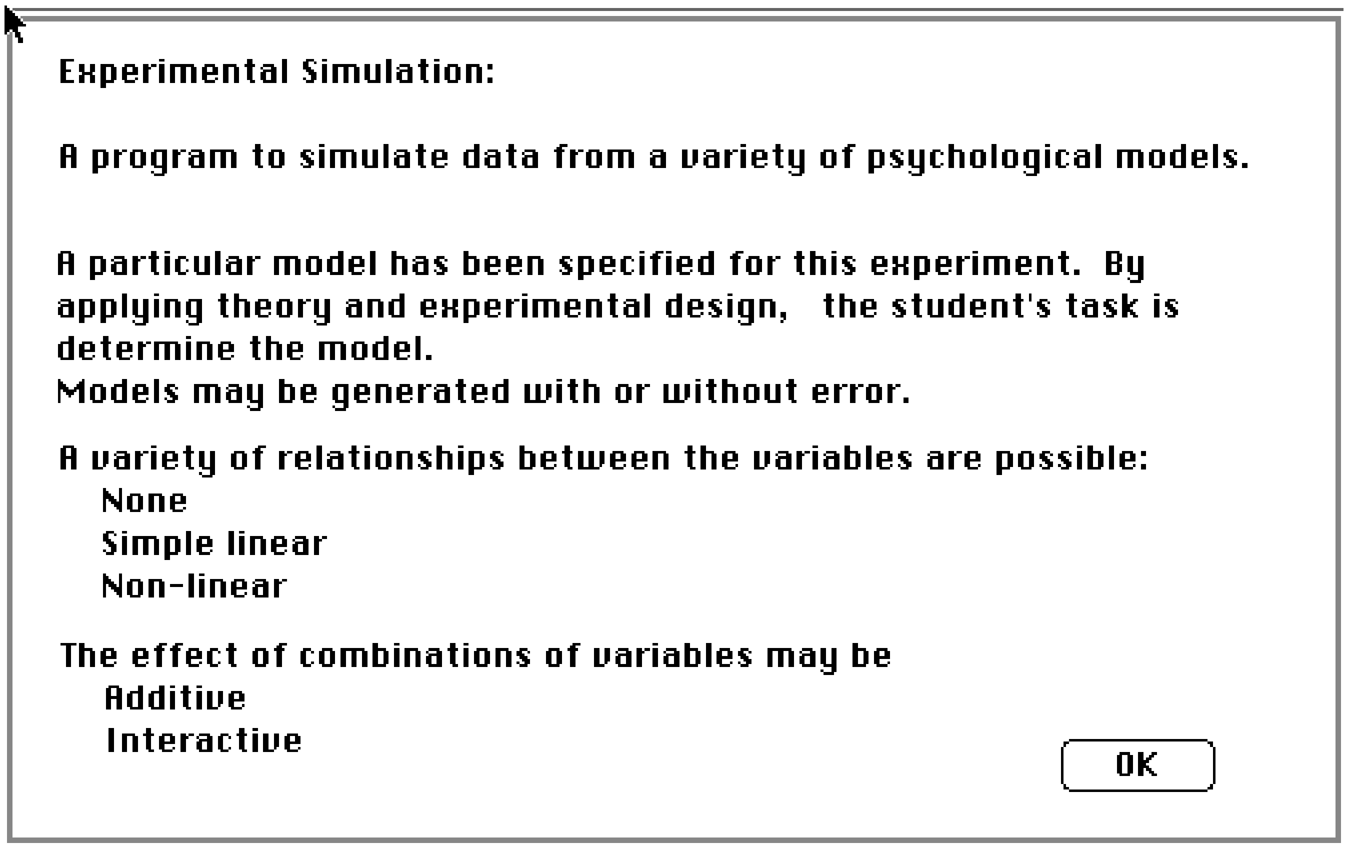
Watson, D. & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin, 98*, 219-235.

How to run the 205-simulation program?

1. Copy the program to your hard drive.

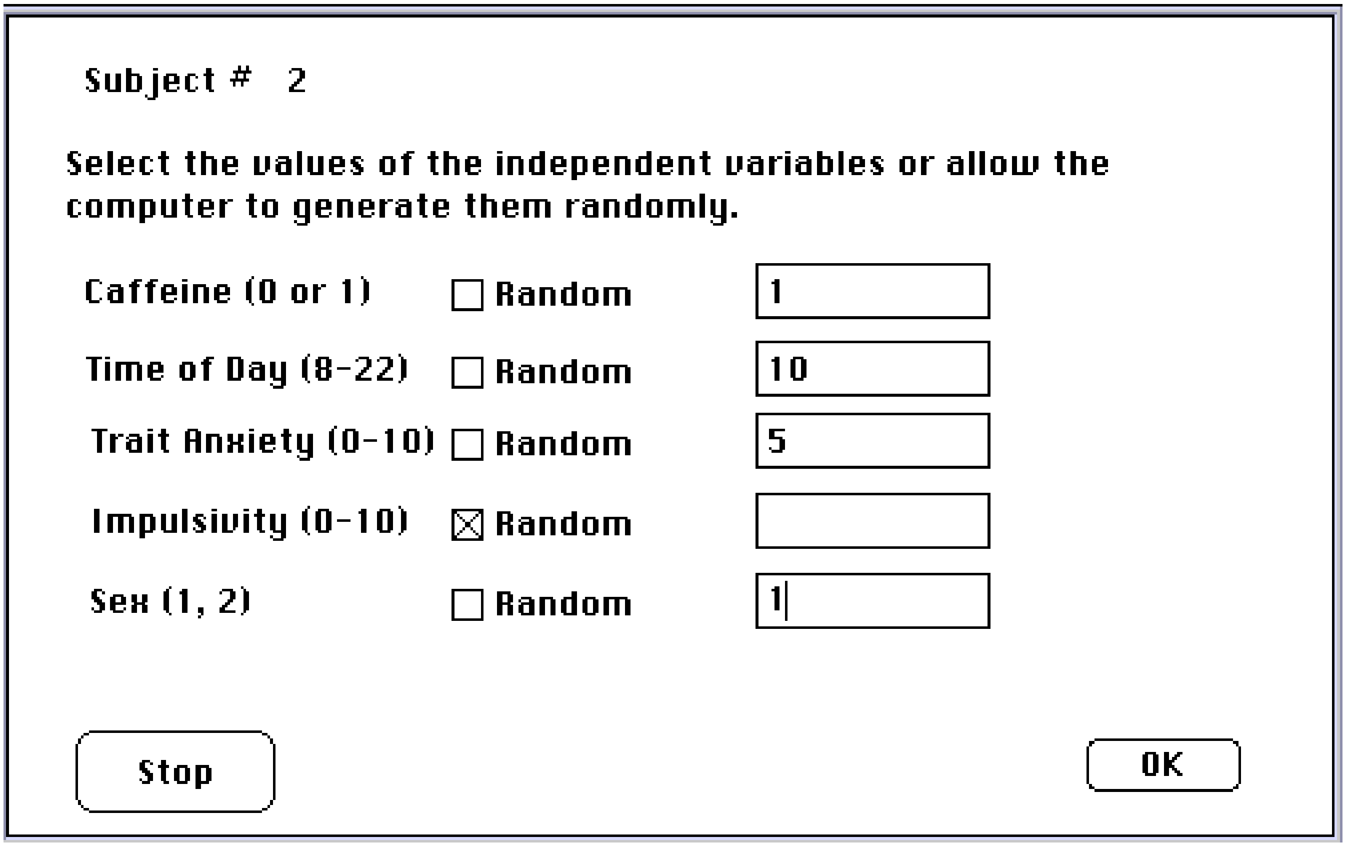
2. Double click on the application program: 205-Simulation.

3. The first 3 screens give a brief introduction to the program. You may move on to the next screen by selecting the "OK" button or pressing "Enter" or "Return".

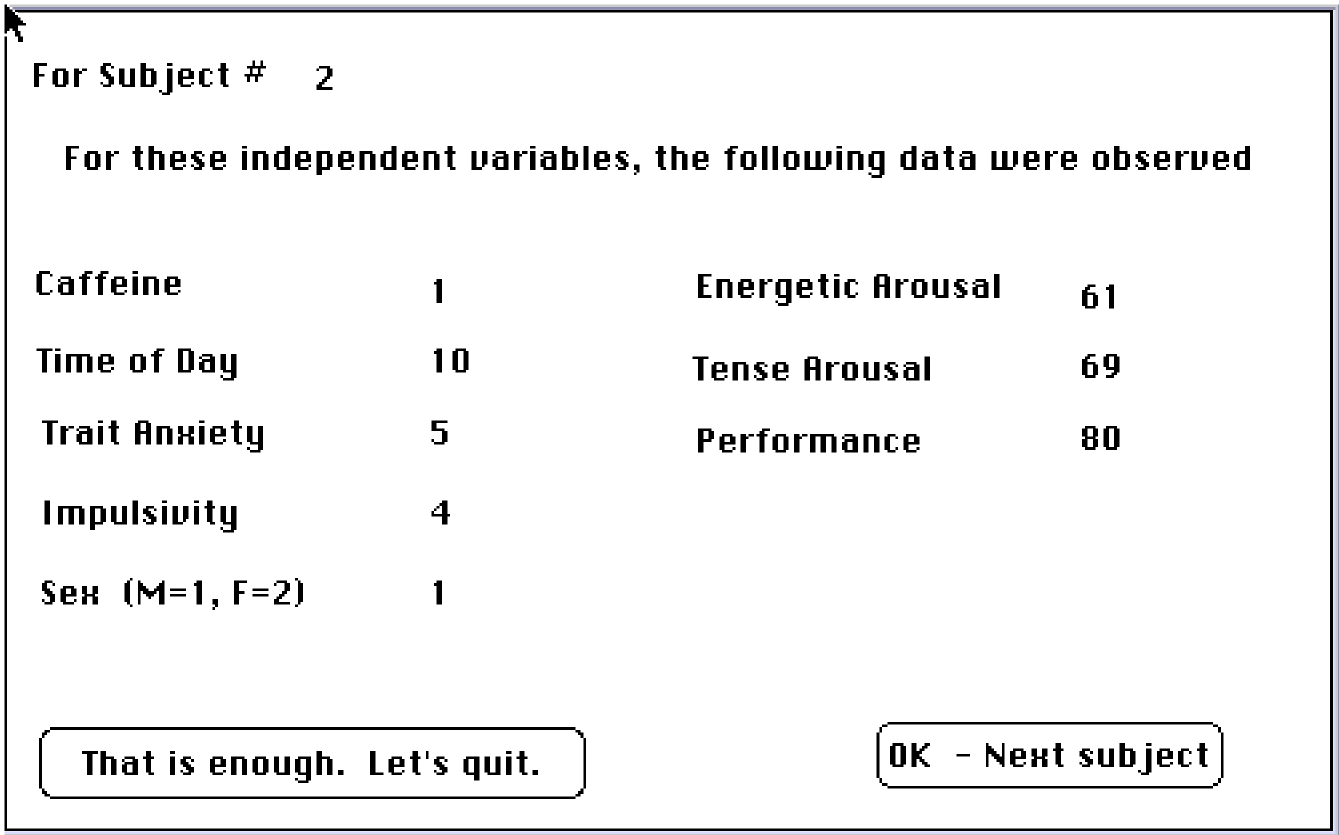


4. Data generated by the program are displayed trial by trial in appropriate dialog boxes. They are also saved in a data file that may be read by any spreadsheet or word processing program. Before you can get to this point, a dialog asking for the name of the data file will appear. The default is "Simulation.Data". If a file with that name already exists, and you choose to do so, it will be erased and the new data will replace it. If you do not want this to happen, change the name of the new data file appropriately.

5. At this point, the first "subject" screen appears. Values of Independent variables may either be assigned at random by the computer, or may be specified in the appropriate box. (Values that are not within the specified range will be replaced with values at the minimum or maximum acceptable). When satisfied with the selection, press "return" or click on the "OK" box.



6. The next screen reports the values chosen of the Independent Variables and the values these produce for the Dependent Variables.



7. You may either "run another subject" or "stop the experiment". Another subject goes back and asks you to specify the characteristics of the next subject. Stop goes on and gives summary statistics.

8. The summary statistics are the means and standard deviations of the subjects you have run up to this point. They are not broken down by condition.

You have asked to stop. The data have been saved to the data file. Here are some summary means. You may quit or run another experiment.

Independent Variables	Mean	SD
Subject ID #	1.0	1.0
Caffeine	0.3	0.5
Time of Day	6.6	5.7
Trait Anxiety	3.3	2.8
Impulsivity	2.7	2.4
Sex (M=1, F=2)	0.6	0.5

Dependent Variables	Mean	SD
Energetic Arousal	39.0	33.8
Tense Arousal	43.6	37.9
Performance	49.3	43.1

Number of subjects run 3

Do another experiment

Thank you and goodbye

9. Once again, you are asked if you want to "run another experiment" (i.e., collect more data), or to "stop". Running another experiment simulates collecting data as if you had started again at the beginning of the quarter.

10. Stopping stops the program and returns you to the Finder.

11. The data that are saved on the Simulation.Data file will look like this: (As seen by either Excel or Simple text).

trials	drug	time	anxiety	impulsivity	sex	arousal	tension	performance	IMP_2	TOD_3
1	0	19	6	5	1	70	66	83	2	3
2	0	20	5	5	1	70	46	88	2	3
3	0	15	3	5	2	66	58	90	2	2
4	0	11	5	2	1	60	54	73	1	1
5	1	9	6	5	2	58	66	65	2	1

The two variables on the right (IMP_2 and TOD_3) are recoded data with the coding system: If Impulsivity <5 then IMP_2 = 1 else Imp_2 = 2 and If Time <12 then Tod_3 =1 else if TIME < 18, then TOD_3=2 else TOD_3 = 3. Similar recoding options are available in Systat and might be more appropriate.

Background for this study is taken from a recent article from the PMC lab, although in the interests of brevity, the citations in that article are not included here.

Impulsivity is one of the dimensions of individual differences frequently identified by theorists concerned with the biological bases of personality. Although the appropriate theoretical interpretation of impulsivity is a matter of ongoing debate, many models either explicitly or implicitly posit a relationship to arousal. Arguments that impulsivity is linked to arousal can be traced largely to Hans Eysenck (1967), who proposed that (a) there are genetically influenced differences in basal arousal levels; (b) all individuals experience maximally positive hedonic tone at intermediate arousal levels; and (c) individuals who are chronically underaroused develop patterns of behavior designed to increase their arousal. Because social, spontaneous, and risky behaviors (for example) typically afford greater arousal potential than solitary, planned, or safe endeavors, Eysenck proposed that phenotypically extraverted behavior patterns tend to develop among those whose basal arousal levels are low. This theory provided an explanatory link between evidence of the heritability of extraversion and data suggesting differences between introverts and extraverts in a variety of laboratory phenomena. In brief, Eysenck proposed that the basal arousal level of introverts is higher than that of extraverts and, as a corollary, that the two primary sub-traits of extraversion, sociability and impulsivity, are also negatively related to arousal.

The term arousal is used here to refer to a state involving nonspecific physiological activation and the nondirectional component of alertness. Reflected in experiences of alertness, peppiness, and liveliness, it varies within individuals from very low levels characteristic of sleep to very high levels associated with great excitement or panic. More specifically, we use the term arousal to denote a hypothetical construct representing the net result of a variety of processes that mediate activation, alertness, and wakefulness. As an abstraction, it reflects several electrocortical, autonomic, and behavioral mechanisms, but is not synonymous with any one of them. Despite difficulties with the concept of a generalized nondirectional energizer, as a hypothetical construct arousal has pragmatic usefulness in organizing a wide array of empirical phenomena.

Moreover, research suggests that the personality-arousal relationship is mediated by phase differences in diurnal arousal rhythms. In general, arousal increases during the morning, levels off or decreases slightly through the afternoon, and then declines during the evening; extraverts lag behind introverts in this pattern. Again, although some inconsistent findings have been reported, data suggest a greater role for impulsivity than sociability in mediating this relationship between personality and diurnal arousal rhythms. Thus, the available data suggest that high impulsive subjects are less aroused than low impulsives during the morning, but that the reverse is true in the evening, when high impulsive subjects are more aroused than low impulsives.

Arguments linking personality to sustained attention follow from a broad base of empirical evidence involving a variety of tasks in which attentional processes are central, that is, tasks such as simple reaction time tasks, simple arithmetic, or letter cancellation in which subjects are required to process a stimulus, associate an arbitrary response to that stimulus, and execute that response. Studies of performance on such tasks have yielded converging results from manipulations including drugs, exercise, heat, and noise, as well as state and trait assessments with presumed relevance to arousal. These parallels led several investigators to propose, as part of their broader models of motivation and performance, that arousal facilitates attentional processing, and sustained attention in particular.

Anderson, K. J. & Revelle, W. (1994) Impulsivity and time of day: is impulsivity related to the decay of arousal? *Journal of Personality and Social Psychology.*, 67,334-344.

How to analyze data from a Psychology study.

One of the most powerful data manipulation programs (not for statistics, but for basic manipulation prior to doing statistical analyses) is Excel. Another good program is ClarisWorks. Both of these programs allow for easy data entry and some basic data recoding. Although they can both do some basic statistical analyses and graphics they are not as powerful as programs developed specifically for statistical analysis or graphical display. Both Excel and ClarisWorks can read data files written as "text" by other programs.

The program we recommend for doing statistical analyses is Systat. However, data entry in Systat is not nearly as convenient as it is in either Excel or ClarisWorks.

First, make sure that you have both Excel and Systat on the computer. Try opening both programs. If there is not enough memory to do this operation, you will have to first open Excel, enter the data directly or get data from a file by opening the file. To copy data from one program to another you can use Cut and Paste. It might be necessary to first copy the appropriate data in Excel, and then close Excel, and open Systat to make the paste.

1) Using either Excel or Claris, open the data file from the simulation experiment (Simulation-Data). Note that you must open the data file from Excel, not by clicking on the data file itself. You may also open the experimental data file directly by clicking on it and openning it with Simple Text.

2) You may now select the data that you want to copy from Excel into Systat by highlighting the appropriate cells (hold down the mouse button while dragging across the appropriate cells.)

3) Copy (Edit menu -- Copy command) this selection.

4) Go to Systat. If the computer does not have enought memory to keep both Excel and Systat open, you must first close Excel and then open Systat.

5) In Systat

Select New from the File Menu.
Open the Edit Window (if it is not already open).
Position the cursor at row 1, Column 1 and select the cell (click).
Paste the data by Edit-Paste.

6) Label the variables by entering names in place of VAR1, VAR2 ...

7) Before you do any statistical analyses, it is useful to set a few parameters in Systat for best operation:

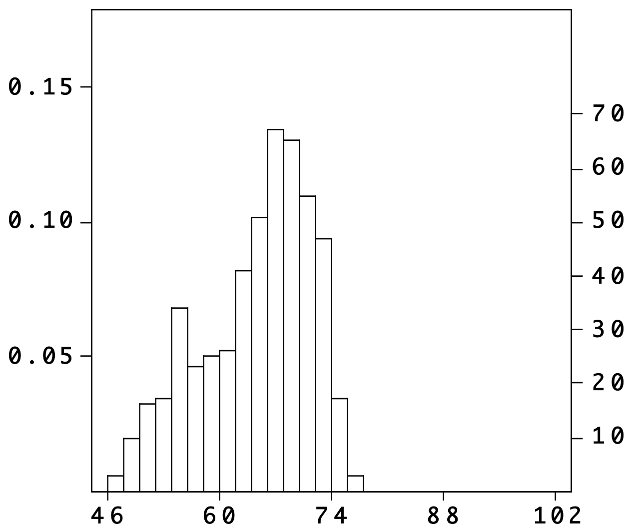
In the Window Menu, Choose Append as the option in Placement. This will allow any graph you make to be saved when you do the next one.
In the Edit Menu, choose Preferences and specify that 2 decimal places are adequate for output.

You are now ready to do both descriptive and inferential statistics.

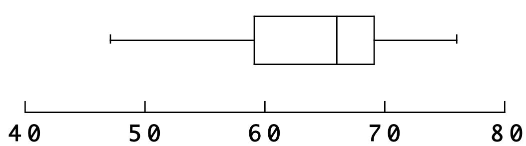
What are they?

Descriptive Statistics

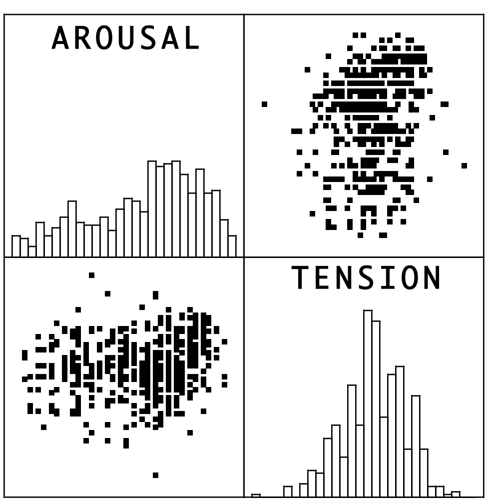
It is best to first to find some descriptive statistics of your data. A great range of options is available under the Graph menu. Examples include
Histograms:



Box and whisker plots



as well as **scatter plots** of the bivariate relationships between variables: (SPLOMS or Scatter Plots of Matrices:



These kinds of graphical displays are most appropriate for exploratory analysis, to help you understand what kind of relationships seem to be present.

Descriptive statistics may also be done using the STATS menu and choosing STATS and specifying the variables you want to describe:

TOTAL OBSERVATIONS: 504

	TIME	ANXIETY	IMPULSIV	AROUSAL
N OF CASES	500	500	500	500
MINIMUM	8.00	0.00	0.00	47.00
MAXIMUM	22.00	10.00	10.00	76.00
MEAN	15.22	4.96	4.98	64.15
VARIANCE	18.24	3.99	4.08	47.18
STANDARD DEV	4.27	2.00	2.02	6.87

Inferential Statistics

Inferential statistics allow you to test specific hypotheses. The typical "Null" hypothesis is that there is no difference between groups or no relationship between variables. This hypothesis is tested by examining the likelihood of observing the data given that the Null hypothesis is true. In general, each statistic may be seen as a ratio of some statistical estimate/the error of that estimate. The larger this ratio, the less likely the particular statistical estimate is to be zero. Many such tests may be done using the Multivariate General Linear Hypothesis (MGLH) option in the STATS menu.

MGLH takes advantage of the fact that Analysis of Variance (ANOVA) is a special case of the General Linear Model (GLM). That is, one can partition the variance of one (or many) dependent variables in terms of the effect of different combinations of the independent variables.

MGLH has two main options to consider, the Fully Factorial Analysis of Variance, and the General Linear Model. If your variables may be ordered into only a few categories (i.e., M/F, Placebo/Caffeine) then the ANOVA model is most appropriate. If the data are continuous and take on many values, the General Linear Model is more appropriate. However, for simplicity, it is also possible to divide a continuous distribution into a few categories. That is, although impulsivity might range from 0-10, it can be divided into those scores less than 5 and those 5 or greater. These two categories (1 and 2 for low and high) can be used in the ANOVA program. (Using the full features of the GLM are more powerful, and will be discussed later.)

To recode the data to make a dichotomous variable from a continuous variable, go to the Data-Recode Menu-Option. To recode Impulsivity into 2 levels, you would do the following:

If Impulsivity <5 then let IMP_2 = 1
and then do it again for
If Impulsivity >=5 then let IMP_2 = 2.

In the ANOVA program (STATS-MGLH-Fully Factorial ANOVA) you can specify the dependent variable by pulling down the menu under DV, and then specify the Independent variables by pulling down the IV menu. Clicking on a variable selects it for the analysis.

To get the cell means associated with this combination of the IVs, select MORE and then click the means and std. error box.

The output of such an analysis might look like this:

```
LEVELS ENCOUNTERED DURING PROCESSING ARE:
DRUG      0.00          1.00          <-- this tells you the two values of this IV
SEX       1.00          2.00

     4 CASES DELETED DUE TO MISSING DATA. <-- some cases were missing

DEP VAR: TENSION       N:      500   MULTIPLE R: 0.418   SQUARED MULTIPLE R: 0.175
         The Dependent Variable was Tension
                          ANALYSIS OF VARIANCE
SOURCE         SUM-OF-SQUARES    DF   MEAN-SQUARE      F-RATIO        P

DRUG                3618.32     1       3618.32       103.38        0.00
SEX                    0.02     1          0.02         0.00        0.98
DRUG*SEX              53.52     1         53.52         1.53        0.22
ERROR              17359.95   496         35.00

ADJUSTED LEAST SQUARES MEANS.    These are the means for each level of the IV's
                                   as well as for the combination of IVs.

                              ADJ. LS MEAN           SE       N
       DRUG     =          0.00         54.35           0.38     243  <-- Placebo
       DRUG     =          1.00         59.74           0.37     257  <-- Caffeine

        SEX     =          1.00         57.04           0.37     250    <--Males
        SEX     =          2.00         57.05           0.37     250   <-Females

       DRUG     =         0.00
        SEX     =          1.00         54.68           0.55     117 <--Placebo/Male

       DRUG     =         0.00
        SEX     =          2.00         54.03           0.53     126 <--Placebo/Female

       DRUG     =         1.00
        SEX     =          1.00         59.41           0.51     133 <--Caffeine/Male

       DRUG     =         1.00
        SEX     =          2.00         60.07           0.53     124 <--Caffeine/Female
```

The analysis of variance gives 3 estimates of the between groups variance: An estimate based upon the group differences between the 2 drug conditions, an estimate based upon the group differences between the 2 sexes, and an estimate based upon the interaction of sex and drug. Each of these "Mean Squares" may then be compared to the Mean Square (the variance) estimated within groups. If the Null hypothesis is true, these estimates should be roughly the same. In this case, the variance estimate based upon the difference of the drug conditions is 103 times as large as the estimate of variance based upon the within group variances. This is VERY unlikely to happen by chance and we would probably reject the hypothesis of no group difference of drug on tension. The other two ratio are quite small, and we would not reject the null hypothesis.

In addition to the confidence we have about group differences, it is also important to consider the means themselves