# The Framework for Understanding Effortful Listening (FUEL): Connecting hearing, cognition, motivation and social factors

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NSERC CRSNG

Pichora-Fuller, M.K. (2016). How social factors may modulate auditory and cognitive functioning during listening. *Ear and Hearing* (Special Issue on Eriksholm Workshop on "Hearing Impairment and Cognitive Energy"), 37 Supp. 1, 92-100S.

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# Disclosures (within 12 months)

- Positions
  - Professor, Psychology, University of Toronto
  - Adjunct Scientist, Toronto Rehabilitation Institute, University Health Network
  - Adjunct Scientist, Rotman Research Institute, Baycrest Health Sciences, Toronto
- Funding for Eriskholm Workshop from Oticon Foundation
- Research
  - Canadian Institutes of Health Research
  - Natural Sciences and Engineering Research Council of Canada
  - Alzheimer's Society of Canada and International
  - Swedish Research Councils
  - National Institutes of Health
  - Phonak/Sonova AG
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  - American Academy of Audiology
  - Canadian Academy of Audiology
  - Hearing International Society
  - Universities: James Madison, Brooklyn College, Montreal, Canterbury, Auckland, Radboud, Salamanca
  - Publishers: Nelson, Elsevier; LWW, Allyn & Bacon/Pearson

OTICON FONDEN

# Eriksholm Workshop V

## "Hearing Impairment and Cognitive Energy"

## June 3-5, 2015

"Cognitive Energy" ~ Titchener (1908) "Psychic Energy"

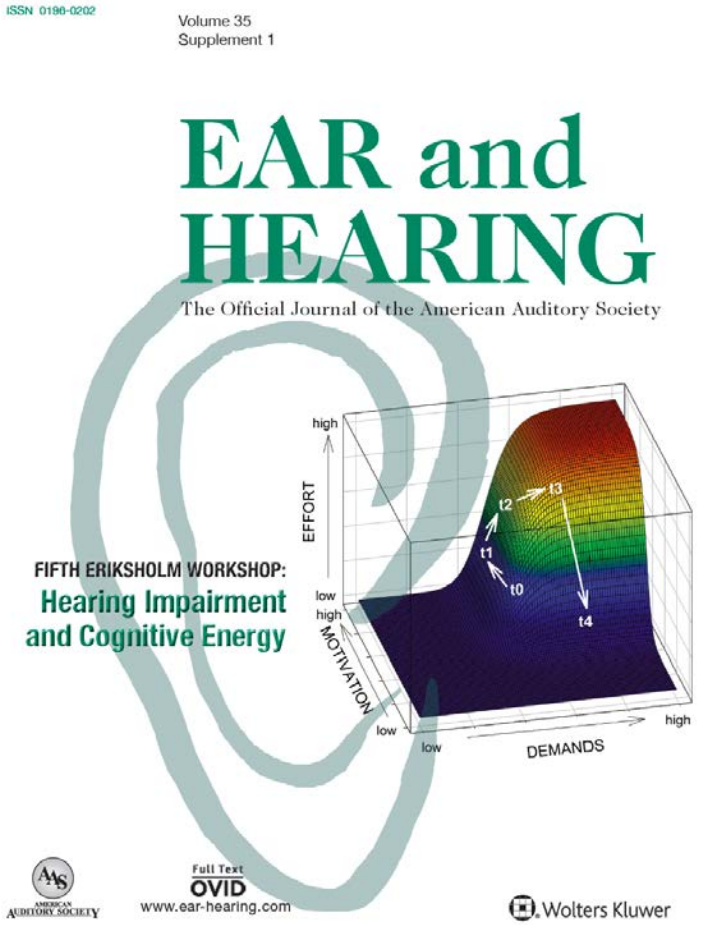
Consensus to address the following questions:

- What is known and what gaps exist in our knowledge? **"listening effort"**
- Can we reconcile the cognitive/behavioural and stress/physiological views?
- Do lab measures of "listening effort" reflect real-world life experiences?
- What is the potential for translation to clinical/engineering applications?

The workshop and consensus paper focused on three main areas:

1) theories, models, concepts, definitions, & frameworks
2) methods and measures
3) knowledge translation

# *FUEL Special Issue*




- July 2016 **FREE online**
  - Pichora-Fuller, MK, Kramer, S.E., et al. (2016).
    Hearing Impairment and Cognitive Energy:
    The Framework for Understanding Effortful Listening (FUEL),
    Ear and Hearing (Special Issue), 37 Supp., 5S-S27.
    zdoi; 10.1097/AUD.0000000000000312

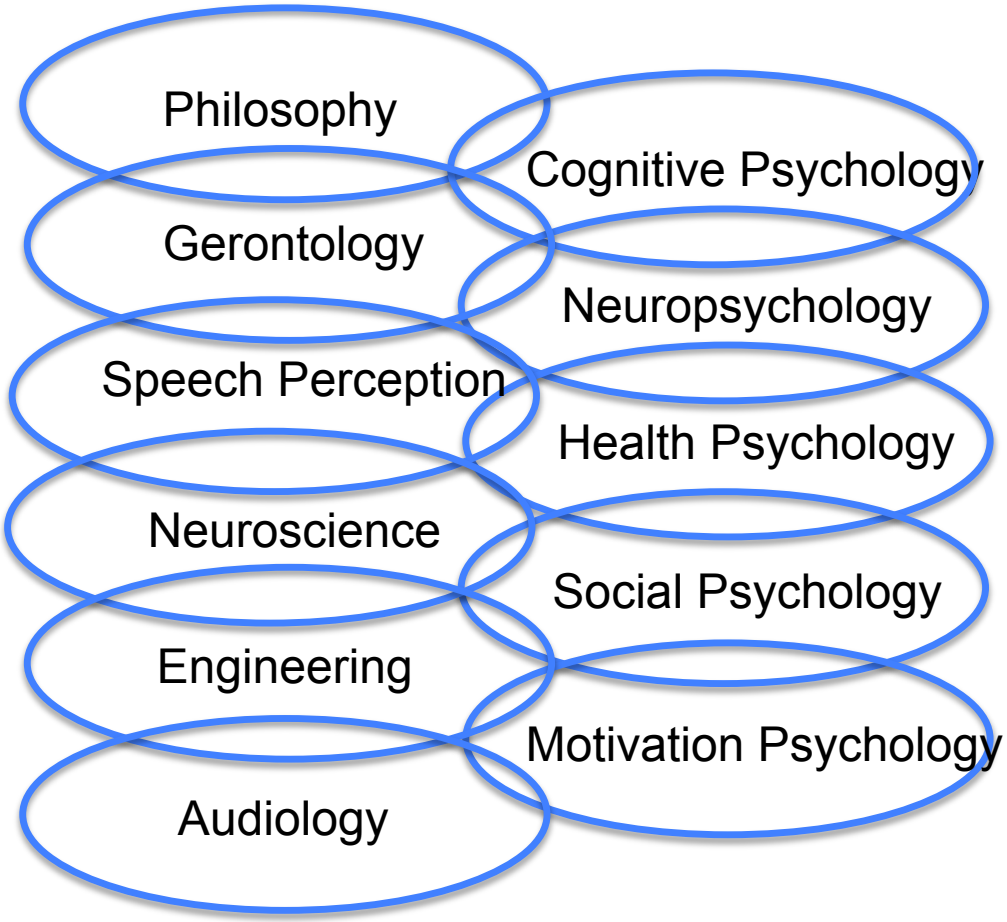
- Consensus plus 16 papers
  - Setting the stage
    - (3 papers: Matthen, Wingfield, Phillips)
  - Behavioural approaches and cognition
    - (6 papers: Humes, Sommer, Rudner, Lemke, Edwards, Pichora-Fuller)
  - Physiological approaches: motivation, stress, and fatigue
    - (6 papers: Eckert, Richter, Mackersie, Kramer, Hornsby/Naylor)
  - Knowledge translation
    - (2 papers: Lunner, Tremblay)

# Participants and Paper First Authors

- Mark Eckert
- Brent Edwards
- Ben Hornsby
- Larry Humes
- Sophia Kramer
- Ulrike Lemke
- Thomas Lunner
- Carol Mackersie
- Mohan Matthen
- Graham Naylor
- Natalie Phillips
- Kathy Pichora-Fuller
- Michael Richter
- Mary Rudner
- Mitchell Sommers
- Kelly Tremblay
- Arthur Wingfield

# International and Interdisciplinary

Canada, Denmark, Netherlands, Sweden, Switzerland, USA (UK)



McGarrigle, R., Munro, K. J., Dawes, P., et al. (2014). Listening effort and fatigue: What exactly are we measuring? A British Society of Audiology Cognition in Hearing Special Interest Group 'white paper'. *Int J Audiol, 53(7),* 433-440

**Table 1.** Listening effort studies published 2008–2013 (based on a 'web of knowledge' literature search using the topic 'listening eff the authors' outcome measure interpretation, and our interpretation.

| *Publication* | *Method used* | *Authors' outcome interpretation* |
|---|---|---|
| *Subjective measures* | | |
| Pichora-Fuller & Healey (2009) | Listening effort 9-point scale | Mental effort |
| Luts et al (2010) | Listening effort 13-point scale | Listening effort |
| Picou et al (2011) | Listening effort rating scale | Listening effort |
| Hornsby et al (2012) | Listening effort 9-point scale | Listening effort |
| McGarrigle et al (2012) | Listening effort continuum scale | Perceived listening effort |
| Nachtegaal & Eddie (2012) | Visual analogue scale effort scale | Listener effort |
| Rudner et al (2012) | Visual analogue scaling effort scale | Perceived effort |
| Van Esch et al (2013) | Listening effort 100-point scale | Listening effort |
| Nachtegaal et al (2009) | 11-point scale taken from a work assessment questionnaire | Need for recovery after work |
| *Behavioural measures* | | |
| Houben et al (2013) | RT during single-task digit triplets test | Listening effort |
| MacPherson & Akeroyd (2012) | The Glasgow monitoring of uninterrupted speech task (GMUST) | Speech intelligibility in noise |
| Sarampalis et al (2009) | Dual-task paradigm | Listening effort |
| Tun et al (2009) | Dual-task paradigm | Perceptual effort |
| Desjardins et al (2010) | Dual-task paradigm | Listening effort |
| Anderson Gosselin & Gagné (2011) | Dual-task paradigm | Listening effort |
| Fraser et al (2011) | Dual-task paradigm | Listening effort |
| Desjardins & Doherty (2013) | Dual-task paradigm | Listening effort |
| Hornsby (2013) | Dual-task paradigm: secondary task RT decline across task | Mental fatigue |
| *Physiological measures* | | |
| Piquado et al (2010) | Pupil response during digit/sentence recall task | Cognitive effort |
| Wild et al (2012) | Brain activation using fMRI during complex speech processing task | Effortful listening |
| Zekveld et al (2010) | Pupil response during SRT task | Processing load |
| Mackersie & Cones (2011) | SCR, skin temperature, electromyographic response and heart rate recordings during dichotic digits task | Listening effort |
| Obleser & Kotz (2011) | Amplitude of the N1 ERP component for processing of degraded speech | Resource allocation |
| Zekveld et al (2011) | Pupil response during SRT task | Cognitive load |
| Koelewijn et al (2012) | Pupil response during SRT task | Listening effort |
| Kramer et al (2012) | Pupil response during a series of auditory and linguistic processing tasks | Processing load |
| Obleser et al (2012) | EEG alpha power during digit memorization task | Cognitive effort |
| Bernarding et al (2013) | Phase-locking of the N1 ERP component during syllable detection paradigm | Listening effort |
| Kuchinsky et al (2013) | Pupil response during a word identification task with varying lexical and acoustic demands | Listening difficulty |

Subjective
Behavioural
Physiological

# Why put effort into effort?

- Patient experience…..
- Better rehabilitation for patients…..
- Better hearing accessibility in society….

# Definition of (Listening) Effort

We defined ***effort*** as

*the deliberate allocation of mental resources to overcome obstacles in goal pursuit when carrying out a task*,

with

***listening effort*** *applying more specifically when tasks involve listening*.

....Not only speech understanding (scene analysis, alarms, music, emotion...)

# Kahneman, 1973 *Attention and Effort*



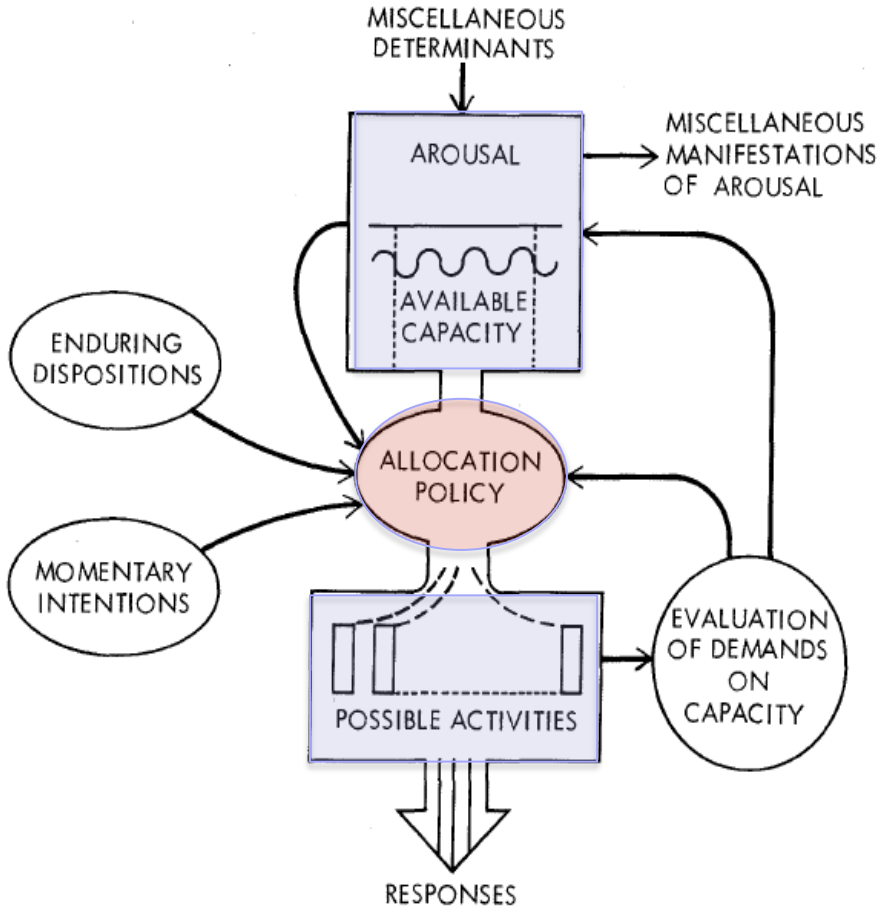
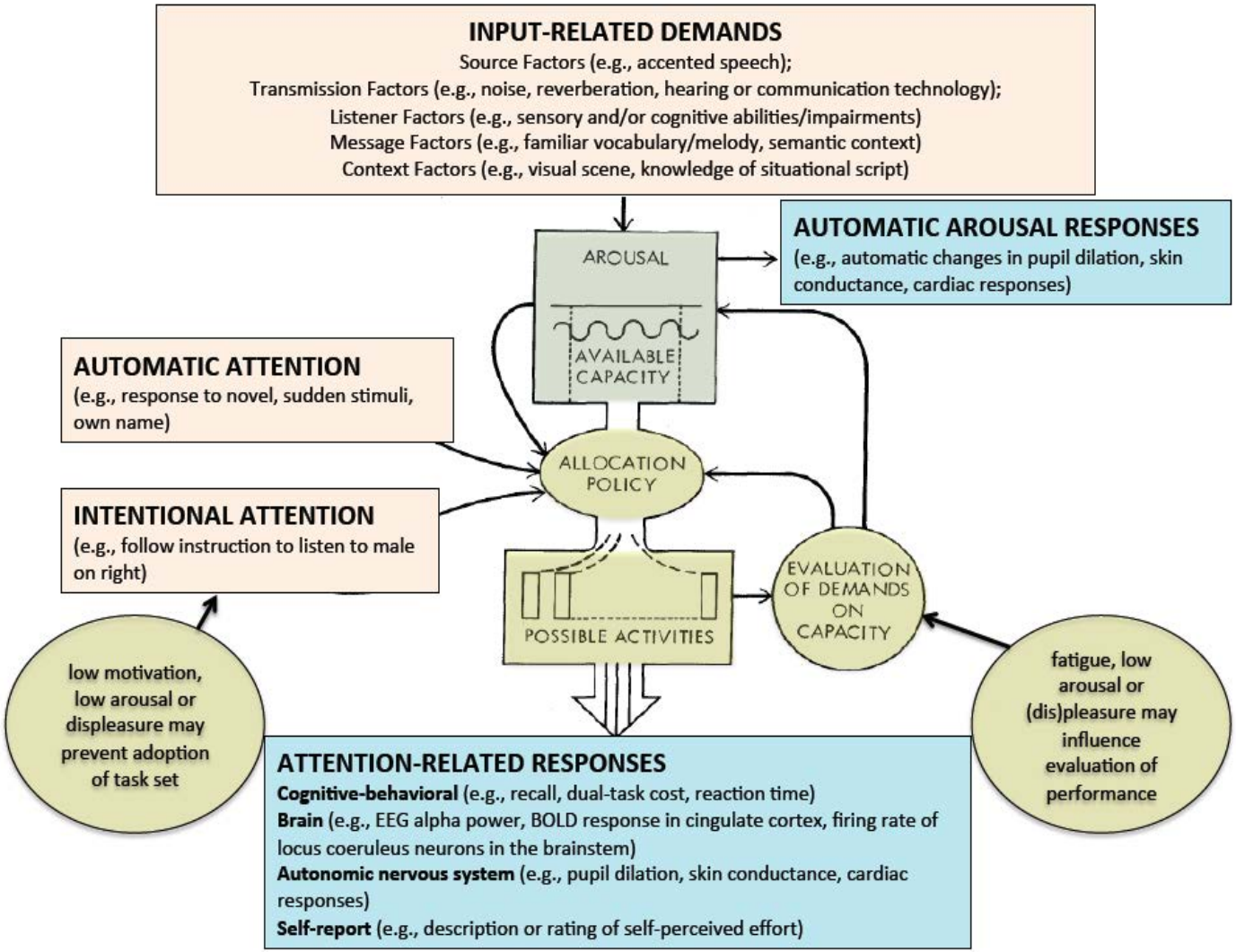



**FIGURE 1-2**
A capacity model for attention.

# FUEL: Framework for Understanding Effortful Listening





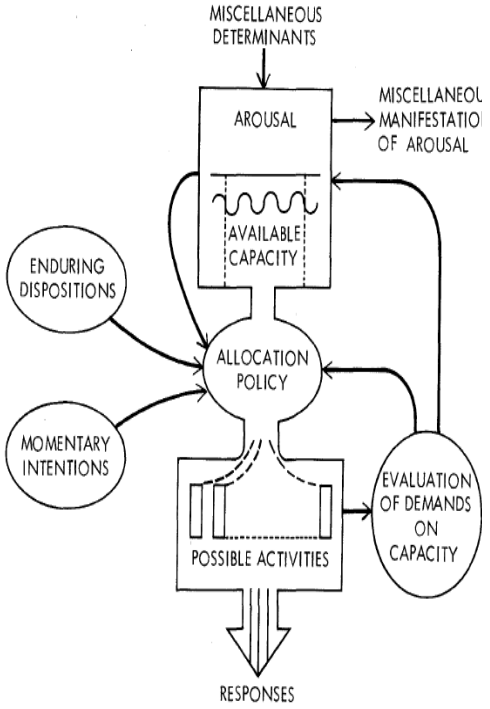




FIGURE 1-2
A capacity model for attention.

# Capacity Supplied x Capacity Demanded (Kahneman, 1973)

EFFORT

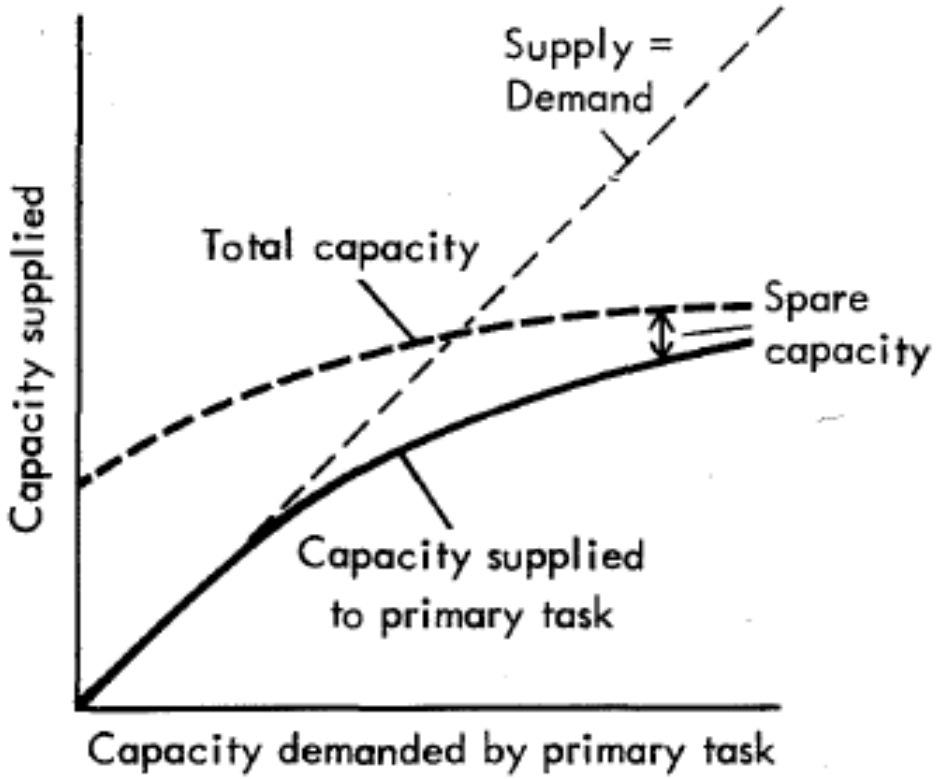
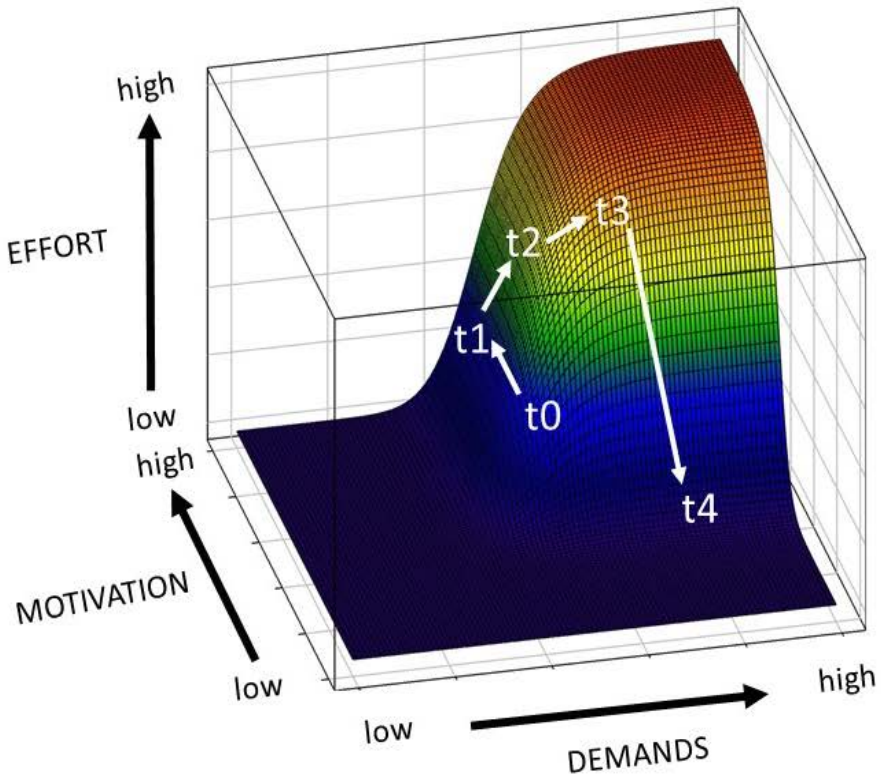



**FIGURE 2-1**
Supply of effort as a function of demands of a primary task.

# 3D: Effort ~ Demands and Motivation





T0 -T1: demand constant, increasing motivation; e.g., noise level is constant but the topic of conversation becomes a highly interesting story;

T1-T2-T3: motivation constant, increasing demand, resulting in increased effort; e.g., story continues to be highly interesting but noise increases as more people arrive at the party;

T3-T4: demand constant, motivation drops, resulting in decreased effort; e.g., noise remains steady but the highly interesting story finishes and the conversation becomes less interesting.

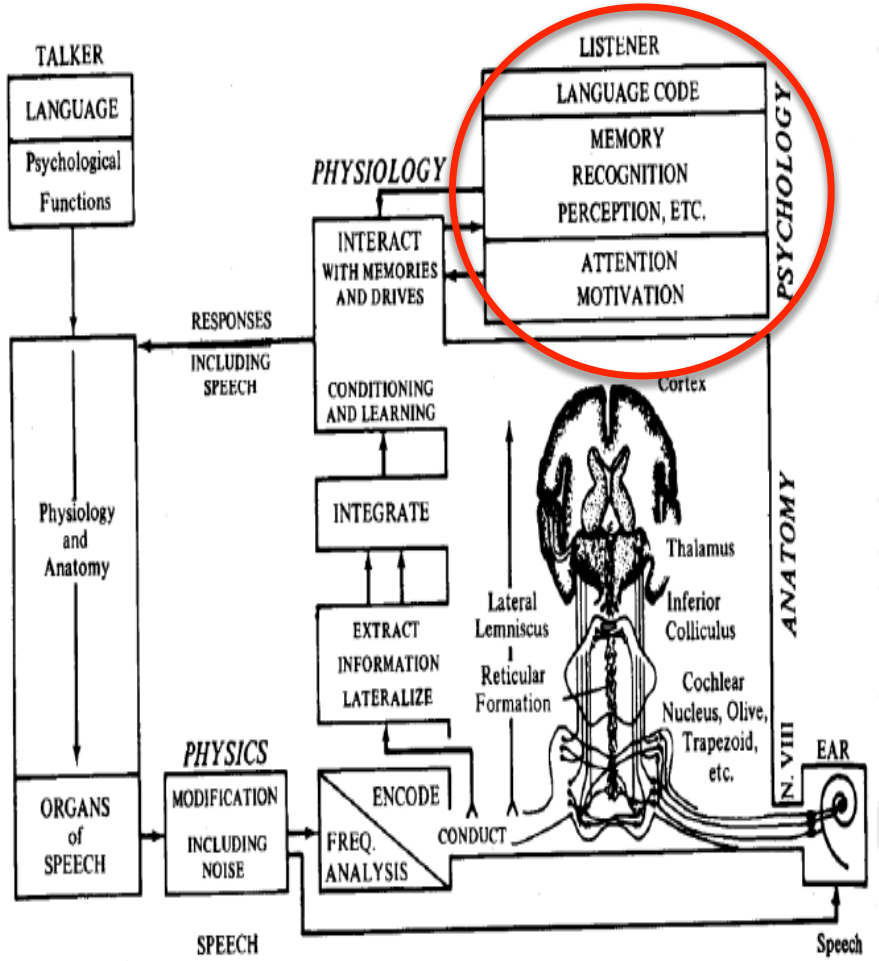
Over the course of an activity,

Demand ~ level of background noise

Motivation ~ person's evaluation of the importance of success in performing the activity.

# Psychology ~ Speech Communication

## Language, Perception, Memory, Attention, Motivation




"*The psychological processes (at the top) are not assigned to any particular level, but in general they require the participation of the cerebral cortex*."

H. Davis, 1964.

1970 edition of the audiology textbook *Hearing and Deafness*

We hear with our ears,
we listen with our brain….

*and **when and how much effort** we expend during listening in everyday life depends on our **motivation** to achieve goals and attain rewards of personal or social value.*

Effort could yield pleasure (Matthen)

# From the words of a person who is hard of hearing to FUEL….

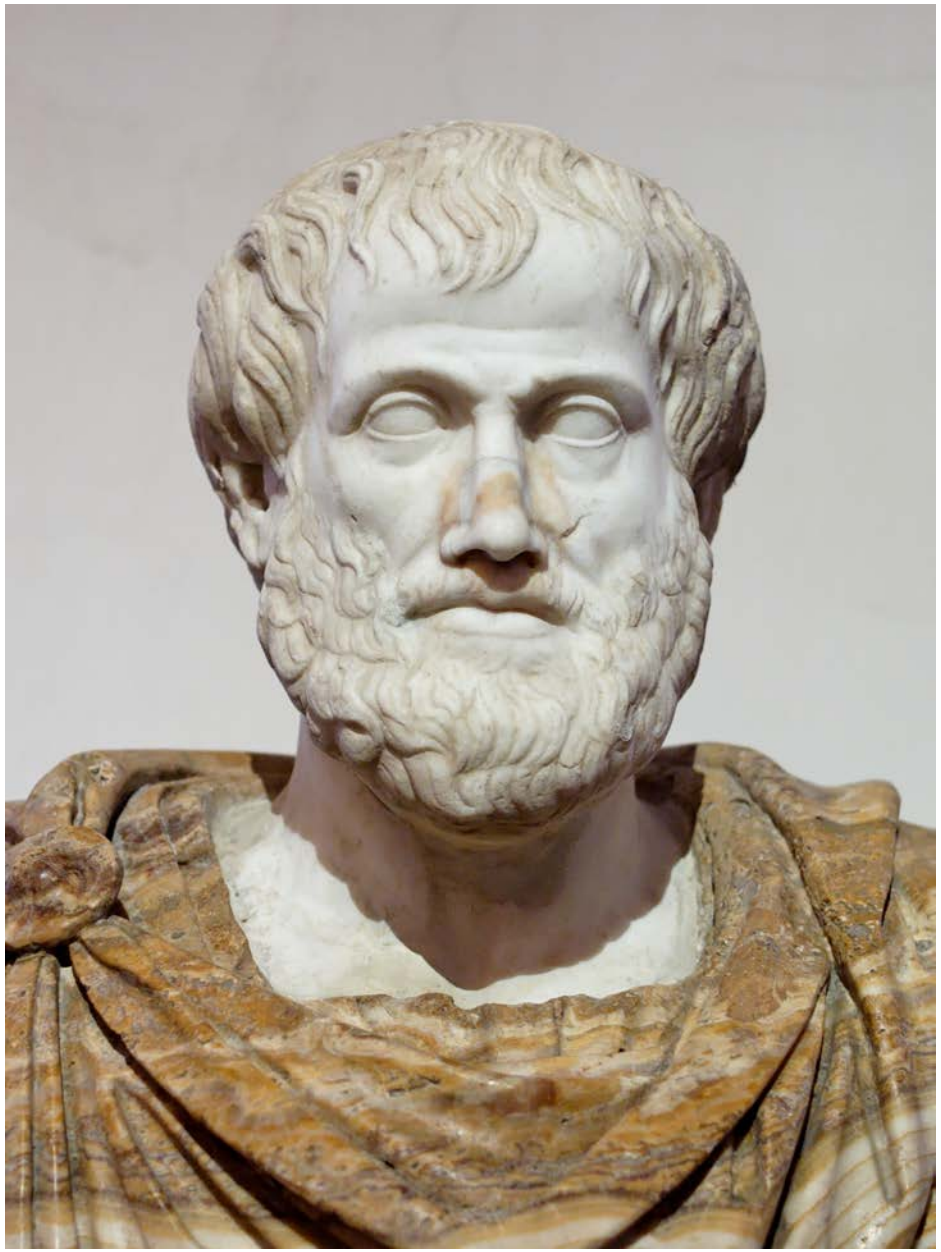
"*When you are hard of hearing you struggle to hear;*
*When you struggle to hear you get tired;*
*When you get tired you get frustrated;*
*When you get frustrated you get bored;*
*When you get bored you quit.*
-- *I didn't quit today*."

Difficulty hearing can
increase demand on cognitive processing resources and
increase emotional and physiological stress such that
individuals may avoid by withdrawal from social interaction….
unless the individual has motivation not to quit!

# Health is…


"*…the capacity of people to adapt to, respond to, or control life's challenges and changes.*"

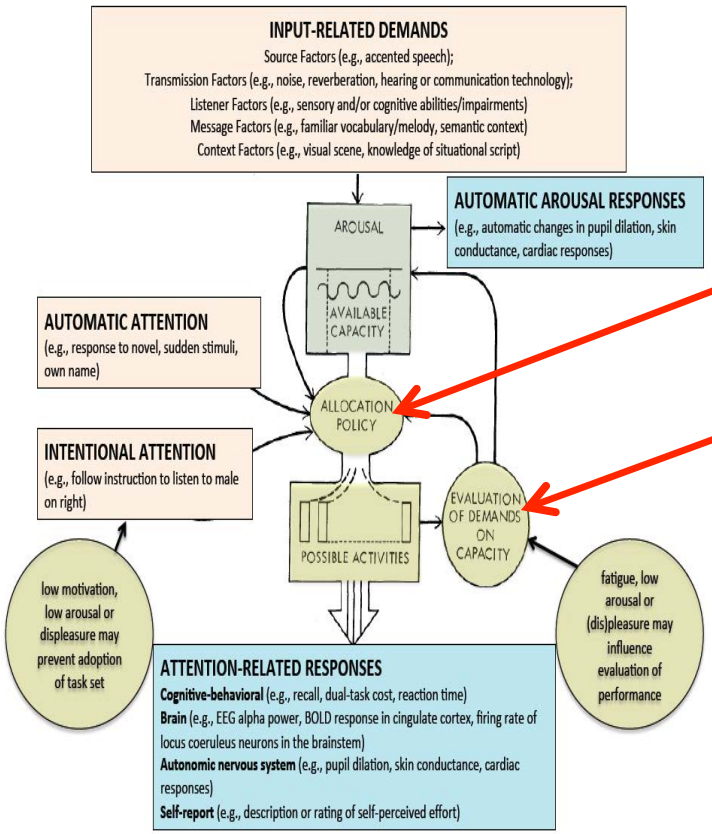
(Frankish et al., 1997)

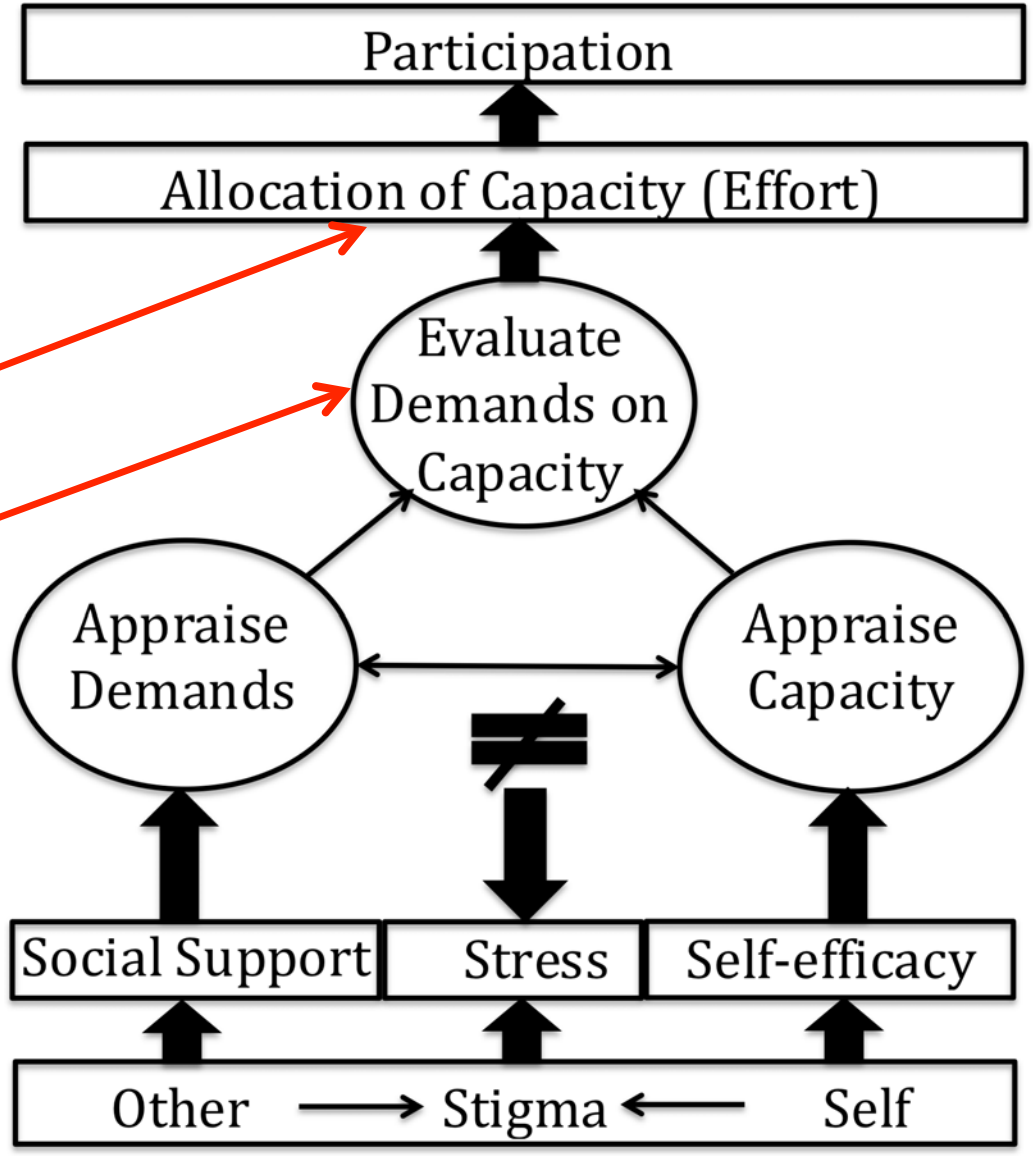


"*Man is by nature a social animal*."
Aristotle,384-382 BC

# Eriksholm Workshop Paper

(Pichora-Fuller, 2016)



# Capacity Supplied x Capacity Demanded (Kahneman, 1973)

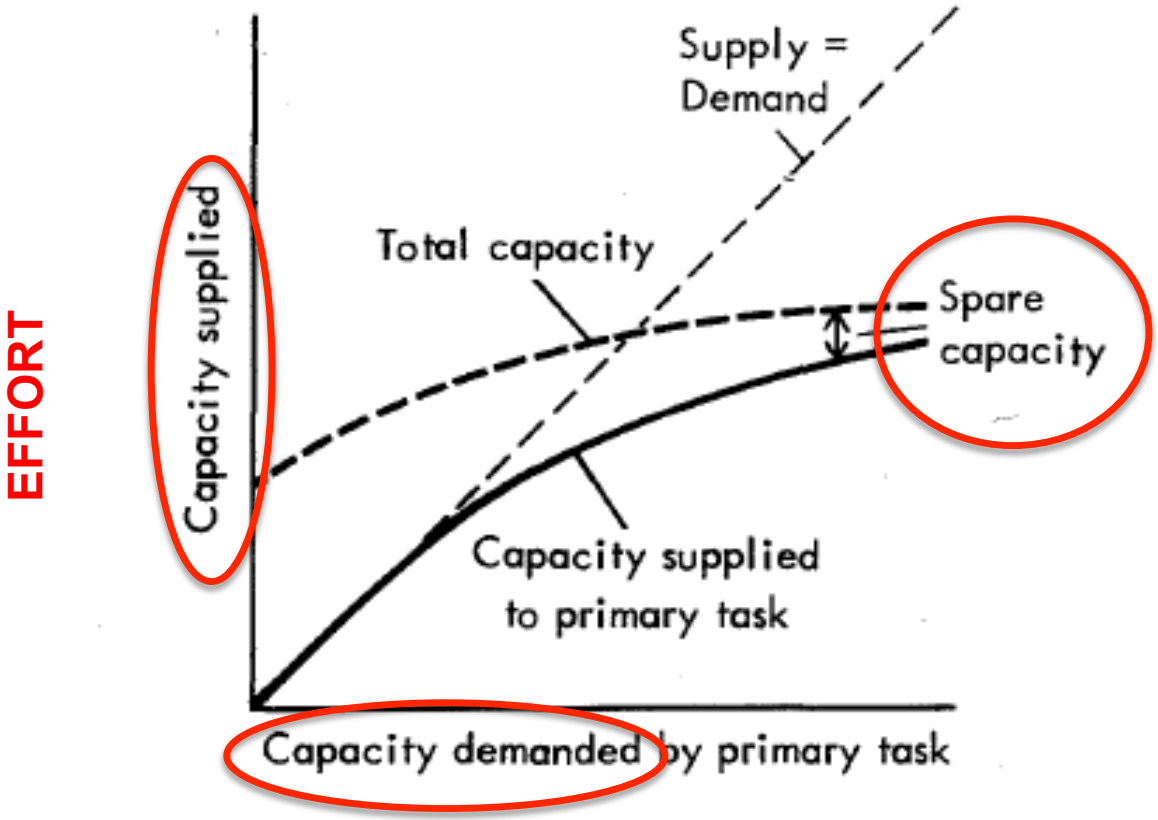
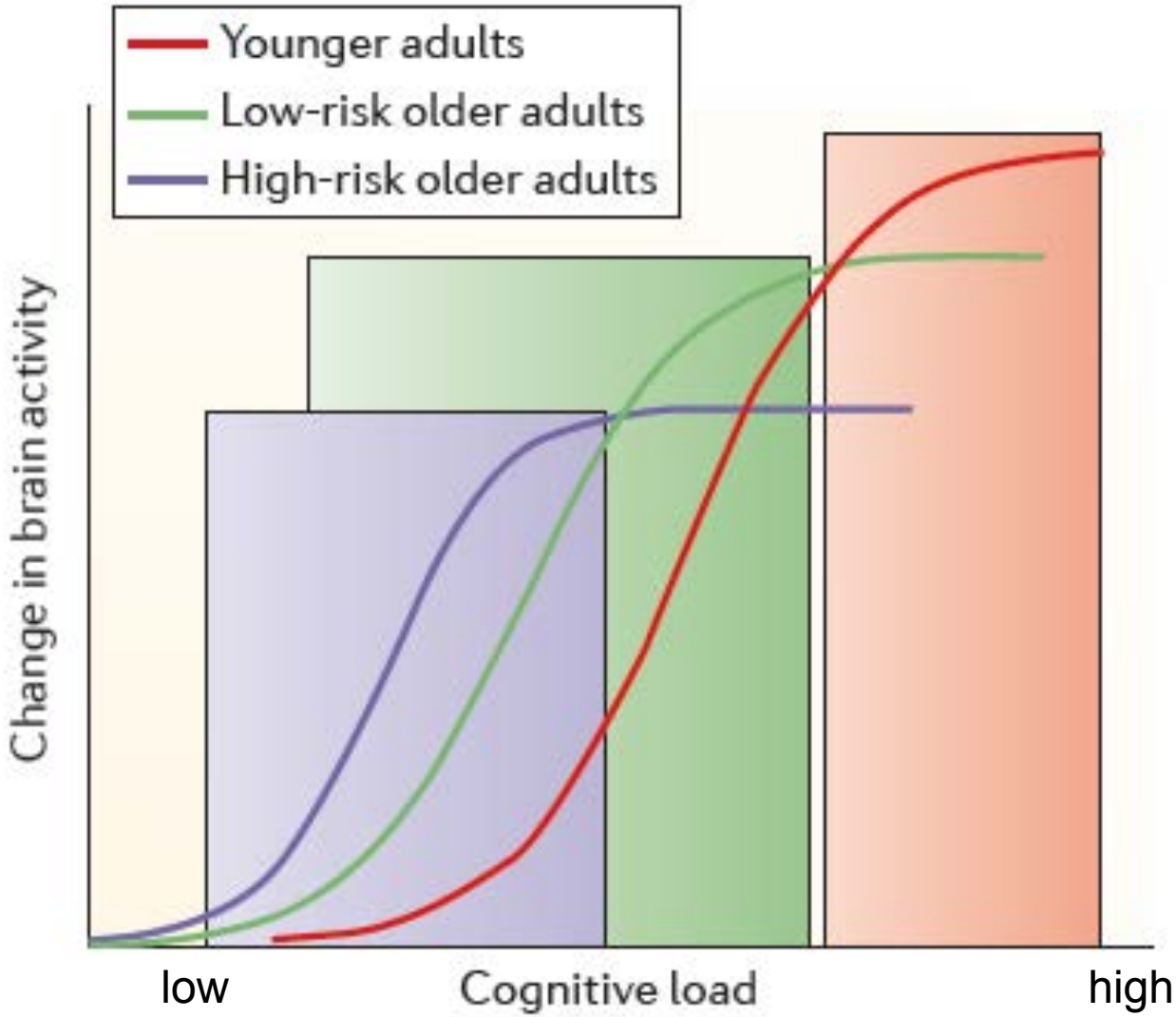



**FIGURE 2-1**
Supply of effort as a function of demands of a primary task.

# Compensation

(Grady, 2012, *Nature Reviews Neuroscience, 13*, 491-505)

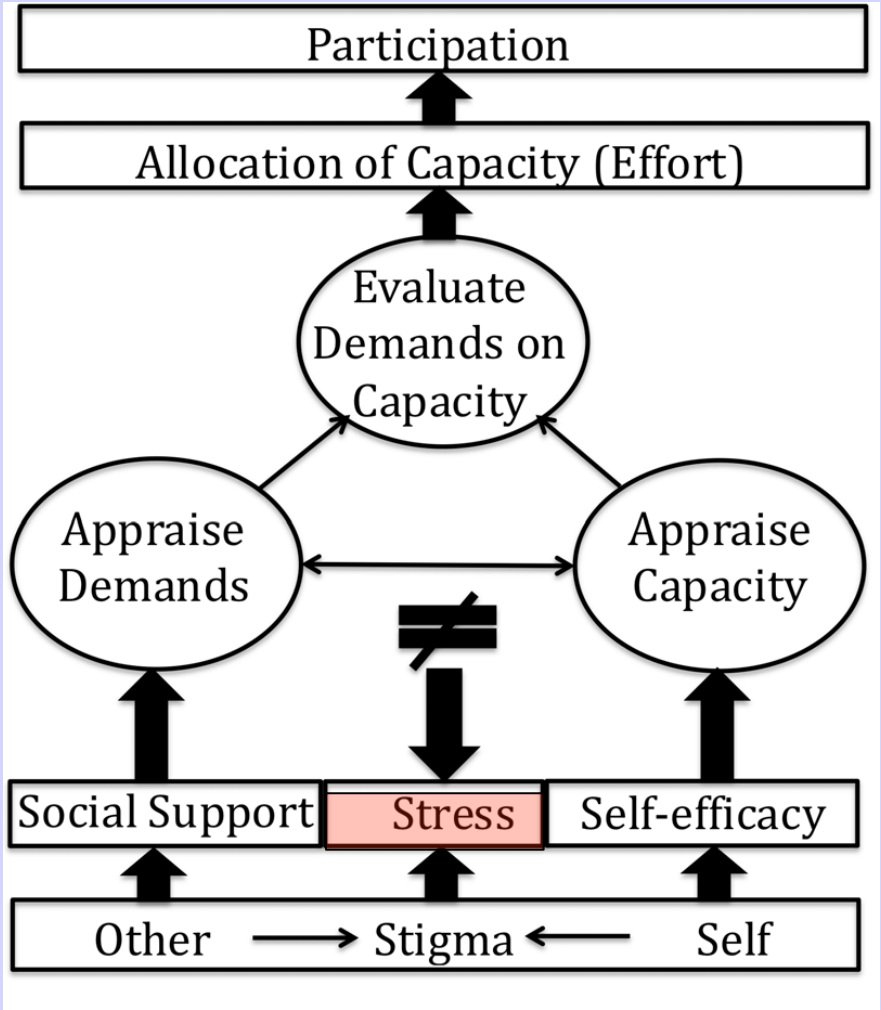


# Implications for Rehabilitation

- Evaluation of demands on capacity – cost
  - HOW to reduce demands
  - HOW to increase capacity
- Evaluation of success importance – benefit
  - WHEN to quit
  - WHEN to persist
- Stress ~ balance of demands given capacity – cost/benefit evaluation

# Social Psychological Factors

- Stress
- Stigma (self & other)
- Self-efficacy
- Social Support



# Coping with STRESS

- People respond differently to stress
  - Imbalance in person-environment fit

- The impact of any potentially stress event is greatly influenced by how a person appraises it (Lazarus & Folkman, 1984)
  - **Primary Appraisal**: Is the event harmful, threatening, or challenging?
  - **Secondary Appraisal**: What are my coping resources? Are they adequate?
  - **Reappraisal** – changes in the situation may change the appraisal
- Coping is the process of trying to manage demands that are appraised as taxing or exceeding one's resources
- As vulnerability (lack of coping) increases,
  it takes less stress to trigger illness…

# Competence and Environmental Press

- **Competence** is the theoretical upper limit of a person's capacity to function
- **Environments** can be classified on the basis of the varying demands they place on the person, a notion called "environmental press"
- Competence x environmental press ~ (mal)adaptive behavior and affect
- Adaptation level: balance competence & press

# Life Cycle Model of Stress

Lupien et al., (2009). *Nature, 10*, 434- 445.

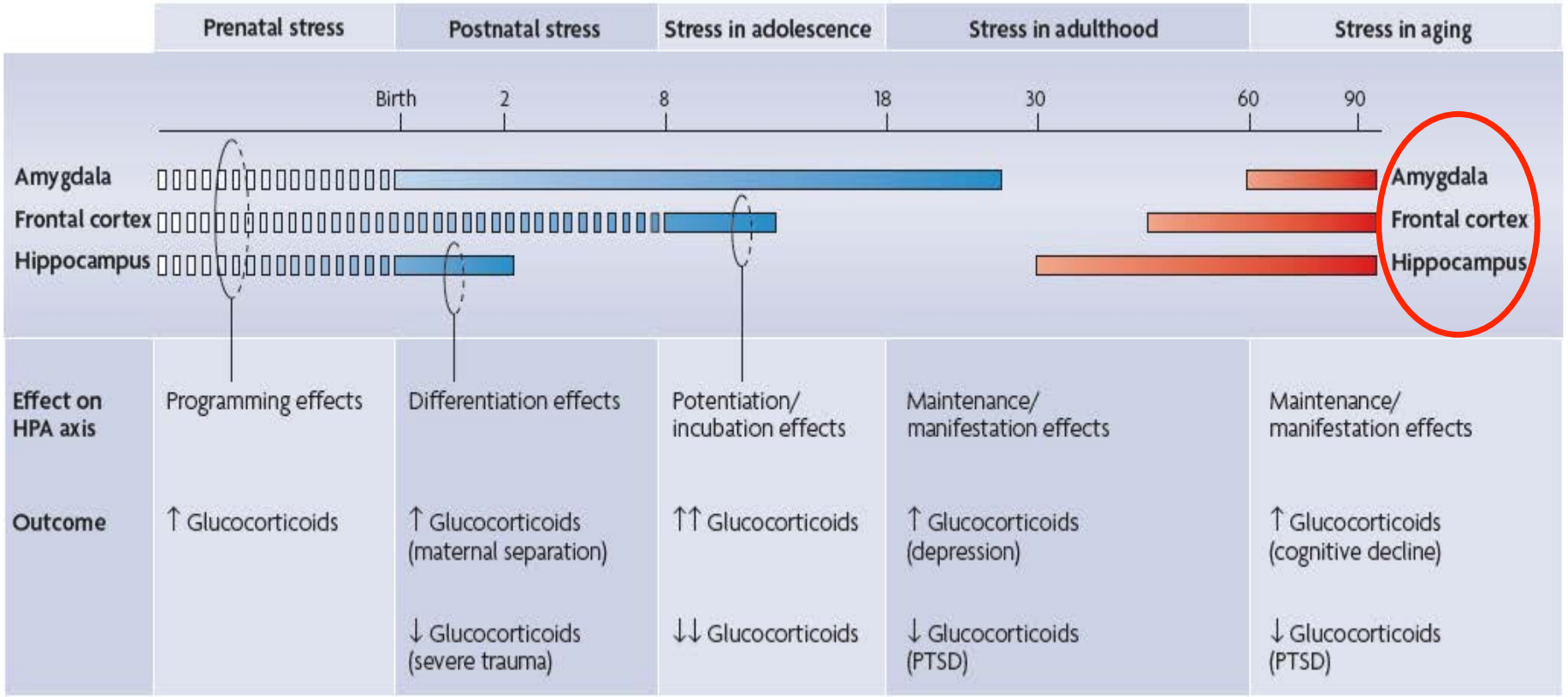
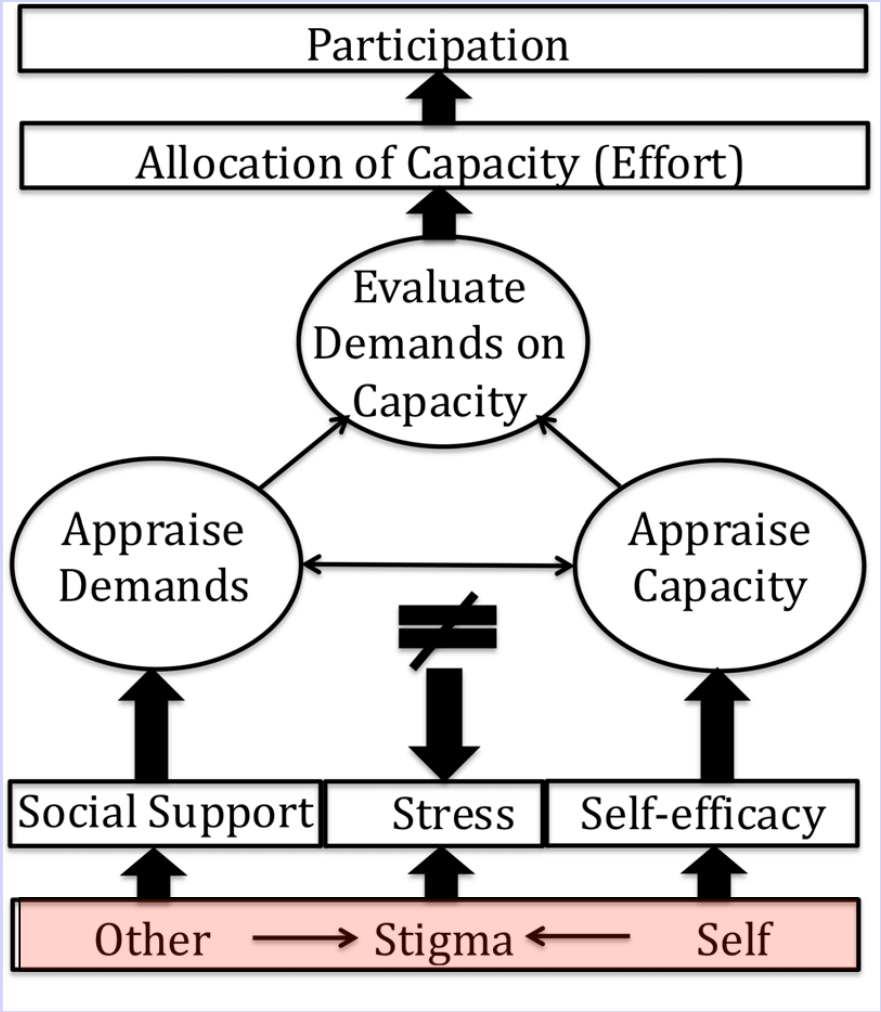



Figure 2 | **The life cycle model of stress.** How the effects of chronic or repeated exposure to stress (or a single exposure to severe stress) at different stages in life depend on the brain areas that are developing or declining at the time of the exposure. Stress in the prenatal period affects the development of many of the brain regions that are involved in regulating the hypothalamus-pituitary-adrenal (HPA) axis — that is, the hippocampus, the frontal cortex and the amygdala (programming effects)….. In adulthood and during aging the brain regions that undergo the most rapid decline as a result of aging (red bars) are highly vulnerable to the effects of stress hormones. Stress during these periods can lead to the manifestation of incubated effects of early adversity on the brain (manifestation effects) or to maintenance of chronic effects of stress (maintenance effects). PTSD, post-traumatic stress disorder.

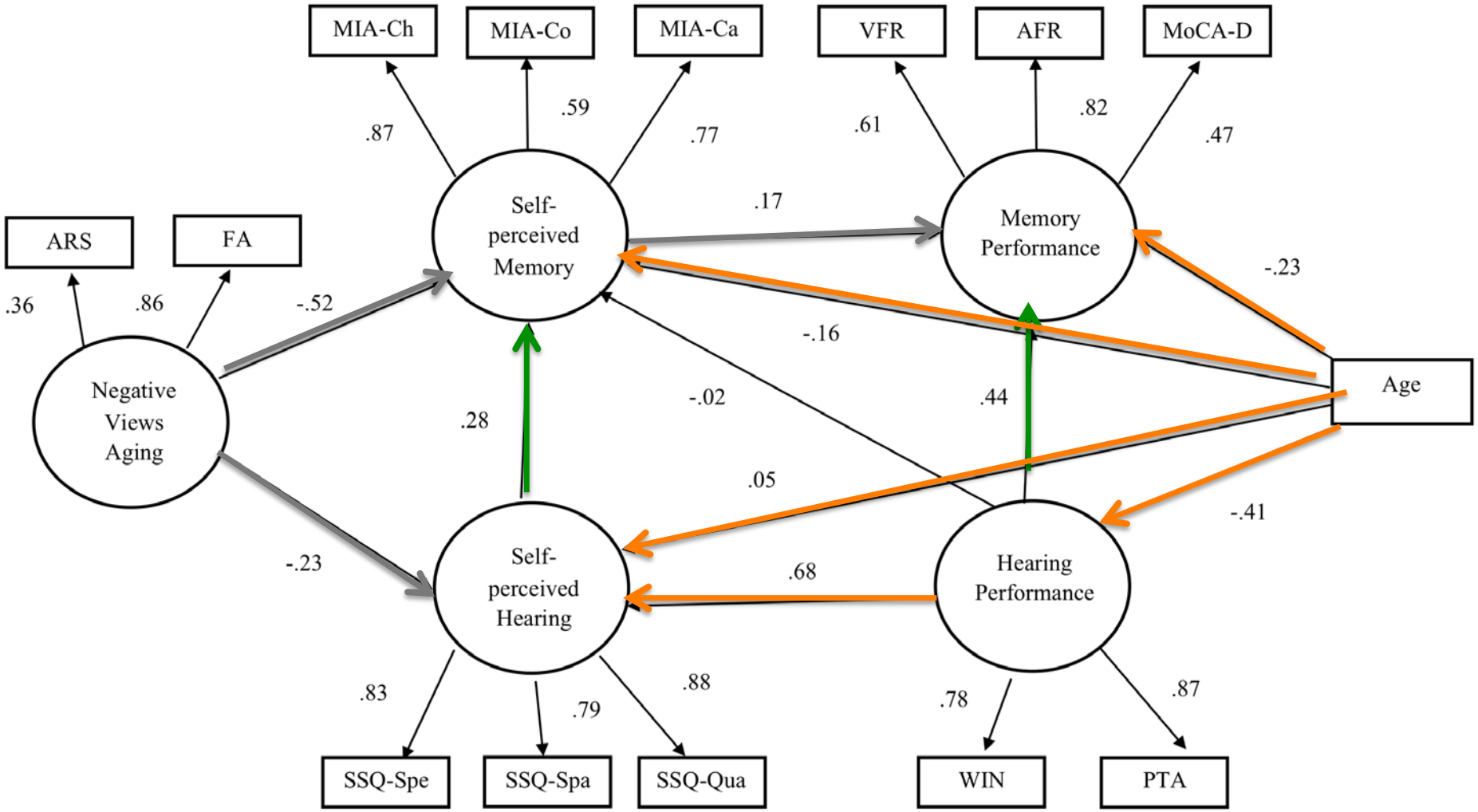
# Social Psychological Factors

- Stress
- Stigma (self & other)
- Self-efficacy
- Social Support

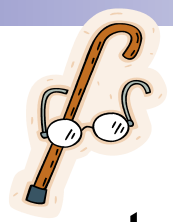
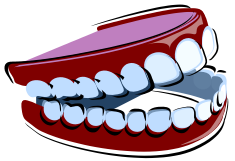


# Negative Views of Aging, Self-perceptions and Memory and Hearing Performance

Chasteen, Pichora-Fuller, Dupuis, Singh, & Smith, *Psychology & Aging,* 2015



# Stereotype Threat


- Risk of confirming a negative stereotype of a group with which one identifies
  - Self or other stereotype
    (Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review, 115,* 336-356.)
  - Reduced walking speed
    (Bargh, J.A., Chen, M., & Burrows, L. (1996). The automaticity of social behaviour: Direct effects of trait concept and stereotype activation on action. *Journal of Personality and Social Psychology, 71*, 230-244.)
  - Working memory
    (Hess, T.M., Hinson, J.T., & Hodges, E.A. (2009). Moderators of and mechanisms underlying stereotype threat effects on older adults' memory performance. *Experimental Aging Research*, *35*, 153-177.)
  - Hearing thresholds
    (Levy, B. R., Slade, M. D., & Gill, T. (2006). Hearing decline predicted by elders' age stereotypes. *Journal of Gerontology B-Psychological Sciences*, *61*, 82-87.)

# Attitudes, Stereotypes, and Ageism

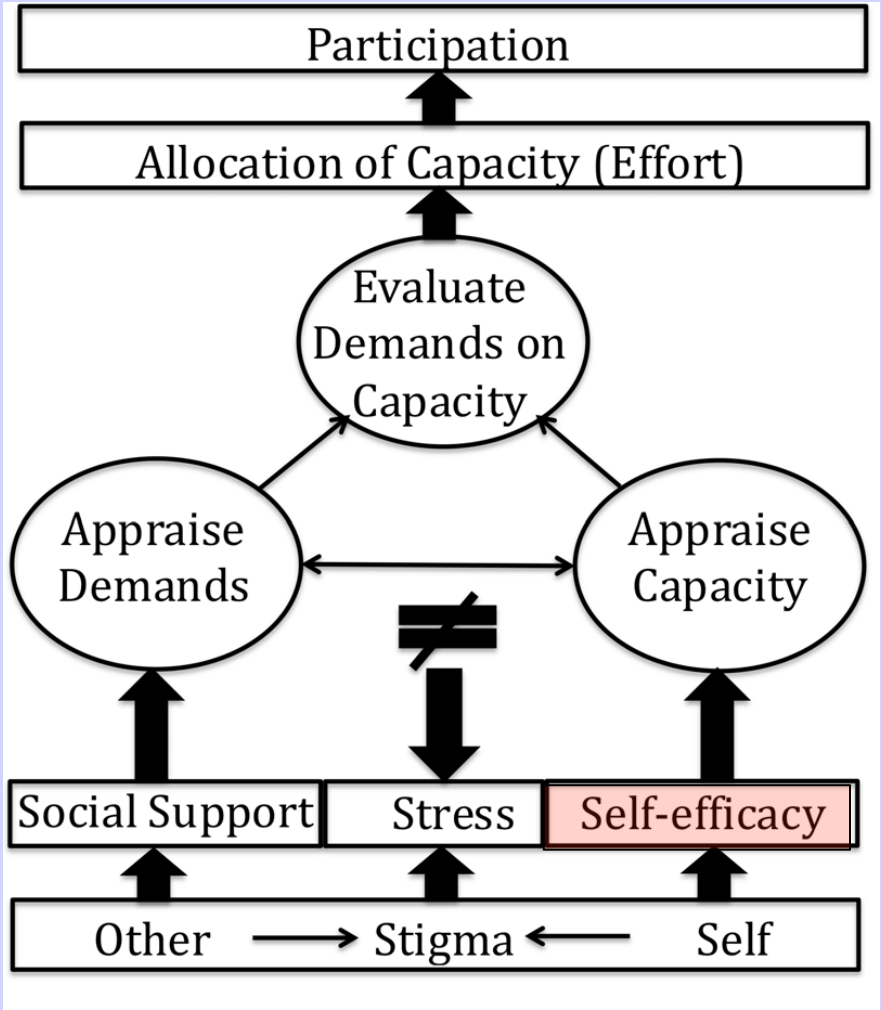
- Attitudes in general population are more negative re: older than younger adults
- Negative stereotypes are destructive for longevity and self-perception

BUT

- **Elderly, 50+ years, with positive self-perception live 7.5 years longer**
- Positive attitudes correlated with less frailty
- Self-efficacy facilitates coping

# Social Psychological Factors

- Stress
- Stigma (self & other)
- Self-efficacy
- Social Support



# Self-Efficacy Theory

- Self-Efficacy
  - Belief individuals have in their abilities to accomplish skills to achieve a certain behavior, including health behaviors (Bandura,1989, 1997)

- Patients with high self-efficacy beliefs for skills needed to manage a health condition:
  - Increased compliance with treatment/management recommendations
  - Improved subjective and objective outcomes
  - Higher health-related quality of life
  - Persevere in face of difficulty
  - Put forth greater effort in managing condition

# Self-efficacy in Audiology

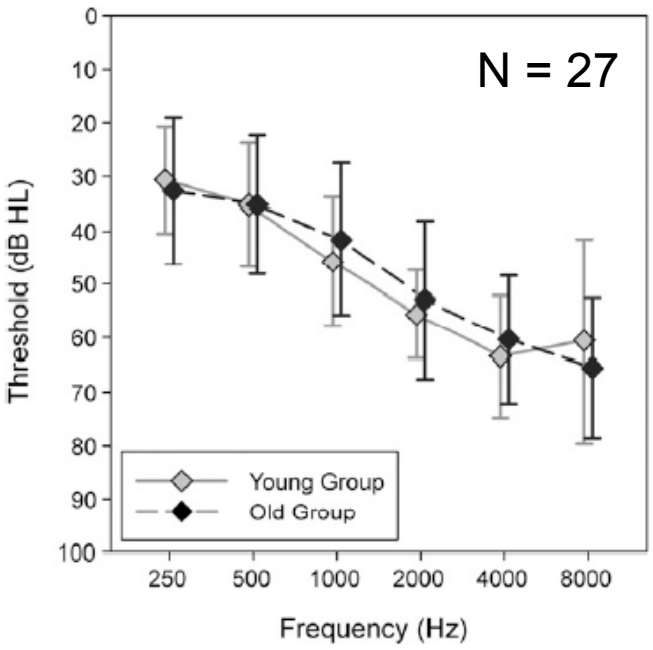
- Smith, S.L. & West, R.L. (2006a). The application of self-efficacy principles to audiologic rehabilitation: a tutorial. *American Journal of Audiology*, *15*, 46-56.
- Smith, S. L. & West, R. L. (2006b). Hearing aid self-efficacy of new and experienced hearing aid users. *Seminars in Hearing*, *27*, 325-329.
- Smith, S. L., Pichora-Fuller, M.K., Watts, K. L., & La More, C. (online April 2011). Development of the Listening Self-Efficacy Questionnaire (LSEQ). *International Journal of Audiology.*

J Am Acad Audiol 23:697–711 (2012)

# Do Older Adults Have Social Lifestyles That Place Fewer Demands on Hearing?

DOI: 10.3766/jaaa.23.9.4

Yu-Hsiang Wu*
Ruth A. Bentler*




*"The data are consistent with the hypothesis that older adults have less active social lifestyles that place fewer demands on hearing"*

*"Social lifestyle, rather than age, is likely a better predictor of listening demand"*

# SOC Model (Baltes)

- How to optimize an overall sense of competence
  - Apply three key adaptive mechanisms for aging
    - **Selection**
      - Select subset of options to focus resources on
    - **Optimization**
      - Find best way to achieve goal (e.g., improve by practice)
    - **Compensation**
      - Use alternative route to find solution
  - The SOC model
  - http://www.margret-baltes-stiftung.de/PBB-Website/SOC.html

# Social Psychological Factors

- Stress
- Stigma (self & other)
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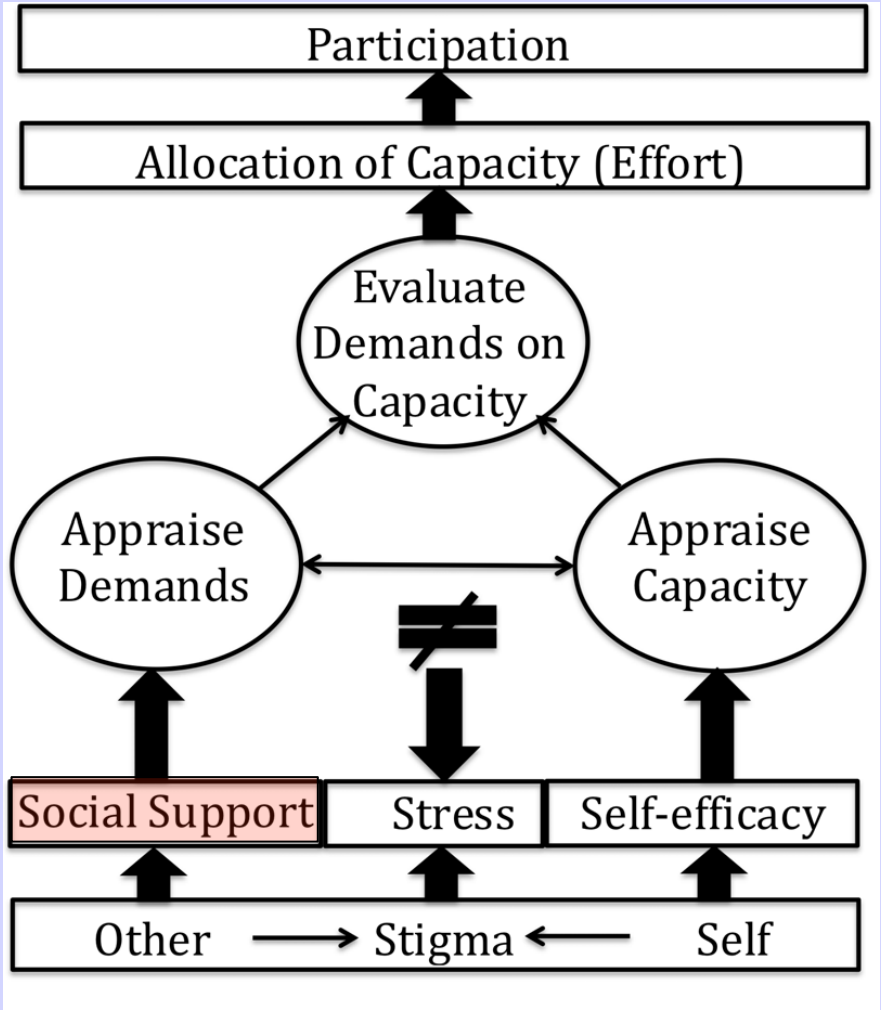


# Social Support

**Definition:** The perception and actuality that one is cared for, has assistance available from other people, and that one is part of a supportive social network.

Typically categorized into 4 kinds of acts:

- **Emotional** support (empathy, love, trust)
- **Instrumental** support (tangible aid, money, service)
- **Informational** support (advice, suggestions, information)
- **Appraisal** support (constructive feedback, affirmation)

## Social Support and Hearing Aid Satisfaction

Singh, G., Lau, S.-T., & Pichora-Fuller, M.K. (2015). Social support predicts hearing aid satisfaction. Ear and Hearing.

Research questions:

1. Is there a significant correlation b/t social support and hearing aid satisfaction?
2. How does social support compare with other known correlates of hearing aid satisfaction?

Methods: Distributed questionnaires (SADL, APHAB, HHIA, HRQoL, NEO, HA use) to users of hearing instruments

- Study 1: 173 adults (mean age = 68.9 years, SD = 13.4)
- Study 2: 169 adults (mean age = 32.0 years, SD = 13.1)

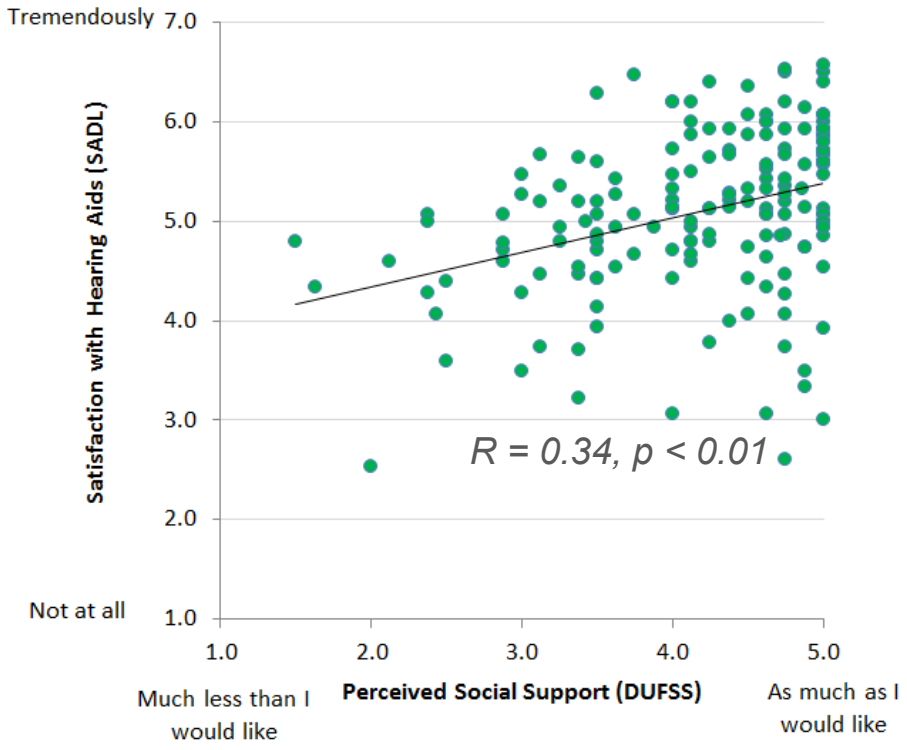
# Duke–UNC Functional Social Support Questionnaire (FSSQ)

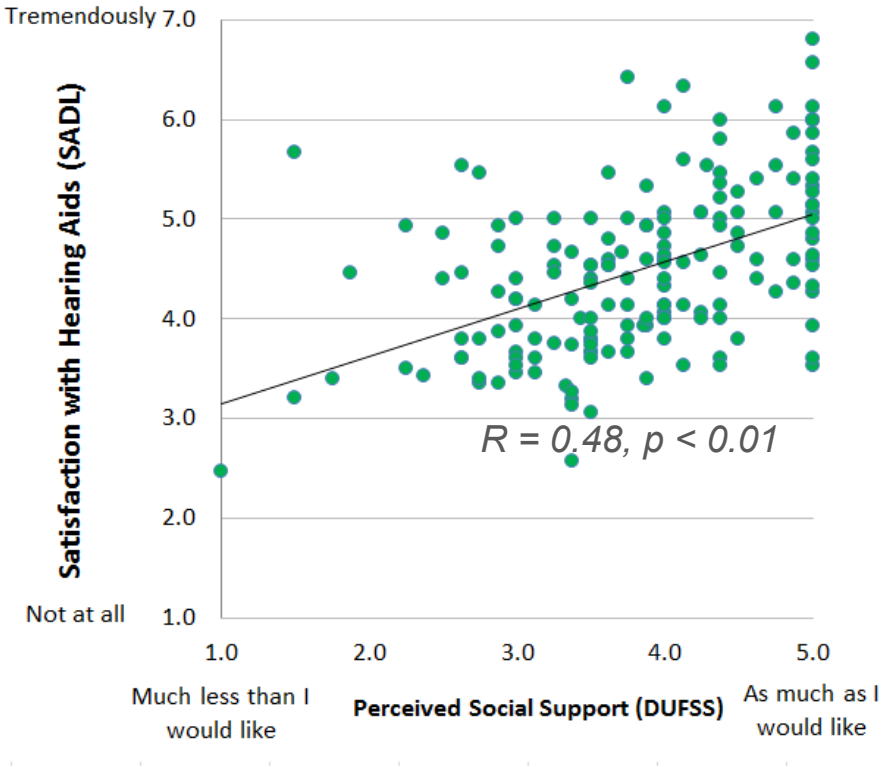
Here is a list of some things that other people do for us or give us that may be helpful or supportive. Please read each statement carefully and place an 'X' in the column that is closest to your situation. Give only 1 answer per row.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Much less than I would like | Less than I would like | Some, but would like more | Almost as much as I would like | As much as I would like |
| 1. I have people who care what happens to me. | | | | | |
| 2. I get love and affection. | | | | | |
| 3. I get chances to talk to someone about problems at work or with my housework. | | | | | |
| 4. I get chances to talk to someone I trust about my personal or family problems. | | | | | |
| 5. I get chances to talk about money matters. | | | | | |
| 6. I get invitations to go out and do things with other people. | | | | | |
| 7. I get useful advice about important things in life. | | | | | |
| 8. I get help when I am sick in bed. | | | | | |

Source: adulteducation.com

# Perceived social support is the strongest correlate of hearing aid satisfaction – two different samples



# Social Support in Audiology

**Significant others can potentially:**

- Encourage help seeking
- Advocate for (or against) the adoption of hearing aids
- Assist with the care and operation of hearing aids
- Boost/reinforce motivation during rehab
- Facilitate communication
- Increase treatment adherence
- Reduce hearing handicap by participating in AR classes
- Decrease hearing-related psychological distress
- Foster hearing aid satisfaction

# Canadian Longitudinal Study of Aging (n > 20,000)

Mick, Parfyonov, Wittich, Phillips, Guthrie, & Pichora-Fuller *(in press). Canadian Family Physician.*

*At the party, but sitting in the corner*

*Stayed home*

| | **Hearing loss** | **Vision loss** | **Dual loss** |
|---|---|---|---|
| Low social network diversity | | **X** (men) | **X** (age 65-85) |
| Low social participation | | **X** | **X** (age 65-85) |
| Low availability of social support | **X** | **X** | **X** |
| Loneliness | **X** | **X** | **X** |


Health states associated with being isolated:
1. Early mortality
2. Cognitive impairment
3. Cardiovascular disease
4. Depression
5. Physical decline
Sources: House *et al* Am J Epidemiol 198
Green *et al* Int J Geriatr 2008,
Oxman *et al* Am J Epidemiol 1992,
Strogatz *et al* 1986

Original Paper

Audiology 1993;32:363–381

# The Impact of Acquired Hearing Impairment on Intimate Relationships: Implications for Rehabilitation

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- Effort and fatigue
- Stress and anxiety
- Social life restrictions
- Impact on intimate communication

Singh et al., Hearing Review, March-April 2016

*Journal of Gerontology: SOCIAL SCIENCES*
2004, Vol. 59B, No. 3, S190–S196



# Impact of Self-Assessed Hearing Loss on a Spouse: A Longitudinal Analysis of Couples

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| | Models Adjusting for Gender | |
|---|---|---|
| | Partners' Outcomes Associated With Spouses' Hearing Loss | |
| Outcomes | OR | 95% CI |
| Less energy than others own age | 1.14 | 1.06–1.22 |
| Fair or poor physical health | 1.12 | 1.02–1.23 |
| Physical disability | 1.12 | 1.04–1.21 |
| Physical frailty | 1.15 | 1.06–1.26 |
| Depressed | 1.14 | 1.03–1.27 |
| Fair or poor mental health | 1.17 | 1.07–1.29 |
| Not happy | 1.20 | 1.06–1.37 |
| Negative affect | 1.18 | 1.06–1.32 |
| Never go out for entertainment | 1.06 | 0.98–1.15 |
| Do not enjoy free time | 1.08 | 1.00–1.17 |
| Hard to feel close to others | 1.11 | 1.03–1.20 |
| Not much understanding from spouse | 1.07 | 0.96–1.20 |

http://blogs.crikey.com.au/culture-mulcher/2010/07/12/genius-radio-the-nerve/ear-brain/