Personality and Arousal
An example of a research problem

background to Experiment 2

Testing personality theory by examining the interaction of subject variables and situational variables
Experiment 2: Overview

- Personality differences as subject variables
- Types of relationships between Independent Variables and Dependent Variables
- Prior work on personality and performance
- Simulation study
Types of relationships and research designs
Types of relationships and research designs

• Univariante
  – monotonic
  – linear
  – non-monotonic

• Multivariante
  – additive
  – interactive
One factor designs: determining the shape of effects

$DV = f(IV)$

but what is the shape of the function?

Requires two data points to determine sign of relationship, more to determine shape.
One factor designs: determining the shape of effects

DV = f(IV)

Requires two data points to determine sign of relationship, more to determine shape
One factor designs:
Monotonic effects- without inflection

Note that first derivative does not change sign
Accelerating vs. de-accelerating
Requires at least 3 data points
One factor designs:
Monotonic effects with inflection

First derivative does not change sign, but second derivative does
“if first or second derivative changes sign is a cue for two processes”
One factor designs: linear effects

Dependent Variable

Independent Variable

DV = f(IV)

Requires two data points to determine sign of relationship, more to determine shape
First derivative changes sign, but second derivative does not change sign. "If first or second derivative changes sign is a cue for two processes"

Requires at least 3 data points to determine non-monotonicity.
Two factor designs: simple additive effects

\[ \text{DV} = b_1(\text{IV}_1) + b_2(\text{IV}_2) \]
Two factor designs:

\[ DV = b_1(IV_1) + b_2(IV_2) + b_3(IV_1 \times IV_2) \]

But need to consider scaling interpretation (floor/ceiling, etc)
Two factor designs: Additive and interactive effects implication of cross over.

Dependent Variable

\[ DV = b_1(IV_1) + b_2(IV_2) + b_3(IV_1 * IV_2) \]

But need to consider scaling interpretation (floor/ceiling, etc)
Two factor designs:

Dependent Variable

Independent Variable-1

IV$_1$-0

IV$_1$-1

IV$_2$-0

IV$_2$-1

DV = b$_3$(IV$_1$ * IV$_2$)

Note that neither IV$_1$ nor IV$_2$ have direct effects on the DV
Experimental Variables and Subject Variables

• Experimental Variables may be randomly assigned and typically are functions of
  – situation (motivation, knowledge, priming)
  – task (memory load, task complexity, resource requirements)

• Subject variables may be observed but not assigned and are typically either
  – stable (gender, ethnicity, ability, anxiety, extraversion)
  – transient (currently depressed)
  – sources of interest or sources of error
Personality and Arousal
An example of a research problem

• Motivation and Performance: The Yerkes Dodson Law
  – Explorations in Arousal and Performance

• Personality and Performance
  – Dimensions of Personality
    • Introversion-Extraversion
    • Emotional Stability - Neuroticism

• Arousal and arousal preferences
  – Wundt
Behavioral Consequences of arousal differences

• Differences in Arousal preference
  – Wundt’s curvilinear hypotheses
    • Moderate levels of arousal are more pleasing than extreme levels
    • (“the Goldilocks hypothesis”)
  – Berlyne
    • Changes in arousal are more pleasing than a steady state
    • Increases or decreases are pleasant
Wundt’s hedonic curve
(adapted from Berlyne)
Berlyne’s hedonic curve
(adapted from Berlyne)

Arousal potential ->

Hedonic tone ->

Calming

Exciting

Adaptation to Current State

Boring

Frightening

Arousal potential ->
Wundt’s hedonic curve + Individual Differences
(adapted from Eysenck)

Arousal potential of situation ->

Hedonic tone ->

Introverts

Boring

Pleasant

Frightening

Extraverts
Yerkes Dodson “Law”

• Electric shock as drive inducer
  – 4-5 levels of shock
• Discrimination Learning
  – 3 levels of difficulty
• Performance as interactive effect of difficulty and drive
• Interpreted as inverted U relationship between arousal and performance
Yerkes and Dodson, 1908

Discrimination learning
Yerkes and Dodson
Learning and shock level

**Fig. 4.** Curves of learning. Ordinates represent series of ten tests each, and abscissae represent the average number of errors for four mice in each series. \( W \), designates the error curve for the individuals which were trained under the condition of weak electrical stimulation; \( M \), designates the corresponding curve for the medium strength of stimulation; and \( S \), that for the strong stimulus.
Fig. 5. A graphic representation of the relation of strength of electrical stimulus to condition of visual discrimination and rapidity of learning. Ordinates represent value of electric stimulus in units of stimulation; abscissae represent the number of tests given. Curve I represents the results of the experiments of Set I. Each dot indicates a value of stimulus which was used in the experiments. For example, the first dot to the left in curve I signifies that the stimulus whose value was 125 units gave a perfect habit, in the case of the four individuals trained, with 187 tests; the second dot, that for the stimulus value of 100 units 80 tests were necessary; and the third that for the stimulus value of 500, 155 tests. Curves II and III similarly represent the results of the experiments of sets II and III, respectively.
Yerkes and Dodson curve in terms of arousal and task difficulty
Arousal and Performance

• Broadbent and the Applied Psychology Unit
  – Sleep deprivation
  – Noise
  – Stress

• Common theme of arousal
  – Problems with arousal:
    • Is it a unified construct?
    • Arousal of the hand, the heart, the head
Personality and Arousal

• Introvert-Extravert differences map into levels of arousal
  – Introverts perform as if more aroused
  – Extraverts perform as if less arousal

• Eysenck and Arousal theory of I-E
  – Introversion-extraversion and arousal
  – Optimal arousal theory
  – Extraverts seeking to increase stimulation, introverts to reduce it
Does Personality make a difference?

• Important Life Criteria
  – Longevity (Friedman et al.)
  – Job Performance (Hunter and Schmidt)
  – Psychological well being

• Laboratory tasks
  – Cognitive sensitivities and biases (eg., McCloud, Mathews, Matthews, etc.)
Early attempts at theory testing

- Subject variable (Introversion-extraversion)
- Stress manipulation (1 variable)
  - Noise
  - Sleep deprivation
  - Threat
- Predict and observe interaction
- But, 3 out of 4 effects fit theory!
Problem with simple studies most predictions work!

Arousal ->

Extravert -c
Extravert -s

Introvert -c
Introvert -s

Easy
Moderate
Hard

Performance
Early attempt at theory testing

- How to manipulate arousal?
  - Presence of others (Social Facilitation effect)
  - Competition (Conspecifics as a source of threat)
  - Monetary Incentives (motivation increases arousal)
  - Noise (moderate to high levels are arousal inducing)
Multiple levels of arousal manipulations

• Combine variables into progressively more arousing
  – Relaxed alone
  – Relaxed together (group size 2)
  – Competing together (group size 2)
  – Competing together for money (group size 2)
  – Competing together for money (group size 8)
  – Competing together for money (group size 8 in noisy room)

• Measurement of arousal using skin conductance
Early attempt

• Prediction of personality by stress manipulation
• With 6 levels of stress, an observed interaction would confirm theory
• Result:
  – Arousal went down as group size went up!
  – Performance went up as incentives increase
Revelle, Amaral and Turriff (1976)

- Introversion-extraversion as assessed by self report
- Placebo-Caffeine to induce arousal
  - 200 mg of caffeine vs. 200 mg of placebo
- Practice Graduate Record Exams
- 3 levels of stress (repeated within subjects)
  - No time pressure
  - Time pressure + placebo
  - Time pressure + caffeine
Introversion, time pressure, and caffeine: effect on verbal performance

Revelle, Amaral and Turriff, Science, 1976
Gilliland’s improvement on Revelle, Amaral, and Turiff

- Used new and improved form of the Eysenck Personality Questionnaire (improved from Eysenck Personality Inventory)
- Used 3 levels of caffeine, dosed by body weight
- Used pre-post design
- Why is this a better design?
Gilliland does not replicate!

- Complete failure to find result
- post hoc reanalysis on partial set of subjects who had EPI showed the effect was there
- Impulsivity, not Extraversion is critical variable
- but is this data snooping, or a real effect?
Extraversion, Caffeine, and Cognitive Performance

Figure 9. EPI based group means for change in number of items correctly answered on GRE practice tests.

Gilliland, 1976
Many failures to replicate!

• Results were due to:
  – Adaptation to lab?
    • Theory predicts extraverts should be stimulated when arriving
    • Experimental delay from time of arrival
  – Type of task
    • GREs, math, verbal analogies
  – Incentives of situation?
Impulsivity, Caffeine, and Time of Day: the effect on complex cognitive performance

Revelle, Humphreys, Simon and Gilliland, JEP:G, 1980
Impulsivity, Caffeine, and Time of Day: the effect on complex cognitive performance

Revelle, Humphreys, Simon and Gilliland, JEP:G, 1980
Morningness/Eveningness and BT
(Baehr, Revelle and Eastman, 2000)

Temperature (°C)

Time (hours)

M-types
E-types

= Average Sleep
Personality and Cognition: early attempts at a synthesis

• Humphreys and Revelle, 1984
  – Personality Traits x situational cues produce
  – Motivational States (arousal and on task effort)
  – Inverted U between arousal and performance is the result of two processes
    • Arousal facilitates Sustained Information Transfer (SIT) and inhibits Working Memory
    • On task effort facilitates SIT
Simple stage model of processing -
Personality effects at each stage

Conceptual Stages of Information Processing

Stimulus Detection and Selection → Stimulus Encoding → Information Integration → Response Selection and Execution

Memory of conditional probabilities of past events

Feedback Loops
Personality affects each stage of processing

- Introversion facilitates detection in vigilance tasks
- Anxiety facilitates detection of threat terms
- Depression facilitates memory for negative events
- Intelligence facilitates processing speed
Arousal and Performance
(Hypothetical description of Yerkes and Dodson Effect)
Arousal and Working Memory

![Graph showing the relationship between arousal and working memory](image-url)
Arousal and Information Transfer

![Graph showing the relationship between arousal and information transfer.](image-url)
Arousal and Performance:
Arousal, Working Memory and Information Transfer
Humphreys and Revelle, Psychological Review, 1984
Using simulation to test theory

- Some theories can be too complicated to see all possible predictions. One solution is to write the theory as a set of complex, interacting relationships and to test whether the theory as simulated produces “real world” like results.
- Examples of such simulations include the global climate change model, simulations of the BIS/BAS, as well as a model developed from Humphreys and Revelle.
Introduction to simulation program

- Web based simulation that includes possible
  - linear effects
  - non-linear but monotonic effects
  - non-monotonic effects
  - person x situation interactions
  - experimental confounds

- Go to http://personality-project.org/revelle/syllabi/205/simulation/simulation.experiment.php
Simulation study

• 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.
Limited tests

• 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.
Variables

• Subject variables:
  – Sex (Male/Female) (1/2)
  – Anxiety (0-10)
  – Impulsivity (0-10)
  – Subject Number (1-100) (time of quarter effect?)

• Experimental variables
  – Time of day (8:00 - 22:00)
  – Placebo/Caffeine (0/1)

• Outcome variables
  – Energetic Arousal (0-100)
  – Tense Arousal (0-100)
  – Performance (0-100)
Variables: elaboration

• **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 without 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)
Outcome (dependent) variables

• **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 to 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.
The simulation is a web based program that allows you to "collect" the data on the web and then save the resulting output file to your computer to do subsequent analyses. The biggest question is what should you study. To answer this, you need to consider the variables available.

**What are the variables you can specify in this simulation?**

**Independent variables** that are under control of the experimenter may be categorized as **experimental** variables and **subject** 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

1. Drug condition (placebo or caffeine),
2. 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** are that are "assessed" are:

1. Sex (Male=1, Female=2)
2. Trait Anxiety (0-10)
3. Trait Impulsivity (0-10)
4. Subject Number reflects when the subject appears in the quarter.
The **Dependent Variables** are measures of motivational state

1. Energetic Arousal
2. Tense Arousal
3. Performance (accuracy on some attention task)

The values of the IVs and DVs 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 Cost of running grows more rapidly than the simple number of subjects who participate.

It is a good idea to think carefully about your design before you run it.
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It is a good idea to think carefully about your design before you run it.

Subject Number increases for every subject run in a particular experiment. Currently, it can not exceed 1000, but most runs will use less than 100. You will be asked to specify the number of subject that you want to run.

How many subjects do you want to run?
Screen shots (p2 -1 )

This form will allow you to run up to the 100 subjects that you specified. For each simulated participant you need to specify the experimental conditions. When you are finished with specifying all the subjects, you can enter submit (at the end of the page). If you specify less than 100 participants, the last N will be filled with random participants. You can edit these out later in the statistical analysis if you choose.

Enter the conditions for the subject 1

Sex Random □ or Male □ Female □
Drug Random □ or Placebo □ Caffeine □
Time of Day Random □ or Fixed 8 □ 9 □ 10 □ 11 □ 12 □ 13 □ 14 □ 15 □ 16 □ 17 □ 18 □ 19 □ 20 □ 21 □ 22 □
Anxiety Random □ or Fixed 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10 □
Impulsivity Random □ or Fixed 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10 □

Enter the conditions for the subject 2
Sex Random □ or Male □ Female □
Drug Random □ or Placebo □ Caffeine □
Time of Day Random □ or Fixed 8 □ 9 □ 10 □ 11 □ 12 □ 13 □ 14 □ 15 □ 16 □ 17 □ 18 □ 19 □ 20 □ 21 □ 22 □
Anxiety Random □ or Fixed 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8 □ 9 □ 10 □
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How to specify conditions

This form will allow you to run up to the 100 subjects that you specified. For each simulated participant you need to specify the experimental conditions. When you are finished with specifying all the subjects, you can enter submit (at the end of the page). If you specify less than 100 participants, the last N will be filled with random participants. You can edit these out later in the statistical analysis if you choose.

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Drug Random ○ or Placebo ○ Caffeine ○
Time of Day Random ○ or Fixed 8 ○ 9 ○ 10 ○ 11 ○ 12 ○ 13 ○ 14 ○ 15 ○ 16 ○ 17 ○
18 ○ 19 ○ 20 ○ 21 ○ 22 ○
Anxiety Random ○ or Fixed 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○
Impulsivity Random ○ or Fixed 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○

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Drug Random ○ or Placebo ○ Caffeine ○
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Study 2: Simulated experiment

• Develop a hypothesis of the relationship between some set of the possible variables

• Design an experiment to test this hypothesis
  – what are the Independent Variables to be tested?
    • what and how many levels to use
    • continuous or discrete categories?
  – What are the Dependent Variables to be observed
  – Should other variables be fixed or random?
    • consider the generality of the result
Simulation study

• Full model is too complicated to study, need to choose a limited set of “interesting” variables.

• Choose among a set of independent and dependent variables

• Examine how these variables interrelate.
Simulation study: Variables

- Impulsivity (0-10)
- Anxiety (0-10)
- Caffeine (0,1)
- Time of Day (8-24)
- Gender (M=1, F=2)
- Energetic Arousal (0-100)
- Tense Arousal (0-100)
- Performance (attention task) (0-100)
Simulation Study: Independent Variables

- Either let the computer randomly assign subjects to values on the IVs or you assign them yourself
- Caffeine
- Time
- Impulsivity
- Anxiety
- Sex
Simulation Study: What to do

- Develop hypotheses that you want to test
- Design an experiment that can test your hypothesis
- Consider issues of counterbalancing, randomization, etc. to control for time in quarter effects (if they are there).
- Consider how subjects are to be run (what conditions, what orders, what should be randomized, what controlled).
- Go to the web page and run the experiment
- Save the data in a text file for later analysis
Simulation study: Things to consider

• Issues of power vs. time
  – More subjects lead to smaller standard errors and greater chance of detecting effects.
  – More subjects take longer to run

• Cost of running subjects
  – Selecting extreme scores on personality variables is done by group testing and leads to fewer subjects being available or greater cost per subject
Issues to Consider

- Design study that makes sense
- Don’t try to study all possible variables
- Design a study that is interesting to you.
- Read the associated literature, develop meaningful hypotheses
- Try running a few subjects, see if the analysis makes any sense
  – see if you can do the analysis