Haptic Interaction Design

Books

- Kingdom, F. A. A., Prins N. (2010) Psychophysics: A Practical Introduction. Academic Press.
- Macmillan NA, Creelman CD (2005) Detection Theory: A User's Guide, 2nd edition. Lawrence Erlbaum Associates.
- Gescheider (2001) Psychophysics – The Fundamentals, third edition. Lawrence Erlbaum Associates.
- Gorsuch, Richard L. (1983) Factor Analysis, second edition, Hillsdale: Lawrence Erlbaum Associates.
- Kruskal, J. B., and Wish. M. (1977). Multidimensional Scaling. Sage Publications. Beverly Hills. CA.

Outline

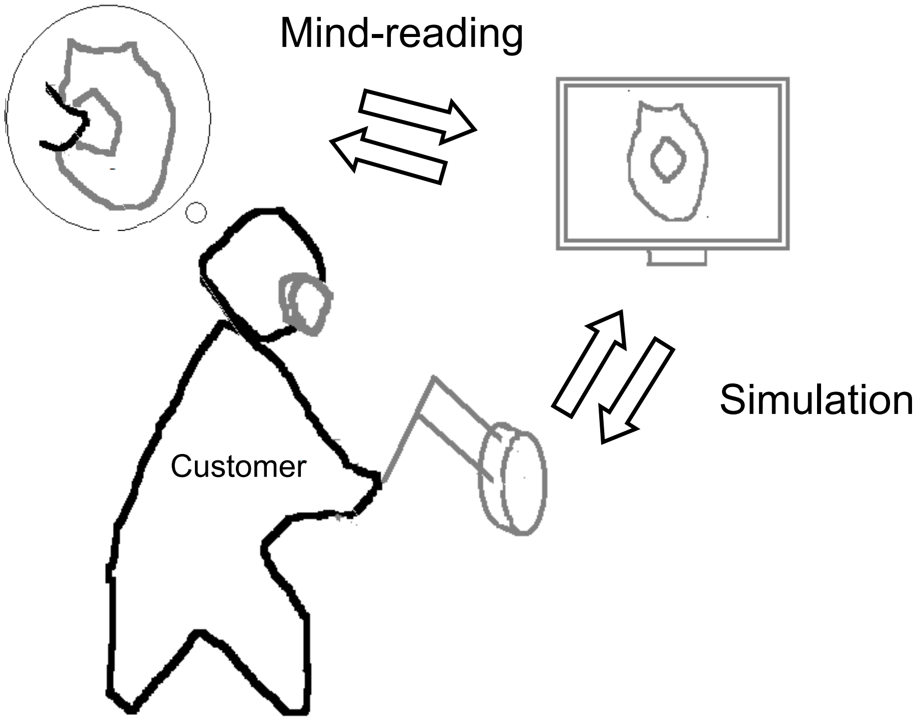
- Some thoughts on haptic interaction design
- The contribution of Psychology
- Psychophysical Methods
- Sensory Psychophysics and the haptic sense
- Non-Sensory Psychophysics and the aesthetic experience
- Conclusions

What is haptic interaction design?




- design of keyboards, handles, ... and other objects where the haptic interaction plays a central role
- design of haptic interfaces such as handheld displays, GUIs for blind people, haptic vest for pilots, ...
- haptic interaction in arts (sculpture) and industrial design (haptic interaction with protoypes), virtual prototyping

Virtual prototyping

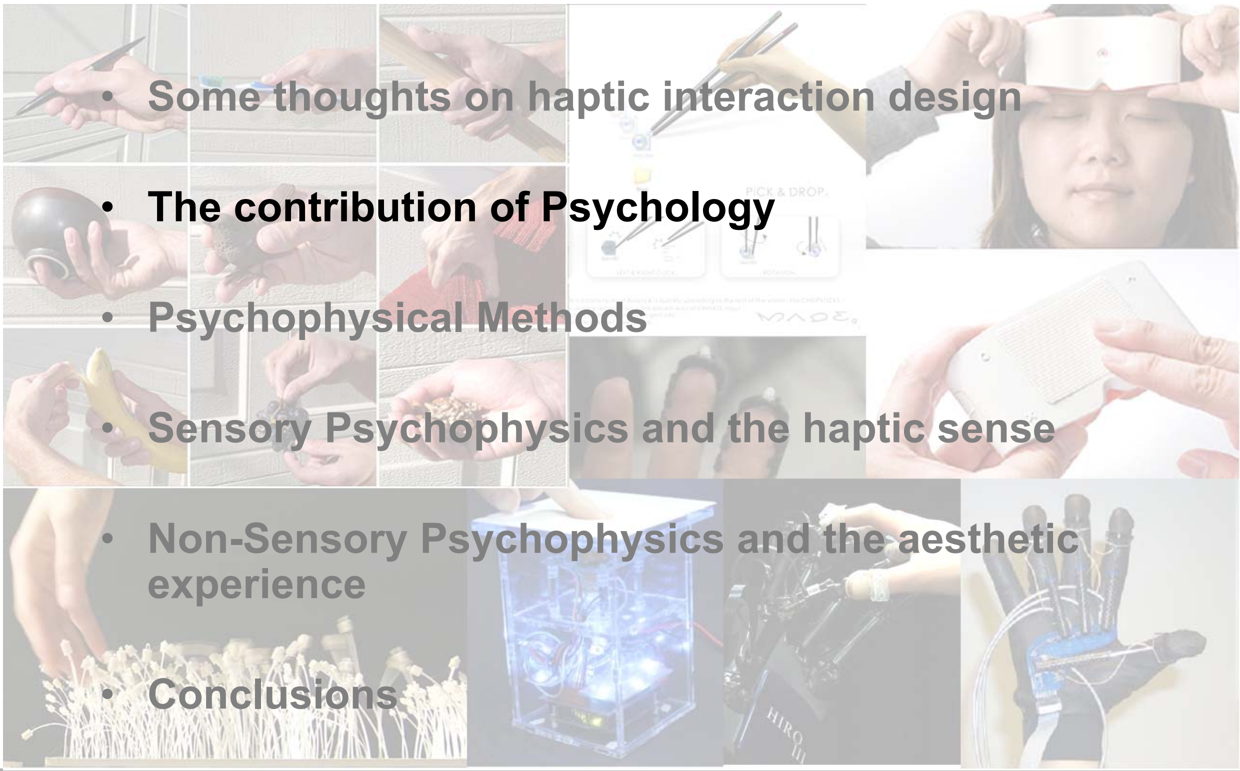


Some thoughts on VP

- Simulation approach
  - haptic devices have many limitations
  - multimodal codes are needed to render object properties that cannot be rendered with current haptic devices
  - simulating tools and their interaction with the object is probably simpler than simulating contacts with the object
  - make specially designed handles on the haptic devices for different tools, invent new tools.
  - do not focuse only rendering issues; a bad VR interface or bad tools will frustrate the designer and make it more difficult to achieve the desired objective

- “Mind-reading” approach
  - one idea is to use physiological signals to get feedback on the state of the customer but available signals with state-of-the-art technology such as EEG, eye movements, skin conductance, pupillary aperture, heart rate, etc. have also strong limitations (low bandwith, lack of specificity, ...).

Outline



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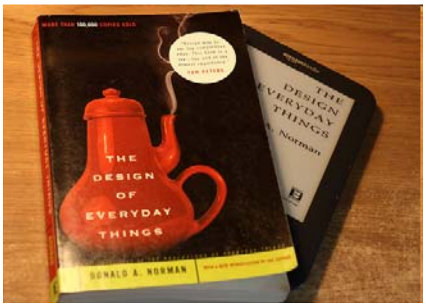
Pyschology and Co*

"Until we do study the processes and experience which people have when designing, it will not be possible to aid design with computers or anything else" Canter (1972) cited in Jerrard R (1998) Quantifying the Unquantifiable: An inquiry into the Design Process. Design issues, 14(1).

- Human factors play a central role in design:
  - Model of user-experience
  - Models of human cognitive and affective response to objects of design and design process
  - Models of the haptic interaction

* Psychology & Co = cognitive sciences, experimental psychology, psychophysics, applied psychology, etc.

Insights from a Cognitive Scientist



- Don Norman, BS in Computer Science at MIT, PhD in Psychology at University of Pennsylvania, Professor of Cognitive science at UCSD, Professor of Computer Science at Northwestern
- Worked for Apple and HP
- Newsweek: The Guru of Workable Technology
- Author of “The Design of Everyday Things” (originally called "The Psychology of Everyday Things")

Automatic processes

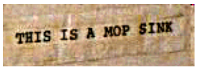
- **The distinction between automatic and effortful processes**
  – Automatic processes occur without conscious "thinking.“
  – Automatic processes don't interfere with each other or with effortful processes.
  – Effortful processes occupy limited cognitive resources (e.g., attention, short-term memory) and interfere with one another.
- **Examples**
  – People remember locations of objects through automatic processing but people don't remember the locations of colors through automatic processing, so it's effortful
  – *See and recognize* is easier than *remember and type* or *remember and hunt*.
- **Good designs must tap automatic processes**

Norman's usability guidelines

- **Visibility**
  - Make the relevant parts visible. By looking the user should be able to tell the state of the device and the alternatives for action (***affordances***)
- **A good conceptual model**
  - Help the user by visually communicating a good mental model of how the system works.
- **Good mappings**
  - Help the user determine the relationship between actions and results, controls and effects, by using natural mappings.
- **Feed back**
  - Give immediate feedback to the user about the results of their actions and the state of the system.

Bad designs

Bad affordance



Bad mapping

Photographs courtesy of Baddesigns.Com

DYNAMIC TOUCH AND INTERACTION
Haptics Symposium, March 3, Vancouver
Gabriel Baud-Bovy
Italian Institute of Technology, RBCS

Emotional and activity-centered design

- Design is more than user-experience. In successive work, Norman developed other aspects of a good design

- **Activity-Centered Design:**
  - Too much focus on the user can be harmful. One needs as well to focus upon the tasks to be done.
    - Violin is definitely not user-friendly
    - Human-Centered Design Considered Harmful, Don Norman (http://www.jnd.org/dn.mss/humancentered_desig.html)

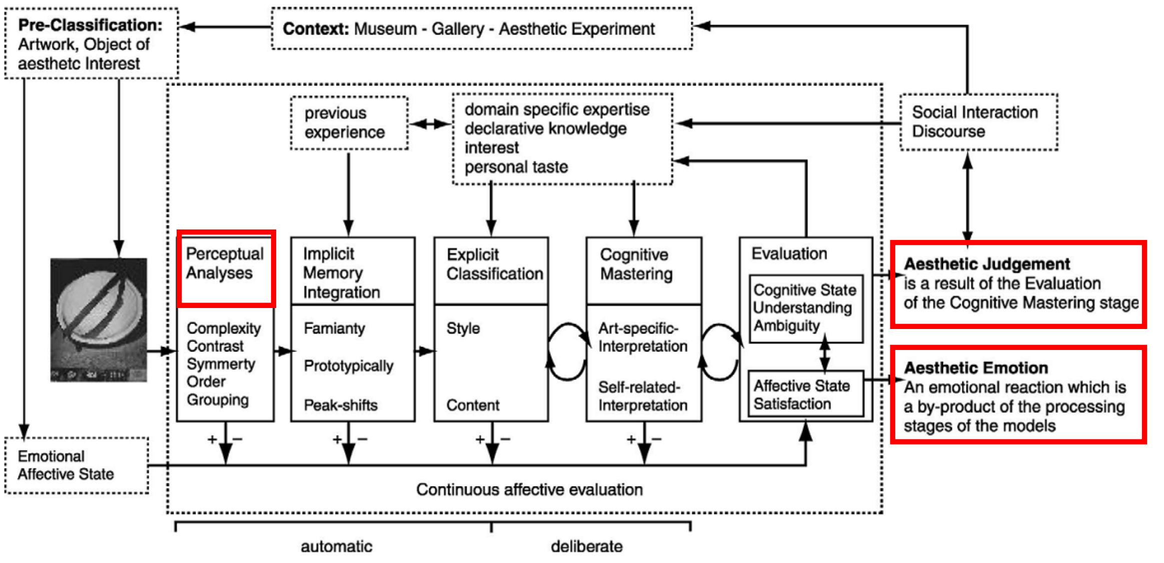
- **Emotional design**
  - Emotions, aesthetic pleasure also play a role in design besides user experience.
    - For the haptic modality, see Klatzky R. L., Peck J. (2011) Please Touch: Object Properties that Invite Touch. IEEE Trans. Haptics.

Guidelines for Haptic Interaction Design

- **Guideline 1: Elaborate a Virtual Object Design of Its Own** (do not try to simulate reality when it is unhelpful)
  - Avoid objects with small and scattered surfaces
  - Use rounded corners rather than sharp ones.
- **Guideline 2: Facilitate Navigation and Overview**
- **Guideline 3: Provide Contextual Information**
- **Guideline 4: Utilize All Available Modalities**
  - Provide well defined and easy-to-find reference points in the environment.
  - Use constraints and paths.
  - Use video and audio labels.
- **Guideline 5: Support the User in Learning the Interaction Method**
  - Give clear and timely feedback on the user's actions

Calle Sjöström (2002) Non-Visual Haptic Interaction Design: Guidelines and Applications, Doctoral Dissertation, Certec, Lund Institute of Technology

A model of aesthetic experience



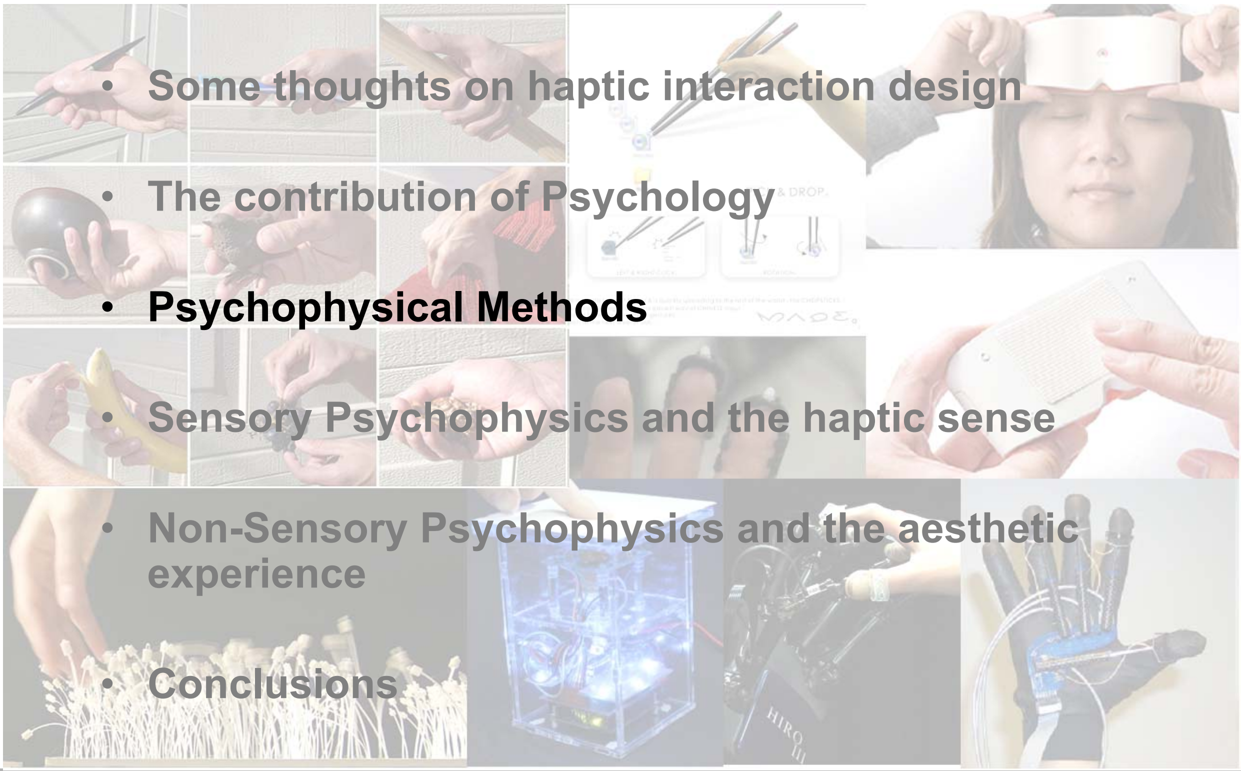
Leder et al. (2004) A model of aesthetic appreciation and aesthetic judgments. British Journal of Psychology, 95, 489–508.

Fragility of aesthetic experience

- We are extremely bad at recognizing when, where and why we like something.
- Many subsconscious factors are involved
  - status cue (e.g. price): Experiment on wine tasting (Plassmann et al., 2008; Brochet, 2001)
  - familiarity
- Pleasure plays certainly a role in aesthetic experience but should not necessarily be cofounded with it.

Kieran, M. (2004) The fragility of aesthetic knowledge: aesthetic psychology and appreciative virtues.

Outline



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Psychophysics

Gustav T. Fechner
(1801-1887)

- Psychophysics is the ***scientific study of the relationship between physical and mental (phenomenal) worlds***, one of the most fondamental problem of modern psychology.
- Psychophysics marked the transition of psychology form a philosophical (introspective method) to a scientific discipline (experimental method).
- Gustave T. Fechner, a trained physicist, coined the word “Psychophysics” and wrote the classical book “Elements of Psychophysics” (1860) where he described methods and theory for the measurement of sensation (including the famous Weber-Fechner Law).

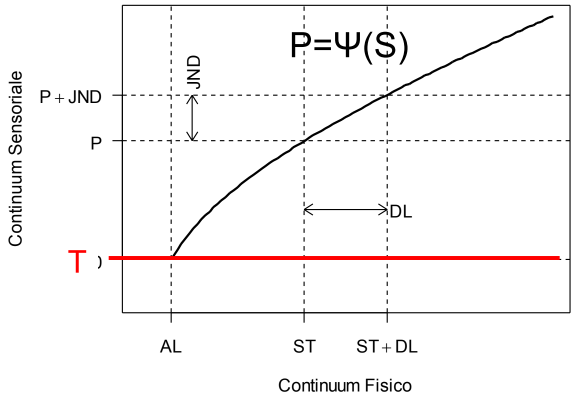
Psychophysics

- **Sensory psychophysics**
  - Historically and still today psychophysics provide usefull model to study sensory systems and perception.
  - Psychophysical methods can also be used to test hypotheses about underlying biological mechanisms that determine sensory capacity (***analytical psychophysics***).
- **Non-Sensory psychophysics**
  - Psychophysical methods have been extended to many different mental phenomena besides measuring sensations.

Fondamental questions

- What is the relationship between the the physical and perceived intensity of the stimulus?

  concepts of psychophysical function Ψ, scaling methods.



- What is the smallest amount of stimulus energy necessary to produce a sensation? (concept of **absolute threshold**)
- What is the smallest amount of changes of a stimulus required to produce a just noticeable difference (JND) in the sensation? (concept of **difference threshold**)

Scaling methods

- "Psychological scaling methods are procedures for constructing scales of the measurement of psychological attributes." (Torgerson, 1958, p. ix)
- Guilford (1938) introduced the distinction between psychophysical and psychological methods, depending on whether psychological attribute can be related to a physical continuum or not.
- **Psychophysical methods** aim at measuring the relationship between the physical intensity of the stimulus and the corresponding sensation (the so-called psychophysical function).
- **Psychological methods** aim measure the perceived distance between attributes of stimulus objects such as "quality of handwriting", a personality trait such as leadership, tactfulness, personal preferences, that have no clear physical evaluation.

Indirect and direct methods

Indirect methods

•Fechnerian scaling

•Thurstonian scaling
•Method of paired comparison
•Method of ranking
•Method of successive intervals

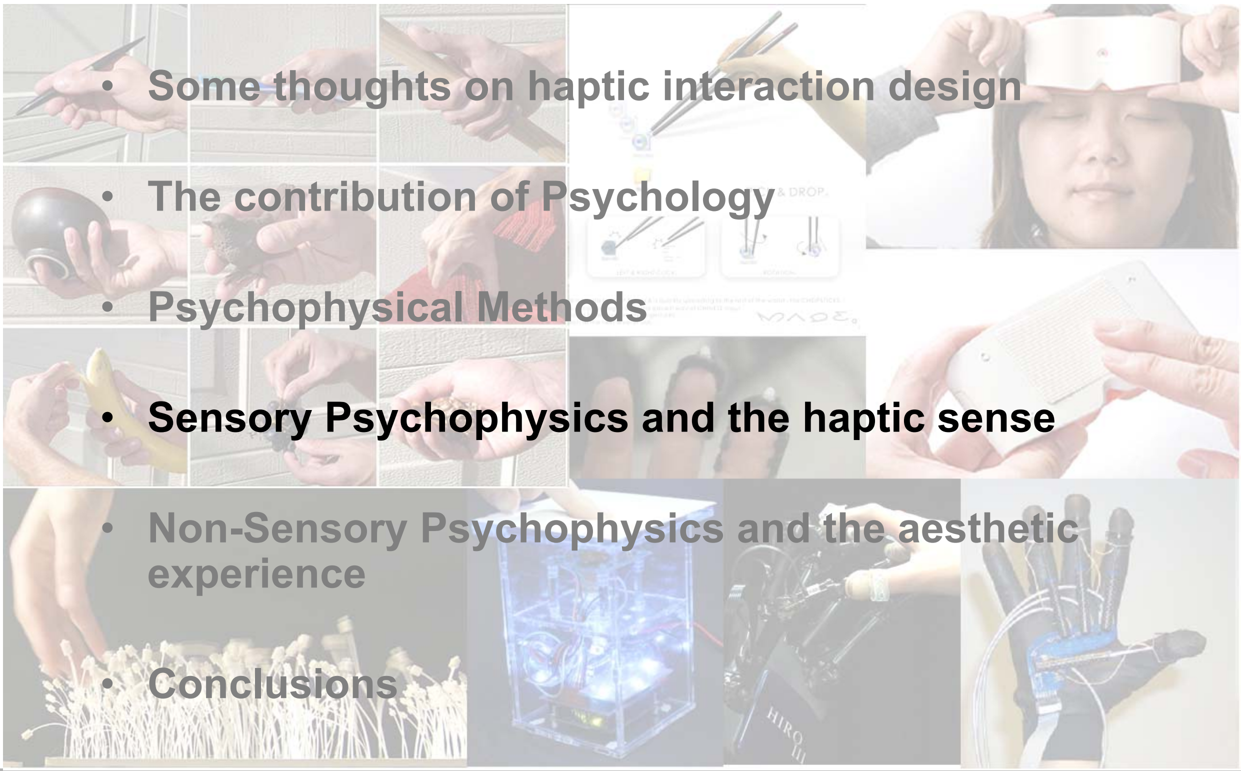
Direct Methods

•Magnitude estimation
•Magnitude production
•Equal-appearing interval
•Bisection
•Equisection

•Ratio estimation
•Ratio production
•Constant sum

- Scaling methods can also divided into two big categories that differ in the kind of judgement abilities required from the subjects:
- **Indirect methods** reconstruct the psychophysical function from its local properties such as the difference thresholds. These methods requires only that the observer is able to judge whether two stimuli appear equal or not, or which stimulus is larger or smaller.
- **Direct methods** assume that the observer is able to quantify (either numerically or using some other device) the magnitude of the stimulus or some quantitative relation betwen two stimuli.

Outline



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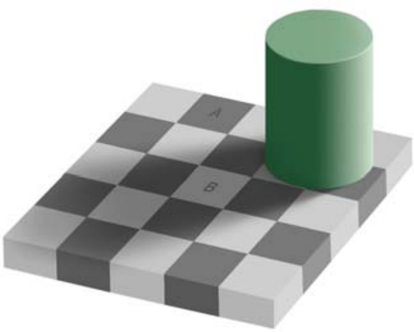
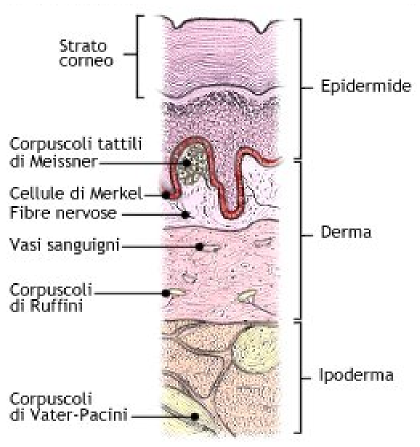
Sensory psychophysics

- The existence of **sensory illusions** demonstrates that **physical** dimensions ≠ **perceptual** dimensions

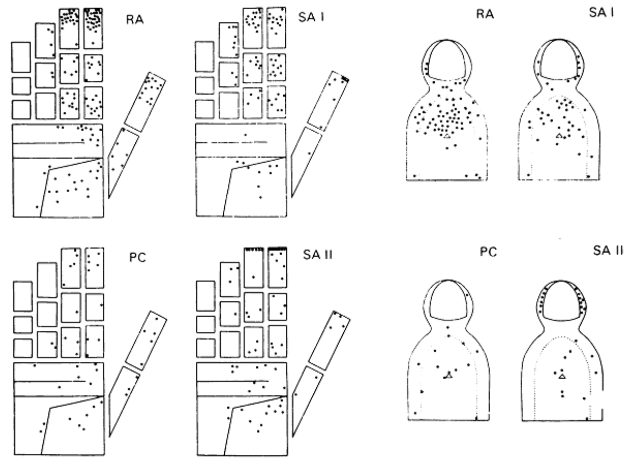


- Psychophysical methods can help to address many issues such as:
  - *Is perception veridical?*
  - *How precise / accurate is a perception?*
  - *Do the different properties of the stimulus interact?*
  - *Do different sensory modalities interact?*

Mechano-receptors



Squire et al. (2003) Fundamental, 2nd ed. Neuroscience, p. 668

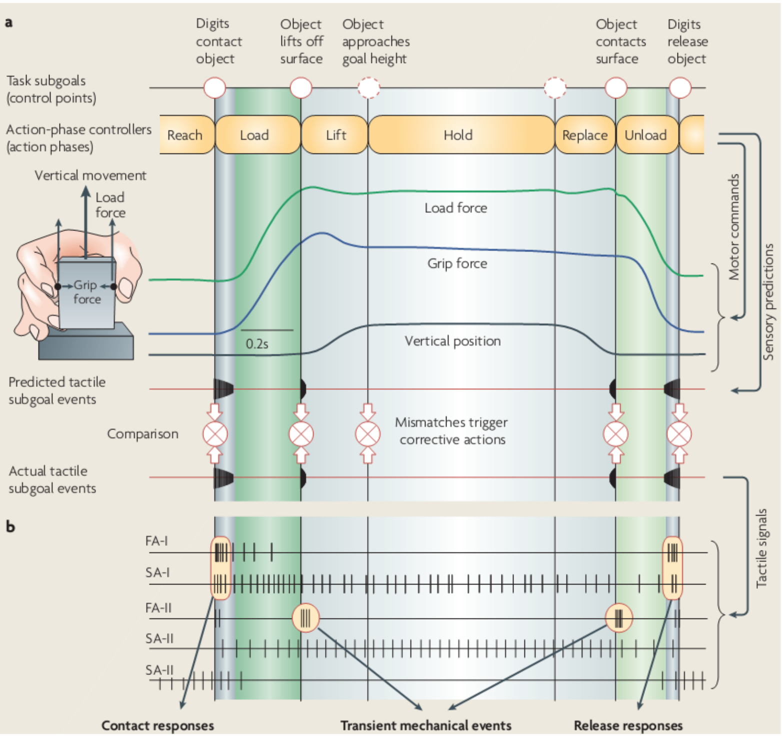


Johansson & Vallbo (1979) J. Physyiol.

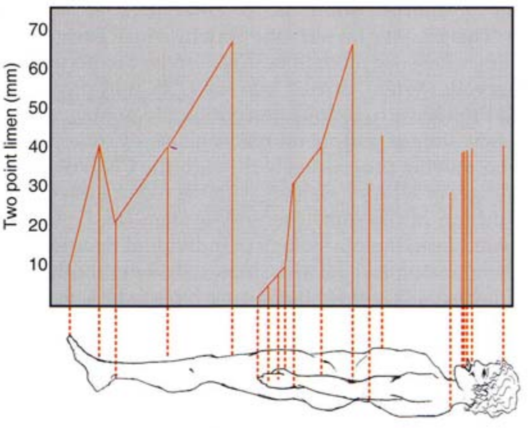
	Adaptation	Receptive field [mm^2]
FA1 or RA (Meissner corpuscle)	Fast	11-12
FA2 or PC (Pacini's organ)	Fast	100
SA1 (Merkel's cell complex)	Slow	11-12
SA2 (Ruffini's ending)	Slow	60

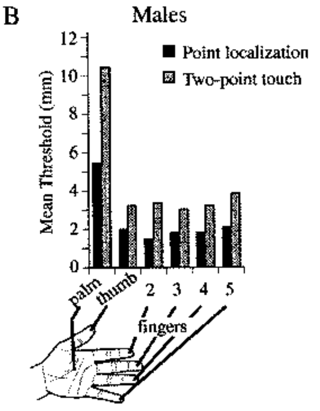
- Four types of mechanoreceptors in the skin with characteristics

Mechano-receptors information

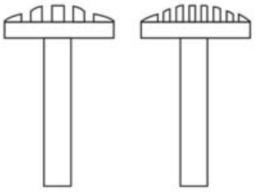


Spatial acuity





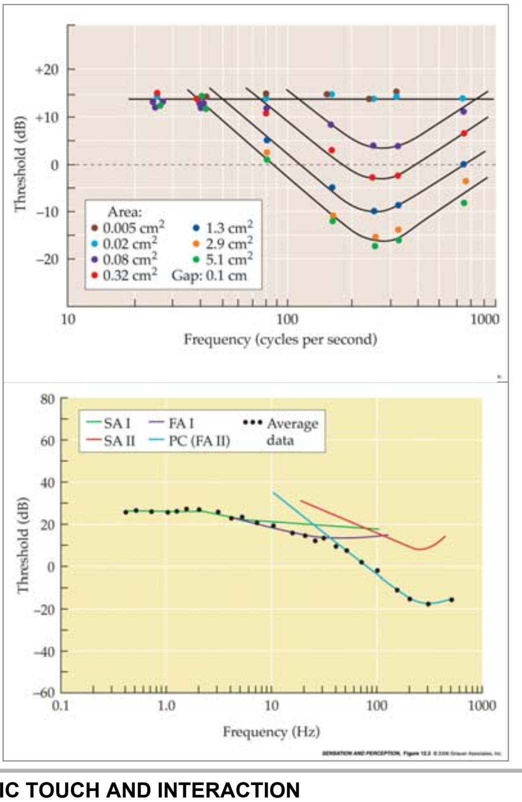
(Weinstein, 1968)



- **Two-point discrimination task**
- **Point localization task**: Identify if two successive one-point stimuli are applied in the same or different position (Weinstein, 1968)

- **Grating orientation task**: Spatial frequency of grating in task where the observer must identify its orientation (about 1 mm, Johnson & Phillips, 1981)

Vibro-tactile sensitivity



- Tactile thresholds for different stimulation areas. When the stimulus was bigger than 0.02 cm^2, the function has a U shape with the minimum around 250 Hz. Absolute tactile threshold depends on size of contact, frequency of vibration, position of skin stimulated.

- By measuring vibrotactile thresholds, Verrillo found that the skin contains at least two receptor systems for detection of mechanical disturbances.

Proprioceptors

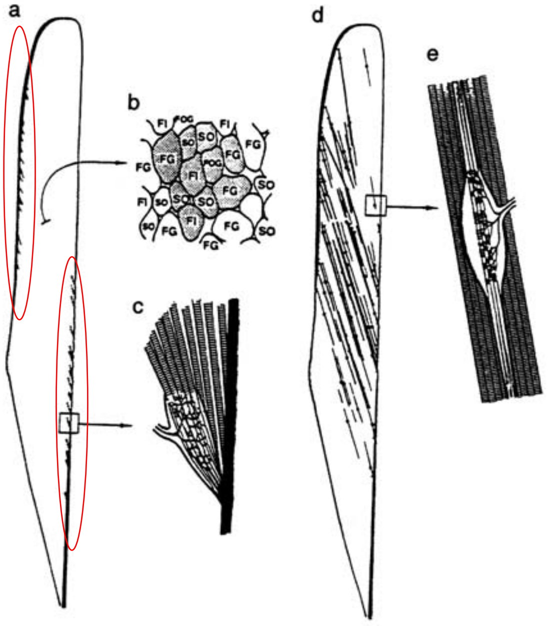
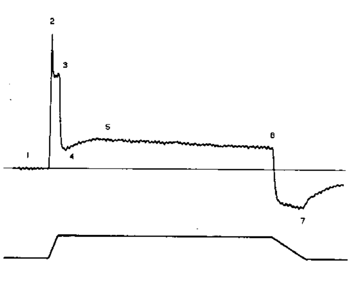


Figure 4.16 Distribution of the muscle spindle and tendon organ in the medial gastrocnemius muscle of the cat:

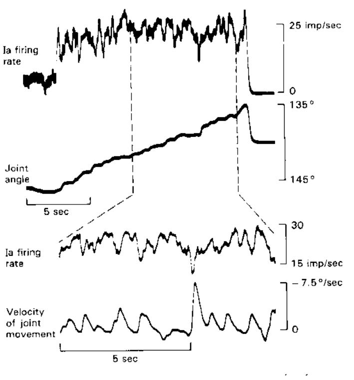
- Representation of a muscle containing diverse muscle fiber types (b).
- **Golgi Tendon Organs** (GTOs) located in the tendons connecting the muscle fibers to the bones (a). Enlarged view of a GTO (c).
- **Muscle spindles** weak contractile element endowed with sensory afferents (e) mounted in parallel to the muscle fiber produced force. Longitudinal section showing distribution of muscle spindles (d).
- **Joint receptors** signalling when an articulation reaches its limits.

Priopriocepters information

Spindle primary afferents (Ia)



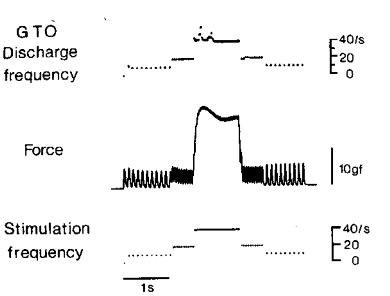
Receptor potential of a primary ending of an isolated cat spindle in response to ramp-and-hold stretch (Hunt, 1990).



Velocity dependent activity of primary endings during active shortening (Vallbo, 1981)

- **Muscle length information**
- Strong phasic activity
- Instantaneous velocity information

Golgi afferent (Ib)

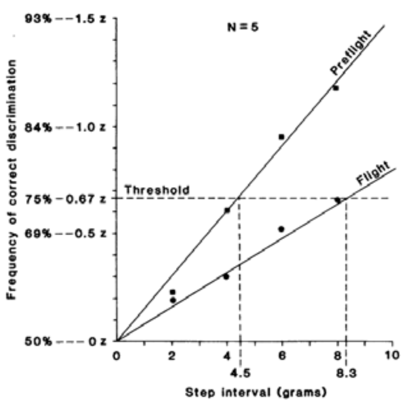


Response of tendon organ to a repetitive simulation of an in-series motor unit (Horcholle-Bossavit et al., 1989)

- **Force information**
- Non-linear

Force and mass discrimination

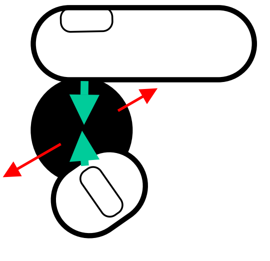
- Psychophysical research on weight perception is as old as Psychophysics. Discrimination threshold for weight perception is typically around 5-8 %. Discrimination threshold rises for small weights.

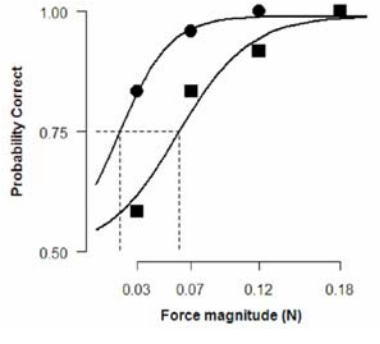


- Standard = 50g, comparison 50-64 g, 18 repetitions
- The JND for weight before was 4.5 gr before flight (5.6%)
- In space (Spacelab station) the JND, was 8.3 gr (10.4%)
- In space, threshold is larger because only inertial cues are present.

Ross (1984) Mass discrimination during prolonged weightlessness. Science

Force sensitivity



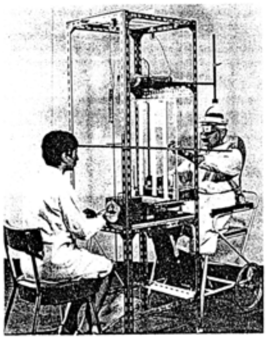


- Identification of the direction of the force transmitted by a hand-held object
- The absolute threshold was 10 g in the static condition and 5 g in the dynamic condition

Baud-Bovy G, Ellia G (2010) Hand-Held Object Force Direction Identification Thresholds at Rest and during Movement. Europhaptics 2010, Amsterdam.

Haptic space perception

- Propioceptors (and mechanorecptors) also give information about the position and movement of the body in space



- Position matching task
- Active positioning or maintenance provides more accurate sense of position

Paillard & Brouchon, 1968

- Many factors (e.g., distance, orientation, velocity) can bias our perception of space

Perceived heaviness

Table 1
Psychophysical Studies of Heaviness and Perceived Force

Study	Activity	Method of estimation	Results
Harper & Stevens (1948)	Lifted weights (constant volume)	Ratio production	62% of standard judged half-heavy
Baker & Dudek (1955)	Lifted weights (hidden)	Constant sum	Positively accelerating function between weight and heaviness
Warren & Warren (1956)	Lifted weights (varying volume)	Ratio production	Half-heaviness judgments varied with volume of comparison weight. At half-volume, 52% of weights judged half-heavy
S. S. Stevens & Galanter (1957)	Lifted weights (constant volume)	Category scaling	Linear function with 3-point scale; negatively accelerating function with 12-point scale
J. C. Stevens & Mack (1959)	Handgrip dynamometer	Ratio production	Power function, exponent 2.0
		Magnitude estimation	Power function, exponent 1.7
		Magnitude production	Power function, exponent 2.0
		Category production	Logarithmic function
Borg (1962)	Bicycle ergometer	Magnitude estimation Ratio estimation	Power function, exponent 1.6
Eisler (1962, 1965)	Plantar flexion and handgrip dynamometer	Cross-modal matching	Linear function between plantar and handgrip force
		Magnitude estimation	Power function, exponent 1.5
		Magnitude production	Power function, exponent 1.7
Curtis, Attneave, & Harrington (1968)	Lifted weights (hidden)	Magnitude estimation	Power function, exponent 0.8
J. C. Stevens & Cain (1970)	Handgrip dynamometer	Magnitude estimation	Power function, exponent 1.6
Anderson (1972)	Lifted weights (hidden)	Weight averaging	Weight and heaviness are linearly related
Rule & Curtis (1976)	Lifted weights (hidden)	Magnitude estimation	Power function, exponent 0.9
Cooper, Grimby, Jones, & Edwards (1979)	Isometric contractions of adductor pollicis and quadriceps muscles	Magnitude estimation Magnitude production (as percentage of maximum effort)	Linear fit as good as power function, exponents: 0.7 for estimation, 1.0 for production
Banister (1979)	Isometric contractions of adductor pollicis and quadriceps muscles	Magnitude estimation (as percentage of maximum effort)	Negatively accelerating exponential relation between force and effort
Jones & Hunter (1982a)	Isometric contractions of third digit	Magnitude production (as ratio of maximum voluntary contraction)	Negatively accelerating function, exponent 0.8

Biases in perceived heaviness

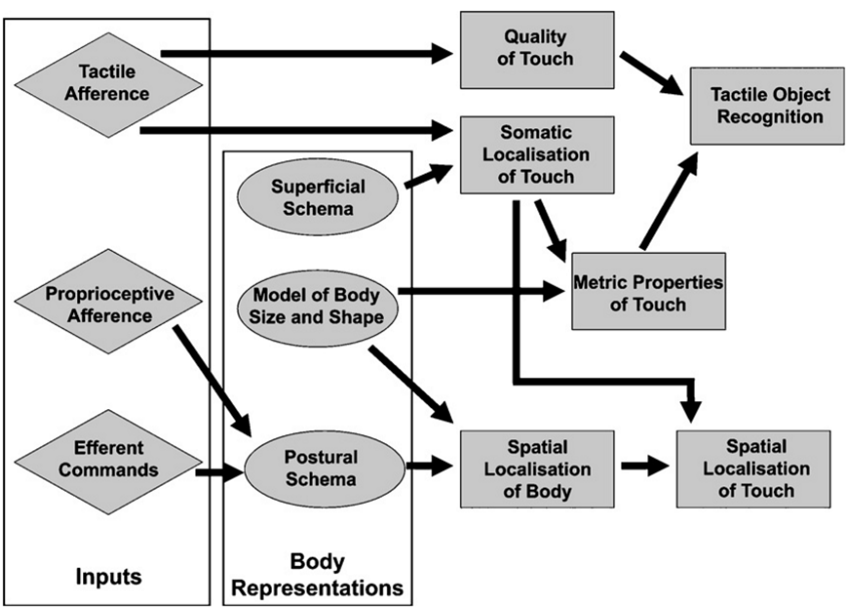
Table 2
Effects of Object Properties on Perceived Heaviness

Study	Stimulus property	Result
Wolfe (1898) H. E. Ross (1969) Harshfield & DeHardt (1970)	Surface material (weight constant)	Objects constructed from more dense materials (brass and steel) are perceived to be lighter than those made from less dense materials (i.e., wood)
H. E. Ross (1969) Anderson (1970) J. C. Stevens & Rubin (1970) Cross & Rotkin (1975)	Volume (weight constant) Size weight-illlusion (Charpentier, 1891)	Heaviness decreases as a logarithmic (Stevens & Rubin) or power (Cross & Rotkin) function of volume at a constant weight. As the weight increases, the effect of increasing the volume diminishes
De Camp (1917) Payne (1958) Payne (1961)	Color (weight constant)	Color has a very slight effect on perceived heaviness. Darker colored objects are perceived to weigh less than lighter colored objects
H. E. Ross (1969) J. Ross & Di Lollo (1970) J. C. Stevens & Rubin (1970)	Density (weight and volume changing)	Perceived heaviness of an object decreases as a linear function of the log of its density. At a constant density heaviness is a nonlinear function of weight
H. E. Ross (1981) H. E. Ross & Reschke (1982) H. E. Ross, Brodie, & Benson (1984)	Weight (at constant mass)	Perceived heaviness of objects decreases under conditions of zero gravity, and increases during macrogravity (1.8 G)

(Jones, 1986)

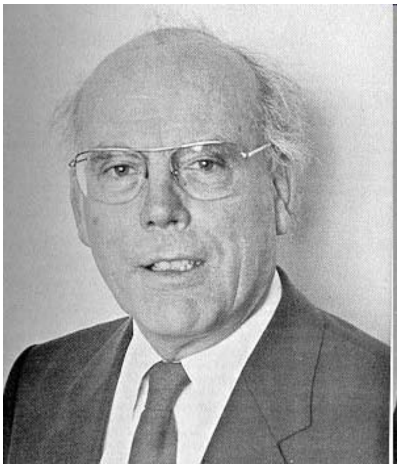
- Haptic size weight-illlusion (Kawai, 2002; 2003)
- Material-weight illusion (Ellis & Lederman, 1999)
- Shape-weight illusion (Kappers et al., 2010)

Somatosensory processes



Longo, Azanon & Haggard (2010) More than skin deep: Body representation beyond primary somatosensory cortex. Neuropsychologia, 48:655-668

Active touch



1919-2005

Gibson (1962) Observations on active touch, Psychological review, 69(6):477-491

"Active touch refers to what is ordinarily called *touching*. This ought to be distinguished from passive touch, or being touched. In one case the impression on the skin is brought about by the perciever himself and in the other case by some outside agency."

"**Active touch is an exploratory rather than a merly receptive sense**."

"Exploratory movements are not the ordinary kin usually thought of as responses. They do not modify the environment but only the stimuli coming from the environment" (Gibson, 1962)

"These touching movements of the fingers are like the movments of the eyes. In fact, active touch can termed *tactile scanning*, by analogy with ocular scanning" (Gibson, 1962)

Haptic glance

- Object recognition is very quick if exploratory movements are free

Table 2
Summary of Experimental Results on Haptic Recognition of Common Objects From Previous Studies and the Present Experiment 1

Study	Variable	Constraints* 1	2	3	4	5	Accuracy (%)	Response Time (sec)
Klatzky et al. (1985)	whole hand	unconstrained					96–99	2–3**
Klatzky et al. (1993)	whole hand, no glove	unconstrained					95	6
	whole hand, gloved, fingertips removed	unconstrained					93	10
	whole hand, gloved		2				93	16
	five fingers splinted			3			90	18
	five fingers splinted + gloved		2	3			90	25
	one finger splinted	1		3			85	23
	one finger splinted + gloved	1	2	3			74	45
Present Experiment 1A	one finger	1					92	31
	one finger in rigid sheath	1			4		42	83
Present Experiment 1B	probe (small)	1				5	41	86
	probe (large)	1				5	39	85

Note—*Constraint numbers correspond to those shown in Table 1. **The response time mode is reported in this study. In all other studies, the response time mean is reported.

Lederman Klatzky (2004) Perception & Psychophysics, 66 (4), 618–628

Exploratory procedures

Lederman and Klatsky have systematically studied exploratory movements in tasks where the subject had to identify some object and/or its properties. They found that subjects made different exploratory movements depending on the property.

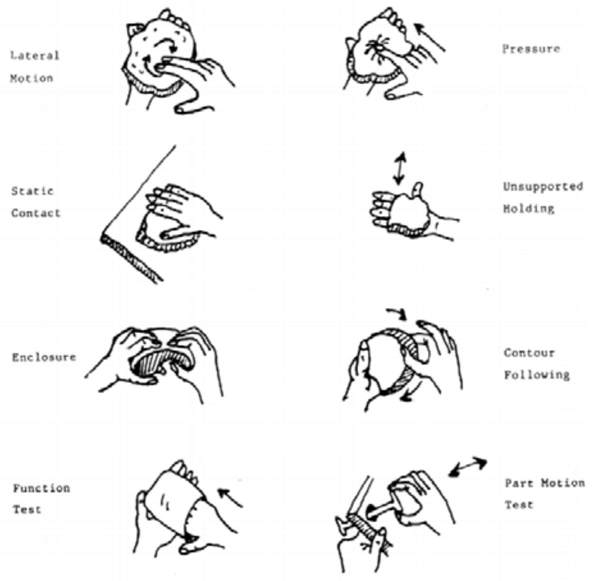


Fig. 5. Typical movement pattern for each of the EPs (from Lederman & Klatzky, 1987)

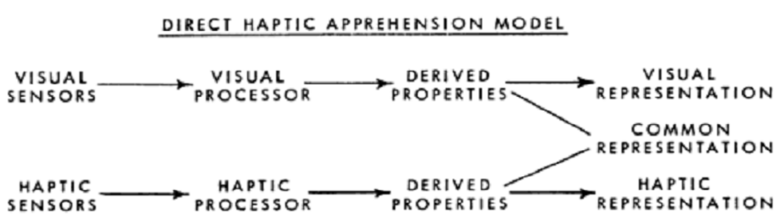
TABLE I

LINKS BETWEEN KNOWLEDGE ABOUT OBJECTS AND EXPLORATION

Knowledge about object	Exploratory procedure
Substance property	
Texture	Lateral motion
Hardness	Pressure
Temperature	Static contact
Weight	Unsupported holding
Structural property	
Global shape	Enclosure, contour following
Exact shape	Contour following
Volume	Enclosure
(Weight)	(Unsupported holding)
Functional property	
Part motion	Part motion test
Specific function	Function test

Lederman S. J. , Klatsky R. L. (1987) Hand movements: A window into haptic object recognition. Cognitive psychology, 19:342-368

Direct Haptic Aprehension Model



"This model assumes that haptics is multidimensional- it processes several different classes of attributes related to the object's substance (e.g., material properites) and geometry (e.g., shape and size).

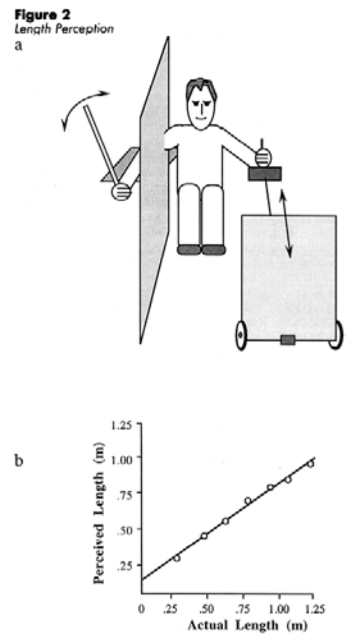
It is proposed that humans enhance their perception of object attributes by "piggybacking" the primitive sensory capacities of the human hand onto its far greater motor capabilities. By performing special kind of movements **(EPs)**, information is extracted concerning the various attribute classes which subject identified as being critical to their ability to recognize the objects." (Lederman & Klatsky, 1987)

Object recognition theories

- Object recognition models can be divided into two very broad categories (Heller, 1997):
- **Cognitive/Constructivist theories**
  - Stimulus is poor
  - Representations play an important role
  - Necessary to use inferential processes to the identify the object
  - Mental imagery, short-term memory and other higher level cognitive function play an imporant role in perception
- **Perceptual/Ecological theories**
  - Stimulus is rich
  - Knowledge about the world is direct and immediate (Gibson’s concept of affordance)
  - No need for representation

Heller, M. A. (1997) Gaps in perception. Perception.

Dynamic touch



Turvey (1996) Dynamic touch. American Psychologist.

- For Turvey, movement is also fundamental but instead of focusing on exploratory procedures aimed at extracting information about the object properties, he emphasizes the richness of perception that accompany wielding hand-held objects.
- His approach rest on an appreciation of the physical underpinnings of wielding hand-held objects, that is of the inertia tensors.
- His experimental work shows, for example, that subjects are able to perceive directely the length or even the shape of an held-object by just wielding it.

Outline

- Some thoughts on haptic interaction design
- The contribution of Psychology
- Psychophysical Methods
- Sensory Psychophysics and the haptic sense
- **Non-Sensory Psychophysics and the aesthetic experience**
- Conclusions

Rating scales and regression



20 stimuli (pictures of medium sized cars)

Three 9-point rating scales :

1. typicality: bad example – good example (of a medium sized car)
2. novelty: not original – original
3. asesthetic preference: ugly-beatuiful

Analysis: regression of aesthetic preference on typicality and novelty.

Hekkert al. (2003) 'Most advanced, yet acceptable': Typicality and novelty as joint predictors of aesthetic preference in industrial de sign. British Journal of Psychology(20 03),9 4,1 11–1 24

Rating scales and ANOVA

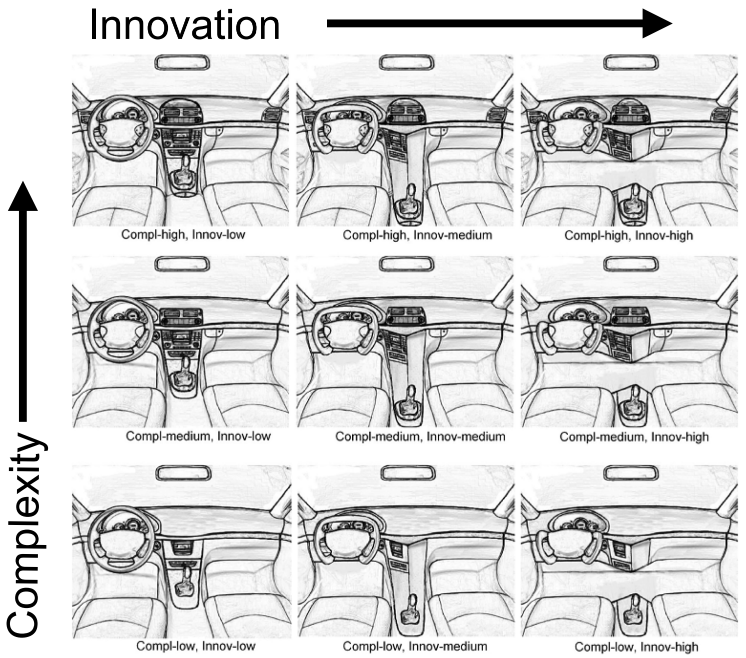


Figure 1. Examples of Form-original stimuli used in Experiment 1. Three levels of complexity (Compl-low, Compl-medium, Compl-high), form (Form-straight, Form-original, Form-curved) and innovativeness (Innov-low, Innov-medium, Innov-high) were used

Stimuli (drawings of car interiors) organized along 2 dimensions:

1. complexity
2. Innovation

Attractivness rating scale (7 levels) analyzed with a 2 way repeated-measure ANOVA.

Leder et al. (2005) Dimensions in Appreciation of Car Interior Design. Appl. Cognit. Psychol.19: 603–618 (2005)

Multi-dimensional scaling analysis

$$\Delta := \begin{pmatrix} \delta_{1,1} & \delta_{1,2} & \cdots & \delta_{1,I} \\ \delta_{2,1} & \delta_{2,2} & \cdots & \delta_{2,I} \\ \vdots & \vdots & & \vdots \\ \delta_{I,1} & \delta_{I,2} & \cdots & \delta_{I,I} \end{pmatrix}.$$

$$\|x_i - x_j\| \approx \delta_{i,j}$$

MDS takes an input matrix giving dissimilarities between pairs of stimuli and outputs a set of coordinates representing the stimuli in a space of prespicified number of dimensions, such as the distances between these points reproduce the original dissimilarities (metric dimensional scaling) or are in the same in the same rank order (non-metric dimensional scaling).

Kruskal JB Wish M (1978) Multidimensional Scaling (Quantitative Applications in the Social Sciences)

Borg I, Groenen P. J. F. (2005) Modern Multidimensional Scaling: Theory and Applications (Springer Series in Statistics)

Multidimensional scaling analysis

Figure 1 Two of the line drawings constructed to vary along the dimensions of line thickness and amount of shading.

Stimuli: 12 drawings of a house organized along 3 dimensions:

1. line thickness
2. amount of shading
3. expressivenss

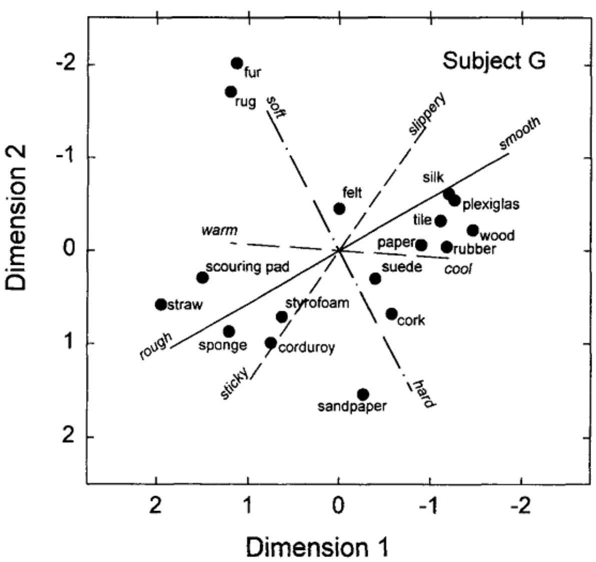
Objective: Investigation of factors underlying sensitivity of children to stylistic properties of drawings.

Procedure: Rating of each pair of stimuli on 7-point same-different scale => 12x12 matrix of dissimilarities.

Analysis: multidimensional scaling analysis and multipe regression analysis to assess the extent to which the dimensions recovered in the MDS reflect the three original dimension of the stimuli.

O'Hare D, Westwood H (1984) Features of Style Classification: A multivariate experimental analysis of children's respondes to drawing. Developmental Psychology. 20(1):150-158.

Texture perception



Two-dimensional MDS solution for one participant (Hollins et al., 2000)

Stimuli: 17 surfaces

Procedure: Experimenter presented sequentially each pair of stimuli and reported with a graphical scale the perceived differentness.

They also rated the stimuli on five adjective scales (e.g. cool-warm, soft-hard)

Analysis: the 17x17 dissimilarity matrix were analyzed using metric MDS.

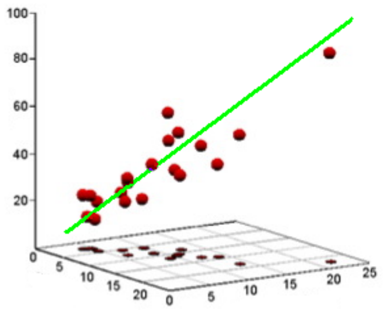
Hollins et al. (2000) Individual differences in tactile texture space. Perception & Psychophysics.

PCA and factor analysis

- **Principal component analysis (PCA)**

  Reduce the number of variables by projecting the observations on a subspace that contains most of the variance.

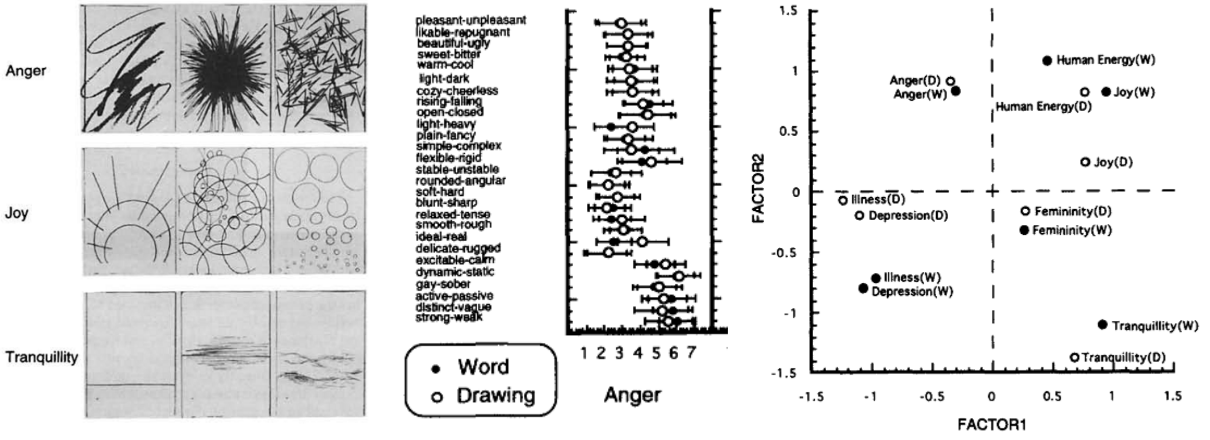
  The selection of the number of factors (dimension of the subspace) is a classic problem of PCA and FA.



- **Factor Analysis**

  After projection, the axes of the subspace can be rotated to ease their interpreation.

Factor analysis

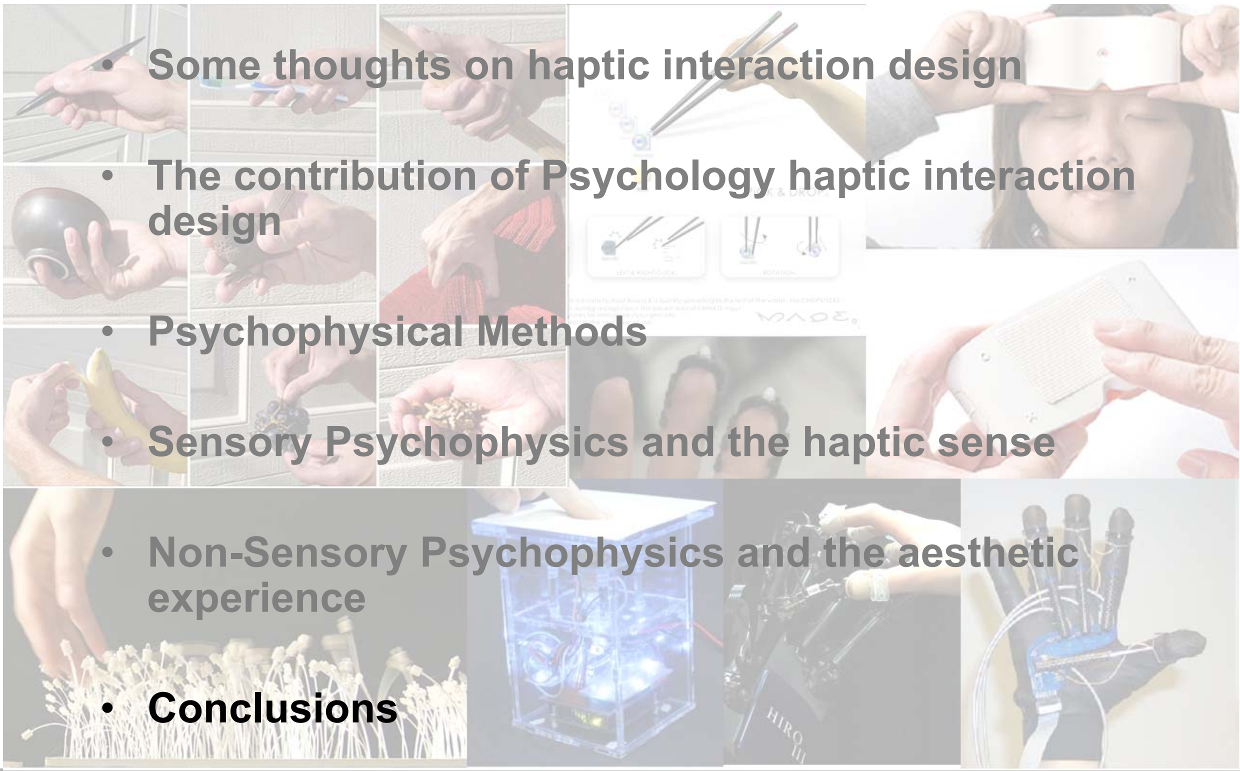


21 drawing and 7 words were rated separately on 27 7-point scales (e.g. pleasant-unpleasant, light-heavy, light-dark, ideal-real, etc.)

Factor analysis was used to identify the three main factors (major semantic dimensions in the context of this study) of the 27x27 correlation matrix.

Takahashi S (1995) Aesthetic Properties of Pictorial Perception. Psychological Review, 102(4):671

Outline



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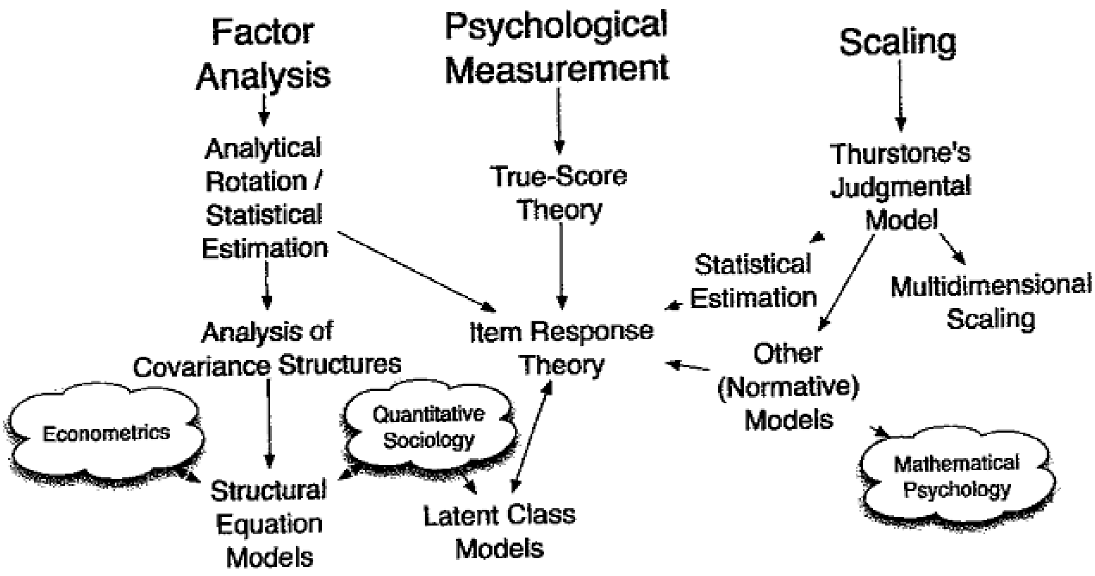
Why bother with Psychology?

- One might want:
  - Theories and models on high-level constructs like creativity or aesthetics that are relevant to design.
  - Theories and models on sensory systems and perception that might help to address the shortcomings of haptic devices.
- One might get:
  - Some general principles to design well your system
  - Methods to study human factors
  - Methods to develop and test well your system

Psychophysical methods

- Many quantitivative methods have been developped to study behavior



DYNAMIC TOUCH AND INTERACTION
Haptics Symposium, March 3, Vancouver
Gabriel Baud-Bovy
Italian Institute of Technology, RBCS