



Institute  
and Faculty  
of Actuaries

## Cognitive, Psychological, and Social Drivers of Longevity

Gordon Woo  
RMS LifeRisks



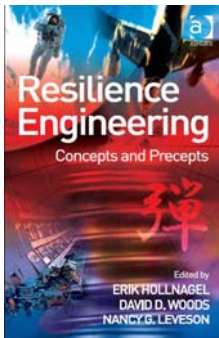
20 February 2014

### What keeps a plane in the air?



The resilience of the flight safety systems  
depends crucially on the pilot

## Resilience engineering



Resilience engineering is concerned not so much with the reliability of individual components but rather with understanding and facilitating a system's ability to actively ensure that things do not get out of control.

A tenet of resilience engineering is that a system is safe if it can adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions.

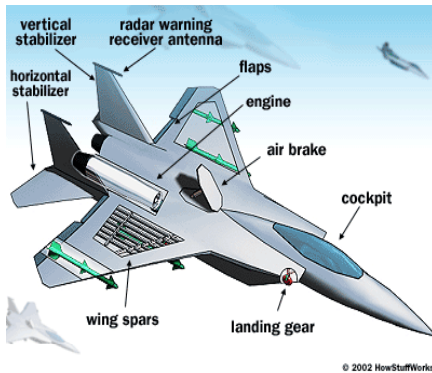
## Extraordinary resilience



On 1st May, 1983, over the Negev desert in Israel, an F15 Eagle collided with an A4 Skyhawk. The Skyhawk was destroyed and the Eagle had a wing torn off.

In a feat of remarkable resilience and skill, the pilot, Zivi Nedivi, managed to regain control,  
- and land safely.

## Sharing resilience insights

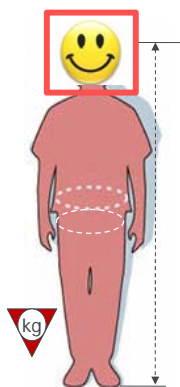


**Flight systems for F-15 jets have damage-adaptive technology relevant for making electric power grids more resilient.**

Nature, 499, July 2013



## A systems perspective on human resilience



What keeps people alive?

### Survival Factors

- Cognitive functioning
- Social functioning
- Well-being

Framingham risk analysis

### Risk Factors

- Age
- Gender
- Smoking
- Blood Pressure
- Cholesterol ratio
- Diabetic
- Etc.

## Criteria for successful ageing: beyond disease avoidance

- Gerontologists have established that, apart from disease avoidance, the criteria for successful ageing include:
  - Maintenance of high cognitive and physical function
  - Sustained engagement in social and productive activities, having close personal relationships with family and friends

## Criteria for successful ageing: beyond disease avoidance

- Much functional loss can be prevented through lifestyle factors which include not just diet, non-smoking, and exercise - **but also mental training and social support.**
- These two factors are significant in keeping the elderly alive, and are a common feature of long-lived communities.

## Gerotranscendence: The three phases of ageing [Gondo, 2012]

- **The Young Old [65-74]**  
Maintenance of health and functional capacity is a primary goal for the physical function of those in **Young Old** age.
  
- **The Old Old [75-84]**  
With physical health deteriorating, cognitive function is vital for navigating through this **Old Old** stage.
  
- **The Oldest Old [85+]**  
*Ikigai* ( reason for living) and social support are vital for surviving in the **Oldest Old** stage.



Institute  
and Faculty  
of Actuaries

## COGNITIVE FUNCTIONING



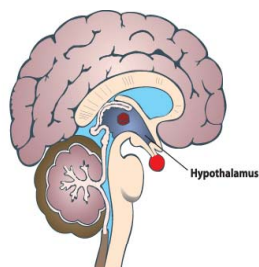
Institute  
and Faculty  
of Actuaries

RMS

## The brain as the control of ageing

The hypothalamus is a crucial part of the brain controlling bodily functions, such as growth, metabolism and reproduction.

**Inflammation in the hypothalamus may underlie ageing of the entire body, according to a recent study published in *Nature* in May 2013.**



NF- $\kappa$ B is a protein factor that turns on genes involved in inflammation and immune response. When researchers blocked the NF- $\kappa$ B pathway in mice, they aged more slowly and lived about 20% longer than mice that didn't receive the treatment.

*'People tend to think about ageing as a passive, chaotic deterioration of tissues. We provide a new view — it includes a brain-controlled process.'*

Dongsheng Cai

**Anti-Ageing alert: treating the brain with anti-inflammatory compounds could potentially slow age-related degeneration.**

## Health importance of cognitive functioning

- There is no health without mental health. Preservation of cognitive functioning is critical to successful ageing.
- Many activities that influence longevity are very cognitively demanding.
- Chronic illnesses require self-regulation to limit damage.
- Better knowledge and reasoning help manage disease.

## Cognitive activity and ageing

- Active mental stimulation is important for maintaining cognitive function. People who exercise their brains consistently throughout their lives live healthier and cognitively smarter lives as they age.
- A unique experimental study in Sweden was able to demonstrate a causal effect of additional years of education (extra cognitive capital) in reducing mortality.
- Frequent engagement in cognitive activity in early and mid-life might help to delay or prevent the abnormal levels of amyloid in the brain, which accompany Alzheimer's disease.



## Cognitive biological age

- Cognitively, individuals may be younger than their actual physical years. Cognitive brain training studies show that it is possible for the cognitive biological age of an individual to be lowered compared with chronological age.
- Brain plasticity research by Michael Merzenich has demonstrated, for older people with mild cognitive impairment, a cognitive age reduction is achievable for some mental tests.
- Participants experienced an improvement in memory equivalent to approximately 10 years.



## Grading of Cognitive Function

<b>Grade 1</b>	<b>Excellent mental health and cognitive reserve; extended length of education; continued brain exercise and training</b>
<b>Grade 2</b>	<b>Very good mental health and cognitive reserve; many intellectually stimulating pursuits</b>
<b>Grade 3</b>	<b>Good MMSE test score (29 or 30); regular engagement of mental faculties</b>
<b>Grade 4</b>	<b>Inferior MMSE test score (26-28); mental distress; prone to anxiety and depression</b>
<b>Grade 5</b>	<b>Poor MMSE test score (25 or less), indicative of incipient mild cognitive impairment</b>

## PSYCHOLOGICAL DRIVER OF LONGEVITY

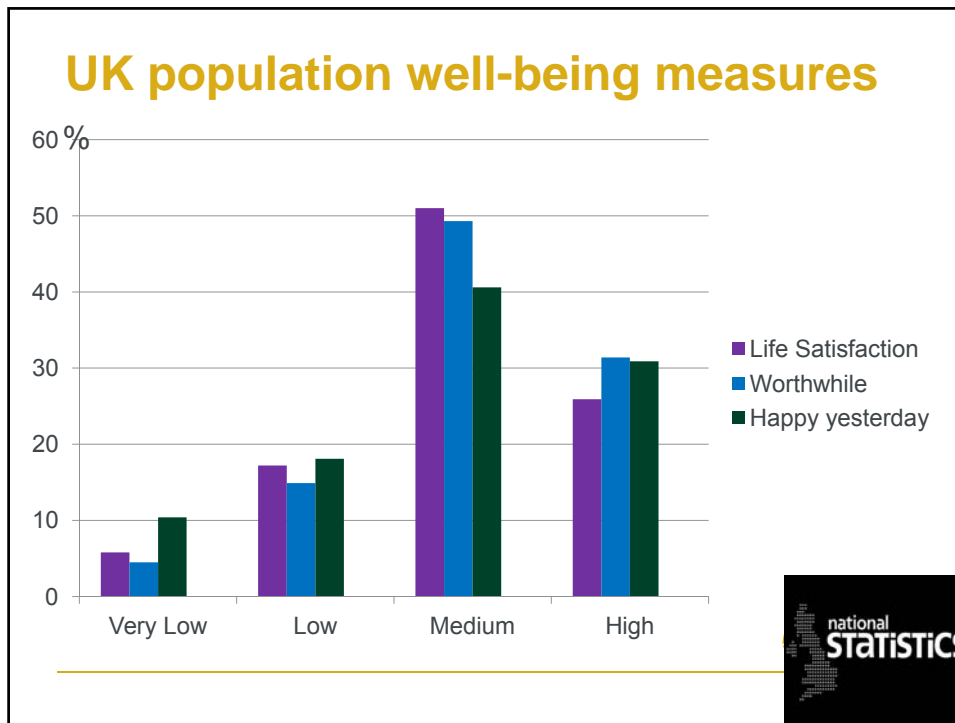


## Purpose in life and longevity

- Feeling needed by social network members may mediate a stronger will to live.
- Possessing a greater purpose in life is associated with lower mortality rates among older adults.
- Deriving meaning from life's experiences and possessing a sense of purpose and well-being is an aspect of successful ageing that depends on *human flourishing*.
- Prime Minister David Cameron is an enthusiast of well-being, and the development of well-being measures.

## UK population well-being assessment

- The second ONS annual experimental subjective well-being population survey [2012-2013] has been conducted. There were small improvements in personal well-being in the UK between 2011-2012 and 2012-2013.
- Responses, on a scale of 0 to 10, were given to these questions:
  - **How satisfied are you with your life nowadays?**
  - **To what extent do you feel the things you do in your life are worthwhile?**
  - **How happy did you feel yesterday?**



### Positive psychology: promoting well-being

- Positive psychology is the study of human flourishing. It focuses on personal traits such as well-being and happiness, rather than on problems.
- It was founded by Martin Seligman et al. in 1998.
- Positive characteristics or feelings help people live longer.
- A Danish study of four thousand twins aged 70 or older showed that subjective well-being predicted increased longevity.



## Grading of Psychological Outlook

Grade 1	Thriving sense of well-being, very happy, smiling and highly optimistic; with purpose and direction in life, and a strong sense of <i>ikigai</i>
Grade 2	Good sense of well-being; contented and optimistic; enjoying making plans for a purposeful future
Grade 3	Happy, with some sense of direction in life; but not too optimistic about the future
Grade 4	Struggling, stressed, unhappy and pessimistic; wandering aimlessly in life with little purpose
Grade 5	Suffering, highly stressed and very dejected, with no goal or meaning in life

# SOCIAL FUNCTIONING



Institute  
and Faculty  
of Actuaries



## Reserves of social capital

- Human social relationships are a form of capital, analogous to economic capital, which can be deployed for health benefits.
- As with economic capital, social capital has a strong association with longevity.



## Social support health advantages

- Emotional social support encourages a sense of being cared for, being esteemed by others, and being of value to others.
- It is especially needed to get through serious illness.
- Hands on care can be essential for basic survival amongst the infirm or incapacitated. They may need help with mobility and nutrition.

## Social support health advantages

- Patients with better social networks may have greater or more reliable access to the health care system.
- Members of the social network may prompt at-risk individuals to seek health care and effective treatment, and encourage treatment compliance.
- Those with a larger social network may be diagnosed earlier and have a better prognosis.

## Physical consequences of social functioning

- People who engage in regular social activities may maintain better brain health.
- Social support is also linked with better immune functioning.
- All human regulatory systems: blood pressure, metabolism, stress hormones etc., are affected by social relationships.
- Major stressful events induce physiological changes.
- Women engage their social support health networks in dealing with stress, whilst men tend to go it alone.

## Health importance of social functioning

- Isolation is a powerful risk factor for poor health. Lack of human contact predicts mortality.
- An influential MacArthur Foundation study of successful ageing reported that friendship is a key factor in keeping older people active and emotionally secure, even in advanced old age.
- Sustained engagement in social and productive activities is central to healthy ageing.



## Loneliness as a longevity risk factor

- Loneliness is a common source of suffering in older persons. It is also a risk factor for poor health outcomes, including all causes of death, and functional decline.
- Consequently, there is a degree of coupling between the longevity of any older person and that of his or her peers.
- The mortality of any older individual is contingent to some extent on the survival of at least one peer. Thus a single life annuity has some characteristics of a joint life annuity.
- Social cohort survival may contribute to the nonlinear rise in the number of those 85+.



## Longitudinal data example: the widowhood effect

- Using data from the Scottish Longitudinal Study, and controlling for a range of individual and household-level characteristics, researchers at St Andrews University recently quantified (2011) the *widowhood effect*.
- Studying the mortality statistics of 58,000 married couples, they found hazard ratios of 1.40 for men and 1.36 for women. The risk is highest shortly after widowhood, but remains raised for at least 10 years.

## Multiple dimensions of social support networks

### Marital Status

Unattached  
Married  
Widowed  
Divorced

### Close Social Contacts

Relatives  
Social Group Members  
Colleagues

### Other Social Contacts

#### Online Links

Facebook is used by 40% of those aged 65+ in UK.

Neighbours  
Acquaintances

## Wide variability in social support networks

Widower living alone with few active family contacts

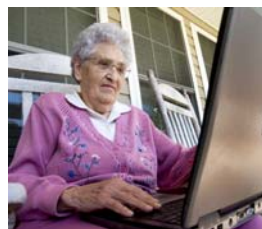


Grandmother with large active family network



## Wide variability in social support networks

Widow who is active in recreational and voluntary social groups, and maintains mental fitness



Unmarried man with hardly any remaining friends and few participatory hobbies, and is housebound







## Grading of Social Reserves

Grade 1	Very extensive supportive social network of family and friends; strong sense of family; well connected with close-knit long-lived tribe
Grade 2	Large extended family and numerous supportive and helpful friends; family prioritized
Grade 3	Some family and confidantes, and a circle of other friends
Grade 4	Moderately lonely, with very few close friends, and no close family
Grade 5	Recently bereaved of partner; lacking a practical social support network; severely lonely

**SIGNIFICANCE  
FOR ANNUITY  
PRICING**



Institute  
and Faculty  
of Actuaries

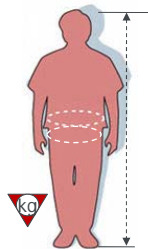


## Annuity portfolio management

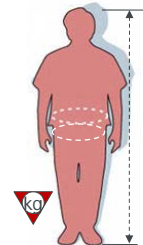
- Recognition of social and psychological drivers of mortality can assist in improving annuity portfolio management.
- In a competitive market, marginal adjustments in annuity pricing can be made which alter the longevity profile of annuitants and lower overall portfolio risk.
- In particular, any tendency towards adverse selection by individuals with high scores on cognitive and social functioning and well-being can be tracked.

## Marginal effect of cognitive and social functioning and well-being

Consider two individuals, same age, BMI and diet, and smoking status, and same physical medical condition:

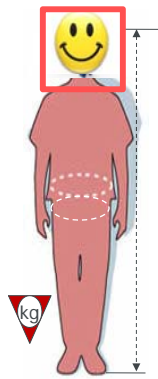


Good cognitive functioning  
Good social functioning  
with positive well-being



Poor cognitive functioning  
Poor social functioning  
with negative well-being

## Composite resilience index



### Mortality Reduction Factors

Cognitive functioning

Psychological well-being

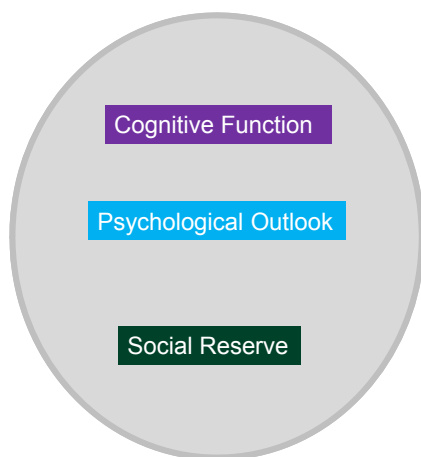
Social functioning

From longitudinal studies, the mortality rate difference between grades is estimated. A composite resilience Index from the three factors can then be obtained.



37

## LifeRisks Resilience index



**Composite Resilience Index**



## Illustrative resilience score matrix for Social Grade 1

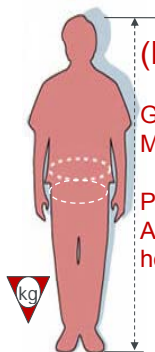
		Psychological Grade				
		1	2	3	4	5
Cognitive Grade	1:	0.55	0.61	0.67	0.74	0.82
	2:	0.57	0.63	0.70	0.77	0.86
	3:	0.59	0.66	0.73	0.81	0.89
	4:	0.62	0.69	0.76	0.84	0.93
	5:	0.64	0.71	0.79	0.87	0.97



20 February 2014

39

## Enhanced annuity quotation request



### (Basic) Personal Details:

Gender; Name; Date of Birth;  
Marital Status; Nationality;

Present or Previous Occupation;  
Address ; Type of home [own  
home; residential, care etc.]

To build up a profile of personal resilience, add supplementary human information, which is not purely medical, e.g. sense of well-being, reason for getting up in the morning....



## Salient supplementary information

- Date of latest change to marital / partner status (widowhood, divorce, marriage, etc.)
- Health status of partner
- Number of years of education
- Principal social and recreational activities
- Number of close family and friends
- Frequency of social support contacts
- Photograph

## Smile intensity in photographs predicts longevity

Psychological Science 2010



Martin Seligman  
founder of Positive Psychology

