Cognitive Decline

Ageing and Older Adulthood

Dr Judith Marshall

Geriatrics and Gerontology

- Geriatrics

  Medical - diseases and health problems of older adults

- Gerontology

  Biological, behavioural and social - maturity to old age

  - Interdisciplinary

Defining age and older adulthood

- Chronological age: Actual age in time
- Biological age: Organ system functioning and physical appearance
  Comparative
- Functional age: Specific task competence
- Psychological age: Adaptation to change
- Social age: Views regarding age-suitable behaviour

Theories/Models of ageing

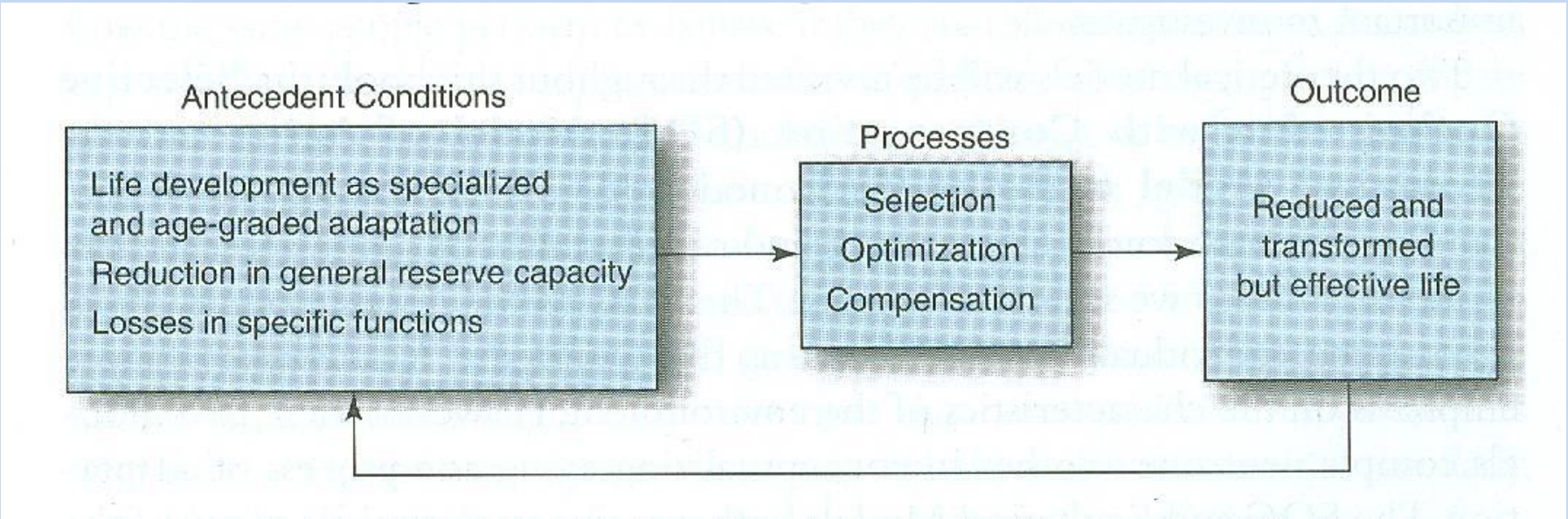
- Selective Optimization with Compensation (SOC) Model of Ageing (Baltes and Baltes, 1990)
- Ecological Model of Ageing (Lawton and Nahemow, 1973)
- Activity Theory

  Disengagement Theory
- Socioemotional Selectivity Theory (SEST) (Cartensen, 1991, 1995)
- Convoy Model
- Hierarchical-compensatory model

Selective Optimization with Compensation (SOC) Model of Ageing

(Baltes and Baltes, 1990)

- Reductions in capacity
  - general reserve
  - specific domains
- Selection
- Optimization
- Compensation



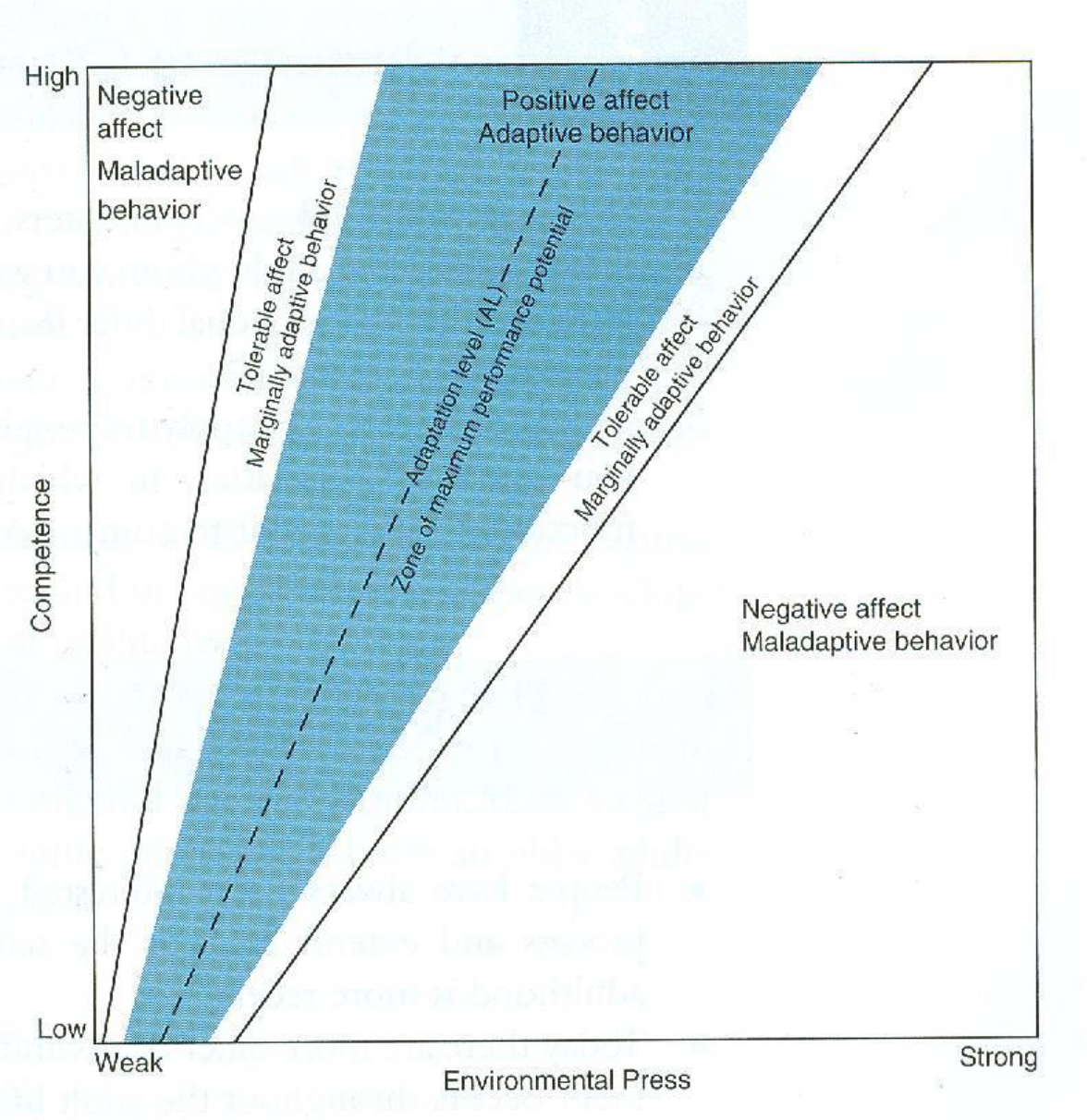
The Ongoing Dynamics of Selective Optimization with Compensation
(Baltes and Baltes, 1990)

Ecological Model of Ageing

(Lawton and Nahemow, 1973)

- Person-environment interaction → adaptation
- Affective well-being and behaviour
- Transactional nature of person-environment interaction

(Lawton, 1989, 1999)


High
Negative affect
Maladaptive behavior
Positive affect
Adaptive behavior
Tolerable affect
Marginally adaptive behavior
Adaptation level (AL)
Zone of maximum performance potential
Tolerable affect
Marginally adaptive behavior
Negative affect
Maladaptive behavior
Competence
Low
Weak
Environmental Press
Strong

Memory

- SOC Model

  Well-maintained memory skills can compensate

  External memory aids

- Ecological Model

  Memory demands in the environment may need to be reduced

Cognition and problem solving

- The SOC Model

  Heavier reliance on top-down processing

  Creative endeavours

- Ecological Model

  Structured and organized alternatives

Intelligence

- Fluid abilities decline
- Crystallised abilities?

- SOC Model

  Pragmatics of intelligence (crystallised abilities) - compensation for decline in the mechanics of intelligence (fluid abilities)?

  Older adults – expertise

- Ecological Model

  Intellectual press, competence and adaptation

  Too many intellectual demands – possibility of confusion, mental stress or physical danger

This next section…

- Age differences in cognitive processing
  - Speed of information-processing
  - Attention
  - Memory
  - Intelligence
- Explanations for age differences in cognitive processing
  - Cognitive-psychological explanations
  - Biological explanations
- Assembled Cognition
- Coping with cognitive limitations

Ageing

- Childhood development – qualitative and quantitative

- Adult development – generally quantitative
  - Adulthood is not marked by stability, but strange (qualitative) changes in personality or cognitive processing indicate pathology

- Cognitive abilities and age
  - Americans as a whole fear cancer the most
  - Americans over 55 fear Alzheimer's Disease the most *(Metlife Foundation, 2006)*

  - Association between cognitive decline and ageing is encoded in language
    e.g. 'senior moment' – negative (*impairment/incompetence, rather than wisdom*)

Age differences in cognitive performance

Speed of information processing

- Basic (perceptual speed) speed little overlap with higher-order cognitive tasks (memory/intelligence)
- Usually measured using relatively simple response-time tasks – comparison with younger adults
- Peak early in adulthood then decline *(Lindenberger and Baltes, 1997)*

Speed of information processing

- *Verhaeghen, 2006* - Meta-analysis (92) studies) conclusions:

1. older adults consistently slower than younger

2. Age-related slowing not random, but predictable, orderly pattern of results over different tasks
   - Stats: 67% differences between mean performance of groups of older adults can be predicted from knowing the mean performance of corresponding younger group – regardless of nature of task

3. Age-related slowing is proportional – e.g. average 70-year-old approx. 40% slower than average 20-year-old *(Charness and Bosman, 1995)*

4. Not all studies show same slowing factor - partially due to differing methods

   Also: two 'slowing' categories:

   Sensorimotor/verbal identifications (reaction time/naming objects) = less slowing

   Spatial search processes (locating item in crowded scene/ 'virtual' rotating or folding) = more severe slowing

Attention

- Meta-analysis of research on ageing and selective and divided attention

  (Verhaeghen and Cerella, 2002)

- Selective attention: focus on single aspect, exclusion of other stimuli
  - Requires effort
  - Test: Stroop task (name colour of word) interference by automatic reading process
    - Older people slower/less accurate

- Divided attention: Spreading attention over number of aspects
  - e.g. mobile phone/driving – loss of peripheral vision 400% increase in risk of accident
  - Test: Dual task test (e.g. tracking a route / learning words – missteps when hear new word)
    - Older people slower

- Divided attention: Attention shifts (switching between tasks)
  - e.g. a day at the office
  - Test: respond to Green digits –odd or even / Red digits – larger or smaller

- Size of the attentional field :

  Number of objects or size of the virtual space that people can attend to

  - Test: visual search tasks e.g. find letter F among many letters E
  - Age difference grows as the number of distractor letters increase
    - Attentional field shrinks with ageing

  - ‘Useful Field of View’ test (Ball et al, 1993) – best predictor of future driving accidents

Memory

Working memory

- Test: digit span
- Meta-analysis (123 studies) (Bopp and Verhaeghen, 2005):
  - Older adults approx. 7.1 digits/younger adults approx. 7.6
  - Small, but significant result

- Dynamic working memory
  - Test: span test interspersed with simple tasks (e.g. verify a maths statement e.g. 2 + 2 = 5?)
  - Older adults hold approx. 3 items/younger adults approx. 4 items

- Age differences in working memory – implications for entire cognitive system e.g.
  - Intelligence (Engle, Kane and Tuholski, 1999)
  - Language abilities (Kemper, Herman and Lui, 2004)

Long-term memory

- Explicit memory: conscious, deliberate use
  - Hippocampus implicated in formation of permanent traces in explicit memory
  - Memory codes transferred during sleep, but retains indicator
  - Hippocampus damage during normal ageing (more so with dementia)

    Two forms of defect:
    1. New traces less precise
    2. Retrieval less accurate (or fails)
  - More recent, less activated memories affected first
  - Seen in Alzheimer's patients
    1. New traces less precise: did not encode moving to care home (confusion)
    2. Retrieval less accurate/fails): activation of redundant routine (e.g. dressing for work)

- Implicit memory: Tasks and processes that rely on memory – unconscious use

  e.g.
  - motor learning
  - recognition of the familiar
  - priming (cues to expectation)
  - semantic understanding of words with multiple meanings

- Bypasses the hippocampus – often remains intact – even in dementias

- Episodic memory:
  - Large decline in due to cognitive ageing
    - Difference between average 70-yr-old and average 20-yr-old – 1.25 SDs *(Park et al, 2002)*
    - Quantitative decrease – applies across the board
      - Depth of processing
      - Encoding specificity
      - Organization

- Semantic memory
  - No age differences
    - Vocabulary tests – older outperform younger adults by approx. 0.8 SD *(Verhaeghen, 2003)*
    - Decreases after age 90 *(Singer et al, 2003)*
    - Semantic information distributed across cortex *(Eichbaum, 2003)*
      - Less vulnerable to changes than memory relying on specific brain structures

- Retrieval:
  - Retrieval – diary of ‘tip of the tongue’ states
    - Older adults more than younger (Older 6.6 / Younger: 5.2)

      – approx. 0.5 SD *(Heine et al, 1999)*

- Prospective memory: memory for intentions e.g. appointments, tasks
  - Test: tasks to do at some point in the future
  - Older adults better than younger in naturalistic settings (e.g. phone a number, mail cards at a specific time) - approx. 1 SD

    (Henry et al, 2004)
    - Improved use of strategies?
  - Older adults do worse than younger in lab settings (e.g. engaged in one task, but have to turn a dial every two minutes) – approx. 0.75 SD

Intelligence

- Early studies (circa 1930s) cross-sectional: differences could be due to cohort effects (generational differences) – different starting points
  - e.g. schooling, environmental experiences

- Longitudinal research: test/re-test effects can occur, selective attrition
  - e.g. if mainly high scorers return, differences may be underestimated

- Schaie (2005) Seattle Longitudinal Study
  Researched temporal changes in:

    - Inductive reasoning
    - Spatial orientation
    - Perceptual speed:
    - Numeric ability
    - Verbal ability
    - Verbal memory

Schaie (2005) Seattle Longitudinal Study

Findings:

- All abilities show decline after age 60

But

- Peak performance for most abilities – much later than thought
  - Only numeric ability peaks in early adulthood
  - Perceptual speed peaks around age 40
  - Verbal ability and memory – around age 50

  - Most dramatic decrease in ability – perceptual speed and numeric ability

- No universal patterns of change – not every individual show decline
  - Approx. half show decline in at least two abilities by age 50 – but no same abilities
  - By age 88 very few showed decline in all six abilities
  - 50-60% showed no difference in test scores over time

- Decline is not a universal given

- Schaie (2005) Seattle Longitudinal Study

- Cohort effects: those born earlier scored lower in:
    - Inductive reasoning
    - Spatial orientation
    - Perceptual speed:
    - Verbal memory

- Exceptions:
    - Numeric ability
    - Verbal ability
        - peaked for those born between 1930 and 1950 – followed by steady decline over successive cohorts

- Part of age-related decline due to starting point, not steep decline in abilities

- Salthouse (1991) – Less optimistic view
  - When time of measurement taken into account, longitudinal and cross-sectional study results are similar
  - Only verbal ability increases with age
  - All other variables decline dramatically - from early adulthood
  - Cites changes in crystallized and fluid intelligence
    - Crystallized (stored information)
    - Fluid (manipulation of information/adaptation)
  - Verbal ability – crystallized intelligence – continues to rise and peaks in older age
  - Other abilities – fluid intelligence – peak in early adulthood
    - Compensates for lack of life experience?
  - Findings confirmed by longitudinal studies (e.g. Duke Longitudinal study; Berlin Ageing Study)

- **Studies of intelligence and ageing: Ecological validity**

- Standardized intelligence tests – de-contextualized – equal disadvantage

- Tests of everyday problem-solving e.g. vignettes about medication-related issues, financial problems etc.
  - Scores number of effective and safe solutions offered by participant

- Thornton and Dunmke (2005) Meta-analysis of 33 ‘everyday’ studies:
  - Older still performing less well, but difference is smaller
    - 0.5 SD everyday tests / 0.9 standardized tests *(Verhaegehen and Salthouse, 1997)*

  - Older – more happy with own solutions
    - Fewer solutions – don’t look further?
    - Working memory limitations – reduce manipulation of a large problem?

    Or
    - Accept no ideal solution

- Medical decision-making

  - Few studies, but indicate:
    - Older adults faster to focus on one alternative
    - Ask doctor fewer questions
    - Provide fewer detailed reasons for their decisions

(Park and Hall Gutchess, 2000)

Problem-solving strategies linked to:

- Cognitive limitations in working memory and processing speed

Problem-solving strategies not affected by

- Prior knowledge about the specific medical problem
- Personal relevance of the problem
- Perceived seriousness of the problem

(Park et al, 2002)

Coffee break

Explanations for age differences in cognitive processing

Cognitive-psychological explanations

- Basic variables that underpin higher-order aspects of cognition

- Three mechanisms proposed:

1. Speed of processing – slowing of the mental clock
   a) Adults performance will break down when information is streaming too fast
   b) Information will be lost when tasks become more complicated and require multiple steps and storage of information along the way
      - e.g. Background tasks can slip from memory if foreground task takes too long

   - Speed of processing explains about two-thirds of age-related variance in *reasoning*, *spatial abilities* and *episodic memory*

2. Control processing in working memory

- Older adults find dual task situations and task-switching problematic
  - Capacity problems
  - Correlation between working memory and many cognitive tasks (*Engle et al, 1997)*
  - Role in age differences in fluid cognition

3. Sensory functioning

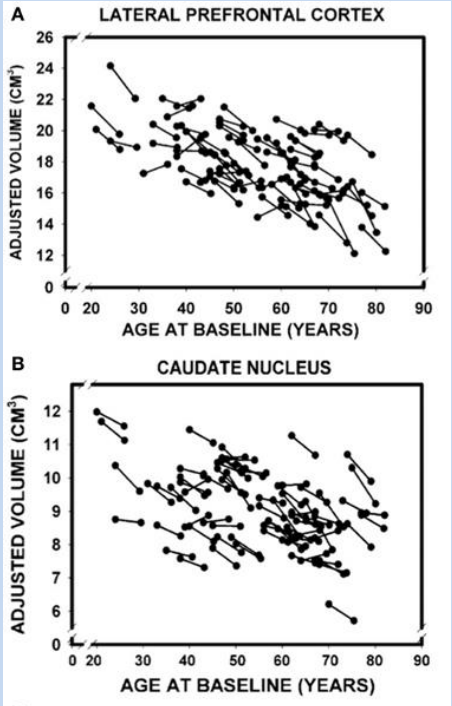
- Correlations between age-related effects on cognition and age-related effects in sensory functioning *(Lindenberger and Baltes, 1997)*
  - Not due to sensory limitations (simulated in younger adults with no decline in performance)
  - Correlation with lung capacity and grip strength – link to general biological fitness

Biological explanations

- Between 20 and 70 years of age, average loss of brain tissue - 250 grams
  - White matter loss
  - Neuronal death
  - Shrinking mass of neurons

- Frontal lobes: largest volume loss – longitudinal changes
- Temporal and parietal lobes – less affected
- Motor and sensory cortices relative unaffected

(Raz, 2000)



- Frontal cortex
  - Mental coordination
  - Cognitive control

- <u>Build-up of deposits</u>

  - **Neurofibrillary tangles** - loose protein segments that serve no purpose, but decrease efficiency of signal transmission

    Found in e.g. cytoplasm of cells in hippocampus

    Effects seen clearly in Alzheimer's patients

  - **Beta-amyloid plaques** – in interneuronal spaces – due to degeneration of local neural structures

- <u>Secretion/Absorption of neurotransmitters</u>
  - e.g. dopamine
  - Less efficient brain functioning

- <u>Compensation in older age?</u>
  - Reduction in brain asymmetry (e.g. language- left/ spatial abilities-right)

    (Cabeza, 2003)
  - Older adults utilise structures on both hemispheres

- Physical health
  - Serious impact of physical factors including
    - Brain damage, hypertension, cardiovascular disorders, thyroid disorders, stroke, medication and alcohol abuse, untreated diabetes

      (Anstey and Christiansen, 2000)
  - Increased prevalence during lifetime
  - Berlin Ageing Study – relation between cognitive performance and:
    - Stroke
    - Heart insufficiency
    - Diabetes
    - Myocardial heart infarction
    - Effect larger for **fluid** intelligence

Assembled cognition

Complex groupings of different psychological aspects of performance

- **Expertise**
  - Form of crystallised intelligence
  - Knowledge base acquired over lifetime
  - Positive impact on performance
  - Domain specific
    - e.g. chess – ability peaks at around 40 years – accumulation of knowledge of strategies etc.

- Research: comparison of novice/expert
  - Differences between younger/older novices and younger/older experts identical
  - Expertise lifts performance but does not stop decline

- Domain-specific expertise can have positive effects on related cognitive systems
  - e.g. Bridge players - larger working memory
  - University professors – age-related differences in memory performance, but memory for text stable

- Job performance
  - No relationship between age and job performance

    Possible explanations:
    - Increase in expertise compensates for decline in basic abilities
    - Many older workers in stable environment – familiar skills
    - Older workers – more detailed knowledge
    - Older workers often more team-oriented – give and receive advice

- Coping with cognitive limitations

  - Fitness training

  - Meta-analysis (18 studies 1966-2001) *(Colcombe and Kramer, 2003)*

    - Effects of cardiovascular fitness on cognition through training interventions
      - Control groups (flexibiliy/power) – 0.2 SD increase
      - Cardiovascular group – 0.5 SD increase

      - Argued that aerobic training can compensate for up to 15 of ageing

      - 'Aerobic training' participants – better on tests of attention (relevant tasks)
      - Correlate with brain scan results:

        Increased activation on frontal and parietal cortex

        Stronger suppression of activity in the posterior cortex

- <u>Cognitive training</u>
  - Importance of strategy use (e.g. memory strategies)
  - Meta-analysis (33 cognitive training studies) *(Verhaeghen et al, 1992)*
    - Memory training generally increased scores on a memory test by 0.7 SD (0.4 SD in control groups)

But

  - Training works better on younger adults than older adults (widening divide)
  - Effects are limited – specific to topic/method of training *(Ball et al, 2002 - The ACTIVE trial)*

- <u>Selective optimization with compensation</u>

- Baltes (1997)

- Selection - make choices
  (restrict goals/activities?)

- Optimization - refine existing means or apply newly encountered means
  (give something your full attentions and effort?)

- Compensation – find alternative ways to achieve goal
  (seek help/advice?)

Gerontechnology

- Technology for older people – a growing research area
- Whitney and Keith (2006) In UK
  - All ages: 63% used Internet in past 3 months
  - Over 65: only 20% had done this
- Charness (2008): age-related problems with using technology
  - Vision
  - Hearing
  - Motor ability
  - Cognition

- Ekberg (2002) 9,600 older people in EU
- **Digitally challenged** – no experience and no interest
- **Technologically open-minded** – non-user, but keen on learning about technology and/or wishing to gain computer skills
- **Old age beginners** – users with fewer computer skills using computers less than once a week
- **Experienced front-runners** – users with advanced computer skills using computers at least once a week
- Overall – 53% of over 70’s stated they were keen to learn about new technologies

- External factors include
  - Cultural contexts
    - expectation
  - Social contexts
    - e.g. technology previously used assistive technology (‘handicap’)
  - Financial factors
    - cost for older people of increasingly complex technology

Reading

Verhaeghen, P. (2011). Cognitive Processing and Ageing. In I. Stuart-Hamilton, *An Introduction to Gerontology.* Cambridge: Cambridge University Press

Woods, B. (2011). The Psychology of Atypical Ageing. In I. Stuart-Hamilton, *An Introduction to Gerontology.* Cambridge: Cambridge University Press

Seminar: Impact of memory decline in later life

Working in groups:

- Research/discuss
  - Memory factors – patterns of memory performance in later life
    - Explanations of memory decline
    - Link to attention (selective and divided attention)
    - Speed of cognitive processing