Issues Addressed

- How does cognitive behavior change with age? (Part I)
- How does brain function change? (Part II)
- What are the implications of these processes and changes for every day life? (Part III)
Part I. Laboratory Data Examining Cognitive Aging

- Building blocks of cognition:
  - Speed: how fast?
  - Working memory: how much?
  - Long-term memory: how durable?

- Conducted a large behavioral study across the lifespan, testing each subject for eight hours across three visits.

- 350 adults: 50 from each decade from 20-80
Pattern Comparison Task

SAME      DIFF

(X)       (  )

(  )       (X)(X)       (  )(  )       (X)

(X)       (  )

(  )       (X)

(X)       (  )

(  )       (X)
Speed of Processing across the Life-span: How fast?

Z-scores

Age Groups

n = 350
Verbal Working Memory: How Much?

Experimenter says:

6 + 3 =

Subject presses A, since 6 + 3 = 9.

Experimenter says:

2 + 8 =

Subject presses C, since 2 + 8 = 10.

Subject RECALLS 3 and 8 on paper.

Working memory span is measured by how many trials people can go through without making an error on either the processing task (answering the equation) or the memory task (remembering the series of digits).
Verbal and Visuo-spatial Working Memory Capacity across the Life-span

- Reading Span - Verbal
- Computation Span - Verbal
- Line Span - Spatial
- Letter Rotation - Spatial

n = 350
Long-term Memory: How Durable?

STUDY 24 words
- book
- dress
- song
- bank

Wait 5 minutes
Recall words
Long-term Memory for Verbal and Visuo-spatial materials

Z-scores

Age Groups
20's 30's 40's 50's 60's 70's 80's

Cued Recall - Verbal
Free Recall - Verbal
Rey - Spatial
Benton - Spatial

n = 350
World Knowledge: Impact of Experience

- Measures of verbal ability
  - Vocabulary test
  - Synonyms
  - Antonyms
Estimates of World Knowledge across the Life span

-1.2 -0.8 -0.4 0 0.4 0.8 1.2

20's 30's 40's 50's 60's 70's 80's

Shipley Vocabulary

n = 350

Synonym Vocabulary

Antonym Vocabulary

Age Groups
The Aging Mind

Neurobiology: speed, working memory, long term memory

Experience: world knowledge

Park, Lautenschlager, Hedden, Davidson, Smith & Smith, 2002. Psychology and Aging
What Do We Know About Cognitive Function with Age?

- Declines in process measures of “cognitive horsepower.” (hardware of the mind)

- Decline is linear and is quite similar across cross-sectional and longitudinal studies.

- Preservation and expansion of knowledge as a result of experience. (software of the mind)

- There is also the ability to rely on highly practiced routines and utilize little cognitive horsepower. These are “automatic behaviors (e.g., driving).

- Implications of “horsepower” decline are greatest for novel situations in everyday life.
Part II: Neural Function with Age

- Does neural circuitry change with age?
- Does less neural activation accompany decreased cognitive function with age?
- Do older adults rely on different neural circuitry?
- Does the brain remodel or rewire with age?
Patterns of Neural Function with Age

- Startling dissociation between behavioral and neural data
- Unlike cognitive function, it appears neural activity increases rather than decreases with age
Brain Areas Implicated in Cognition

- Frontal cortex: decision-making, strategies, conscious recollection
- Hippocampus (medial temporal cortex): repository of memory; locus of Alzheimer’s disease
- Visual/Sensory Cortex: Object recognition; less deterioration with age
Hippocampal and Frontal Function in Old and Young

- Hippocampus is repository of memory.

- Processing of complex pictures is demanding of both hippocampal (memory) and frontal (strategy) areas.
About Research Participants

- **Young (n = 11)**
  - Mean age = 20.55
  - Mini Mental = 29.70
  - Vocabulary = 32.82
  - Accuracy visual: .837
  - Accuracy imaginal: .816

- **Old (n = 10)**
  - Mean age = 67.00
  - Mini Mental = 29.10
  - Vocabulary = 35.40
  - Accuracy visual: .827
  - Accuracy imaginal: .804
The Task

Visual Condition

Maintenance Condition
3T Scanner
Left Motor Cortex:

Young

Red=Visual
Blue=Imag

Left Motor Cortex: Old
Left Anterior Hippocampus Time Course

Activations in Left and Right Inferior Frontal Areas During Probe
Behaviorally, old and young were identical.

Old, however, did not spontaneously “grab” information from the pictures to be stored in long-term memory (hippocampus) like young and showed decreased hippocampal function.

However, at the time of the probe, old recruited more frontal cortex than young to perform the task and also had longer reaction times.

The frontal activations may be compensatory for the lack of hippocampal activations (subsequently reported by Gutches, Welsh & Park (In press)).
Visual Cortex: Object Recognition and Aging

- Directed attention to early stages of processing: What does object recognition circuitry look like in old versus young?
- Decided to look at specialized areas in ventral-visual cortex
Ventral Visual Cortex

- Shows little or no volumetric atrophy with age
- Highly specialized and activations should be easily interpretable
- Focus on fusiform face area (Kanwisher)
- Parahippocampal place area (Epstein & Kanwisher)
- Orthography area (Polk & Puce)
Experimental Stimuli

- Face
- Pseudoword: moit
- House
- Chair
- Phase-scrambled
Results

Isolated brain tissue (top 15 voxels) most active to faces.

Then looked at how active were top face voxels to houses? Should see considerable segregation in young.

But what about old?

*For each subject, developed a mask of ventral-visual cortex*

*Within the mask, we functionally defined three ROI’s for each subject by selecting the 15 most activated voxels within ventral/vis cortex for faces, for places, and for pseudowords (relative to phased control items).*

*These 15 voxels thus functionally defined the face, place, and word areas.*

*We then calculated the mean t value of the activation in each of the three ROI’s to the four types of stimuli for young and old.*
Activation to Faces, Houses, Chairs and Pseudowords in Fusiform Face Area
Activations for Faces, Chairs, Houses and Pseudowords in PPA

Place Area

Avg. t

Young | Old

Age

Faces
Houses
Chairs
Letters
Activation for Faces, Houses, Chairs and Pseudowords in Fusiform Word Area

Pseudowords

Age

Avg. t

Young

Old

Faces

Houses

Chairs

Letters
Compelling Evidence for Decreased Neural Specialization with Age

- Repeatedly found evidence for decreased selectivity at the level of object recognition with age
- Behavioral theory suggests that this decreased selectivity is likely evidence for a deteriorating neural system
- Maybe older adults are slower and use more frontal function because they are sapping neural energy to perform basic functions like object recognition.
Summary of Neural Data

- Decreased neural selectivity in ventral visual cortex with age.
- Decreased hippocampal activation with age (memory site).
- INCREASED frontal activation, likely as compensation for decreased activation of these other structures.
- Brain remolds and reorganizes with age.
Part III. Basic Processes and Everyday Life

- What are the implications of declines in basic processes and changes in neural function for function in everyday life?
- Medical Adherence
- Medical Information Processing
Effortful versus Automatic Processes

Tasks that are effortful (require speed and working memory) show age related declines.

There is little decline in automatic processes

Automatic processes rely on feeling of familiarity about information and events so highly practiced that they require little capacity or effort.

Examples of effortful processes would be recalling a list of words or trying to remember a grocery list; automatic would be listing months of the year, reading, or driving.

Many important tasks in everyday life rely on automatic processes.

An important way to get older adults to remember things is to utilize the part of memory that is still intact—the habit-based or automatic component of memory.
Medication Adherence

- This would appear to be a cognitive problem with multiple components.

- With age, there are
  - Decreases in comprehension of medication plan (Morrell, Park & Poon, 1989)
  - Decreases in memory of prescription information (Morrell, Park & Poon, 1990)

- Became interested in studying medication adherence in the field.
Studying Adherence in Rheumatoid Arthritis Patients

- Studied a lifespan population of 122 rheumatoid arthritis patients for four weeks
- Used unobtrusive MEMS technology
- Collected exhaustive basic cognitive and psychosocial measures from subjects

- Chris Hertzog, Howard Leventhal, Roger Morell, Mike Martin
Medical Adherence Errors Across a One Month Period as a Function of Age

A Model of Adherence Behavior

From Park, et al. (1999)
Who was most nonadherent?

- Middle-aged adults
- Busy people
- We believe that having a routine changes medication adherence from a memory behavior to an automatic behavior, so that busy people are most nonadherent
- Older adults took medications accurately in these studies
- Replicated this finding with hypertension medications
- Context over cognition, except in the case of very old adults where cognition matters
Summary on Medication Adherence

- Context is more important than cognition
- Automatic processes may play an important role in medication adherence
- Began focusing on role of automaticity and unconscious cues in cognitive function.
- Target populations should be old-old and very busy people
Increasing Compliance through Automatic Behaviors

- By attaching a behavior to a routine, it will be performed automatically.
- One way to artificially create automatic behaviors is to have individuals imagine implementing the behavior, creating cues that they will later encounter, and cause them to perform the behavior.
Using Automatic Processes To Improve Adherence

- Chasteen, Park and Schwarz (2001) demonstrated that they could improve memory for writing a date on a page by more than 100% if older adults imagined the intention compared to rehearsed the intention.

- Because automatic processes are preserved relative to effortful processes as people age, the use of implementation intentions may be a particularly valuable tool for increasing compliance among senior adults. Began work with Linda Liu.
Elite XL: A Microcurrent meter

- Glucose reacts with a catalyst in the test strip, releasing electrons.
- Electrons move to the electrodes, producing a current proportional to the amount of glucose in the
### Instruction conditions

<table>
<thead>
<tr>
<th>Control</th>
<th>&quot;At (12:00 / 1:30 / 6:00 / 7:30), I will test my blood sugar.&quot; Rehearsed instructions out loud for 3 minutes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deliberative</td>
<td>&quot;Testing my blood may be slightly inconvenient, but it will help me decide what to eat.&quot; Generated pros and cons for 3 minutes.</td>
</tr>
<tr>
<td>Implementation</td>
<td>&quot;At (12:00 / 1:30 / 6:00 / 7:30) when I am _______ , I will test my blood sugar.&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;Look around at your surroundings and concentrate on the objects in your environment. What do you see? ___________.&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;Imagine the actions that lead up to what you will do at (12:00 / 1:30 / 6:00 / 7:30). What will you do?&quot; ______</td>
</tr>
<tr>
<td></td>
<td>&quot;Imagine each step of each action, one at a time. What does each step feel like? ______</td>
</tr>
<tr>
<td></td>
<td>For each test time, handwrote responses to each question.</td>
</tr>
</tbody>
</table>
Effects of Age and Instructions on Adherence

Compliance for Weeks 1, 2, and 3 by Instruction-Younger adults

Week of study

 Avg. number of readings per week

Compliance for Weeks 1, 2, and 3 by Instruction-Elderly adults

Week of study

 Avg. number of readings per week
Conclusions

- By simple instructions that involved imagining completion of an act (blood-glucose monitoring), we greatly increased the probability that the act would be completed.
- The glucose task was automatically performed as a result of the instructions.
- These effects are especially compelling, given that all of these participants were healthy and that learning to use this medical device was a novel experience for them. One can argue, they may have had very little reason to care about testing their blood sugar.
But reliance on automatic processes can also work against you.

Can we make people think false information is true?
How does memory decline cause older adults to come to believe false statements are true?

- Elderly often remember the gist of the information they hear but not the specific context in which they heard it or specific details.

- There is a tendency to believe familiar information is true.

- What if you forget context but information feels familiar?

- Will this make false information seem true to you?

- We think that there is a possibility that the more older adults hear false information, the more likely they will be to believe later on that it is true. (Illusion of truth effect)

- **Skurnik, Park & Schwarz** In press. Journal of Consumer Research
General Procedure

- We developed a series of medical statements, all of which were true, but which subjects found to be unfamiliar and to have uncertain truth value.

- DHEA supplements can lead to liver damage, even when taken briefly.

- Most cold medications cause the eye’s pupil to dilate.

- Corn chips have twice as many calories per cup as potato chips.
Experimental procedure

Study Phase

• Present 36 claims as true or false
• 1/2 presented once, 1/2 three times
• Inform participants 1/2 true, 1/2 false

Test Phase

• Study Phase claims and new claims
• Remind participants 1/2 true, 1/2 false
• True, false, or new?
Experiment 1 results: After 1/2 hour

Mean proportions of responses

Response presented:

"true" to false
"false" to true

Younger vs. Older

- 1x: Younger 0.11, Older 0.28
- 3x: Younger 0.10, Older 0.17

Mean proportions of responses range from 0.00 to 0.45.
Experiment 1 results: After 3 days

Mean proportions of responses

<table>
<thead>
<tr>
<th>Response Type</th>
<th>Younger</th>
<th>Older</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;true&quot; to false</td>
<td>.31</td>
<td>.40</td>
</tr>
<tr>
<td>&quot;false&quot; to true</td>
<td>.17</td>
<td>.19</td>
</tr>
</tbody>
</table>

Presented:

- 1x
- 3x
The Effects of Presenting Negative Information

- Presenting “myths” about a disorder may ultimately create false memories and beliefs.
- “Myths about diabetes.”
  - “Weight control doesn’t matter.”
  - “Medications easily control diabetes.”
- Information that an individual disbelieves at the time it is presented may come to seem true later on, particularly if the “myth” is repeated.
Summary

- Aging mind can only be understood if cognitive function, experience, and context are jointly integrated.

- The impact of age-related decline is most apparent in a novel environment where experience and practice don’t confer any benefits.

- The effects of age-related decline, knowledge, and context are all powerful alone, but they interact in interesting ways as the data on medical adherence and false memories show.

- We need to understand the impact of novelty and stimulation on neural, cognitive and emotional function.
Part IV. Reorganizing Neural Function and Improving Cognition with Age

- New frontier and new focus of my laboratory.
- The Roybal Center for Healthy Minds