

# Psychology 360: Personality Research

## Introversion-Extraversion

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## Outline

Descriptive vs. Causal models

Descriptions of Introversion-Extraversion

A personal digression

Eysenck's influence on personality theory

Measurement

Eysenck, the development of theory

Eysenck's arousal theory as a theory of performance

Personality and Performance

Personality and performance

Theory comparison and development

Theory Testing

References

## I/E

## 1. Simple descriptive basis

- Self reports on SAPA correlated with other scales from the Big Few and the Little 27
- Sociable
- Active
- Impulsive
- Spontaneous

2. Peer ratings (As an example, [Zola, Condon & Revelle \(2021\)](#) asked for peer ratings of SAPA participants.)

## 3. People who describe themselves as outgoing are more known to others.

## Big Few and mighty many correlations with Extraversion

Variable	Self Report	Peer ratings
Extraversion	<b>0.90</b>	<b>0.71</b>
Sociability	<b>0.78</b>	<b>0.67</b>
AttentionSeeking	<b>0.70</b>	<b>0.42</b>
Charisma	<b>0.66</b>	<b>0.70</b>
Humor	<b>0.56</b>	<b>0.44</b>
EmotionalExpressiveness	<b>0.53</b>	<b>0.36</b>
Peer Ratings Extraversion	<b>0.49</b>	<b>0.52</b>
WellBeing	<b>0.46</b>	<b>0.66</b>
Adaptability	<b>0.39</b>	<b>0.37</b>
SensationSeeking	<b>0.37</b>	0.28
Anxiety	-0.29	<b>-0.41</b>
Agreeableness	0.28	<b>0.34</b>
Trust	0.28	<b>0.38</b>
Neuroticism	-0.28	<b>-0.40</b>
HonestyHumility	-0.23	-0.06
Impulsivity	0.23	-0.13
Creativity	0.22	0.26
EasyGoingness	-0.22	<b>-0.50</b>
Compassion	0.22	0.25
Intellect	0.20	<b>0.31</b>
Industry	0.20	<b>0.51</b>
Conservatism	0.16	0.29
Conscientiousness	0.13	<b>0.42</b>
Openness	0.13	0.17
Attractiveness	0.11	0.11
IntellectOpenness	0.09	0.15
SelfControl	-0.08	0.17
Irritability	-0.06	-0.07
Introspection	-0.06	-0.05
Stability	0.05	<b>0.38</b>
Conformity	-0.05	0.09
EmotionalStability	-0.04	-0.23

## Correlations of SAPA items with Extraversion score

Variable	Extrv	item	B5	L27
q_1027	-0.76	Hate being the center of attention.	Extra	AttentionSeeking
q_565	-0.75	Dislike being the center of attention.	Extra	AttentionSeeking
q_1904	0.74	Usually like to spend my free time with people.	Extra	Sociability
q_312	-0.73	Avoid company.	Extra	Sociability
q_1296	0.71	Like to attract attention.	Extra	AttentionSeeking
q_1416	0.70	Make myself the center of attention.	Extra	AttentionSeeking
q_254	0.70	Am skilled in handling social situations.	Extra	Charisma
q_901	-0.68	Find it difficult to approach others.	Extra	Charisma
q_1923	-0.68	Want to be left alone.	Extra	Sociability
q_4243	0.67	Like going out a lot.	Extra	Sociability
q_684	-0.66	Dont like crowded events.	Extra	Sociability
q_803	0.63	Express myself easily.	Extra	EmotionalExpressiveness
q_1243	0.59	Laugh a lot.	Extra	Humor
q_1244	0.56	Laugh aloud.	Extra	Humor
q_1371	0.52	Love life.		WellBeing
q_219	0.49	Am open about my feelings.		EmotionalExpressiveness
q_1081	-0.49	Have difficulty expressing my feelings.		EmotionalExpressiveness
q_1045	0.49	Have a natural talent for influencing people.		Charisma
q_3840	0.48			
q_131	0.48	Am good at making impromptu speeches.		Charisma
q_296	0.47	Amuse my friends.		Humor
q_1635	-0.47	Reveal little about myself.		EmotionalExpressiveness
q_1242	-0.47	Lack the talent for influencing people.		Charisma
q_1248	0.46	Laugh my way through life.		Humor
q_1052	-0.43	Have a slow pace to my life.		EasyGoingness
q_1781	0.41	Take risks.		SensationSeeking
q_1662	0.41	Seek adventure.		SensationSeeking
q_2765	0.41	Am happy with my life.		WellBeing



## Items correlating with peer ratings of extraversion

Variable	Extrv	item	B5	L27
q_312	-0.82	Avoid company.	Extra	Sociability
q_254	0.80	Am skilled in handling social situations.	Extra	Charisma
q_1371	0.73	Love life.		WellBeing
q_578	-0.69	Dislike myself.	Neuro	WellBeing
q_1052	-0.67	Have a slow pace to my life.		EasyGoingness
q_2765	0.67	Am happy with my life.		WellBeing
q_901	-0.67	Find it difficult to approach others.	Extra	Charisma
q_1904	0.62	Usually like to spend my free time with people.	Extra	Sociability
q_1923	-0.61	Want to be left alone.	Extra	Sociability
q_1744	0.61	Start tasks right away.	Consc	Industry
q_131	0.60	Am good at making impromptu speeches.		Charisma
q_1444	-0.59	Need a push to get started.	Consc	Industry
q_1328	0.58	Like to stand during the national anthem.		Conservatism
q_1027	-0.58	Hate being the center of attention.	Extra	AttentionSeeking
q_820	0.57	Feel comfortable with myself.		WellBeing
q_811	-0.55	Feel a sense of worthlessness or hopelessness.	Neuro	WellBeing
q_1248	0.54	Laugh my way through life.		Humor
q_803	0.52	Express myself easily.	Extra	EmotionalExpressiveness
q_1242	-0.51	Lack the talent for influencing people.		Charisma
q_4243	0.49	Like going out a lot.	Extra	Sociability
q_1244	0.48	Laugh aloud.	Extra	Humor
q_90	0.48	Am concerned about others.	Agree	Compassion
q_1024	-0.48	Hang around doing nothing.		EasyGoingness
q_689	-0.48	Dont like the idea of change.		Adaptability
q_808	-0.48	Fear for the worst.	Neuro	Anxiety
q_4252	-0.47	Am a worrier.	Neuro	Anxiety
q_377	0.47	Believe that others have good intentions.	Agree	Trust
q_871	-0.46	Feel that most people cant be trusted.	Agree	Trust
q_1662	0.46	Seek adventure.		SensationSeeking
q_565	-0.45	Dislike being the center of attention.	Extra	AttentionSeeking
q_684	-0.44	Dont like crowded events.	Extra	Sociability
q_1045	0.44	Have a natural talent for influencing people.		Charisma

## Three reasons to study extraversion (Wilt & Revelle, 2009, 2016)

1. Extraversion as one of the broad “Big Few” (Möttus, Wood, Condon, Back, Baumert, Costani, Epskamp, Greiff, Johnson, Lukaszewski, Murray, Revelle, Wright, Yarkoni, Ziegler & Zimmerman, 2020) and one of the “Giant 3” (Eysenck, 1994)
2. Extraversion predicts effective functioning and well-being across a wide variety of domains Ozer & Benet-Martinez (2006a)
  - from cognitive performance Matthews (1992)
  - social endeavors Eaton & Funder (2003)
  - social economic status Roberts, Kuncel, Shiner, Caspi & Goldberg (2007).
3. Extraversion predicts risk Bagby, Costa, Jr., Widiger, Ryder & Marshall (2005) and also resilience Jylha & Isometsa (2006) for different forms of psychopathology Trull & Sher (1994); Widiger (2005).

## American Taxonomists – European Theorists

1. While most US researchers were studying the dimensionality of self reports, Europeans were developing casual models.
2. The most complete (and changing) causal model of extraversion was that of Hans Eysenck ([Eysenck, 1967](#), [1990](#))
3. In the past 20 years the field has exploded in its interest in extraversion.



## Where I first learned about personality theory (and Hans Eysenck)

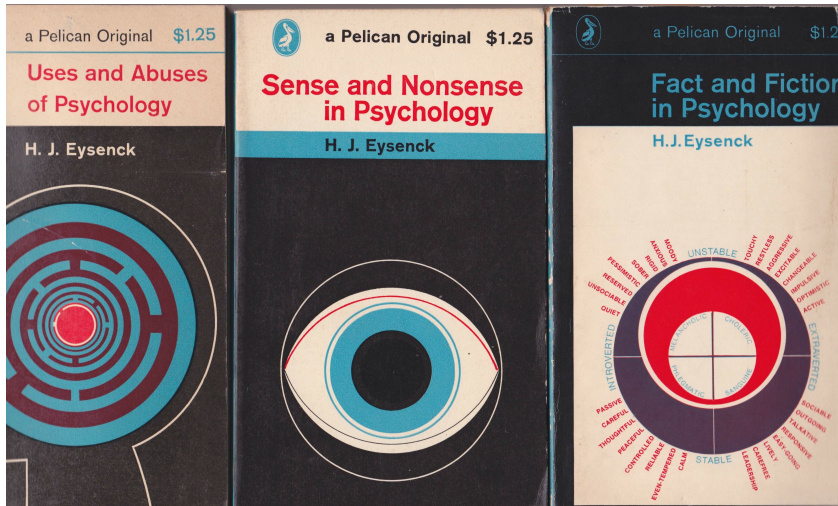


Figure: Nanga Medamit, ulu Limbang, Sarawak, Malaysia, 1965-1967

# My first exposure to Hans Eysenck



## The only psychology books in the Brunei bookstore (100 Km or 10 hours by boat downriver) were by Hans Eysenck



## Who was this man?



published by Penguin Books

Psychology occupies a somewhat ambiguous place in the world today. Its findings are being widely applied in clinics, in industry, in education, and in the armed forces. At the same time, many intelligent people are critical of the alleged laws of human behaviour discovered by psychologists, psychiatrists, and psychoanalysts, and doubtful about the applicability of scientific methods to the study of human beings. In this book, a well-known psychologist has tried to strike a balance, to indicate to what extent the claims made for his science are justified, and to what extent they fail to have any factual basis. The discussion is very fully documented by references to the most important and relevant researches carried out in this country and abroad. Topics dealt with are the testing of intelligence, selection procedures in schools and universities, vocational guidance and occupational selection, psychotherapy and its effects, national differences, racial intolerance, Gallup surveys, industrial productivity, and many others. In each case, psychological findings are submitted to a searching criticism, and a clear distinction made between those uses of psychology where enough is known to support social action, and those abuses where personal opinions rather than experimentally demonstrated fact seem to be involved.

Cover design by Eric Kitson



published by Penguin Books

Here is the long awaited final volume of Professor Eysenck's Pelican trilogy: *Uses and Abuses of Psychology*, *Sense and Nonsense in Psychology* - and now *Fact and Fiction in Psychology*.

The author's style is as incisive and his wit as keen as ever, while the range of subjects that he deals with is, as always, provocatively wide. Of special interest in this volume is his application of behavioural therapy to the theory and practice of neurotic behaviour and especially to the severe clinical problem of the alcoholic. Also Professor Eysenck's most recent views on the criminal personality are set out with challenging authority.

Further chapters on the psychology of road traffic offenders and a hard look at the more exclusive claims of depth psychology complete a fascinating volume.

Cover design by Germano Facetti



## The influence of Eysenck on personality and individual differences

### 1. Popular books

- Uses and abuses of psychology ([Eysenck, 1953](#))
- Sense and nonsense in psychology ([Eysenck, 1964](#))
- Fact and fiction in psychology ([Eysenck, 1965](#))

### 2. Scholarly books (a small selection)

- Dimensions of personality ([Eysenck & Himmelfeit, 1947](#))
- The scientific study of personality (1952)
- The structure of human personality (1953)
- The dynamics of anxiety and hysteria (1957)
- The biological basis of personality ([Eysenck, 1967](#))
- Eysenck of extraversion (1973) (Edited reprints)
- The measurement of personality (1976) (Ed.)
- A model for intelligence (1982) ([Eysenck, 1982](#))
- Personality and Individual differences ([Eysenck & Eysenck, 1985](#))
- A new look at intelligence ([Eysenck, 1998](#))

See also ([Revelle, 2016](#))

## European personality research was a beacon of light in the “Dark Ages of personality”

- While personality was under attack in the US (Mischel, 1968; Endler & Magnusson, 1976) it was alive and well and living in Europe (Eysenck, 1967), Gray (1970, 1982, 1991), Strelau & Angleitner (1991)
  - It is hard to remember now in the third decade of the 21st century the attacks of the 60s-80s on the study of stable, biologically based, important personality traits.
  - These attacks had a perverse and long lasting influence on American personality research.
  - The scars of these debates persist in that a generation of American researchers avoided the field.
  - However, it is because of the contributions of (mainly) European personality researchers that we have such a vibrant field today.
- Whether we agree or disagree with Hans Eysenck’s theoretical program, we all owe a great debt to his contribution in advancing the field.

## All American/European taxonomies of the 20th century include Extraversion

1. The Giant 3 of Eysenck (Eysenck, 1994)
  - Maudsley Personality Inventory (MPI) (Eysenck, 1959) (E and N)
  - Eysenck Personality Inventory (EPI) (Eysenck & Eysenck, 1967a) (E and N)
  - Eysenck Personality Inventory (EPQ) (Eysenck & Eysenck, 1975) (P, E, and N)
2. The NEO-PI-R (Costa & McCrae, 1985) (N, E, O, A, C)
3. IPIP (Goldberg, 1999) Open source personality items – IPIP-NEO - IPIP Big 5
4. (Tellegen, 1982) 7 dimensions
5. HEXACO (Lee & Ashton, 2004)
6. SPI (Condon, 2018) 135 item test including measures of E
7. BFAS (DeYoung, Quilty & Peterson, 2007) splits E into enthusiasm and assertiveness

## Commonly used inventories measuring extraversion

Inventory	Abbreviation	Author
Abridged Big Five Circumplex	AB5C	Hofstee, de Raad, & Goldberg
Big Five markers	BFM	Goldberg
Big Five Inventory	BFI	John, Donahue, & Kentle
Big 5 Aspect Scales	BFAS	DeYoung, Quilty, & Peterson
Eysenck Personality Inventory	EPI	H.J. & S.B. Eysenck
Eysenck Personality Questionnaire	EPQ	S.B. & H.J. Eysenck
Eysenck Personality Profiler	EPP	H.J. Eysenck & G. D. Wilson
Five Factor Non Verbal Personality Questionnaire	FF-NPQ	Paunonen and Ashton
Guilford Zimmerman Personality Survey	GZTS	Guilford & Zimmerman
HEXACO Personality Inventory	HEXACO-PI	Lee and Ashton
International Personality Item Pool	IPIP	Goldberg
Maudsley Personality Questionnaire	MPQ	H.J. Eysenck
Multidimensional Personality Questionnaire	MPQ	Tellegen
Neuroticism-extraversion-Openness Personality Inventory Revised	NEO-PI-R	Costa & McCrae
NEO Five Factor Inventory	NEO-FFI	Costa & McCrae
Riverside Behavioral Q-Sort	RBQ	Funder, Furr, & Colvin



## Representative Items from extraversion scales emphasize Affective and Behavioral aspects

Inventory	ABCD	Item
AB5C	A	Radiate joy
BFI	A	I see myself as someone who is full of energy
GZTS	A	You are a happy-go-lucky individual
HEXACO	A	Am usually active and full of energy
MPQ	A	Have a lot of fun
NEO-FFI	A	I really enjoy talking to people
BFAS	B	Am the first to act
BFM	B	Talkative
EPI	B	Do you like going out a lot?
EPQ	B	Do you like telling jokes and funny stories to your friends?
EPP	B	Would you prefer to fight for your beliefs than let an important issue go unchallenged?
FF-NPQ	B	Picture of person riding a bucking horse
IPIP	B	Am the life of the party
MPQ	B	Do you like to mix socially with people?
NEO-PI-R	B	I am dominant, forceful, and assertive
RBQ	B	Exhibits social skills

## Top 20 Extraverison items from the Sapa Personality Inventory (SPI)

Variable	item	Little 27
q_1904	Usually like to spend my free time with people.	Sociability
q_565-	Dislike being the center of attention.	AttentionSeeking
q_1045	Have a natural talent for influencing people.	Charisma
q_1243	Laugh a lot.	Humor
q_219	Am open about my feelings.	EmotionalExpressiveness
q_312-	Avoid company.	Sociability
q_1027-	Hate being the center of attention.	AttentionSeeking
q_254	Am skilled in handling social situations.	Charisma
q_1244	Laugh aloud.	Humor
q_1081-	Have difficulty expressing my feelings.	EmotionalExpressiveness
q_1923-	Want to be left alone.	Sociability
q_1416	Make myself the center of attention.	AttentionSeeking
q_1248	Laugh my way through life.	Humor
q_803	Express myself easily.	EmotionalExpressiveness
q_4243	Like going out a lot.	Sociability
q_1296	Like to attract attention.	AttentionSeeking
q_901-	Find it difficult to approach others.	Charisma
q_296	Amuse my friends.	Humor
q_1635-	Reveal little about myself.	EmotionalExpressiveness
q_684-	Dont like crowded events.	Sociability

## Obvious behavioral correlates

1. E's talk more  
But this interacts with group size
2. More well known
3. Occupational differences  
Extraversion and success in sales  
(but is this ambition or sociability?)
4. Introversion and preference for isolation
5. Extraversion and stimulation seeking  
Higher risk of arrest (interacts with social class)  
Higher risk of auto accidents
6. Greater sexual activity  
E's have  
More partners  
Earlier onset  
Prefer more positions

## Eysenck's theories as integration of individual differences with general laws

Eysenck always tried to integrate his taxometric study of individual differences with the best general psychological theories available at the time. That meant that the theory changed. (Although sometimes without comment.) Thus, to read [Eysenck & Himmelweit \(1947\)](#) or [Eysenck \(1952\)](#) is to read a completely different theoretical integration than proposed in [Eysenck \(1967\)](#) or [Eysenck & Eysenck \(1985\)](#) or finally, that of [Eysenck \(1997\)](#).

### 1. Personality and Learning Theory

- [Hull \(1943, 1952\)](#)
- [Eysenck & Himmelweit \(1947\)](#); [Eysenck \(1952\)](#)

### 2. Personality and Arousal Theory

- [Hebb \(1955\)](#); [Berlyne \(1960\)](#); [Berlyne & Madsen \(1973\)](#); [Broadbent \(1971\)](#)
- [Eysenck \(1967\)](#); [Eysenck & Eysenck \(1985\)](#)

### 3. Personality, genetics, structures, and neurotransmitters

## The original Eysenck factors (of behavior)

Table: The original Eysenck matrix

The original Eysenck factor output

Variable	1	2	3	4
Age above 30	0.08	0.14	-0.27	-0.22
Unskilled	0.22	-0.45	0.12	-0.48
Unemployment	0.55	-0.23	-0.12	-0.36
Degraded work-history	0.16	-0.29	0.16	-0.29
Abnormality in parents	0.47	0.21	0.35	0.31
Unsatisfactory home	0.43	0.06	0.45	0.00
Married	0.21	0.39	-0.12	-0.19
No group membership	0.46	-0.40	-0.16	-0.32
Narrow interests	0.55	-0.57	0.04	-0.10
Alcohol	0.07	0.00	0.17	-0.36
Abnormal before illness	0.61	-0.09	0.24	0.33
Badly organized personality	0.92	-0.12	0.35	0.15
Dependent	0.65	-0.22	0.06	0.24
Little energy	0.53	-0.69	0.06	-0.24
Cyclothymic	0.46	0.31	0.00	0.37
Schizoid	0.52	-0.07	0.26	0.29
Hypochondriacal personality	0.31	-0.22	-0.41	0.07
Obsessional	0.00	0.51	0.07	0.25
Somatic anxiety	0.05	0.25	-0.37	0.12
Effort intolerance	0.23	0.13	-0.63	0.26
Dyspepsia	0.54	0.17	-0.36	-0.01
Fainting, fits	0.23	-0.23	-0.42	0.23
Pain	0.12	0.00	-0.39	0.03
Tremor	0.30	0.34	0.17	0.10
Sex anomalies	0.14	-0.50	0.54	-0.01
Irritability	0.18	0.41	0.13	-0.10
Apathy	0.18	0.48	-0.02	-0.46



## Learning theory

1. In the late 1940s to the late 1950's, theories of learning were the major theoretical approach.
2. Eysenck's first attempt to explain extraversion was based on the notions of excitation and inhibition [Eysenck \(1957\)](#), which were thought to influence the acquisition and extinction of behavior [Pavlov \(1927\)](#); [Hull \(1943\)](#). Specifically, Eysenck proposed that introverts had higher cortical excitability than extraverts, and thus would condition more efficiently.
3. Eysenck (and Spence) tried to integrate individual differences into these approaches by examining differential rates of learning
4. To Eysenck introverts condition more rapidly than extraverts ([Eysenck & Himmelweit, 1947](#); [Eysenck, 1952](#))
5. Thus, introverts learned to be rule followers, Extraverts not so much.

## Differences in conditionability

### 1. Original hypothesis

- Introverts are easily conditioned
- Introverts become well socialized

### 2. Later findings

- Conditioning differences depend upon situation
- Low arousal situations lead to better conditioning for introverts
- Impulsivity more important than extraversion (Eysenck & Levey, 1972; Levey & Martin, 1981)

### 3. Problems of meta analyses – meta silliness? (Eysenck, 1978)

- Does pooling good studies with bad really provide the best estimate of an overall effect?
- But how to choose good studies?
- Inconsistency between Spence lab and Eysenck lab in terms of conditioning results.
- Greg Kimble compared the two labs, differed in the subtle ways that the experimenters treated subjects.
- Does pooling across different studies really work?

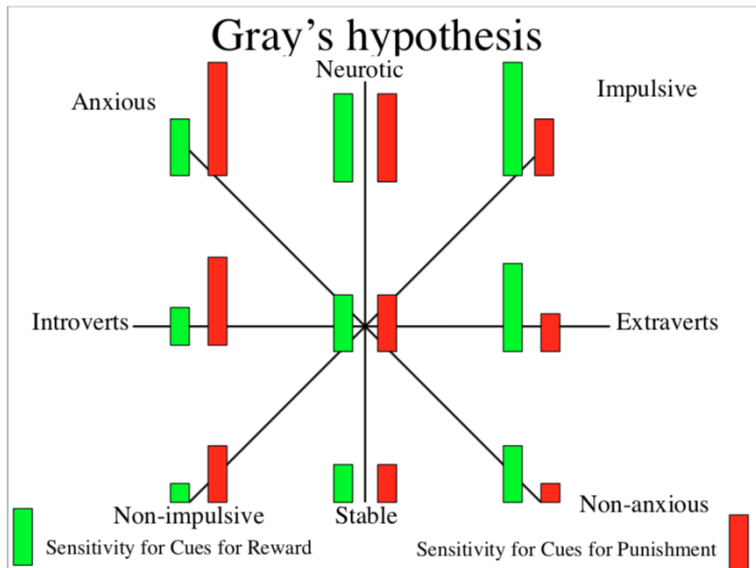


## I-E and conditioning

A good theory should be lead to programmatic research with modifications reflecting new data.

1. (Newman, Widom & Nathan, 1985; Patterson, Kosson & Newman, 1987) work on psychopaths and conditioning
  - inability to stop
2. Gray's model of anxiety, impulsivity and conditioning (reinforcement sensitivity) (Gray, 1981, 1987, 1991)
3. (Zinbarg & Revelle, 1989a; Zinbarg & Mohlman, 1998)
  - Sensitivity to cues of reward and action (impulsivity)
  - Sensitivity to cues of punishment and inaction (anxiety)
4. Gray's revised model of Reinforcement Sensitivity Theory (Gray & McNaughton, 2000; Corr, 2002)

## The Gray model



## In 1960's experimental research by Broadbent (1971) and others highlighted arousal

1. Studies of human performance done at Cambridge and then Oxford examined performance under stress and boredom.
2. Concerned with effective performance and the effect of
  - Sleep deprivation
  - Noise
  - Stress
3. Introducing the arousal construct as the common theme to these manipulations was a change from the simple behaviorist approach.
4. Others noticed that Eysenck was studying similar manipulations and phenomena.

## Hypothesis of arousal differences

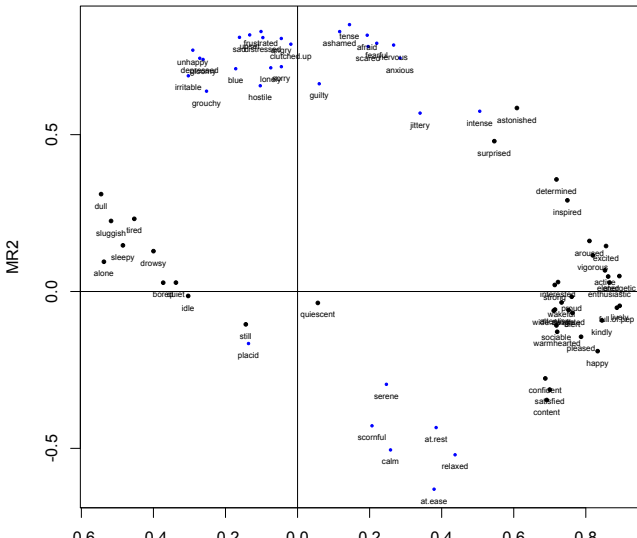
1. What is arousal?
  - Arousal of the hand, the heart, and the head
  - Skin conductance
  - Heart rate
  - EEG desynchronization
2. Self reports ([Thayer, 1970, 1989, 2000](#); [Matthews, Jones & Chamberlain, 1990](#))
  - Energetic arousal
  - Tense arousal
3. The Motivational State Questionnaire (MSQ) had 75 items selected from ([Thayer, 1970](#); [Watson, Clark & Tellegen, 1988](#); [Larsen & Diener, 1992](#))

MSQ data were collected over 10 years for 3800 participants.

Data are available as the `msq` data set in the *psychTools* package

# Measuring Tense and Energetic Arousal

2 dimensions of the Motivational State Questionnaire



## Representative MSQ items arranged by angular location

Variable	PA	NA	$\theta$	Vector length
wide.awake	0.74	0.00	0.21	0.74
alert	0.76	0.01	1.01	0.76
full.of.pep	0.84	0.03	1.77	0.84
lively	0.86	0.03	2.14	0.86
energetic	0.86	0.04	2.89	0.86
elated	0.73	0.04	3.03	0.73
active	0.82	0.06	3.96	0.82
anxious	0.28	0.56	63.02	0.63
nervous	0.21	0.62	71.01	0.66
afraid	0.12	0.62	78.90	0.63
fearful	0.11	0.61	79.79	0.62
sad	-0.08	0.66	97.15	0.67
lonely	-0.09	0.52	99.93	0.53
blue	-0.14	0.63	102.66	0.65
unhappy	-0.17	0.68	103.78	0.70
depressed	-0.18	0.66	105.31	0.68
tired	-0.53	0.14	165.32	0.54
sleepy	-0.50	0.13	165.78	0.52
drowsy	-0.50	0.12	166.68	0.51
calm	0.08	-0.40	281.25	0.41
serene	0.10	-0.33	287.11	0.34
relaxed	0.21	-0.44	295.22	0.49
at.ease	0.29	-0.45	302.64	0.54
at.rest	0.20	-0.31	302.84	0.37
content	0.54	-0.36	326.45	0.64
satisfied	0.58	-0.27	335.30	0.64
warmhearted	0.57	-0.18	342.37	0.60
happy	0.71	-0.23	342.42	0.75
attentive	0.72	-0.02	358.53	0.72
enthusiastic	0.80	-0.01	359.12	0.80

## Sedation threshold (Shagass, 1958)

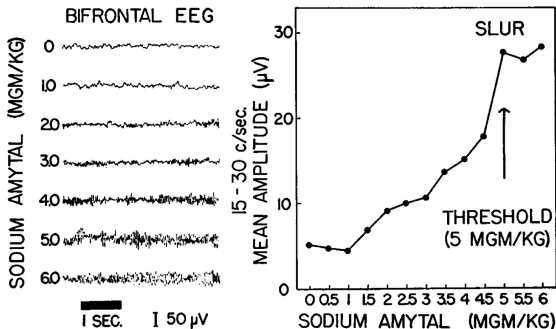


Fig. 1. Illustrates effect of Sodium Amytal on bifrontal EEG. Note progressive increase of the fast-frequency amplitude. Arrow points to inflection point in the amplitude curve which indicates sedation threshold.

## Threshold differences detected by psychophysical methods

### 1. Light Sensitivity (threshold)

(Siddle, Morrish, White & Mangan, 1969) staircase method

### 2. Sound sensitivity

(Smith, 1968) forced choice

### 3. Electrocutaneous threshold (Edman, Schalling & Rissler, 1979)

### 4. Pain sensitivity

(Haslam, 1967, 1972) (Petrie, Collins & Solomon, 1960; Petrie, 1967)

**Barnes (1975)** integrated several studies

### 5. Bi-modal sensitivity (Shigehisa & Symons, 1973)

### 6. Reaction to lemon juice

(Eysenck & Eysenck, 1967b; Corcoran & Houston, 1977; Corcoran & Hajduk, 1980; Deary, Ramsay,

Wilson & Riad, 1988)

Many of these were small sample studies – problem of replication and over interpretation, We would now worry about experimenter degrees of freedom, p hacking, selective reporting.



## Basal arousal differences

1. Detected in psychophysiological experiments ([Stelmack, 1990](#))
2. Electrophysiology (EEG) Now you see it, now you don't [Gale \(1981\)](#)
  - In very boring, or very exciting situations,  $E_s > I$
  - But in relatively average situations,  $I > E$ .
3. [Gale, Coles & Blaydon \(1969\)](#) suggestion conditions need to be just right
4. Was this a problem of non-replicability of low powered experiments?
5. Or over reliance on theory driven but inadequate research methods?
6. Confirmatory studies, selective publishing of supporting studies?

## Basal arousal differences (continued)

1. Sedation threshold – Shagass (1955), Claridge et al. (1981)
2. Skin Conductance – Revelle (1973) – Wilson (1989)
3. Spontaneous GSR ([Crider & Lunn, 1971](#); [Crider, 2008](#))
4. Photic Driving –([Robinson, 1982, 1983](#))
5. All of these studies show predicted differences between high and low introversion-extraversion. But are the results real?

## Sedation threshold (Shagass, 1958)

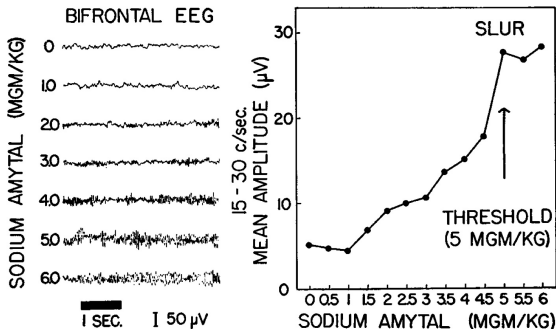


Fig. 1. Illustrates effect of Sodium Amytal on bifrontal EEG. Note progressive increase of the fast-frequency amplitude. Arrow points to inflection point in the amplitude curve which indicates sedation threshold.

## Body temperature and time of day

1. **Blake (1967)** was cited as showing biological differences related to arousal but how relevant is this to basic theory?
2. Folkard (1976)
3. **Eysenck & Folkard (1980)**
4. Wilson (1990)

## Blake and time of day

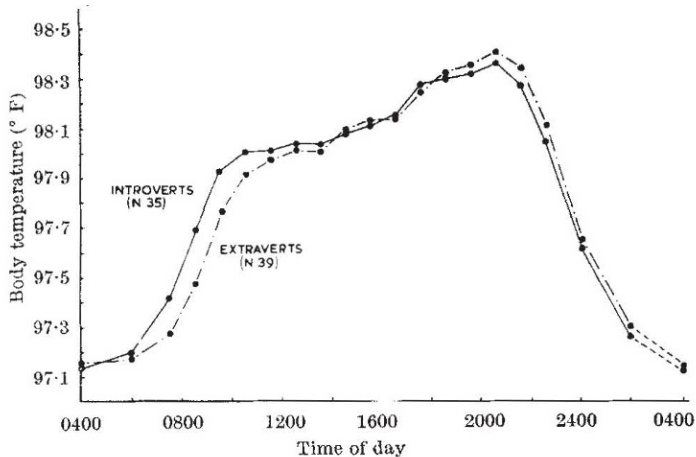
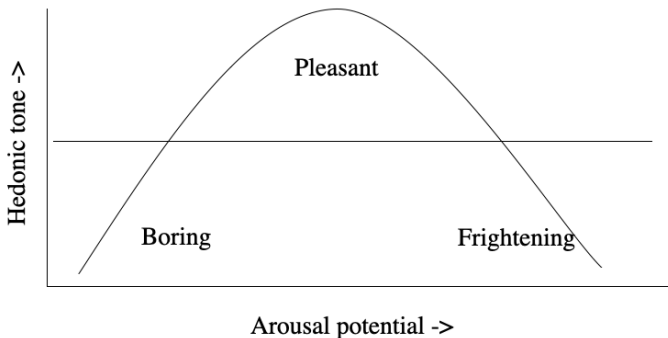


Fig. 1. Mean circadian rhythm of body temperature in introvert and extravert groups.

## The Wundt curve of hedonic tone

### Wundt's hedonic curve

(adapted from Berlyne)



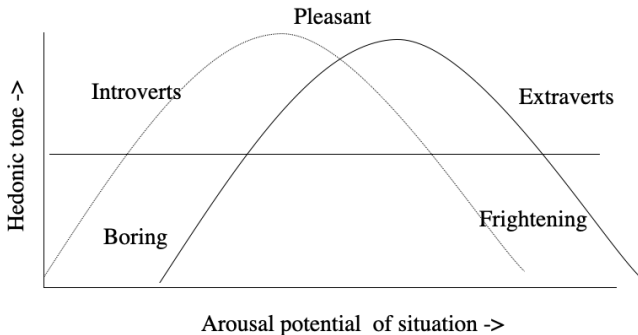
## Extraversion, arousal, and hedonic tone

1. If introverts are more aroused than extraverts (or more accurately, if introversion-extraversion is negatively correlated with arousal)
2. If there is an optimal level of arousal (([Wundt, 1904](#)))
3. Then, those more introverted should prefer less external stimulation than those more extraverted.

## Eysenckian prediction of optimal hedonic arousal

# Wundt's hedonic curve + Individual Differences

(adapted from Eysenck)

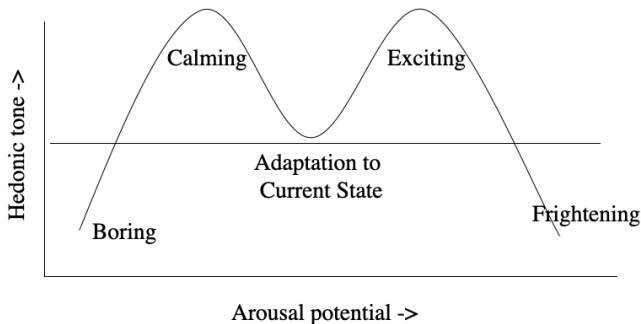




## Berlyne hypothesis

# Berlyne's hedonic curve

(adapted from Berlyne)



## Behavioral Consequences of arousal differences

1. Differences in Arousal preference
2. Wundt's curvilinear hypotheses
  - Moderate levels of arousal are more pleasing than extreme levels
  - ("the Goldilocks hypothesis")
3. (Berlyne, 1960)
  - Changes in arousal are more pleasing than a steady state
  - Increases or decreases are pleasant

## Most preferred arousal level

1. Sound preference  
(Elliott, 1971)  
(Davies, G.R.G.Hockey & Taylor, 1969)
2. Complexity preference – (Bartol, 1975)
3. Extraversion and the “three F’s syndrome”  
Fags (cigarettes)  
Fornication  
Firewater

## Logical problems with arousal preferences hypothesis

1. What is arousing?
  - Mountain climbing?
  - Chess playing?
  - Small boat sailing?
2. What has subject done before coming to laboratory
  - Extraverts being sociable
  - Introverts studying

## Does Personality make a difference?

### 1. Important Life Criteria

Longevity (Friedman, Tucker, Schwartz, Tomlinson-Keasey, Martin, Wingard & Criqui, 1995)

Job Performance (Schmidt & Hunter, 2004)

Psychological well being (Ozer & Benet-Martinez, 2006b)

### 2. Laboratory tasks

Cognitive sensitivities and biases e.g., (Williams, Mathews & MacLeod, 1996)

Systematic pattern of results with cognitive performance by stress manipulations (eg., (Anderson, 1990; Anderson & Revelle, 1994; Revelle, Amaral & Turriff, 1976; Revelle, Humphreys, Simon & Gilliland, 1980)

## Performance as a curvilinear function of arousal and task difficulty

1. Yerkes & Dodson (1908)
2. (Hebb, 1955)
3. (Broadhurst, 1957, 1959)
4. (Broadbent, 1971)

## Discrimination Learning in the mouse

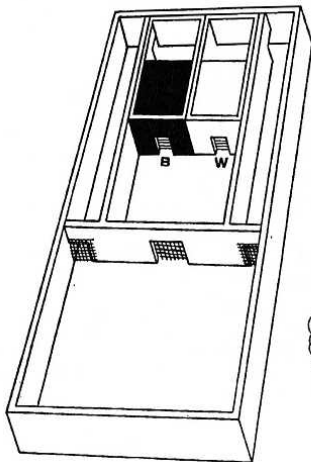


FIG. 1.

FIG. 1. Discrimination box. *W*, electric box with white cardboards; *B*, electric box with black cardboards.

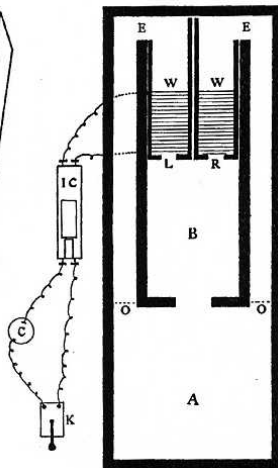
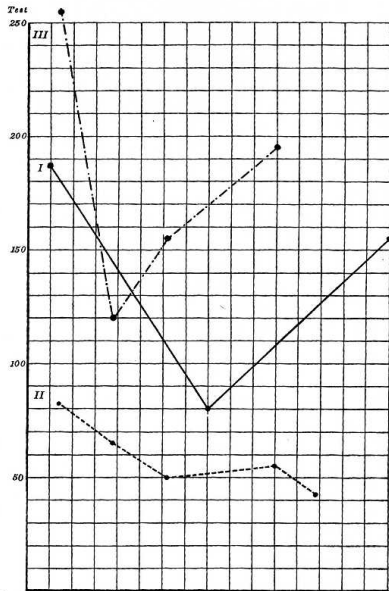


FIG. 2.

FIG. 2. Ground plan of discrimination box. *A*, nest-box; *B*, entrance chamber; *W* *W*, electric boxes; *L*, doorway of left electric box; *R*, doorway of right electric box; *E*, exit from electric box to alley; *O*, swinging door between alley and *A*; *IC*, induction apparatus; *C*, electric battery; *K*, key in circuit.

# Discrimination Learning in the mouse: interacts with task difficulty





## Yerkes and Dodson revisited

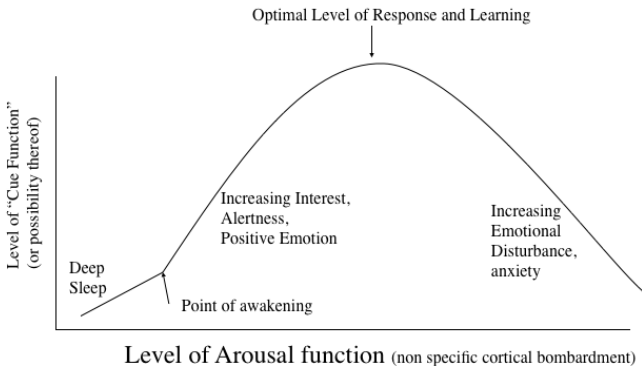
1. Is it a lawful relationship?
2. Does performance in fact vary as stress/ arousal
3. Is there a relationship with task difficulty
4. Continues to be controversial interpretation ([Anderson, 1990, 1994](#))

## (Hebb, 1955) and arousal

1. Level of “cue function” as a function of arousal
2. Arousal as pleasing up to a point
3. Arousal as facilitating performance up to an optimal level

# State of the art theory in 1955—Hebb's Conceptual Nervous System

## Hebb Curve (1955)

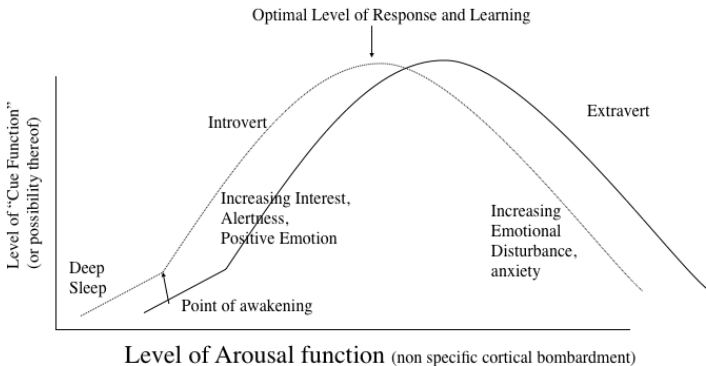


## Eysenck and the Hebb Curve

1. Performance as curvilinear function of arousal
2. Introverts more aroused than extraverts
3. Therefore, introverts should do well under low stress situations, extraverts in high stress situations

## Predicting individual differences in performance under stress

### Eysenck (1967) + Hebb (1955)



## Evidence in support of I-E performance hypothesis

1. No curvilinearity, but consistent  
(Frith, 1967) detection of flicker fusion  
Quiet versus noise  
Extraverts versus introverts
2. (Corcoran, 1965, 1972) tracking performance  
Sleep deprivation (12, 36, 60 hours)  
Extraversion-introversion

## Supporting evidence

### Curvilinear and consistent

1. (Davies & Hockey, 1966; Davies et al., 1969)
  - Detection task
  - Quiet versus noisy
  - Low versus high signal frequency
  - Extraverts versus introverts
2. (note that 2\*2\*2 design has many possible compatible results)

## Feeble attempts at theory testing (Revelle, 1973)

1. Performance on digit symbol, maze tracking, and anagrams (3 levels of difficulty for each task)
2. 6 stress levels
  - 1 person, relaxed
  - 2 person, relaxed
  - 2 person, competing
  - 2 person, competing for money
  - 8 person, competing for money
  - 8 person, competing for money, noise
3. Mixed results
4. What is arousing?



## Confirmation experiment $\neq$ theory testing: The example of caffeine by extraversion

### 1. Basic hypothesis

- Introverts are more aroused than extraverts [Eysenck \(1967\)](#)
- Caffeine or time stress will increase arousal
- Performance is a curvilinear function of arousal ([Yerkes & Dodson, 1908](#); [Hebb, 1955](#); [Easterbrook, 1959](#); [Broadbent, 1971](#))

### 2. [Revelle et al. \(1976\)](#)

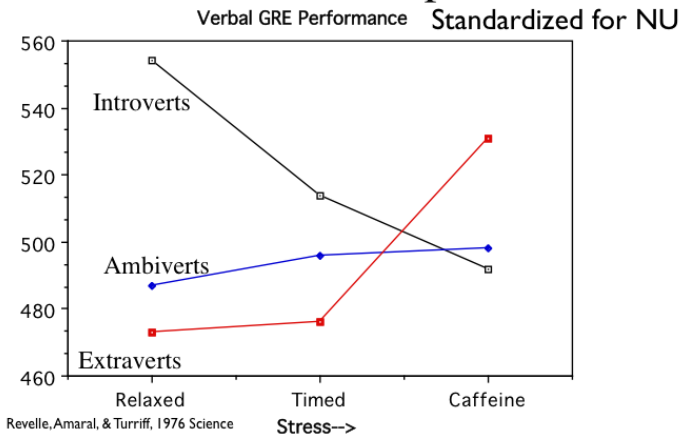
- I-E measured with Eysenck Personality Inventory
- caffeine given as placebo or 200 mg in capsule
- Performance on practice Graduate Record Exams (GRE), reported in standardized scores

### 3. Predictions

- Introverts  $>$  extraverts in relaxed condition
- Introverts  $<$  extraverts with time pressure and caffeine

## Caffeine and time stress on complex performance

# Introversion, time pressure, and caffeine: effect on verbal performance



## Failures to replicate lead to theory improvement: The discovery of the imp/soc distinction

Failures to replicate can lead to better science for they show the limits of an effect.

1. Kirby [Gilliland \(1976\)](#) failed to replicate the [Revelle et al. \(1976\)](#) effect
  - A better study, caffeine was dosed by body weight and had 3 levels of caffeine
  - Used the Eysenck Personality Questionnaire (EPQ) instead of Eysenck Personality Inventory (EPI)
  - Failed to find the same results
2. Did replicate the results when using the EPI ([Gilliland, 1980](#))
3. What was the difference?

## Gilliland's dissertation results did not replicate Revelle et al. (1976)

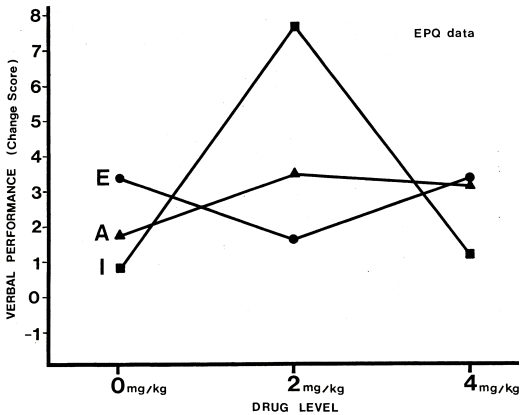


Figure 8. EPQ based group means for change in number of items correctly answered on GRE practice tests.



## Using psychometrics to explain experimental results: **Rocklin & Revelle (1981)**

1. Eysenck Personality Inventory
  - Extraversion
  - Neuroticism
2. The new and improved Eysenck Personality Questionnaire
  - Extraversion
  - Neuroticism
  - Psychoticism
3. Cross form correlations were high for E (.74) and N (.83)
4. Structure was completely different for the two Extraversion scales
  - Number of factors determined by the Very Simple Structure criterion ([Revelle & Rocklin, 1979](#))
  - 2 primary factors of EPI E (sociability and impulsivity)
  - one factor for EPQ E
5. This led to a small cottage industry of replications using EPI instead of EPQ (e.g., [Campbell, 1983](#); [Campbell & Heller, 1987](#)).

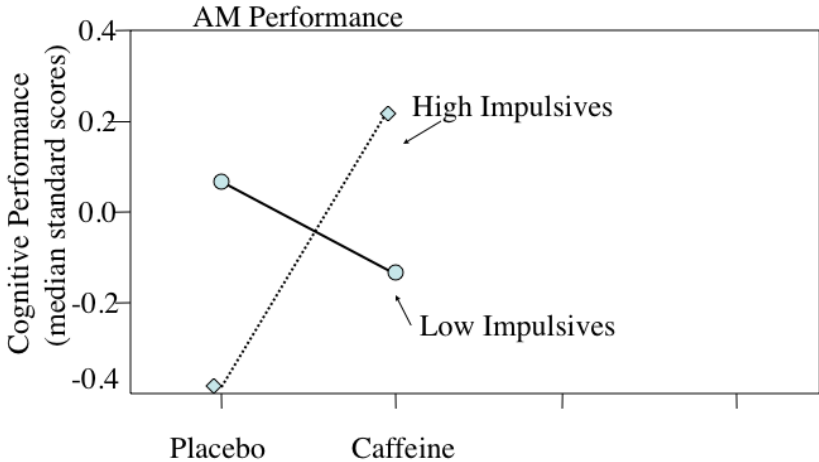
## Theory testing and rejecting by finding limiting cases

1. Over three years, we could replicate the [Revelle et al. \(1976\)](#) study about half the time.
  - We tested many different explanations, none worked.
  - Had varied time of day because we thought everyone would be more aroused later in the day. That is we hypothesized
    - $E < I$
    - $am < pm$
    - $placebo < caffeine$
2. Eventually we found a consistent interaction of Imp x drug x Time if we assumed an inverted U relationship of arousal and performance and
  - $E_{am} < I_{am}$
  - $I_{pm} < E_{pm}$
  - $placebo < caffeine$

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

# Theory testing by rejection: The example of time of day x caffeine

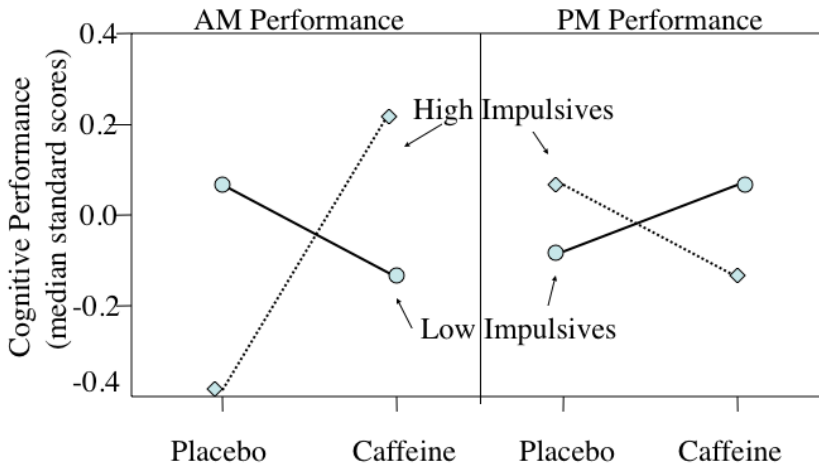
## Impulsivity, Caffeine, and Time of Day: the effect on complex cognitive performance





# Theory testing by rejection: The example of time of day x caffeine

## Impulsivity, Caffeine, and Time of Day: the effect on complex cognitive performance

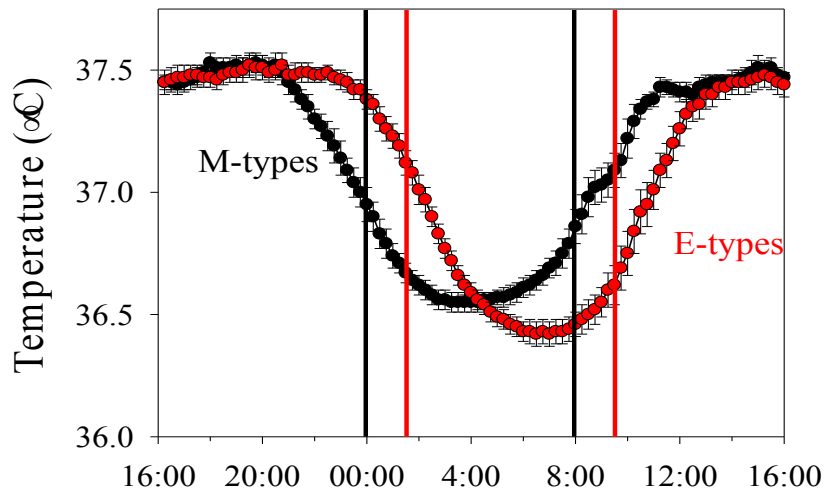


## Using experimental data for correlational analysis: body temperature and personality

1. Charmane Eastman had examined core body temperature over two weeks to study the effects of shift work.
  - Multiple, small experimental studies
  - Each study had included measures (MMPI-2) that could be interpreted as impulsivity.
  - Each study included measures of morningness-eveningness.
2. Erin Baehr synthesized these studies to examine individual differences in body temperature.
  - We also measured average bed time and average rise time for all subjects.
  - Acrophase of Body Temperature differed more than differences in behavior (biology meets society)
3. Although we plot the data in terms of Morningness/Eveningness, somewhat weaker results were true for impulsivity (Baehr, Revelle & Eastman, 2000).

Baehr, E. K., Revelle, W., & Eastman, C. I. (2000). Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness-eveningness. *Journal of Sleep Research*, 9(2), 117-127.

# Biology meets society – time of day and morningness/eveningness



## Theory development by integrating multiple alternative theories

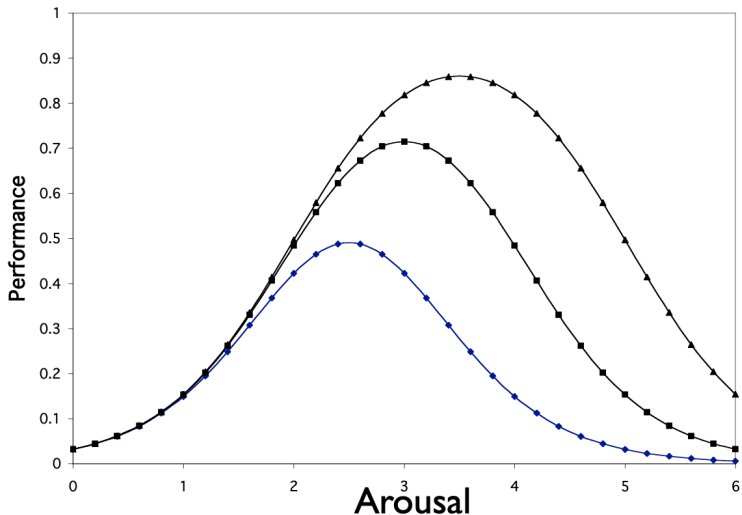
Multiple theories about personality and efficient performance

1. H.J. [Eysenck \(1967\)](#) and arousal theory
  - Introverts more aroused than Extraverts
  - Arousal has an inverted U relationship to performance
2. J.W. [Atkinson \(1957, 1974\)](#) and achievement motivation theory
  - High need achievement and low test anxiety lead to high motivation ([Atkinson, 1957](#))
  - Motivation has inverted U relationship to performance ([Atkinson, 1974](#))
  - Motivation has inertial properties ([Atkinson & Birch, 1970](#); [Revelle & Michaels, 1976](#); [Revelle, 1986](#))
3. Theories of anxiety and cognitive performance
  - Anxiety and task difficulty ([Spence, Farber & McFann, 1956](#))
  - Anxiety and working memory ([Eysenck & Mathews, 1987](#); [Eysenck, Derakshan, Santos & Calvo, 2007](#); [Eysenck, 2000](#))
  - Anxiety and resource allocation ([Wine, 1971](#))
4. [Easterbrook \(1959\)](#) and the [Yerkes & Dodson \(1908\)](#) “law”

## Integrating multiple theories of performance: **Humphreys & Revelle (1984)**

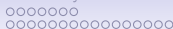
1. Multiple dimensions of personality relating to efficient cognitive performance
  - Introversion/Extraversion – Impulsivity
  - Anxiety (not just neuroticism)
  - Achievement motivation
2. Decomposing motivation
  - Arousal
  - Effort
3. Decomposing Performance
  - Attention tasks
  - Short term (working) memory tasks
  - Complex tasks that reflect some mixture of attention and memory

## The Yerkes Dodson effect varies by task difficulty

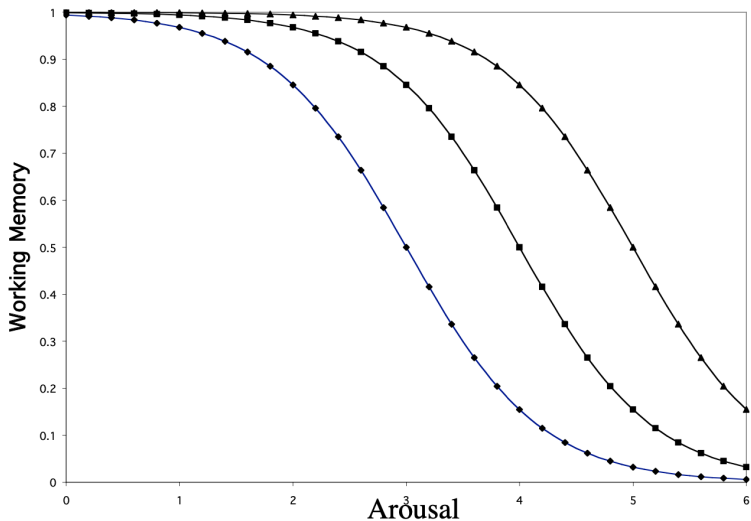


## Coombs' dictum

1. Any function where the first or second derivative changes sign may be decomposed into two processes (Coombs & Avrunin, 1977)
2. Performance as a singled peaked function of arousal.
3. Decompose that function into two monotonic functions: (Humphreys & Revelle, 1984)
4. Working memory decreases as arousal increases.
5. Sustained Information Transfer increases with arousal.

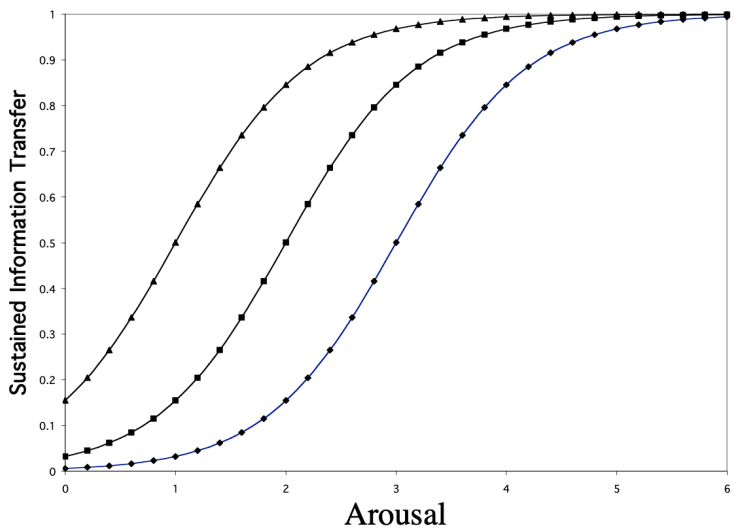


## Arousal effects on working memory

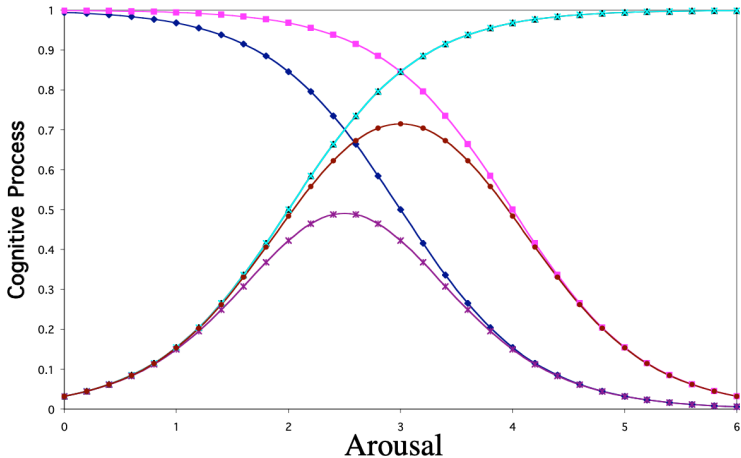




## Arousal effects on Sustained Information Transfer (attention)



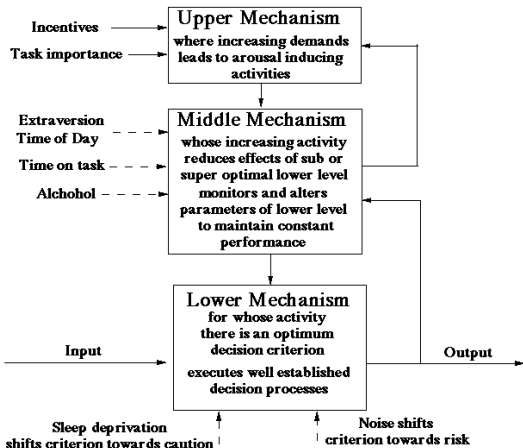
# Performance = SIT + STM



## But performance varies not just by arousal

1. Arousal affects resource availability
2. Effort affects resource allocation
3. Can integrate several personality dimensions in terms of effort and arousal.

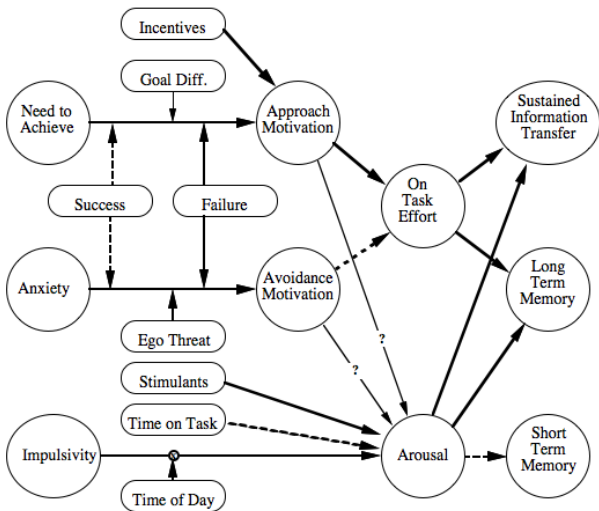
### 3 levels of processing (after Broadbent)



(Revelle, 1993; Ortony, Norman & Revelle, 2005)

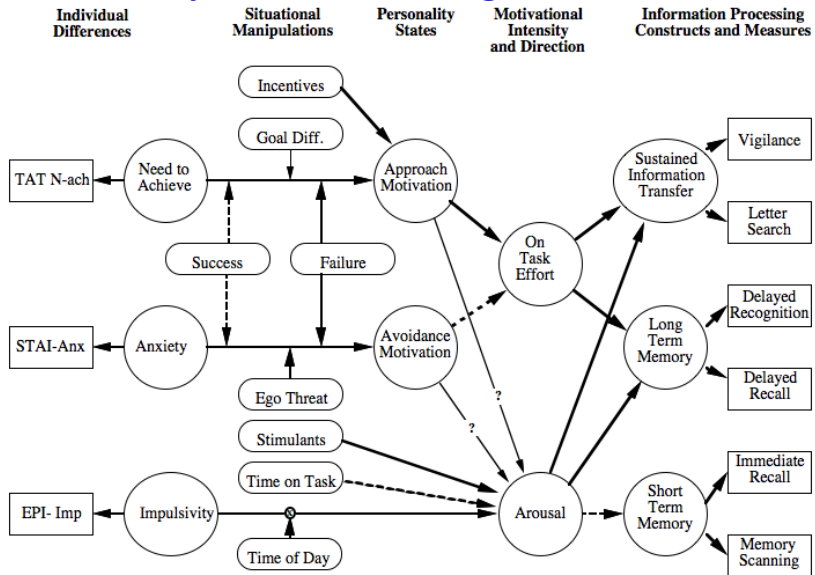
## A "simple" model of personality and performance

**Individual Differences**      **Situational Manipulations**      **Personality States**      **Motivational Intensity and Direction**      **Information Processing Constructs and Measures**



Adapted from Humphreys & Revelle, 1984; Revelle, 1989

# Personality, Motivation, and Cognitive Performance



Adapted from Humphreys & Revelle, 1984; Revelle, 1989

## Theory testing by critical comparisons

### 1. Theories differ in breadth and depth

- Many theories are silent for some phenomenon
- Some sets of theories are mutually compatible, but with different range

Phenomenon	Theory 1	Theory 2	Theory 3	Theory 4
A	+	+	+	+
B	+	+		+
C	+		+	+
D		+	+	
E	+	-	0	
F	0	+		

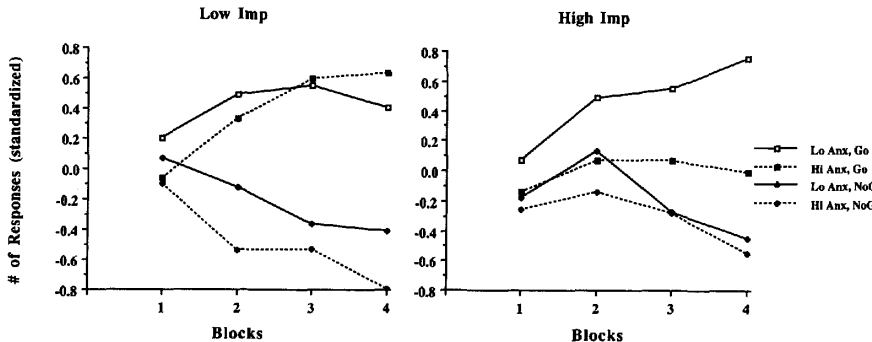
2. We test alternative theories by looking for where they make different predictions.
3. It is not enough to disconfirm a theory, we must show better alternatives.

## Testing four models of conditioning: Zinbarg & Revelle (1989b)

1. Drive Theory (Hull, 1943; Spence, 1964)
  - Anxiety and performance (Spence et al., 1956) but see Weiner & Schneider (1971)
2. Eysenck (1967); Eysenck & Eysenck (1985) specify the variables that affect conditioning:
  - Partial reinforcement
  - weak conditioned stimuli
  - discrimination learning
3. Impulsivity and cues for reward, anxiety and cues for punishment Gray (1981)
4. Extravert's focus on reward blinds them to punishment Newman et al. (1985); Patterson et al. (1987)



## Zinbarg & Revelle (1989b) used a go-nogo discrimination task



Reliable anxiety x impulsivity x Cue type interactions across four studies. Results not directly supportive of any of the four theories but suggested a revision of the Gray model.

From Zinbarg, R. E. & Revelle, W. (1989). Personality and conditioning: A test of four models. *Journal of Personality and Social Psychology*, 57(2), 301-314.

## Tests of competing theories of anxiety and information processing Leon & Revelle (1985)

How does anxiety affect performance?

1. Anxiety interacts with task difficulty [Spence et al. \(1956\)](#)
  - But see [Weiner & Schneider \(1971\)](#)
2. Anxiety limits working memory capacity [Eysenck & Mathews \(1987\)](#); [Eysenck et al. \(2007\)](#); [Eysenck \(2000\)](#)
3. Anxiety narrows the breadth of attention [Easterbrook \(1959\)](#)
4. Anxiety leads to off task thoughts [Wine \(1971\)](#)

Leon, M. R. & Revelle, W. (1985). Effects of anxiety on analogical reasoning: A test of three theoretical models. *Journal of Personality and Social Psychology*, 49(5), 1302-1315.

## Geometric analogies differing in memory load (transformations) and complexity (number of elements)

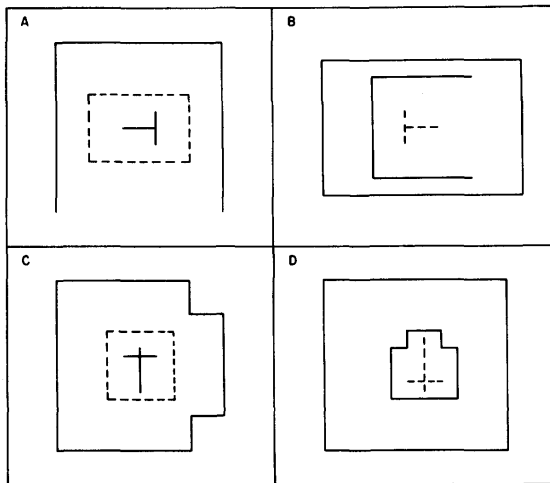


Figure 1. Sample 3-element two-transformation analogy problem.

# Memory load, stress and anxiety Leon & Revelle (1985)

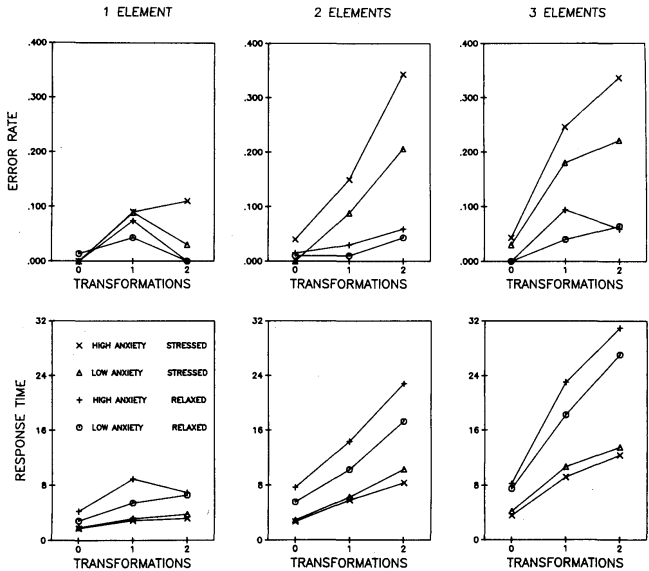


Figure 3. Error rates and response times for true analogies. (Error rates are calculated for all true analogies.)

## **Integrating cognitive theory with personality theory: Impulsivity, arousal and breadth of processing**

1. Strong theories make testable predictions and theory develops by testing these predictions. Who is better able to test one's theories than oneself?

## Integrating cognitive theory with personality theory: Impulsivity, arousal and breadth of processing

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2. [Anderson & Revelle \(1994\)](#) examined sustained performance on a recognition memory task to test the hypothesis that high trait impulsives were consistently faster to suffer from a decay in arousal than low trait impulsives.
3. We examined this effect at two times of day and unexpectedly found a time of day by impulsivity interaction.

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4. But science advances by disconfirmation as well:
  - “Two particular models deserve attention here. First, [these data obviously contradict our own previous arguments](#) (e.g., [Revelle et al., 1987](#); [Revelle & Anderson, 1992](#)) that impulsivity is linked to stable differences in rate of change in arousal states.” ([Anderson & Revelle, 1994](#))

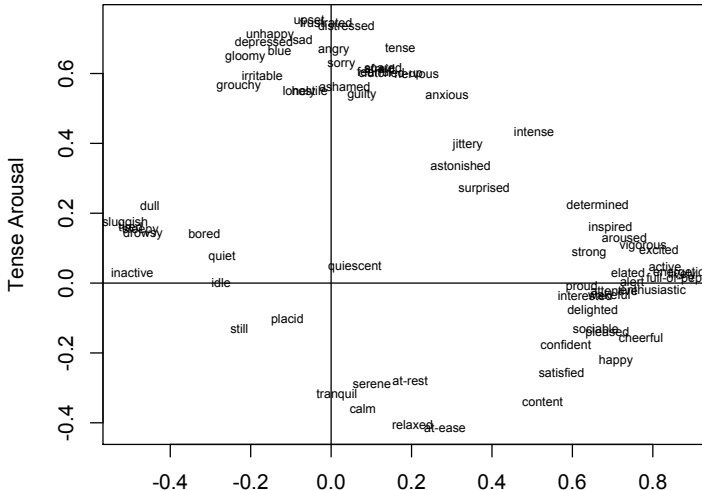


## Integrating experimental and correlational data: Aggregating data across experimental studies for psychometric analysis

1. For about 10 years, we collected mood and arousal data as part of every experimental study we did.
  - Typical design was a mood pretest
  - Some arousal or motivation manipulation (e.g., caffeine, time stress, movies)
  - Then some post test
2. Motivational State Questionnaire (MSQ) was formed from items taken from Thayer's AD-ACL [Thayer \(1978\)](#), the PANAS ([Watson et al., 1988](#)) and various circumplex measures of emotion ([Larsen & Diener, 1992](#))
3. Factor structure of the 72 items for 3896 subjects and their correlations with basic personality scales from the EPI is reported by [Rafaeli & Revelle \(2006\)](#)
4. The actual data are available as the `msq` data set in the *psych* package ([Revelle, 2022](#)) in R.

# Dimensions of the Motivational State Questionnaire

## Dimensions of affect



- Anderson, K. J. (1990). Arousal and the inverted-U hypothesis: A critique of Neiss's "reconceptualizing arousal". *Psychological Bulletin*, *107*(1), 96–100.
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- Baehr, E. K., Revelle, W., & Eastman, C. I. (2000). Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness-eveningness. *Journal of Sleep Research, 9*(2), 117–127.
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