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Foresight

Mental capital through life:

Future challenges

MENTAL CAPITAL AND WELLBEING PROJECT

Mental Capital and Wellbeing: Making the most of ourselves in the 21st century

Mental capital through life: Future challenges

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This report is intended for:

Policy makers and a wide range of professionals and researchers whose interests relate to mental development. The report focuses on the UK, but is also relevant to the interests of other countries.

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The Foresight Programme is run by the UK Government Office for Science under the direction of the Chief Scientific Adviser to HM Government. Foresight strengthens strategic policy-making in government by embedding a futures approach.

Contents

Executive summary

The aim of the Foresight Project on Mental Capital and Wellbeing[1] (www.foresight.gov.uk) is to advise the Government and the private sector on how to achieve the best possible mental development and mental wellbeing for everyone in the UK in the future.

The starting point of the Project was to generate a vision for the size and nature of future challenges associated with mental capital and wellbeing, and to assess how the situation might change over the next 20 years, using the baseline assumption that existing policies and expenditure remain unchanged. To make this analysis tractable, the work was divided into five broad areas:

- Mental capital through life
- Learning through life
- Mental health
- Wellbeing and work, and
- Learning difficulties.

This report presents the findings for "Mental capital through life". It discusses how to optimise mental capital through life for the population in the future, and concludes by assessing the policy implications. For background it draws upon a number of reviews of the state-of-the-art of science commissioned by the Project[2].

The concept of **mental capital** is defined as "*the totality of an individual's cognitive and emotional resources, including their cognitive capability, flexibility and efficiency of learning, emotional intelligence (e.g. empathy and social cognition), and resilience in the face of stress. The extent of an individual's resources reflects his/her basic endowment (genes and early biological programming), and their experiences and education, which take place throughout the lifecourse.*" It therefore captures those elements that serve to establish how well an individual is able to contribute effectively to society and also to experience a high personal quality of life. The idea of 'capital' naturally sparks association with ideas of financial capital and it is both challenging and natural to think of the mind in this way.

Mental capital alters through life and can be thought of in terms of a 'trajectory' which rises during an individual's early years, reaches a plateau during the middle years, and finally declines in later life due to intrinsic age-related changes. Since the vast majority of people in today's society will traverse the full extent of the lifecourse, investing in optimisation of the trajectory across all age groups will ultimately benefit everyone equally. However, in order for these benefits to accrue, policy makers will need to resolve two potential obstacles:

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1 Mental wellbeing is a dynamic state in which the individual is able to develop their potential, work productively and creatively, build strong and positive relationships with others, and contribute to their community. It is enhanced when an individual is able to fulfil their personal and social goals and achieve a sense of purpose in society.

2 Appendix B details the Project reports and papers: all are available through www.foresight.gov.uk

- The rewards from many interventions will be long-term and will be fully realised only in the future, whereas the costs are incurred now, when they may be unpopular with those who must make the commitments to invest.
- Some interventions will require action within a given domain (for example a specific Government Department), but produce benefits that principally contribute to delivering the objectives within other domains (for example, other Departments).

Prenatal and childhood

The health and lifestyle of pregnant mothers can have important effects via processes that are not presently well understood, but which are often described as '*in utero* programming'[3]. Important factors include maternal diet, smoking and stress. These all affect foetal brain development through exposure to stress hormones and inflammatory mechanisms which have impacts on biological systems and cognition. The socioeconomic status (SES) of the mother is also a factor, although its effects are thought to be mediated through a complex array of immediate factors such as diet, housing and stress.

Avoidance of alcohol exposure during pre-natal development is particularly important since 'foetal alcohol syndrome' is currently recognised as the most common known environmental cause of mental retardation, affecting from 1 to 7 per 1000 live-born infants. However, a continuing controversy involves the degree to which the deficits derive from prenatal alcohol exposure, rather than from neglectful and/or non-stimulating environments often provided by alcoholic mothers who continue to drink.

An individual's genetic make-up is determined at conception and remains essentially constant throughout life, although there is growing evidence that environmental factors can have long-term impacts on which genes are expressed and which are silent through processes of 'epigenetic' modification. In terms of 'broad-sense heritability', the genetic contribution to cognitive ability has been estimated to rise from well below 50% in childhood to over 60% in adulthood, and is still probably at least this level in old age[4]. However, an individual's genetic make-up can affect the mental capital trajectory in far-reaching ways. For example, a gene has been found, some variants of which appear to be associated with the level of risk of antisocial behaviour in abused children[5].

Infants (0–4)

The environment in which children are nurtured is important for mental capital. For example, adverse experiences in the post-natal period can lead to cognitive impairment. These include a range of disadvantages ranging from low SES status to specific trauma such as childhood sexual abuse[6]. Evidence increasingly shows that children's mental development is associated with their housing quality. Children living in poorer quality housing have been shown to have higher levels of stress hormones and behavioural problems[7]. Conversely, positive parental style promotes cognitive-language and social development, especially in very-low-birth-weight infants[8].

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3 Packard (SR-E17) – this is one of a number of science reviews commissioned for the Project. See Appendix B for a full list.

4 Deary and Gow (SR-E14) – see Appendix B

5 Elliott et al. (SR-E7) – see Appendix B

6 Wolf and Buss (SR-E20) – see Appendix B

7 Dunn (SR-E27) – see Appendix B

8 Wolf and Buss (SR-E20) – see Appendix B

Anxiety disorders track strongly within families, and disorders experienced by adults are usually developed from an early age and may have manifested as separation-anxiety disorder in pre-adolescent children[9]. This family aggregation of such disorders appears to be mainly determined by environmental factors although genes and gene-environment interactions may also be important[10]. Since most anxieties remit in adult life, an important challenge is how to identify children who will develop chronic disorders from those that will present only transient anxiety.

Children (5–12)

The risks to the mental capital trajectory of children in this age range are similar in nature to those that apply in earlier stages. If a child experiences an insecure home environment or is deprived of essential nutrition, sleep, warmth, exercise and mental stimulus, then learning and the development of life skills may suffer. It is particularly important during this stage of the lifecourse that any intrinsic learning disabilities are detected as early as possible and appropriate measures taken to minimise their impacts[11]. Understanding further the science of motivation and reward will be important for developing new ways to secure engagement of all generations in education.

Adolescence

This is a decisive phase in the mental capital trajectory and a period when significant emotional, hormonal and behavioural changes occur. Additionally there may be ongoing biological development. For example a 'Year 8 dip' (12-13 years) in academic performance has been reported, which might correspond, at least in part, to a reorganisation of the brain so that it can learn more efficiently.

During this period of reorganisation the brain may be particularly vulnerable to disruption by drugs or alcohol[12] leading to neural and behavioural changes[13] such as increased risk-taking (see below). Conditions such as mood disorders, triggered by adolescent hormonal changes, may additionally predispose adolescents to substance abuse. In addition, adolescents subjected to familial risk, with affective disturbance, conduct problems, and neurotic or disinhibited personalities, appear to be at risk for escalating substance abuse, once initiated[14].

- Neuroimaging and neuropsychological studies indicate that adolescent substance use is associated with neural disadvantages, particularly in the networks involved in learning, attention, and executive function (namely, strategic control over one's cognitive and emotional processes).
- Heavy use of cannabis during adolescence may adversely affect brain development. The few studies that have examined cognitive functioning in cannabis-using adolescents report decreases in attention[15], learning and memory[16]. However, from

9 Pine and Leibenluft (SR-E12) – see Appendix B
10 Ibid
11 See the Project report: Goswami. *Learning Difficulties: Future Challenges;* see also the final report of the present Foresight Project; (Appendix A refers)
12 Ersche and Nutt (SR-E13) – see Appendix B
13 Paulus and Tapert (SR-E8) – see Appendix B
14 Ibid
15 Tapert et al. (2002)
16 Millsaps et al. (1994); Schwartz et al. (1989); Paulus and Tapert (SR-E8) – see Appendix B

ages 16 to 24 greater use of cannabis predicted poorer effective concentration[17], while drug-associated decreases in memory showed evidence of persisting after six weeks of abstinence[18]. However, some studies report an absence of correlations between cannabis use and cognition[19], and some abnormalities may predate cannabis use[20].

Several studies indicate that adolescents process reward differently than children or adults[21]. This shift in the anticipation of outcomes may help explain why some young people gravitate toward risky behaviours such as substance abuse. Immediate positive outcomes (for example, peer approval) may outweigh potential long-term negative consequences[22].

New knowledge about the maturation and plasticity of the adolescent brain[23] informs the development of effective interventions to encourage positive engagement and social functioning in adolescents. In particular, the Positive Youth Development (PYD) model emphasises the role of contextual factors such as parental warmth and involvement in school or the presence of role models in the community and targeting cognitive and affective abilities. It also highlights the "Five Cs" of Competence, Confidence, Connection, Character, and Caring[24]. The implications are considerable. If coordinated engagement of the relevant neural networks does indeed shape morphological properties of these brain regions, successful intervention along the lines of the PYD model could produce enduring changes in brain biology.

While motivation is important at other periods of life, it is in adolescence that patterns appear to be established, and where failure of motivation has the potential for the greatest long-term threat to mental capital. Social approval, acceptance and inclusion, for example, are powerful motivators of behaviour, and a particular feature of adolescence is sensitivity to social reward[25]. While pleasure is derived increasingly from social interaction with peers, adolescents may become more sensitive to the pain of social exclusion. This could lead to greater sensitivity to peer pressure.

Social maladjustment can generate a negative, self-reinforcing spiral, but equally, there is evidence of a protective effect from social 'lifestyle components' against risks which may diminish mental capital. The cognitively beneficial effect of having a close, supportive family or a strong social network may act through health-related and physiological pathways or serve to encourage cognitive stimulation via increased contact and engagement[26].

Some forms of social marginalisation have a tendency to originate during adolescence, especially when coupled with a significant degree of maladjustment. Those who are marginalised can experience lack of access to economic, educational or social support, and this can affect mental capital, including emotional abilities. Adverse effects on

17 Tapert et al. (2002)
18 Schwartz et al. (1989)
19 Teichner et al. (2000)
20 Aytaclar et al. (1999)
21 Bjork et al. (2007); Galvan et al. (2006), Galvan et al. (2007)
22 Galvan et al. (2007)
23 Paus (SR-E5) – see Appendix B
24 Lerner et al. (2005)
25 Sebastian et al. (SR-E15) – see Appendix B
26 Deary and Gow (SR-E14) – see Appendix B

mental wellbeing include stigmatisation, feelings of shame, hopelessness, victim mentality, stress, lack of control, loss of self-confidence, and low expectations.

Adults

Nutrition appears to be important through its impact on long-term trajectories of health in adulthood and into old age. However, there is little evidence that nutrition makes a specific contribution to brain development and to the acquisition of mental capital[27], provided extremes are avoided, and as long as essential nutrients (including vitamins and other micronutrients) are available.

Although it is never too early to adopt healthy eating preferences, it is during adulthood that such choices may be most important:

- Specific nutrients (i.e. n-3 polyunsaturated fatty acids, folic acid, vitamin E) show little or no benefit in trials, except where there is clear deficiency.
- However, a higher intake of most "healthy" food categories, including those included as part of a Mediterranean diet, are associated with better cognition.

In the absence of more specific understanding, the importance of good or appropriate general nutrition should be emphasised.

Physical activity can have beneficial effects throughout the lifecourse, but evidence suggests that it merits particular attention in adulthood:

- In middle and old age, it can slow or prevent age-related cognitive decline and is associated with a lower risk of dementia.
- The greatest cognitive effects after fitness training were seen in executive control tasks (for example, planning, working memory, concentration); improvements that were accompanied by structural changes in the brain[28].
- Exercise need not be particularly vigorous to offer protection of mental capital[29].
- Regular exercise protects against the development of depressive symptoms. There is also promising preliminary evidence for the use of exercise programmes in the treatment of anxiety[30].

However, not enough is known about optimal parameters of physical activity. For example, what type (aerobic or anaerobic), frequency, intensity and duration of exercise are most appropriate? Also, it will be a major challenge to achieve change in the general population so that exercising becomes a sustained behaviour.

For those who are exposed to chronic stress over extended periods of time (for example, shift workers, aircrew, soldiers), there may be cognitive deficits in several domains (for example, working memory and declarative memory[31]). One recent study of carers of people with long-term disabling conditions showed that that their telomeres (the protective tips at the ends of the chromosomes) were found to be

27 Ordovas (SR-E18) – see Appendix B
28 Hendrickx and van der Ouderaa (SR-E24) – see Appendix B
29 Weuve et al. (2004); Yaffe et al. (2001)
30 Hendrickx and van der Ouderaa (SR-E24) – see Appendix B
31 Cho et al. (2000); Cho (2001); Morgan et al. (2006)

prematurely shortened[32]. This discovery, if confirmed by others, may be of profound significance since it associates psychological stress with the gradual, underpinning processes of biological ageing, increased risk of mortality and a range of age-associated diseases.

The concepts 'cognitive resilience' and 'cognitive reserve' describe two important aspects which affect the maintenance of effective mental capital and mental wellbeing.

- Cognitive resilience can be defined as an individual's successful adaptation and functioning in the face of stress or trauma[33].
- Cognitive reserve describes an individual's resistance to impairment in cognitive processes such as memory, reasoning and attention, which may arise through brain injury or neuropsychiatric disorder or disease. Importantly, it can protect against the normal ageing process[34]. Although cognitive reserve can be manipulated in adult life, its development in early life may also be important[35,36]. Recent evidence suggests that cognitive reserve is not fixed, and can be increased through physical or mental activity, social stimulation, and potentially also through medication or dietary interventions[37]. It can also be affected by environmental factors acting during adulthood.

Depression has major adverse effects on mental capital and wellbeing. Its symptoms may directly or indirectly lead to reduced productivity (due to lack of concentration and slowed functioning), and impaired social functioning (due to social withdrawal and reduced communication ability). These consequences, along with the negative thinking associated with depression, may be associated with loss of confidence and reduced self-esteem and can lead to further impairment in work functioning and disturbed relationships with work colleagues and family members[38].

Older people

The demographic age-shift in the population means that older people will become an increasingly critical sector of the population in the future. There are two principal challenges.

The first is how to ensure that the greatest number of older people maintain the best possible mental capital, and so preserve their independence and wellbeing, both for their own benefit, and also to minimise their need for support.

- The contribution of white matter lesions to lifetime cognitive ageing is relatively large, and independent of prior cognitive ability[39]. Therefore, one line of intervention concerns combating their determinants, such as hypertension and other vascular risk factors, e.g. diabetes[40]. Stress is also relevant since worse cognitive ageing is associated with greater evidence of chronic exposure to stress[41].

32 Epel et al. (2004)
33 Elliott et al. (SR-E7) – see Appendix B
34 Barnett and Sahakian (SR-E4) – see Appendix B
35 Richards and Deary (2005)
36 Barnett and Sahakian (SR-E4) – see Appendix B
37 Ibid
38 McKeith and Scott (SR-E21) – see Appendix B
39 Deary et al. (2003); Leaper et al. (2001)
40 Deary et al. (2003); Murray et al. (2005)
41 Seeman et al. (2001)

- In older people, physical fitness contributes to cognitive ability after adjustment for true prior ability[42]. The most proactive steps an individual can take to ensure cognitive vitality in later life are likely to include adopting cognitively-protective lifestyles such as concerted efforts to reduce cardiovascular risk factors and disease, and increased activity and engagement.

- The changing nature of both work and society means that, in order to realise the potential value of the aggregate mental capital that is held by older people, specific training in current transferable and specific skills could be highly effective. In particular, training in IT could increase social connectedness and generate new opportunities for taking up business or volunteering roles within society, creating a virtuous cycle of benefit, both for the individual and for society[43].

The second major challenge is how to ensure that the considerable resource which older people offer (particularly through their mental capital) is recognised and valued by society, and that they have the opportunity to realise the maximum benefit from that, both for themselves and for society. In the absence of specific diseases that impair cognitive performance, the adverse effects of intrinsic ageing on the memory and capacity for intellectual work are greatly exaggerated in the popular mind. The result of the persistent negative stereotyping of older people is responsible for a massive waste of mental capital in later life.

- Revaluation of the under-utilised mental capital of older people has the potential to lead rapidly to novel opportunities for retraining, continued productivity and social engagement. These will have strong potential to enhance quality of life and to benefit the economy by reducing premature dependency.

- However, changing the attitudes of society to older people will be an important, but crucial challenge.

Cognitive enhancement

Pharmacological cognitive enhancers (PCEs) are used in parts of the general population, for example to combat fatigue, jet lag and even temporary sleep deprivation along with continuous stress[44,45]. However, the benefits of PCEs to the normal healthy population are debatable and there are many unknowns concerning side effects. This implies the need for careful and critical evaluation. Alternative forms of enhancement, such as cognitive training or therapy, may be more suitable.

Cognitive training seems to have a beneficial effect on some functions, but generally the benefits are limited to the targeted domain; for example, training in solving crossword puzzles does not transfer to other tasks and claims that 'brain-gyms' for children are useful remain controversial. In order to reap rewards from cognitive training programmes, these may have to be tailored to individual requirements due to a lack of transfer of the effects[46].

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42 Deary et al. (2006b)

43 For further discussion of continuing education in older people, see Project reports: Feinstein et al. *Learning through life: Future challenges*; Jenkins et al. *Mental health: Future challenges*; Dewe and Kompier. *Wellbeing and work: Future challenges* – Appendix A refers.

44 Sapolsky (1998)

45 Sahakian and Morein-Zamir (2007); Academy of Medical Sciences (2008)

46 Fillit et al. (2002); Salthouse (2006); Deary and Gow (SR-E14) – see Appendix B

Cognitive memory aids are now available to address shortcomings and deficits in human cognition, action and communication. Examples of their use by cognitively impaired users in everyday settings include: access to large repositories of personal data and records of personal experience; and the provision of information about future commitments and ongoing activities[47].

Technologies for supporting daily activities include timed reminders and cognitive support at specified intervals from telephone calls or Personal Digital Assistants (PDAs). These are currently employed only by sub-sets of the population and realising their potential for wider application will require that better understanding of user needs and capabilities should contribute to their design. Non-technological interventions, such as "stimulus control" – relying on associations between actions or "visual cues" and training – have been used to help in cognitively-impaired subjects.

Although the impetus for many of the above applications has been to support those with severe cognitive-impairment, growing convergence with the development of technology to support everyday functions for cognitively-normal individuals can be anticipated in the future. Such developments will offer many potential advantages in promoting optimal mental capital trajectories through life.

The need for further work

This falls into three broad areas (see Chapter 7):

- Research to promote basic understanding. There are many important areas where substantially more basic research needs to be undertaken across diverse areas of science relevant to the subject of mental capital through life.
- Further work to engage, educate and change the behaviour of the public.
- Topics relating to specific classes of interventions: work is particularly needed where the analysis of economic costs and benefits is necessary, for example relating to gains associated with quality-of-life.

As mentioned above, these are not insuperable challenges but they will require cross-departmental and cross-disciplinary collaborations of a kind not often encountered.

47 Olivier et al. (SR-E25) – see Appendix B

1 Introduction

1.1 The significance of mental capital

1.2 The mental capital trajectory

1 Introduction

Chapter 1 introduces this report, placing it in the context of the Foresight Project on Mental Capital and Wellbeing.

The terms 'mental capital' and 'mental wellbeing' are explained, and their importance discussed – both for the individual and for society. The idea of the 'mental capital trajectory through life' is also presented; this concept forms the foundation for subsequent chapters which consider successive stages through life.

1 Introduction

The aim of the Foresight Project on Mental Capital[48] and Wellbeing[49] (www.foresight.gov.uk) is to advise the Government on how to achieve the best possible mental development and mental wellbeing for everyone in the UK in the future.

The starting point of the Project was to generate an understanding of the science of mental capital and wellbeing (MCW). To make this analysis tractable, the work was divided into five broad areas:

- Mental capital through life
- Learning through life
- Mental health
- Wellbeing and work, and
- Learning difficulties.

This report presents the findings for "Mental capital through life". It discusses how to optimise mental capital through life for the population in the future, and concludes by assessing the policy implications. For background, it draws upon the current research literature and upon a number of reviews of the state-of-the-art of science commissioned by the Project[50]. The authors of these commissioned reviews were from diverse disciplines including medicine, biology, psychiatry, psychology, technology and social science.

As the Foresight Project is particularly concerned with meeting future challenges, three alternative future scenarios have been developed for the UK. These have been used to gain insights into how the situation could evolve in different ways for each of the above five areas (including 'mental capital through life'). Further information on those is beyond the scope of this report, but they are presented in detail in a separate paper[51], and drawn upon in the final report of the Project.

1.1 The significance of mental capital

During the evolution of humankind, the brain is thought to have been the major driving force in shaping our contemporary biological, social and cultural nature. The trend towards a larger brain size has been associated with increased control over our environment, increased longevity, extended infancy, enhanced capacity for social living and trans-generational cooperation, and the use of tools and language that has culminated in today's capacity for industry, agriculture, science, technology and culture. The functional status of the brain underpins the quality of the life of the individual and

48 "Mental capital" refers to the totality of an individual's cognitive and emotional resources, including their cognitive capability, flexibility and efficiency of learning, emotional intelligence (e.g. empathy and social cognition), and resilience in the face of stress. The extent of an individual's resources reflects his/her basic endowment (genes and early biological programming), and their experiences and education, which take place throughout the lifecourse.

49 "Wellbeing" in this report refers to "mental wellbeing". It is a dynamic state in which the individual is able to develop their potential, work productively and creatively, build strong and positive relationships with others, and contribute to their community. It is enhanced when an individual is able to fulfil their personal and social goals and achieve a sense of purpose in society.

50 See Appendix B for a full list of the commissioned reviews and Project reports.

51 The paper on scenarios will be made available through www.foresight.gov.uk

provides the substrate for economic and social activity. However, the mind does not function alone; physical state is also an important determinant of how the individual engages with the social milieu. There is thus a powerful interconnection between mind, body and social context, as reflected in the World Health Organization's definition of health as "a state of complete mental, physical and social wellbeing".

In this report, the concept of **mental capital** is defined as "*the totality of an individual's cognitive and emotional resources, including their cognitive capability, flexibility and efficiency of learning, emotional intelligence (for example, empathy and social cognition), and resilience in the face of stress*". It therefore captures a key dimension of those elements that serve to establish how well an individual is able to contribute effectively to society and also to experience a high personal quality of life. The idea of 'capital' naturally sparks association with ideas of financial capital and it is both challenging and natural to think of the mind in this way.

To the individual, the brain is a resource of immeasurable worth, as we see all too plainly when the well-capitalised brain is damaged by injury or disease. For some, however, their *potential* mental capital is under-realised for a variety of other reasons, which include factors as diverse as an insecure home environment, poor schooling, drug abuse, social marginalisation or mental ill-health. In later life, mental capital may be eroded by age-related disease, or left to waste through lack of opportunity resulting directly or indirectly from the pervasive negative stereotyping of older people as a non-contributory 'burden'. Individuals have much to gain by optimising their mental capital. High performance and productivity can translate into increased earning potential, as well as sense of achievement. Also, good social functioning yields strong relationships and social networks, as well as bringing fulfilment.

For society, brains are instruments which may contribute to the common good through innovation, work (in all of its forms), friendship, or entertainment. The concept of mental capital attempts to capture the worth of a brain not only in terms of how well it is put together and functions, but also in terms of how successfully it has learnt its skills and matured its emotional and reasoning capabilities. Benefits to society include high workforce performance, empowerment of families and communities, and reduction of anti-social behaviour. In this sense mental capital can be regarded as a stock that must be nurtured and accumulated. However, merely having capital in the bank is not the only measure of its importance. How that capital is put to work is equally critical. The concept of **mental wellbeing**, here defined as "*a dynamic state in which the individual is able to develop their potential, work productively and creatively, build strong and positive relationships with others, and contribute to their community*", complements that of mental capital. In this regard, an important difference between mental and fiscal capital is that mental capital is not depleted by 'spending' it. There is growing recognition also of the importance of 'happiness', which must be closely associated with mental wellbeing, as a social good.

The specific attributes contributing to mental capital may differ greatly between individuals. For example, in some people and contexts it may be the level of academic ability that is of greatest importance whereas in others, 'people skills' may be much more valued. Furthermore, the resources that contribute to mental capital are likely to be developed at different stages through life, whether as innate ability (nature), learned experience (nurture), or flexibility in response to change or challenge. The ability to deploy these resources is moderated by factors affecting or influencing mental wellbeing, such as the social environment.

Engaging with the issues which relate to mental capital through life requires an intensely multidisciplinary approach. To a neuroscientist, brain function can be expressed in terms of the molecular and cellular integrity of the central nervous system (CNS), the robustness of the networks of connections between neurones, and the neurochemical signalling that connects the activities of the CNS with other organ systems in the body. For a social scientist, the operation of the mind is concerned more with emotional and functional performance within the domain of social competence. For a psychiatrist or psychologist, the state of the mind is more concerned with the integrity and normality of cognitive and emotional functions. In education, the mind is an entity to be trained and encouraged to flourish. In business, the mind is there to analyse problems, and discover solutions and apply skills to the job in hand. In each domain, we need to add to the basic attribute of capacity some indication of whether that capacity is present in a form that combines appropriate flexibility and resilience, and whether the possessor of that capacity is able to deploy it. All of these facets have their place in the integrated consideration of mental capital through life.

1.2 The mental capital trajectory

Mental capital alters through life and can be thought of in terms of a 'trajectory' which rises during early life and development, reaches a plateau during the middle years, and finally declines in later life due to intrinsic age-related changes, including a growing vulnerability to disease. It is helpful to distinguish five major life-stages that are associated with this trajectory: prenatal life and early childhood (0-4); childhood (5-12); adolescence; adulthood; and older people. An important caveat is that the boundary between the last two categories, in particular, is somewhat arbitrary. This is, first, because life expectancy continues to increase at a rate of two or more years per decade; a change that is now driven purely by the continuing declines in later-life mortality which have taken demographers by surprise. Secondly, opinion polls show that there is no clear consensus about when 'old age' commences. Intriguingly, the boundary when a person thinks of old age beginning is, on average, about 15 years beyond his or her current age. In this report, the term 'older people' is taken to comprise those beyond the normal age of retirement, but this transition is beginning to shift and is in any case quite variable within any given population.

The concept of a mental capital trajectory focuses attention on the various factors that can either boost mental capital to a higher level or push it downwards at different stages in life. Policy interventions can therefore be framed in terms of their potential impacts on the trajectory. To this end, we examine a range of factors (for example genetics, nutrition, SES) that influence the mental capital trajectory and assess their implications for developing policy in order to deliver the best outcomes.

In some cases, we show that the current state of knowledge about these factors is only indicative; this serves to highlight areas where further information is needed to quantify the effects with sufficient precision to enable realistic cost-benefit analyses. However, unlike fiscal capital, mental capital is not defined on a precise scale. Therefore, to some extent the relationship between factors and the mental capital trajectory must remain uncertain, even though the factors themselves are in principle capable of precise measurement. Furthermore, the connections between positive effects on mental capital and the resultant benefits to the individual and to society are largely unquantifiable. Whilst these are important issues, they are not so serious as to invalidate the framing of these essential domains of human activity within the context of the mental capital trajectory. Ultimately, resources invested in enhancing the average mental capital trajectory can and must be measured against eventual outcomes, which can be

measured in terms both of economic and quality-of-life metrics. There may be elements of inter-connecting pathways linking cause and effect that remain elusive to precise quantification, but this does not fundamentally undermine the importance of attempting such an analysis, nor of trying to deliver evidence-based policies on the resulting platform of albeit partial understanding.

Two further aspects of the mental capital trajectory merit preliminary comment. First, the idea of a trajectory naturally lends itself to thinking in terms of maximising the 'area under the curve' as a measure of success. This provides a straightforward form of weighting across the age range in terms of the gains to be made; the higher the trajectory rises in the initial stages, the greater will be the area under the curve across the whole lifecourse. Many would see that this places an appropriate emphasis on the formative phases of life. However, the age at which the trajectory peaks and the rate of subsequent decline will also make sizeable contributions to the area under the curve. Thus, all phases of the lifecourse have important impacts on the aggregate measure of success. Secondly, although the trajectory is most easily represented in terms of a single height dimension (mental capital), the reality is that mental capital is multidimensional and it is an oversimplification to suppose that all of its dimensions will necessarily follow identical trajectories. This is seen, for example, in the impact of ageing on cognitive performance. In general, when one cognitive ability starts to decline in a person, so do the others[52], but when individual cognitive domains are studied in detail, there are found to be important differences in rates of decline[53]. When components of mental capital other than cognitive performance are factored into the picture, some significant heterogeneity in rates of change is to be expected.

Figure 1.1 provides a synthetic view of the mental capital trajectory and of the various factors that may act upon it. The earliest influences are experienced well before the individual gains the capacity for independent application of his or her mental capital and relate primarily to brain growth and development, and to the important emotional patterning that derives from the early home environment. As the infant engages with the wider social environment, for example through early school experiences, influences are felt that may have important positive or negative effects on the rate of growth of mental capital. These processes and influences continue through subsequent schooling and social engagement, with an increasingly important dimension being developed among peers.

As the individual progresses through adolescence and into adulthood, mental capital develops further and acquires the important elements that relate, in particular, to the capacity to apply skills in the workplace. The diversity of forms of mental capital becomes strongly apparent during this phase, with some individuals progressing to acquire advanced cognitive skills (for example doctors, scientists, lawyers, accountants, musicians) while others develop mental capital in ways that are less easily measured than by the passing of formal examinations. There is great heterogeneity within the UK population in the level of mental capital attained by the end of the period of life during which it is primarily acquired. Some of this heterogeneity results directly from the aggregate impacts of the earlier influences; some of it will derive from current circumstances and may include social marginalisation, for example through racial identity or geographical location; and some of it will arise through current individual circumstances such as the quality of the work environment, personal relationships and health.

52 Salthouse and Ferrer-Caja (2003); Wilson et al. (2002)

53 Singer et al. (2003)

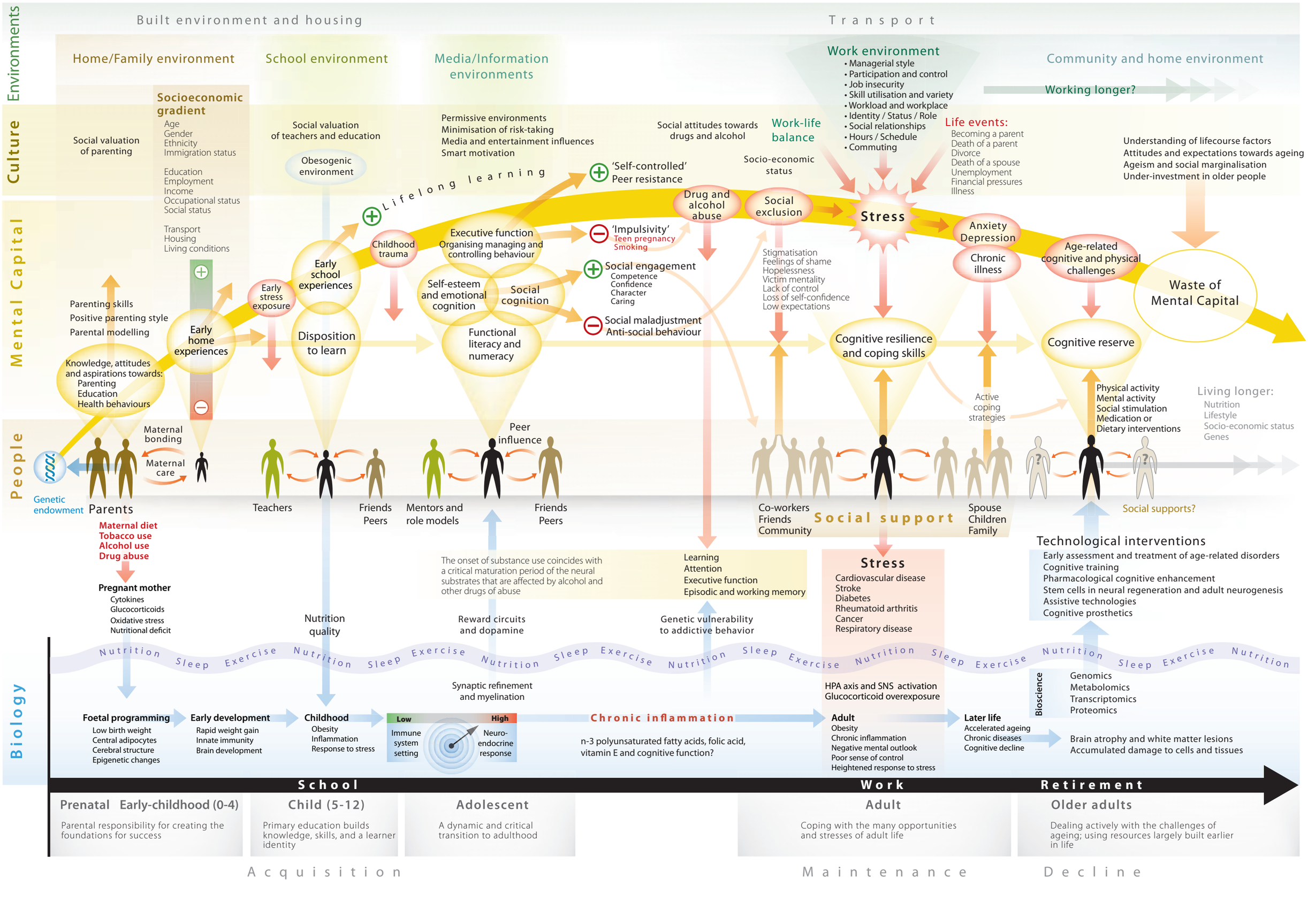
During adulthood, the dominant feature of the mental capital trajectory may be characterised as 'maintenance' although this term should also be taken to include the further development of mental capital through acquisition of life experience and through continuing formal or informal education. In today's world the pace of change in many domains of life is rapid, both within the workplace and in the wider social context. The skills and attitudes learned during earlier phases of life may quickly lose their relevance, so a crucial feature of mental capital and wellbeing may be the flexibility and resilience to adapt to change.

For older people, the mental capital trajectory poses a particular set of challenges and opportunities. Until very recently, attitudes to later life were based essentially on a model where those who survived long enough were 'pensioned off' and expected to pass the period between active contribution to society and eventual death living out their remaining years at leisure, financed either by their own previous investments in a pension fund or by the state old-age provision. However, it has become clear that this model requires radical overhaul.

The major driver that is changing the position of older people within society, and which has far-reaching implications for mental capital and wellbeing, is the continuing rise in life expectancy. This has increased steadily across most of Europe since 1800, since when it has shown a remarkably uniform rise. The rise was originally due to improved sanitation, nutrition and housing, all of which led to a steady decline in the rates of mortality due to infectious disease. In time, the control of infection was advanced through development of vaccines and then antibiotics. By the 1960s and 1970s, there was no room for significant further increase in life expectancy as a result of further reducing mortality rates during the early and middle years of life. However, the increase in life expectancy did not slow down because a new factor then came into play: the improving health and vitality of older people. The current increase is the result overwhelmingly of the continuing decline in death rates at older ages. This is in spite of the fact that the increased number of older people has led to higher prevalence of age-associated conditions such as Alzheimer's disease, osteoporosis and macular degeneration.

With average UK life expectancy now about 80 years, the period of time between the traditional age of retirement and death is 15 years or more and adjustments have already been announced, following the 2005 review by the Pensions Commission, to postpone the age of qualification for the state pension. It is clear that for many older people there is both a desire and necessity to continue paid employment for longer and this calls for profound reassessment of attitudes to later life and to the phase of 'decline' of the mental capital trajectory. Moreover, the increasing vitality of today's older people is coupled with a desire for mental engagement in further education and in voluntary contributions to society. Recognising and harnessing the potential mental capital in older age groups, much of which has been wasted in the traditional model, is likely also to contribute substantial gains in mental wellbeing. These will have major quality-of-life advantages for individuals and will lessen the health and social care costs associated with unnecessary marginalisation and its attendant ills.

Figure 1.1: Synthetic view of the mental capital trajectory



2 Prenatal, early childhood (0–4) and childhood (5–12)

2 Prenatal, early childhood (0–4) and childhood (5–12)

Chapter 2 considers the first important stages in the development of mental capital: from conception to age 4, and from age 5 until the onset of adolescence. In so doing it considers the evidence for the impact of key factors affecting mental development. The relative influence of genetic factors (nature) compared to environmental factors (nurture) is also discussed.

2 Prenatal, early childhood (0–4) and childhood (5–12)

Many excellent textbooks describe current biological understanding of normal brain development. During the coming decades we can anticipate significant progress in identifying the details of the developmental processes with ever-increasing precision. It is likely that this research will bring to light some of the innate factors that influence how different brain regions develop in ways that might better explain individual differences in brain growth and maturation, possibly opening novel paths to tailoring individualised paths to optimal brain development. While these possibilities can be anticipated, it is impossible at present to predict the magnitude of the realisable effects and the cost-effectiveness and acceptability of such interventions. Furthermore, the timescale is essentially unknown. The prospect of future impacts on enhanced brain development, as opposed to minimising adverse factors (where the scope is clear and defined), will not be considered further.

2.1 Brain development: nurturing the foetus and infant

It is clear that the health and lifestyle of pregnant mothers can have important effects via processes that are not presently well understood, but which are often described as '*in utero* programming'[54]. Factors such as maternal diet, smoking and stress all affect foetal brain development through exposure to stress hormones and inflammatory mechanisms which have an impact on biological systems and cognition. The socio-economic status (SES) of the mother is also a factor. Precisely how SES exerts its effects is poorly understood but it seems likely that a combination of pathways – relating to the mother's nutrition, lifestyle, housing, access to and utilisation of health services, education and cognitive ability – are involved. As regards maternal diet, supplementation of molecules involved in brain development such as docosahexaenoic acid [22:6(n-3)] (DHA) and folate (at least to the extent of preventing deficiency) has beneficial effects on cognitive development[55]. Pre-natal exposure to maternal smoking is associated with lower scores for healthy psychological and social functioning[56].

Pre-natal stress, experienced by the foetus either through its connection to the mother's blood supply (and hence to maternal anxiety and stress) or through prematurity and low birth weight, may have important effects on cognition. Early exposure to stress has been shown to be associated with impaired cognitive and intellectual performance in later life. This is believed to result from exposure to stress hormones during critical periods of brain development which impair its maturation with effects on morphology, physiology and neurochemistry. As a consequence, such pathological changes seem to have important implications for future cognitive functioning[57].

Avoidance of alcohol exposure during pre-natal development is important since 'foetal alcohol syndrome' (FAS) is currently recognised as the most common known environmental cause of mental retardation, affecting from 1 to 7 per 1000 live-born infants. Individuals with FAS suffer from changes in brain structure, cognitive impairments,

54 Packard (SR-E17) – see Appendix B
55 Ordovas (SR-E18) – see Appendix B
56 Paus (SR-E5) – see Appendix B
57 Wolf and Buss (SR-E20) – see Appendix B

and behaviourial problems. Researchers investigating neuropsychological functioning have identified deficits in learning, memory, executive functioning, hyperactivity, impulsivity, and poor communication and social skills in individuals with FAS and foetal alcohol effects (FAE) – defined as a state with less extreme difficulties than FAS[58]. Alcohol is a teratogen (an agent causing disruption of normal developmental patterning). During pre-natal development it may act as a cytotoxic or mutagenic agent, causing cell death or chromosomal aberrations and disorganising or delaying cell migration and development in the brain. The production of neurotransmitters is also affected, leading to neuroendocrine abnormalities. A continuing controversy in the assessment of cognitive functioning in children with FAS involves the degree to which the deficits derive from prenatal alcohol exposure rather than from neglectful and/or non-stimulating environments often provided by alcoholic mothers who continue to drink. While this issue cannot be resolved definitively, it has been pointed out that some children with FAS have been raised entirely by excellent adoptive families and continue to exhibit developmental delay[59].

Adverse experiences in the post-natal period can also lead to cognitive impairment. Such experiences can be wide-ranging in nature, from general disadvantages associated with low SES to specific trauma such as childhood sexual abuse[60], the latter being more or less equally distributed across SES groups. As an example of the disadvantage associated with low SES, evidence shows that children's mental development is associated with their housing quality. Children living in poorer quality housing have been shown to have higher levels of stress hormones and behavioural problems[61].

The family environment in which children are nurtured is important for mental capital. Positive parental style promotes cognitive-language and social development, especially in very-low-birth-weight infants[62]. Anxiety disorders aggregate strongly within families. Disorders experienced by adults are usually developed from an early age and may have manifested as separation-anxiety disorder in pre-adolescent children[63]. Initial signs of risk for anxiety can manifest as "behavioural inhibition", a stable temperament profile involving wariness when confronted with novelty. Inhibition is seen in both boys and girls, but more females go on to develop disorders. The use of twin and adoption studies has shown that genes and gene-environment interactions are likely to play a part in how disorders of this kind might be transmitted within families; however, the greatest contribution appears to come from environmental factors[64]. Since most anxieties remit in adult life, an important challenge is how to distinguish children likely to develop chronic disorders, and therefore requiring special intervention, from those that will present only transient anxiety.

2.2 Childhood (5–12)

The period from 5 to 12 years of age is a crucial phase in the acquisition of mental capital. However, the issues concerning the mental capital trajectory during this period are relatively straightforward. They combine, on the one hand, the avoidance of adverse factors that can inhibit the growth and development of a child's social and

58 Niccols (2007)
59 For example, Streissguth and LaDue (1987); see also review by Niccols (2007)
60 Wolf and Buss (SR-E20) – see Appendix B
61 Dunn (SR-E27) – see Appendix B
62 Wolf and Buss (SR-E20) – see Appendix B
63 Pine and Leibenluft (SR-E12) – see Appendix B
64 Ibid

cognitive strengths and skills, and, on the other, the provision of an appropriate learning environment.

The development of the primary school curriculum, and the inclusion of appropriate stimuli within it, has received considerable attention already and is the subject of continuing review. There is little or no dispute about the priority that must be attached to this area although there has been significant debate about how best to develop basic skills such as reading and numeracy, as well as non-cognitive skills in coping, resilience and executive function[65]. The fact that these debates are still vigorous might be seen as indicating that there is actually a lack of compelling evidence for the merits and/or deficiencies of competing approaches. However, the question of how best to fine tune the delivery of primary education is outside the scope of this report[66].

Of chief concern here are the various threats to a child maintaining an optimum trajectory during the growth phase of mental capital. Many of these are similar in nature to the threats that apply in earlier stages. If a child experiences an insecure home environment or is deprived of essential nutrition, sleep, warmth, exercise and mental stimulus, then learning and the development of life skills may suffer. It is also particularly important during this stage of the lifecourse that any intrinsic learning disabilities are detected as early as possible and appropriate measures taken to minimise their impacts; these issues are addressed more fully within other Project reports[67].

2.3 Genetic factors

This section considers the evidence for underlying genetic factors that, from the outset, influence the mental capital trajectory through life. The influence of genetics will be revisited when we look at older people, since it is here that genetics plays a specific role with respect to long-term maintenance of cognitive function and eventual cognitive decline.

An individual's genetic make-up is determined at conception and remains essentially constant throughout life, although there is growing evidence that environmental factors, particularly nutrition, can have long-term impacts on which particular genes are expressed and which are silent through processes of 'epigenetic' modification. In terms of the conventional understanding of genetic influence, as expressed in 'broad-sense heritability', the genetic contribution to cognitive ability has been estimated to rise from well below 50% in childhood to over 60% in adulthood, and is still probably at least this level in old age[68].

Why genes make a greater or lesser contribution at different ages is bound up with the relative importance of genetic and environmental factors. A gene might, for example, have a greater influence at older than younger ages if it predisposes to greater cognitive robustness. Disentangling the role of genes (nature) from environmental (nurture) effects is therefore difficult, since cognition and other types of mental capital are likely to have numerous genetic origins, with individual genes making small contributions. At the non-genetic end of the gene-environment spectrum, the environmental factor of deprivation can have a striking effect on general and cognitive

65 Interventions to equip children with non-cognitive skills are considered in the final Project report.

66 See the Project report: Feinstein et al. *Learning through life: Future challenges;* (Appendices A and B refer)

67 See the Project report: Goswami, *Learning difficulties: Future challenges;* see also the final report of the present Foresight Project; (Appendix A refers)

68 Deary et al. (2006a); Deary and Gow (SR-E14) – see Appendix B

health. For example, in Glasgow against a fairly uniform genetic and ethnic background, those in the more deprived areas have a reduced life expectancy (53.9 years in Calton compared to 82.6 years in Milngavie); a five-fold higher prevalence of diabetes; and a ten-fold higher level of stroke[69]. This does not preclude a role for genetic factors, which may be revealed by research in the future, but it seems *a priori* likely that strong environmental factors will be most significant. In addition, mental health is poorer in deprived populations; in Glasgow, new psychiatric hospital admissions (as distinct from re-admissions) are three times higher in the least affluent compared to the most affluent communities[70]. These are areas where new policies should be able to make a substantial difference.

As noted above, the genetic contribution to cognitive ability in early life is only modest, although this rises to 60% in adulthood. Thus genes make an important contribution to cognitive function, although the nature of this contribution is presently unknown. In medical circles, there is much discussion about the potential for personalised medicine based on identifying individuals' specific vulnerability to disease from their genotype and on identifying which drugs or other interventions may or may not affect them. In the area of education and cognitive development, it may also prove relevant to consider whether genetic differences might warrant similarly personalised approaches, although it is currently too early to speculate on whether or when this might become something needing to be given practical consideration.

There are, however, other aspects of an individual's genetic make-up that have a bearing on the early stages of the mental capital trajectory. In recent years, genetic influences related to resilience have been studied, in particular, whether abused children developed anti-social personality disorders[71]. A functional polymorphism in the gene encoding the enzyme monoamine oxidase A (MAOA) was found to be important. Low MAOA was associated with an increased risk of anti-social behaviour, particularly following exposure to an abusive environment, suggesting that the gene may confer a degree of resilience[72]. Here, however, an important caveat must be noted: in this context (as in others), it must be recognised that "anti-social" is as much a social construct as a scientific one.

69 Hanlon et al. (2006)

70 Hanlon et al. (2006); Packard (SR-E17) – see Appendix B

71 Caspi et al. (2002)

72 Elliott et al. (SR-E7) – see Appendix B

3 Adolescence

3 Adolescence

This chapter draws on developments in neuroscience and shows that adolescence is a crucial phase in the maturation of the brain. It also outlines ways in which the adolescent brain functions differently than in children and adults.

This perspective is used to discuss critical issues affecting the development of mental capital, such as motivation and drug and alcohol use, as well as providing insights into social development and behavioural problems.

3 Adolescence

Adolescence is a decisive phase in the mental capital trajectory. During adolescence, important changes occur to complete the biological development of the brain, and the adolescent begins to develop great autonomy of action. It is a period when a diverse array of factors can have deleterious effects on the full attainment of an individual's optimum mental capital trajectory, and when it is crucial that appropriate actions are taken to minimise their impacts. These include specific issues with learning, mental health and learning difficulties, which are addressed in other reports[73].

3.1 Brain maturation

The brain continues to undergo significant structural and functional changes during adolescence[74], over a period when the adolescent must also cope with significant emotional, hormonal and behavioural adjustments. Although a 'Year 8 dip' (12-13 years) in academic performance has been reported, this might correspond, at least in part, to the reorganisation of the brain so that it can learn more efficiently. In the grey matter of the brain; synaptogenesis (the formation of new connections between nerve cells) peaks around 9 to 12 years (earlier in girls than boys). Grey matter then decreases, possibly due to synaptic pruning. White matter myelination, as an indication of neural connectivity, increases linearly throughout childhood and adolescence. This period of brain reorganisation may be particularly vulnerable to disruption by drugs or alcohol, and evidence from human and animal research suggests that adolescence is a period of particular vulnerability to adverse effects of alcohol and other drugs on the brain. Neuroimaging and neuropsychological studies indicate that adolescent substance use is associated with neural disadvantages, particularly in the networks involved in learning, attention and executive function.

These significant structural and functional changes in the brain coincide with the development of social cognition during adolescence, when teenagers experience increases in social and emotional sensitivity, developing self-concept and perspective, and testing out their place in society (social adjustment)[75]. During adolescence, "behavioural maturation" is attained by acquiring a well-balanced interface between emotion, reasoning and decision-making, and action. Sociological studies suggest that this is the result of acculturation and socialisation processes in which individuals learn to be competent participants in social life. With respect to the interplay between cognitive and affective processes, it is likely that the two domains are particularly tasked in social situations in which the right balance must be struck between peer-based influences and the individual's goals. Adolescents vary in their sensitivity to peer pressure, and their ability to resist peer influences[76]. Some have argued that the notion of peer pressure needs to be treated more critically, particularly as it tends to be used as an explanation to make troublesome behaviours warrantable. In other words, individuals justify actions constructed as being bad by the majority, by appealing to a deviant group norm. The majority rely on conformity to group norms as a form of glue

73 See the Project reports: Feinstein et al. *Learning through life: Future challenges*; Jenkins et al. *Mental health: Future challenges*; and Goswami, *Learning difficulties: Future challenges*; (Appendices A and B refer)

74 Paus (2005), Lenroot and Gledd (2006), Blakemore and Choudhury (2006); Paus (SR-E5); Paulus and Tapert (SR-E8); Blakemore et al. (SR-E15) – see Appendix B

75 Sebastian et al. (SR-E15) – see Appendix B

76 Paus (SR-E5) – see Appendix B

that holds society together. Thus, in some contexts, a capacity to resist peer group pressure may be seen as one of the marks of a sociopath.

Some evidence is available regarding the concept of brain plasticity ("experience-driven structural plasticity"), including examples where functional behaviour seems to have affected brain structure/function[77]. Several studies have confirmed that repeated engagement of a particular neural circuit leads to changes in its structural properties, which can be detected *in vivo* with magnetic resonance imaging: for example, in the brains of musicians, London taxi drivers, bilingual subjects and initially naïve jugglers[78]. Although determining directionality of such structure-function relationships is impossible in the majority of current studies (with the exception of the study on jugglers), the existing literature in experimental animals confirms the possibility of experience having a direct impact on brain structure[79].

In the light of this evidence, it might be asked whether it is useful to consider how to encourage positive engagement and social functioning in adolescents. Paus[80] suggests that new knowledge about the maturation and plasticity of the adolescent brain provides additional information for the development of effective interventions, specifically referring to the example of the Positive Youth Development (PYD) model. The PYD model emphasises the role of contextual factors such as parental warmth and involvement in school or the presence of role models in the community and targeting cognitive and affective abilities. It also highlights the "Five Cs" of Competence, Confidence, Connection, Character, and Caring[81]. These factors have been found to be the outcomes of functionally and developmentally appropriate (adaptive) interactions between the young person and his or her social environment[82]. The implications of such discoveries are considerable. If coordinated engagement of the relevant neural networks does indeed shape morphological properties of these brain regions, it can be predicted that successful intervention along the lines of the PYD model will produce enduring changes in brain biology.

The complexity of the factors influencing learning and maturation suggest that much further work needs to be done to identify the determinants of optimal acquisition of mental capital in adolescents. In addition to the factors discussed above, it is clear that for many children and adolescents, there is a powerful array of forces that may discourage making the necessary commitment to learning and acquisition of mental capital. The fact that the major benefits of acquiring a greater stock of mental capital will be realised some time in the future plays into an all-too-common scenario where discounting into the future subordinates a much greater future gain to the prospect of immediate gratification. Recognising the lifecourse trajectory of mental capital helps frame the problem, but does not immediately solve it.

Finally, it may be important to note that the period of adolescence is a time of particular risk for traumatic brain injury, which may result from any of a wide variety of causes. Although the maturing brain has some plasticity to cope with injury, there can be lasting deleterious impacts on the growth of mental capital, together with increased risk for depression and in later life for Alzheimer's disease.

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77 Paus (SR-E5) – See Appendix B

78 Gaser and Schlaug (2003); Sluming et al. (2002); Maguire et al. (2000); Mechelli et al. (2004); Draganski et al. (2004)

79 e.g. Sirevaag and Greenough (1988)

80 Paus (SR-E5) – see Appendix B

81 Lerner et al. (2005)

82 Gestsdottir and Lerner (2007)

3.2 Motivation

Closely connected with the goal of achieving maximal growth in the mental capital trajectory is the question of motivation. Issues around motivation are by no means confined to the adolescent period of life, but it is here that patterns appear to be established and where failure of motivation has the potential for the greatest long-term threat to mental capital. Part of learning and maturation is the development of decision-making processes. The vast majority of our behaviour is motivated by either obtaining rewards or avoiding punishments, both of which modify behaviour through reinforcement[83]. Models of human reward have been based on economic theories and gambling models, for example risk-taking and delay or discounting of rewards to be received in the future, when given an alternative choice of a smaller, immediate reward (instant gratification)[84].

Animal studies show that there are distinct circuits within the brain for reward-related behaviour. Critical regions of this circuitry include the midbrain, the ventral and dorsal striatum, the amygdala and regions of the prefrontal cortex. The function of this circuitry is modulated by the neurotransmitter dopamine[85]. Neuroimaging has identified areas of reward processing in the brain associated with different types of reward (physiological, financial and social) while functional magnetic resonance imaging of taste and smell stimuli[86] has shown specific neuronal responses. Financial reward was associated with activation in regions of an extended "reward system", while mutual cooperation was associated with enhanced neuronal response in reward areas, suggesting that social cooperation is intrinsically rewarding[87]. When considered in conjunction with the evidence of plasticity in brain development during adolescence (see previous section), this suggests that there is potential for significant gain or loss of mental capital depending on whether the reward system is appropriately stimulated.

Social approval, acceptance and inclusion, for example, are powerful motivators of behaviour, and a particular feature of adolescence is sensitivity to social reward[88]. While adolescents increasingly derive pleasure from social interaction with peers, they may also become more sensitive to the pain of social exclusion. This could lead to increased sensitivity to peer pressure.

The experience of reward is critically dependent on the extent to which outcomes match expectations. Reward is composed of a feeling and an action. Components of reward include the hedonic aspects i.e. the degree to which a stimulus is associated with pleasure, and the motivational aspects i.e. the degree to which a stimulus induces an action towards obtaining it[89]. Several studies indicate that adolescents process reward differently than children or adults[90]. Children seem to anticipate negative outcomes, adults positive outcomes, and adolescents both negative and positive outcomes[91]. This shift in the anticipation of outcomes may help explain why some adolescents gravitate toward risky behaviours such as substance abuse as immediate positive outcomes (for example, pleasure, excitement, peer approval), which may

83 Elliott and Deakin (SR-E2) – see Appendix B
84 Elliott and Deakin (SR-E2); Dolan (SR-E3); Bradshaw (SR-E6) – see Appendix B
85 Elliott and Deakin (SR-E2) – see Appendix B
86 Rolls et al. (1997)
87 Elliott and Deakin (SR-E2) – see Appendix B
88 Sebastian et al. (SR-E15) – see Appendix B
89 Elliott and Deakin (SR-E2) – see Appendix B
90 Bjork et al. (2007); Galvan et al. (2006); Galvan et al. (2007)
91 Paulus and Tapert (SR-E8) – see Appendix B

outweigh potential long-term negative consequences[92]. Taken together, persons prone to risky behaviour are particularly vulnerable during the adolescent period, when neural systems underlying risky behaviours[93] incur significant maturation of nerve cell connections[94]. There is, however, an important downside to regarding "proneness to risky behaviour" as inherently undesirable; few of the military or civilian 'heroes', whose actions have at times changed the course of our history for the better, will have been individuals averse to taking risks.

In the next section the perspective gained on children and adolescents is used to discuss critical issues affecting the development of mental capital such as motivation and drug and alcohol use, as well providing insights into social development and behavioural problems.

3.3 Drug and alcohol abuse

Growing evidence points to drug and alcohol abuse as significant threats to the acquisition and maintenance of mental capital. Again, these problems are by no means confined to the adolescent stage of the lifecourse, but it is here that they can most seriously affect the mental capital trajectory. Alcohol and drug use is quite common in the United Kingdom. Alcohol use is particularly high among youth in the UK, with 91% of 15-16 year-olds reporting past-year drinking[95] and, more significantly, 68% reporting past-year drunkenness in the UK. Regarding cannabis use, 38% of UK 15-16 year-olds have used it at least once. Other drugs are used by 9% of UK adolescents, with most of the other drugs being inhalants (12%) and ecstasy (5%). A concerning pattern is that 7% report use of alcohol and pills in combination[96].

Chronic heavy drinking during adolescence is associated with subtle yet consequential effects on the development, functioning, and performance of the brain. The abnormalities include reduced hippocampal volume, disturbed white-matter integrity, and abnormal brain response during tasks requiring working memory. These abnormalities may represent early harm to neurons and other brain constituents from the neurotoxic effects of alcohol[97]. Chronic alcohol consumption has been shown to exert particularly deleterious effects on the functioning of episodic and working memory[98], which in turn impacts negatively on the learning of associations and on the acquisition of semantic knowledge[99]. Disturbingly, young drug users already have moderate to severe impairment in executive function – the higher-level cognitive abilities necessary for goal-directed behaviour, such as planning, decision-making, cognitive flexibility, problem solving and inhibitory control[100]. However, it is not clear if this is due specifically to drug use or to some pre-existing condition[101].

Heavy use of cannabis during adolescence may adversely affect frontal and hippocampal development. The few studies that have examined cognitive functioning in

92 Galvan et al. (2007)
93 Galvan et al. (2005)
94 Galvan et al. (2006); Paulus and Tapert (SR-E8) – see Appendix B
95 Hibell et al. (2004)
96 Paulus and Tapert (SR-E8) – see Appendix B
97 Ibid
98 Ambrose et al. (2001); Nixon et al. (1998)
99 Fama et al. (2004); Pitel et al. (2007); Ersche and Nutt (SR-E13) – see Appendix B
100 Bolla et al. (1998); Ersche et al. (2006); Rogers and Robbins (2001); Verdejo-Garcia et al. (2005)
101 Ersche and Nutt (SR-E13) – see Appendix B

cannabis-using adolescents report decreases in attention[102], learning and memory[103]. Neuropsychological studies of adults using cannabis heavily have found deficits[104], although most resolve within a month of abstinence[105]. Few studies have examined cognitive functioning in cannabis-using adolescents. Over an eight-year period, from ages 16 to 24 on average, greater use of cannabis predicted poorer attentional functioning[106], while short-term memory decrements showed evidence of persisting after six weeks of abstinence[107]. However, some studies report no correlations between cannabis use and cognition[108], and some abnormalities may predate cannabis use[109]. Abuse of amphetamines has been associated with impairment in the processing of feedback, which may cause difficulties in predicting outcome probabilities and decision-making[110]. In opiate users, by contrast, the impairment in the processing of feedback seems to be specific to feedback of negative inputs, such as errors and punishment[111].

Negative reinforcing cycles may limit the ability of drug users to benefit from treatment. This causes motivational difficulty in engaging in vocational activities and social functioning. Also, consequent impairment to learning and the processing of feedback (non-verbal cues, humour) is likely to have negative impacts on relationships[112].

Since there may be significant variation in susceptibility to drug and alcohol abuse within the UK population, as well as in the risk of adverse effects, it is important to consider the factors that may influence susceptibility and risk. Adolescents may be particularly susceptible to substance abuse because of neural and behavioural changes[113] as in the case of increased risk-taking, as discussed previously. Other conditions may additionally predispose them to substance abuse, such as mood disorders. Thus, it is not surprising that the concept of "negative emotionality" has been invoked as a risk factor for problems with substances, and has found empirical support by some[114] but not others[115]. In addition to familial risk, young people with affective disturbance, conduct problems, and neurotic or disinhibited personalities appear to be at risk for escalating substance abuse once initiated[116].

Concerning motivation and commitments to actions that might enhance mental capital, there is a growing body of evidence that habitual users of harmful substances, including not only illicit drugs, but also alcohol and tobacco, tend to display higher-than-normal rates of "delay discounting" (i.e. the undervaluation of future rewards or hazards)[117]. In general, this tendency transcends preference for any particular substances; for example, heavy smokers and alcoholics show enhanced delay discounting when offered

102 Tapert et al. (2002)
103 Millsaps et al. (1994); Schwartz et al. (1989); Paulus and Tapert (SR-E8) – see Appendix B
104 Pope and Yurgelun-Todd (1996); Solowij et al. (2002); Bolla et al. (2002)
105 Pope et al. (2001)
106 Tapert et al. (2002)
107 Schwartz et al. (1989)
108 Teichner et al. (2000)
109 Aytaclar et al. (1999)
110 Paulus et al. (2003)
111 Ersche et al. (2005); Yucel et al. (2007); Ersche and Nutt (SR-E13) – see Appendix B
112 Ersche and Nutt (SR-E13) – see Appendix B
113 Paulus and Tapert (SR-E8) – see Appendix B
114 Kilbey et al. (1992); Sher et al. (2000)
115 Teichman et al. (1989)
116 Paulus and Tapert (SR-E8) – see Appendix B
117 Reynolds (2006)

hypothetical and concrete monetary rewards. It remains unclear whether a high delay discounting rate is an enduring personality feature of people who are vulnerable to abusing harmful substances, or whether it is associated only with current substance abuse. Favouring the latter hypothesis are reports that reformed heroin users, long-term abstinent alcoholics and ex-smokers generally show 'normal' rates of delay discounting. A possible exception to this generalisation is cocaine abuse; it has been found that ex-cocaine users (abstinent for more than 30 days) showed abnormally high discounting rates that did not differ from those of active users[118].

When considering future trends and their implications, it important to note that fruitful prevention and intervention programmes for adolescent substance abuse may need to address factors associated with an increased risk for substance problems, such as treating pre-existing anxiety and depressive disorders, and perhaps even sub-syndromal presentations of these disorders[119]. Future studies will need to link these differences in symptom to genetic features on the one hand and behavioural or neural substrate differences on the other, in order to understand what puts youth at risk for substance abuse. Further studies are needed to examine neural, familial, and social factors that predict escalation and de-escalation of substance abuse and related problems; identify resiliency traits that can be accentuated by interventions; and determine risky populations and contexts at greatest need of interventions and policy change. For example, young people who are at risk may require safer settings for meeting peers, deriving the appropriate level of sensation and stimulation, increasing autonomy, and setting personal goals[120].

3.4 Social maladjustment and marginalisation

Factors throughout life can affect an individual's social adjustment and his or her mental and social capital. As an individual develops, self-image is crucially important and the formative stages of this process become most evident during adolescence. A recent study found that having a negative self-concept (high scores on self-hate, self-neglect and self-blame) was associated with both internalising behaviours such as depression and anxiety, and externalising behaviours such as delinquency and aggression[121]. The influence of others is particularly important, as can be clearly seen in drug or alcohol abuse. For an individual substance user, the transition from occasional use to abuse or dependence cannot solely be explained by genetic or shared environmental factors, but may arise from the effects of the peer and social context within which the drug is used[122]. Individuals growing up in substance-abusing families scored higher on neuroticism and had a higher rate of suicide[123].

A particular feature of adolescence is sensitivity to social reward. Adolescents report that they are most happy when talking with peers, and spend increasing amounts of time with peers and less time with their families[124]. Peer influence among adolescents is important, as young people develop into independent adults, but there are negative outcomes too. For example, it has been found that, while adults who commit crimes do so alone, most adolescent crimes are committed with peers[125]. This suggests that

118 Heil et al. (2006)
119 Judd et al. (1998)
120 Paulus and Tapert (SR-E8) – see Appendix B
121 Ybrandt (2008); Sebastian et al. (SR-E15) – see Appendix B
122 Lynskey et al. (2003)
123 O'Connor et al. (1995); Paulus and Tapert (SR-E8) – see Appendix B
124 Csikszentmihalyi et al. (1977)
125 Zimring (1998)

peer influence may contribute to teenage engagement in inherently risky activity (although it may also reflect the fact that teenagers spend more time with peers than do adults)[126].

There are two dimensions to social maladjustment and marginalisation: that which is felt by the person who is marginalised, and that which may be felt by those who see others as unacceptable. Focus groups with residents showed how exposure to anti-social behaviour (ASB) by adolescents can provoke a profound sense of powerlessness and lack of control over the social environment. This sense of powerlessness appeared to be both a consequence of ASB and a cause, as it increased the chances that worsening ASB would go unchecked. When talking about the causes of local ASB problems, respondents tended to provide explanations rooted in broader conceptions of social and cultural change. In one study, three main strands of thought or perspectives on ASB emerged, although these were by no means mutually exclusive or discrete:

1. Social and moral decline – ASB problems were seen as symptoms of wider social and cultural change, and more specifically a decline in moral standards and family values.

2. Disengaged youth and families – ASB was thought to be rooted in the increasing disengagement from wider society of a significant minority of children and young people and (in many cases) their families.

3. 'Kids will be kids' – ASB was seen as a reflection of the age-old tendency for young people to get into trouble, challenge boundaries and antagonise their elders[127].

It is clear that social maladjustment can generate a negative, self-reinforcing spiral, but equally there is evidence of a protective effect from social 'lifestyle components' against the threat to mental capital. The cognitively beneficial effect of having close, supportive family or a strong social network may act through health-related and physiological pathways or serve to encourage cognitive stimulation via increased contact and engagement[128]. It will be interesting to see what the impact is of the individualisation of entertainment, for example, each child having a television or gaming console in their own room, rather than participating in recreational activities in a (family) group.

Closely linked to the idea of social maladjustment is the concept of social marginalisation, where individuals or groups find themselves excluded from the mainstream of society. Maladjustment can lead to marginalisation, although there may be many reasons for marginalisation that are not the result of any maladjustment. Although marginalisation can affect all age groups, there is a strong tendency for some forms of marginalisation to have their origins during the years of adolescence, especially when this is coupled with a significant degree of maladjustment. The idea that the United Kingdom, the US and other western societies are witnessing the rise of an underclass of people at the bottom of the social heap, structurally and culturally distinct from traditional patterns of `decent' working-class life, has become increasingly popular and, if true, represents a substantial threat to mental capital. Cultures that are anti-work, anti-social, and welfare-dependent are said to typify this new 'dangerous class', and 'dangerous youth' are taken as the prime subjects of underclass theories. Debates about the family and single-parenthood, about crime and about unemployment and

126 Sebastian et al. (SR-E15) – see Appendix B

127 http://www.jrf.org.uk/knowledge/findings/housing/0305.asp

128 Deary and Gow (SR-E14) – see Appendix B

welfare reforms have all become embroiled in underclass theories which, whilst highly controversial, have gained currency in the United Kingdom and the US[129].

Gender differences in social behaviour have been well documented during the adolescent years. For example, young adolescent females are reported to be much more likely to use social aggression, such as ostracism during interpersonal interaction[130] while males tend to use physical aggression, although recent trends suggest increasing physical aggression among females as well. Additionally, teenage girls who have a negative self-concept (high levels of self-hate, self-neglect and self-blame) are more likely to engage in internalising behaviours, i.e. depression, anxiety and withdrawn behaviour, while boys tend to engage in more outwardly aggressive externalising behaviours[131].

Efforts to intervene against the risk of social maladjustment and marginalisation among adolescents belong within the pastoral side of education, for example through anti-bullying and extra-curricular policies. Secondary school is often socially stressful, just at the time when the social brain is undergoing profound development. If schools can provide a more positive social environment at this important time, this may help to optimise the course of social development of the brain[132].

129 MacDonald (2007)

130 Williams et al. (2000); Cairns et al. (1989)

131 Moffitt et al. (2001); Roussos et al. (2001); Sebastian et al. (SR-E15) – see Appendix B

132 Sebastian et al. (SR-E15) – see Appendix B

4 Adulthood

4 Adulthood

This chapter considers the development and maintenance of mental capital in the years following adolescence, but before the onset of older age.

The important concepts of cognitive reserve and resilience are first discussed. Subsequent sections then consider the influence of factors that are particularly important to mental capital in adulthood: nutrition, exercise, stress and anxiety, social marginalisation, depression and chronic illness.

4 Adulthood

During adulthood, an individual's mental capital is deployed in a wide variety of contexts, including work, family, society and leisure. There are continuing threats to mental capital and wellbeing, which include drug and alcohol abuse, social marginalisation and maladjustment, stress, mental and physical ill-health. However, there are also continuing opportunities to enhance and further develop mental capital, for example through continuing education; social engagement; and learning from experience, including travel and recreation.

The need for continuing education is increasingly important to maximise the potential mental capital trajectory through life[133]. One reason for this is that the world of work is constantly changing at a rapid pace. In the future people will no longer be able to depend on a single career through life, and are likely to need to maintain flexibility to adapt or re-train[134]. The "use it or lose it" principle (in which an individual's mental capital is nurtured in order to protect against cognitive decline) will also be important. The consideration of policy interventions and other measures to incentivise individuals to build and nurture their own mental capital throughout life, and to ensure continuing education and support for such development, will be considered in detail in the final Project report.

4.1 Cognitive resilience and reserve

The concepts 'cognitive resilience' and 'cognitive reserve' describe two aspects of mental capital, which affect the maintenance of effective mental capital and mental wellbeing. Cognitive resilience can be defined as an individual's successful adaptation and functioning in the face of stress or trauma[135]. Cognitive reserve describes an individual's resistance to impairment in cognitive processes such as memory, reasoning and attention, which may arise as a consequence of brain pathology caused by injury, neuropsychiatric disorder, disease or the normal ageing process[136]. Cognitive reserve chiefly comes into play in older people but it is thought to have its origins in earlier life stages and will therefore be considered in this chapter (although it may also be relevant for childhood and adolescence).

Cognitive or psychological resilience is a relatively stable feature of personality that allows an individual to cope effectively with stress or adversity[137]. The salient aspect of cognitive resilience is the ability to reinterpret an adverse event to find meaning or opportunity. Active coping strategies involve adopting a problem-solving approach to a stressful situation, and this type of strategy (as opposed to passive approaches such as denial) has been associated with resilience in various contexts. A number of specific psychological characteristics have been associated with resilience. Studies of children raised in a variety of adverse situations have consistently revealed that successful adaptation is predicted by factors including high levels of intellectual functioning, strong attachment behaviour, optimism, altruism and active coping styles[138]. In adults who are employed in stressful professions (for example, military forces, fire-fighting, police),

133 See the Project report: Feinstein et al. *Learning through life: Future challenges;* (Appendix A refers)
134 See the Project report: Dewe and Kompier. *Wellbeing and work: Future challenges;* (Appendix A refers)
135 Elliott et al. (SR-E7) – see Appendix B
136 Barnett and Sahakian (SR-E4) – see Appendix B
137 Elliott et al. (SR-E7) – see Appendix B
138 Masten and Coatsworth (1998); Bell (2001)

resilience to stress is associated with group bonding, altruism and effective performance under stress. Other important psychological constructs related to resilient responses to stress and trauma include positive affectivity or optimism, cognitive reserve, cognitive flexibility and the development of coping strategies[139]. Religious coping and social support also confer resilience, and both social cooperation and inclusion or exclusion may be relevant to understanding how social support networks mediate resilience[140].

The biological basis of resilience has been investigated, for example, through brain imaging studies that have looked at responses to various emotional stimuli. These have identified the amygdala and regions of the medial prefrontal cortex as particularly important as mediators of responses to anxiety-inducing challenges. Normal hippocampal volumes in the face of severe stress and chronic post-traumatic stress disorder symptomatology may also be a marker for resilience. Neurochemical studies also suggest that high levels of particular brain compounds may serve as a biological marker for resilience to stress and trauma[141], and there have been suggestions that elevated levels of the hormone DHEA confer psychological resilience[142]. Despite these leads, there is still much work to be done to uncover the brain mechanisms underpinning cognitive resilience. However, if it is confirmed that cognitive resilience depends on top-down control of amygdala function by prefrontal cortical regions, it may become possible to strengthen resilience through pharmacological and non-pharmacological means, including cognitive behavioural or other psychological therapies and education[143].

The idea of cognitive reserve arose from the observation that people with similar amounts of brain pathology did not always experience dementia upon reaching advanced old age, and this tended to be predicted by variation in some indicator of 'reserve', such as education[144]. Although the concept remains somewhat controversial, it has attracted significant attention from neuroscientists and others. The controversy arises because the term tends still to be used vaguely and in different ways, and because its foundation in the brain is as yet unknown. One view is that the accumulation of 'reserve' must be over and above the level of healthy cognitive ability and add something definite to later cognitive function[145]. Using this definition, there is evidence that education and occupational social class do provide some cognitive reserve[146].

Cognitive reserve appears to be affected by environmental factors acting during adulthood. Recent evidence suggests that cognitive reserve is not fixed, and can be increased through physical or mental activity, social stimulation, and potentially also through medication or dietary interventions[147].

Cognitive ability and flexibility confer both cognitive reserve and resilience[148]. For example, high cognitive ability when young can protect against cognitive decline

139 Yehuda et al. (2006a); Barnett et al. (2006)

140 Elliott et al. (SR-E7) – see Appendix B

141 Yehuda et al. (2006b)

142 Goodyer et al. (2001)

143 Elliott et al. (SR-E7); Interventions to promote and enhance resilience specifically in childhood will also be considered in the final Project report; (Appendix B refers)

144 Stern (2002)

145 Richards and Deary (2005) p. 618

146 Staff et al. (2004); Deary and Gow (SR-E14) – see Appendix B

147 Barnett and Sahakian (SR-E4) – see Appendix B

148 Barnett and Sahakian (SR-E4); Elliott et al. (SR-E7) – see Appendix B

later in life. Although cognitive reserve can be manipulated in adult life, its development in early life may also be important. Studies from the 1946 British birth cohort[149] showed that both childhood IQ (measured at age 15) and adult verbal ability (measured with the National Adult Reading Test at age 53) were negatively correlated with decline in memory and processing speed between ages 43 and 53 years. These relationships were independent of the effects of educational attainment and social class and suggest that the protective effect of ability can either arise during childhood or be attained during adulthood[150]. Educational attainment may also confound any association, although it is frequently used as a proxy for prior ability. This is insufficient as educational attainment is not only predicted by childhood ability (both of which will partly determine later occupational attainment) but it also adds unique, independent variance to cognitive ability in later life and is thus cited as a cognitively protective factor[151].

4.2 Nutrition

Nutrition is important at all stages of life and we have observed that inadequate foetal nutrition can have long-term adverse consequences for health generally. Appropriate nutrition is also important during childhood and adolescence to ensure on the one hand that sufficient energy and raw materials are available for growth and on the other that an individual is not launched on the path to obesity. However, provided these extremes are avoided, and as long as essential nutrients (including vitamins and other micronutrients) are available, there is little evidence that nutrition makes a specific contribution to brain development and to the acquisition of mental capital[152]. Where nutrition does appear to be important, however, is through its impact on long-term trajectories of health in adulthood and into old age. This is consistent with current understanding of the biological mechanisms underpinning the ageing process, which indicates that ageing is driven by the gradual, lifelong accumulation of a wide variety of molecular and cellular faults[153]. The growing evidence for intrinsic malleability of this process, which is operative throughout the lifecourse, supports the idea that adverse nutritional factors (e.g. excess sugars and fats) accelerate the build-up of damage, whereas beneficial factors (e.g. fruits and vegetables) support the working of the body's natural protection against damage accumulation. Although it is never too early to adopt healthy eating preferences, it is during adulthood (the longest phase in the life history) that such choices may be most important.

Dietary and nutritional factors have been implicated in conferring protection from ageing of cognitive abilities; fish, vegetables, and fish oil supplements being reported to be helpful in some single observational studies[154]. However further replication is required, not least because of possible reverse causation (people of higher cognitive ability tend to take supplements). The epidemiological evidence linking specific nutrients (i.e. n-3 polyunsaturated fatty acids, B vitamins and antioxidants) to cognitive health is presently inconclusive. Studies aimed at assessing the potential effects of the intake of dietary fat on cognitive function have focused on n-3 polyunsaturated fatty acids (n-3 PUFA). The reason for this interest arises because docosahexaenoic acid [22:6(n-3)] (DHA) is the most abundant n-3 PUFA in the mammalian brain. DHA

149 Richards and Deary (2005)
150 Barnett and Sahakian (SR-E4) – see Appendix B
151 Staff et al. (2004); Deary and Gow (SR-E14) – see Appendix B
152 Ordovas (SR-E18) – see Appendix B
153 Kirkwood (2005), (2008)
154 e.g. Whalley et al. (2004); Morris et al. (2005), (2006)

supplementation during pregnancy seems to have a beneficial effect on cognitive development of pre-natal and pre-term infants, but not for term infants or older children. In later life, the current evidence suggests some protective effect of n-3 PUFA against dementia. However, until more data from randomised trials become available, there is insufficient evidence to support the use of dietary or supplemental n-3 PUFA for the preservation of mental capital[155].

Studies of dietary antioxidants have focused in particular on vitamin E, with specific interest in its protective role against mild cognitive impairment (MCI) and Alzheimer's disease (AD). Epidemiologic data lend some support for this role when vitamin E is derived from food rather than from supplements[156].

The B vitamins, namely vitamins B6, B12 and folate, are more clearly involved in traits related to cognition. Vitamin B6 is involved in the regulation of mental function and mood, and there is some evidence that deficiency of vitamin B12 contributes to age-associated cognitive impairment. However, the value of B vitamin supplementation is unproven, with most studies showing no evidence of benefit of supplementation on cognition[157]. However, sub-clinical folate deficiency may represent a risk factor for the cognitive decline associated with ageing that could contribute to AD as well as other dementia development. In susceptible individuals, supplementing the diet with folic acid can significantly improve cognitive functions that decline with age.

It remains unresolved why specific nutrients (i.e. n-3 PUFA, folic acid, vitamin E) show little or no benefit in supplementation trials, except where there is clear deficiency, and yet a higher intake of most "healthy" food categories, including those eaten as part of a Mediterranean diet, are associated with better cognition[158]. Presumably such nutrients need to be consumed in the food matrix or within the synergy of a healthy dietary pattern. Conversely, for some food categories (i.e. refined sugars, high cholesterol and trans fats) higher intake results in lower cognitive scores[159].

In the absence of more specific understanding, the importance of good or appropriate general nutrition should be emphasised. The 'healthy body and healthy mind' principle is apparent in the example of how deprivation and poor nutrition can be linked to poor cognitive wellbeing through biological stress and inflammation and metabolic syndrome[160]. Excessive consumption of dietary fat leads to increases in lipid metabolism, which lead eventually to obesity and other metabolic syndrome outcomes. Since ischaemic vascular disease and diabetes are strong predictors of cognitive function, it is not difficult to postulate indirect pathogenic connections between nutrition and cognition. However, there is emerging evidence that the relationship between nutrition, the pro-inflammatory state and cognitive wellbeing may be more intimate than initially thought[161]. People with obesity and type-2 diabetes exhibit a heightened inflammatory state and it is likely that the presence of diabetes or the pre-diabetic (insulin resistant) state accelerates the trajectory of cognitive decline with age. In a large US study[162] it was found that the combination of metabolic syndrome (which is associated with obesity and insulin resistance) and chronic inflammation

155 Ordovas (SR-E18) – see Appendix B
156 Ibid
157 Ibid
158 Scarmeas et al. (2006); Solfrizzi et al. (2007); Morris et al. (2006)
159 Engelhart et al. (2002b)
160 Packard (SR-E17) – see Appendix B
161 Ibid
162 Yaffe et al. (2004)

identified those who exhibited the greatest decline in cognition in a population of ostensibly healthy older adults.

If the link between poor nutrition and cognitive outcomes is mediated by inflammatory mechanisms, the effect of deprivation on cognitive wellbeing can be understood. Most studies which have examined the relationship between deprivation and inflammatory markers report raised levels of cytokines such as CRP, IL-6, cellular adhesion molecules and MCP-1 in populations of lower socioeconomic status (SES) as determined by educational achievement or income. There are a number of potential explanations as to why deprivation leads to heightened chronic inflammation. It is envisaged that stressors acting throughout the lifecourse can stimulate the innate immune system to adopt a more aggressive stance[163]. Future research avenues may, in due course, also yield insights into individual response to diet (gene-diet interactions[164]).

4.3 Exercise

Like nutrition, exercise is another factor that exerts an influence across the entire lifecourse but which merits particular attention during adulthood. Concerns about increasingly sedentary habits of children and adolescents are of course important, particularly when these are compounded with over-eating. It is also arguable that developing a habit for exercise in youth is essential for maintaining exercise in adulthood and later life. However, the evidence is strong that even when exercise is compulsory in schools, the great majority of individuals on attaining adulthood greatly reduce their exercise levels.

Again, as for nutrition, there is evidence that exercise is generally protective against the accumulation of molecular and cellular damage that leads eventually to degenerative diseases and therefore it is during adulthood that exercise is of particular importance. Following on from the holistic 'healthy body, healthy mind' discussion above, there are general grounds to expect that exercise should have positive effects of mental capital and cognitive wellbeing. In adults, physical activity is positively associated with enhanced cognitive function and its maintenance, particularly in groups of individuals vulnerable to the loss of independence and cognitive decline. In particular, in middle-aged and elderly subjects, cross-sectional and longitudinal studies consistently show that exercise slows or prevents age-related cognitive decline and is associated with a lower risk of AD and other types of dementia. Interestingly, this contrasts with the situation in children and adolescents, for whom evidence of an association between physical activity and cognitive function is more limited[165]. This raises the interesting possibility that although much attention has been directed towards the promotion of exercise in schoolchildren, a greater impact on the development of their mental capital might actually result if this attention were directed instead at getting their parents and teachers to exercise.

Longitudinal observational studies have shown that in adults physical activity appears to protect against cognitive decline[166]. Again, such studies may be confounded by volunteer characteristics, unmeasured personality influences, and reverse causation. The stronger evidence therefore arises from studies where individuals are randomly assigned to a fitness intervention or a control condition, and the cognitive effects are

163 Packard (SR-E17) – see Appendix B
164 Ordovas (SR-E18) – see Appendix B
165 Hendrickx and van der Ouderaa (SR-E24) – see Appendix B
166 Studenski et al. (2006)

subsequently assessed. Colcombe and Kramer[167] performed a meta-analysis of 18 such studies, comprising nearly 200 older individuals who undertook cognitive testing both before and after a fitness programme. Fitness training was found to have robust effects on cognitive function, but these were relatively selective, with the largest improvements found in executive control processes. The effects appeared larger in women and in 'middle old' individuals aged 66 to 70 years[168].

The greatest cognitive effects after fitness training were seen in executive control tasks (e.g. planning, working memory, being able to focus in face of distractions). Brain imaging data revealed that the improvement in cognitive function was accompanied by structural changes in the brain. Physical activity may influence brain structure and function through various cellular and molecular mechanisms, including vascular benefits, increased neurogenesis and neuronal plasticity[169].

With respect to physical activity, there is evidence that it need not be particularly vigorous (walking, for example) in order to offer protection of mental capital[170]. Since vascular disease has been linked to cognitive decline, increased physical activity may affect cognitive outcomes in later life via a reduction in vascular risk factors (such as hypertension) and vascular disease[171]. There may also be a direct effect of physical activity on brain physiology by facilitating neurogenerative, neuroadaptive, and neuroprotective processes[172].

Epidemiological data provide strong evidence to support the notion that regular exercise protects against the development of depressive symptoms. Similarly, there is promising preliminary evidence for the use of exercise programmes in the treatment of anxiety[173]. The mechanisms through which exercise contributes to wellbeing may be psychological (by increasing self-confidence and distracting from negative emotion) as well as physiological (for example, by correcting dysregulation of central monoamines involved in depression, and by promoting resistance to stress and stressors)[174].

Although exercise-based interventions appear very promising for the maintenance of both mental capital and mental wellbeing, not enough is yet known about optimal parameters of physical activity. For example, what type (aerobic or anaerobic), frequency, intensity and duration of exercise are most appropriate? Also, a largely unaddressed major challenge is how to achieve change in the general population so that exercising becomes a sustained behaviour.

4.4 Stress and anxiety[175]

Stress occurs when an individual experiences a challenge to his or her internal or external balance[176]. A stressor can be physical (e.g. heat, hunger) or psychological (e.g. work overload, threat of violence), and acute or chronic. Individuals differ in their

167 Colcombe and Kramer (2003)
168 Barnett and Sahakian (SR-E4) – see Appendix B
169 Hendrickx and van der Ouderaa (SR-E24) – see Appendix B
170 Weuve et al. (2004); Yaffe et al. (2001)
171 Hendrie et al. (2006)
172 Dishman et al. (2006), p. 345; Deary and Gow (SR-E14) – see Appendix B
173 Hendrickx and van der Ouderaa (SR-E24) – see Appendix B
174 Ibid
175 For further consideration of stress, anxiety and other mental disorders, see Project reports: Jenkins et al. *Mental health: Future challenges;* Dewe and Kompier. *Wellbeing and work: Future challenges;* (Appendix A refers)
176 De Kloet et al. (2005); McEwen (1998)

perception of the stressor, in how they respond to it, and in how it affects them. In general, there is a marked biological response to stress involving activation of the hypothalamus-pituitary-adrenal (HPA) axis and of the sympathetic nervous system (SNS), leading to release of 'stress hormones' (glucocorticoids).

As mentioned earlier, exposure to stress can occur prenatally and in childhood. Such early stress exposure is associated with specific effects leading to impaired cognitive and intellectual performance in later life[177]. However, stress is also very much a feature of adult life, and the way in which an individual is exposed and reacts to stress has major implications for mental capital and mental wellbeing.

For those who are exposed to chronic stress over extended periods of time (for example shift workers, aircrew, soldiers), there may be cognitive deficits in several domains (for example, working memory and declarative memory[178]), which can be explained by overexposure to glucocorticoids, which in nature, would normally be experienced only transiently. The extent and potential reversibility of these negative effects is as yet mostly unknown. In animal studies, it is observed that chronic stress induces long-term changes with the hippocampus undergoing some degree of atrophy, whereas the amygdala become hypertrophic. Thus, in the animals, the balance between brain regions involved in cognition is altered by chronic stress, with the "analytic" cognitive functions that are mediated by the hippocampus and prefrontal cortex being impaired and the "affective" fear-related functions that are mediated by the amygdala being enhanced[179].

Stress can also be experienced in relation to perceived social status or hierarchy. This is evident in the well-established links between SES and health, only a small portion of which can be ascribed directly to SES-related differences in lifestyle. Evidence is increasingly suggesting the importance of psychosocial factors; for example, "feeling" poor may be at the core of why being poor leads on average to worse health outcomes. Studies in animals that explore the influence of social hierarchy suggest that poor health arises directly from exposure to stress and point to physiological mechanisms (e.g. glucocorticoids) that might be involved. Animal studies show that neurological changes in brain structure and alterations in the neurochemistry of anxiety can occur in animals that are socially stressed by their low position within dominance hierarchies for prolonged periods. Furthermore, in a study of humans exposed to long-term stress through functioning as carers of family members with chronic disabling disease, it was found that telomeres (the protective tips at the ends of the chromosomes) were prematurely shortened[180]. This discovery has the potential to be profoundly significant since progressive telomere shortening is associated with the gradual, underpinning processes of biological ageing, and several studies have linked prematurely shortened telomeres with increased risk of mortality and a range of age-associated diseases.

Whether the effects of exposure to stress alter in later life, and whether the physiological changes are due more to stress or to 'normal' ageing processes is unclear. Increases in basal cortisol levels occur during ageing[181] and, in older adults, correlations have been reported between elevated cortisol levels and cognitive impairments[182].

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177 Meaney et al. (1991); Vallee et al. (1999); Brunson et al. (2005)

178 see Cho et al. (2000); Cho (2001); Morgan et al. (2006)

179 Wolf and Buss (SR-E20) – see Appendix B

180 Epel et al. (2004)

181 Lupien et al. (2005); Van Cauter et al. (1996)

182 Kalmijn et al. (1998); Karlamangla et al. (2005); Lupien et al. (1994); MacLullich et al. (2005)

Interventions to mitigate the adverse effects of stress include strategies to alter psychological stress and to provide social support which can confer resilience to stress. Pharmacological treatments include beta blockers to aid memory retrieval and the 11beta-HSD inhibitor carbenoxolone to improve memory in older men and in older patients with type 2 diabetes[183]. An interesting dimension of the relationship between SES and health is the emerging body of evidence on the impact of housing quality on stress[184].

The term "anxiety disorders" refers to a collection of mental syndromes characterised by abnormally high levels of distress and avoidance associated with scenarios perceived as dangerous. Anxiety disorders affect approximately 7% of adults (4% anxiety, 2% phobias and 1% panic disorder), and a further 9% are affected by a non-specific common mental disorder group termed 'mixed anxiety-depression'. Together these exert profound effects on health and wellbeing[185]. These conditions typically arise early in life, often persist over time, and prospectively predict high risk for many serious mental syndromes, particularly major depressive disorder (MDD), as well as medical illnesses, such as cardiovascular and respiratory disease. When they are established, anxiety disorders have profound effects on function, causing great damage to mental capital and wellbeing through their effects on work or school performance as well as their impact on social relationships[186].

Anxiety disorders include specific phobias such as social anxiety disorder with predicted high risk for MDD; post-traumatic stress disorder (PTSD); panic disorder which can develop into agoraphobia; separation anxiety disorder; general anxiety disorder; and obsessive-compulsive disorder (OCD). Adult anxiety disorders typically develop in individuals who have suffered anxiety in childhood although most children with anxiety disorders remit without becoming anxious as adults. Anxiety disorders in adults generally exhibit some waxing and waning in severity.

Clinical anxiety, described by changes in brain structure and functional imaging, suggests dysfunction in cognitive processing by the specific neural circuitry for anxiety that encompasses the amygdala, ventral prefrontal cortex, and striatum. Anxiety disorders and mood problems can be a risk factor for substance abuse, which can then contribute to further problems. In one epidemiological study[187], about 22% of subjects who reported substance abuse also had a mood disorder, and one third of these individuals reported that the mood disorder occurred prior to substance abuse. Similarly, of the 20% of substance users found to have an anxiety disorder, 60% were found to have the anxiety disorder prior to substance use.

4.5 Social marginalisation

Social marginalisation arises voluntarily (for example new age travellers or certain religious sects) or more often by exclusion or discrimination of groups or individuals, for example, by race, gender, age, disability, social class, educational status, SES, poverty, and changing labour markets. Those who are marginalised can experience lack of access to economic, educational or social support, which can affect mental capital if opportunities are limited to develop and maintain cognitive and emotional abilities.

183 Wolf and Buss (SR-E20) – see Appendix B

184 Dunn (SR-E27) – see Appendix B

185 See Jenkins et al. *Mental health: Future challenges*; Appendix B refers.

186 Pine et al. (2008); Pine and Leibenhuft (SR-E12) – see Appendix B

187 Wittchen et al. (1992)

Effects on mental wellbeing include stigmatisation, feelings of shame, hopelessness, victim mentality, stress, lack of control, loss of self-confidence, and low expectations. Social marginalisation can be a dynamic state, changing at different life stages. For example, children and young people may be less marginalised as they become older, and older people more marginalised as they age.

People who are marginalised have relatively little control over their lives and the resources available to them; they may become stigmatised and are often at the receiving end of negative public attitudes. Their opportunities to make social contributions may be limited and they may develop low self-confidence and self-esteem. If, for example, they do not have work and live with service supports, they may have limited opportunities for meeting with others, and may become isolated. A vicious circle is set up whereby their lack of positive and supportive relationships means they are prevented from participating in local life, which in turn leads to further isolation. Social policies and practices may mean they have relatively limited access to valued social resources such as education and health services, housing, income, leisure activities and work. The impacts of marginalisation, in terms of social exclusion, are similar, whatever the origins and processes of marginalisation, irrespective of whether these are to be located in social attitudes (such as towards impairment, sexuality, ethnicity etc.) or social circumstance (such as closure of workplaces, absence of affordable housing etc.).

4.6 Depression

Depression is one of the most common mental disorders seen in community settings[188]. It is characterised by a persistent and significant change in mood state that most individuals describe as different in quality or quantity to their previous reactions to negative events or experiences. Depression is a major public health problem[189] and its epidemiology and risk factors are addressed in more detail in another Project report[190].

It is clear that depression has major adverse effects on mental capital and wellbeing. Aspects of the symptomatology of primary depression can be characterised in terms of reinforcement deficits[191]. Lewinsohn et al.[192] suggest that depressed patients may show either a reduced capacity to experience reward or a reduction in reward-seeking behaviour, or both. There is some evidence that this group has deficits in gambling-type situations[193]. Elliott et al.[194] have argued that depressed patients may fail to use normal motivational cues to modify performance on complex tasks[195]. The symptoms of depression may directly or indirectly lead to reduced productivity (due to lack of concentration and slowed functioning) and impaired social functioning (due to social withdrawal and reduced ability to communicate). These consequences along with the negative thinking associated with depression may be associated with loss of confidence and reduced self-esteem and can lead to further impairment in work functioning and disturbed relationships with work colleagues and family members[196].

188 McKeith and Scott (SR-E21) – see Appendix B
189 Greenberg et al. (1993)
190 See Jenkins et al. *Mental health: Future challenges*; Appendix B refers.
191 Lewinsohn et al. (1979); Murphy et al. (1998)
192 Lewinsohn et al. (1979)
193 Pacini et al. (1998); Must et al. (2007)
194 Elliott et al. (1997)
195 Elliott and Deakin (SR-E2) – see Appendix B
196 McKeith and Scott (SR-E21) – see Appendix B

Overall, depression is a major cause of reduced quality of life. In many individuals reduction or amelioration of symptoms does not immediately restore the individual to their pre-morbid level of functioning, and so impairments may persist even when the person is no longer regarded as meeting criteria for a depressive episode.

In addition to its effects on individuals, depression brings substantial economic costs to society, where the direct health care costs are dwarfed by the indirect costs[197]. For example, in a study of depression in Manchester[198], total service costs during six months were about £425 per person, but lost productivity costs due to morbidity were on average £2,575 per person. Days lost from work due to depression exceed all other disorders and on average individuals reporting depression are estimated to lose 22 workdays per annum compared with 4-6 days for non-depressed individuals plus impaired performance even when attending work[199]. When taken as a whole, the UK Health and Safety Executive has estimated that 5-6 million days are lost because of depression.

The trends for the future look bleak as the prevalence of depression seems to be increasing and the nature of work is changing with some potentially negative impacts on mental wellbeing. As the nature of work changes towards a 'knowledge economy', the 'happiness paradox' shows that people may be wealthier but are less happy. Investments in improving the early identification and treatment of depression are essential for economic development[200].

4.7 Chronic illness

Long-term limiting illness and disability, such as chronic pain, also have significant detrimental effects on mental capital and wellbeing. Chronic conditions are expected to become the main cause of death and disability in the world by 2020, contributing around two thirds of the global burden of disease with enormous healthcare costs for societies and governments[201]. In the UK, every week, nearly 3,000 people enter long-term incapacity due to ill-health[202]. Currently, 5% of the working-age UK population is unemployed and 7% unable to work through long-term illness or disability[203]. The most common chronic diseases in the UK, as illustrated by a comprehensive assessment in Easington and Sedgefield within North East England, are musculoskeletal problems (back pain, arthritic or joint trouble), heart disease and mental health problems (particularly depression, stress and anxiety). These conditions together account for 60% of long-term sickness[204].

For those in work, there is evidence that prevalence, frequency and duration of sickness absence cannot be explained by medical reasons alone. Risk factors for such absence include social deprivation, increasing age and, to a lesser extent, gender[205]. Apart from severe and progressive illnesses (such as cancer and severe mental disorder), mild mental disorders are particularly associated with claimants developing longer-term sickness absence. Relatively few of these long-term claimants ever return to paid employment. For claimants with the largest diagnostic group of mild mental

197 Berndt et al. (2000)
198 Goldberg et al. (1996)
199 Lepine et al. (1997)
200 McKeith and Scott (SR-E21) – see Appendix B
201 Epping-Jordan (2001)
202 Health Service Journal (2004)
203 Brown (2004)
204 Brown (2004)
205 Shiels et al. (2004)

disorders, additional risk factors for chronic incapacity are age, addiction and social deprivation. Within the second largest group (musculoskeletal problems), while age increased risk, older back pain sufferers tended to return to work earlier. The study by Shiels et al.[206] identified groups at risk of long-term incapacity from potentially reversible conditions who might benefit from interventions to enable them to recover and return to work. The authors suggested that a substantial proportion of the patients with mild mental problems (accounting for almost 40% of sickness absence) might fall into that category. The importance of chronic illness as a source of social incapacity does not stem from changing epidemiological incapacity. Rather, it can be attributed to pressure to reduce the number of people claiming unemployment benefit during the 1980s and 1990s with many transferring to incapacity benefit. There is a strong case for arguing that much of this incapacity is iatrogenic and a product of political pressures on the benefits system (similar shifts occurred in Sweden, but not the US).

Limiting long-term illness can have a serious effect on employment, in terms of both sickness absence and the reduced ability to get work, raising problems for both employer and employee. In addition to the costs of any benefit payments made, there is a significant wastage of mental capital and an increased threat to mental wellbeing. In addition to the direct costs of chronic illness, there are also significant indirect costs for carers of those who are ill.

The Sedgefield Expert Patient pilot[207] is an example of a successful self-management intervention for chronic illness which also illustrates the importance of social support in building self-efficacy and wellbeing. Amongst the participants, arthritis and back/neck injury/pain were the most commonly suffered conditions, followed by anxiety/depression then asthma/bronchitis and diabetes. The evaluation shows the scheme to have been extremely successful so far in improving the mental wellbeing of the patients. 98% of participants felt the course provided them with skills to manage their condition more confidently and all felt they had made new friends through the scheme. 89% felt better able to cope, and 93% felt they were more in control of their condition. An important point about the Sedgefield Expert Patient programme is that it offers a continuing support service for patients who complete it. The social group formed has recently also voted to become constituted so that it can apply for funding. This empowerment is itself a valuable outcome.

206 Shiels et al. (2004)
207 Brown (2004)

5 Older people

5 Older people

Chapter 5 considers older people: an increasingly important group in society due to the demographic age shift.

Two principal challenges are considered: how to maximise and preserve the mental capital in older people; and how to unlock the considerable resource of that capital, so that the greatest benefit results for the individual and for society.

5 Older people

The demographic age-shift in the population means that older people will become an increasingly critical sector of the population in the future. There are two principal challenges. The first is how to ensure that the greatest numbers of older people maintain the best possible mental capital, and so preserve their independence and wellbeing – both for their own benefit, and also to minimise their need for support as they age. The second challenge is how to ensure that the considerable resource which older people offer (particularly through their mental capital) is recognised and valued by society, and that they have the opportunity to realise the maximum benefit from that, both for themselves and for wider society. Although the impacts of population ageing are most often seen negatively, in terms of a 'burden' of rising costs, an authoritative study of the costs and benefits of improving health[208] estimated the contribution to US economic wellbeing of the increase in life expectancy since 1970 to have been $73 trillion, or about $2.6 trillion per year. This is without significant exploitation of the intrinsic value of mental capital of older people during this period which, although hard to estimate, is likely to be considerable.

5.1 Changing expectations

The mental capital trajectory for older people inevitably involves some decline due to the negative impacts of the ageing process itself. However, the trajectory that is currently realised for the great majority of older people is well below that which is possible.

In the absence of specific diseases that impact on cognitive performance, the adverse effects of intrinsic ageing on memory and capacity for intellectual work are greatly exaggerated in the popular mind, as has been demonstrated repeatedly by psychological testing. The persistent negative stereotyping of older people by society, including many older people themselves, is responsible for a massive waste of mental capital in the later decades of life. These attitudes are beginning slowly to change although many older people still complain of being marginalised and 'on the scrap heap' of society.

There has been recent legislation to remove age discrimination in the workplace, although this will take some time for its full effect to be realised. Also, opportunities for continuing education in later life continue to be a low priority for funding compared with that for other age ranges (for example, for children in particular). This is despite the potential to continue growth and development of mental capital and wellbeing in older people. Revaluation of the under-utilised mental capital that is carried by older people has the potential to lead rapidly to novel opportunities for retraining, continued productivity and social engagement, which will have strong potential to enhance quality of life and to benefit the economy by reducing premature dependency.

Effecting change in the attitudes of wider society to older people is important and will be a challenge. However, without such change, there is likely to be little impetus to enhance and make full use of mental capital in later life. Indeed, the negative attitudes (ageism) prevalent among the old will also need to be addressed, since there is little reason to assume that simply experiencing a change of status will necessarily alter long-held beliefs. Nevertheless, it is widely expected that as the current generation

208 Murphy et al. (2003)

which is nearing retirement (the 'baby boomers') approach old age, they will carry forward something of the social confidence which they have displayed throughout the lifecourse to challenge current stereotypes to some degree, if only for reasons of self-interest.

The challenge of generating the necessary impetus for policy changes runs the risk, however, of falling prey to the same problem of future discounting that undermines the motivation of adolescents. The rewards from many interventions will be long-term and will become fully apparent only in the future, whereas the costs are incurred now when they may cause unpopularity for those who must make the commitments to invest. It is for precisely this reason that the lifecourse trajectory is so important. Since the vast majority of individuals in today's society will traverse the full extent of the lifecourse, from conception to advanced old age, investing in maximising the trajectory across all age groups will ultimately be to the equal benefit of all, even if for some those benefits may be a long way into the future.

5.2 Age-related cognitive and physical challenges

Studies such as the Newcastle 85+ Study[209] are revealing that many, even of the oldest, retain high levels of cognitive and physical fitness. However, the reality of ageing needs also to be recognised, together with the great variation within any age group. Intrinsic ageing, sometimes described as 'normal' ageing, has impacts on cognitive and physical performance and presents increasing risk for age-related frailty, disability and disease. Research into the underlying processes of ageing and age-related disease is now a fast-growing area of biomedical research, with increasing recognition of opportunities to connect our understanding of the science with social factors impacting on ageing trajectories[210]. This research is confirming the potential malleability of the ageing process, so that it is likely that in time there will be effective interventions to postpone and/or prevent a growing number of age-related conditions.

The specific cognitive disorders of ageing, such as the various forms of dementia, lie outside the scope of this report although inevitably there is some overlap and connection with the intrinsic processes of normal ageing[211]. In the case of cognitive functions, the normal ageing process is associated with relatively minor effects, chiefly a slowing in processing speed. The reality of such changes is clearly measurable, although their significance is generally exaggerated. For example, forgetfulness is seen in people of all ages, but when it occurs in anyone over the age of 50 it is attributed to age. Society is poor at making allowance for slightly slower cognitive rate, even though the result of performing a cognitive task by an older person may be just as good as that obtained marginally faster by a younger person, or even better if experience is called for. The marginalisation of older people often generates a lack of self-confidence, or even anxiety and depression, which can exacerbate any inherent decline in cognitive functions.

Interestingly, there is growing evidence that components of mental capital in early life may influence maintenance through adulthood and the timing of decline in old-age. Prior ability may itself be a predictor of the amount of cognitive change. Some evidence shows that people who begin with higher ability tend to decline less as they

209 Collerton et al. (2007)

210 For extensive discussion on this topic, see http://ageaction.ncl.ac.uk

211 Dementias are considered more fully in the Project report: Jenkins et al. *Mental health: Future challenges*. The final Project report also considers interventions to address these.

grow older[212]. Further research is needed to unpick the complex interrelationship between biological and psychosocial aspects of normal cognitive decline. Factors such as smoking, diet, manual/unskilled work and education all have impacts on cognitive ageing and are related also to socioeconomic status[213].

The extent to which genetic factors influence cognitive ageing is receiving considerable attention. If such factors are found to be significant, the results might in future help both to identify novel routes to therapy and identify those who may be in particular need of preventive measures. When seeking to identify genetic factors that influence the decline in the mental capital trajectory, the key is to discover genetic influences that are present in old age but not earlier. For example, possession of the E4 allele of the gene for apolipoprotein E contributed significantly to verbal reasoning ability in 79 year olds, but not to variance in the same test in the same sample at age 11[214]. There are reports of associations between cognitive change within old age and genetic variation in, for example, the serotonin transporter gene[215], PPAR-γ[216], CETP[217], and MPO[218]. Though small in effect, most of these genetic differences have plausible mechanisms through which they might influence cognitive ageing. However, in an area where effect sizes are small and human cohorts with the appropriate phenotypes are rare, there is, as yet, insufficient replication of any individual contribution except, perhaps, APOE, which has a well-established association with normal as well as pathological cognitive ageing[219]. There is a body of opinion that suggests that the increased variation in cognitive function as people grow older has its major roots in either environmental factors or in sources driven largely by chance. This is supported by a sophisticated study of ageing Swedish twins which showed that cognitive change within old age might have very little genetic foundation.[220] Further analysis[221] has suggested that sources driven by chance were probably the major influence, since shared environmental factors explained relatively little of the non-genetic variation. Nevertheless, some specific genes have been associated with mental capital traits related to resilience, anxiety disorders, depression and ageing.

Current research is addressing the underlying causes of cognitive changes with age. The contribution of white matter lesions to lifetime cognitive ageing is relatively large, and independent of prior cognitive ability[222]. Therefore, lessening the burden of white matter lesions, by finding and combating their determinants, is one direction of intervention. This includes hypertension and other vascular risk factors, such as diabetes[223]. Stress is also relevant since faster cognitive ageing is associated with greater evidence of chronic exposure to stress[224]. Although little studied, there are reasons for assuming that cognitive deficits in normal ageing and in chronic drug users share a similar neuropathology. The characteristic profile of cognitive deficits in older adults and in drug users is a lack of fine cognitive control, which is thought to be modulated by a

212 Richards and Deary (2005)
213 Deary and Gow (SR-E14) – see Appendix B
214 Deary et al. (2002)
215 Payton et al. (2005)
216 Yaffe et al. (2008)
217 Barzilai et al. (2006)
218 Pope et al. (2006)
219 Small et al. (2004)
220 Reynolds et al. (2005)
221 Ibid
222 Deary et al. (2003); Leaper et al. (2001)
223 Deary et al. (2003); Murray et al. (2005)
224 Seeman et al. (2001)

decline in dopamine neurotransmission[225]. Ageing is itself associated with a variety of biological changes which affect drug disposition and metabolism, and may alter physiological reactions to psychoactive substances[226]. For example, with ageing there is increased sensitivity and decreased tolerance to alcohol[227], and data on drug effects may soon become apparent as the number of older drug users is expected to rise significantly when the 'baby boomer' generation reaches retirement age[228], since this cohort has more drug misuse than any previous generation[229].

In older people, physical fitness (as measured by a combination of lung function, grip strength and walking speed) contributes to cognitive ability after adjustment for true prior ability[230]. The most proactive steps an individual can take to ensure cognitive vitality in later life are likely to include adopting cognitively-protective lifestyles, consisting of: concerted effort to reduce cardiovascular risk factors and disease; and increased activity and engagement. However, for the practical researcher and those wishing to develop and influence policy, the pressing and growing problem of cognitive ageing presents special challenges. Among these are the facts that: the assessment of change is technically difficult and demands unusually burdensome studies; most studies are observational; the influences in cognitive ageing are heterogeneous, demanding collaboration amongst biomedical, physical and social scientists; and some of the theoretical constructs in the field require further clarification[231].

5.3 Continuing education

In a society where the mental capital of older people is seriously undervalued, it is unsurprising that there has been little investment to date in providing other than recreational classes for older students and very little research on its utility with regard to mental capital trajectories. Nevertheless, there are good grounds for supposing that such investments might be highly cost-effective. In the current educational model, in spite of increasing attention to the principle of lifelong learning, the great majority of those entering older age will have had little education since attending school many decades earlier. The changing nature of both work and society means that in order to realise the potential value of the aggregate mental capital that is held by this age group, specific training in current transferable and specific skills (for example, IT) might be highly effective. Furthermore, in an era when a growing fraction of retail and leisure activity, including self-education, is conducted via the internet, such training is likely to increase social connectedness and generate new opportunities for taking up business or volunteering roles within society. Education also has important benefits in terms of mental (and physical) health by increasing an individual's sense of self-esteem, encouraging social interaction and activity[232].

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225 Braver and Barch (2002); Goldstein and Volkow (2002); Jentsch and Taylor (1999)

226 Mangoni et al. (2004); Turnheim (2003)

227 Dufour and Fuller (1995); Lamy (1987)

228 Patterson and Jeste (1999); Reinhardt (2000)

229 Boeri et al. (2006)

230 Deary et al. (2006b)

231 Deary and Gow (SR-E14) – see Appendix B

232 For further discussion of continuing education in older people, see Project reports: Feinstein et al. *Learning through life: Future challenges*; Jenkins et al. *Mental health: Future challenges*; Dewe and Kompier. *Wellbeing and work: Future challenges*; (Appendix A refers)

6 Enhancing mental capital

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In this chapter, new approaches are discussed which could be used in the future to enhance mental capital: to promote its acquisition, enhance its maintenance, and postpone its decline.

6 Enhancing mental capital

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6.1 Smart motivation

Understanding further the science of motivation and reward will be important for developing new ways to secure engagement of all generations in education. Particular challenges exist with respect to adolescents, where the long-term discounting of future benefits, particularly those which will accrue in old age, is a potent force. When US comedian Eubie Blake jokingly remarked on reaching the age of 100: "If I had known I was going to live this long, I'd have taken better care of myself", he was also touching on an important truth. With current trends in longevity, where UK life expectancy continues to increase at the rate of five hours a day, it is important that individuals are motivated to ensure that those five hours will be as good as possible, when they come to be needed. Programmes for education, social adjustment, and 'Positive Youth Development' (see above, section 3.1) have the potential to contribute strongly to this.

In this connection it may be noted that advertisers have invested considerable effort in analysing motivational structures, even to the extent of developing the concept of "neuromarketing", in which favoured brands elicit neuronal responses in the brain's reward circuitry. The logic for advertisers is that understanding human reward mechanisms will inform the development of better methods to sell products. These concepts also have (arguably more important) implications for health promotion and other public education campaigns[233], although it has to be said that at this stage many of the messages from this work remain largely speculative, rather than evidence-based.

6.2 Pharmacological cognitive enhancers

Some interest is being shown in potential pharmacological interventions to enhance cognitive performance, which may increase mental capital and wellbeing[234]. While substances such as caffeine are routinely used by the general population for exactly this purpose, there are obvious ethical dilemmas regarding the acceptability and safety of any widespread use of cognitive enhancing drugs[235]. Many substances show benefits to cognition in healthy volunteers[236] and evidence from neuroimaging studies suggests that they may act by inducing more efficient use of neural circuitry[237]. However, their long-term utility is currently unknown[238].

Pharmacological cognitive enhancers (PCEs) have been based on the understanding of neurochemistry and functioning of neurotransmitters. In view of the major scientific challenges and the issues around licensing PCEs for use in healthy individuals, most research to date has focused on improving the substantial cognitive impairment

233 Elliott and Deakin (SR-E2) – see Appendix B
234 Duka et al. (2007); Jones et al. (2007)
235 Turner et al. (2006)
236 For example, Turner et al. (2003)
237 Furey et al. (2000); Mehta et al. (2000)
238 Barnett and Sahakian (SR-E4) – see Appendix B

resulting from brain injury and neuropsychiatric disorders[239]. Current trends include broadening the application of already licensed drugs to additional conditions (for example, cholinesterase inhibitors developed for AD used in schizophrenia[240]; modafinil approved for sleep disorders, now applied to shift workers and sufferers of excessive daytime sleepiness). However, some PCEs treat memory and learning deficits, such as cholinesterase inhibitors for dementia. In a broader context, the intrinsic complexity of the system may necessitate a multi-drug approach, as multiple neurotransmitters are involved. Potential targets have also been examined for executive functioning and attention, but there may be unwanted side effects.

The application of PCEs to the general population is now increasingly being discussed as the effects of some cognitive enhancing drugs may be suitable for healthy individuals (e.g., modafinil[241]). The daily demands of contemporary life often entail fatigue, jet lag and even temporary sleep deprivation along with continuous stress. Such factors impair a wide range of cognitive functions, including attention, executive functions, learning and memory[242]. The use of PCEs could, in principle, increase mental capital in healthy individuals by helping them to overcome such stressors – even mild uncontrollable stressors can impair working memory functioning[243] and PCEs are increasingly being viewed as a viable means of coping with them[244].

Advocates of PCEs note that the use of stimulants in students is evident in North America[245]. In England, prescription rates of stimulants have almost doubled in the past decade[246]. Stimulants are used to improve concentration and alertness, and students use them to study longer and perform better during exams. However, in spite of some cognitive-enhancing abilities[247], stimulants may also have deleterious cognitive effects, a potential for abuse and even psychosis, thus precluding them from being considered good cognitive enhancers. Presently, effective PCEs with less potential for abuse are appearing on the market, such as modafinil, which can enhance attention and some aspects of executive functions in both sleep-deprived individuals as well as normal young adults[248]. While individual responses to PCEs vary considerably, research is elucidating factors predicting individual variations. Pharmacogenomics enables a more targeted approach, though the interactions between genes are largely unknown at present. As the particular mechanisms by which drugs influence cognition become better understood, they can be applied more effectively and better predictions made about those likely to benefit.

In spite of the considerable interest in some quarters in PCE research, there are several important concerns about these developments which need to be noted. Even with more research and understanding, the beneficial effect of PCEs to treat clinical disorders is uncertain and has to be considered carefully in relation to cost and unwanted side effects. The benefits of PCEs to the normal healthy population are debatable and there are still many unknowns. Public opinion is reluctant to accept performance enhancement in sport and whether or not this may be different in the

239 Morein et al. (SR-E9) – see Appendix B
240 Stip et al. (2005)
241 Turner et al. (2003)
242 Sapolsky (1998)
243 Arnsten (2000)
244 Morein et al. (SR-E9) – see Appendix B
245 National Institute on Drug Abuse (2007)
246 Parliamentary Office of Science and Technology (2007)
247 Barch (2004); Elliott et al. (1997); Mehta et al. (2000)
248 Turner et al. (2003); Morein et al. (SR-E9) – see Appendix B

realm of cognitive enhancement remains an open question. More fundamentally, cognitive function is likely to have been under intense pressure of natural selection to secure a high level of sustained performance. The suggestion that pharmacological intervention can improve this without adverse effects needs careful and critical evaluation. Alternative forms of enhancement, such as cognitive training or therapy, may be more suitable.

6.3 Cognitive training

Cognitive training seems to have a beneficial effect on some functions, but generally the benefits are limited only to the targeted domain. A single-blind randomised controlled trial in 2832 independently-living volunteers aged 65 to 94 years found that cognitive training improved the targeted cognitive ability over a two-year period compared with the baseline performance. However, the effects appear limited to the targeted domain, and there was no improvement in other cognitive domains[249]. A randomised trial involving extensive cognitive training in older people in a number of individual cognitive domains showed some improvement in cognitive functions specific to the mode of training, but not in others, and lasting up to five years[250]. To reap rewards from cognitive training programmes, these may have to be tailored to individual requirements due to a lack of transfer of the effects[251].

Cognitive training may be used to help drug users. Research has shown that cognitive training can ameliorate age-related under-activation in the prefrontal cortex in older adults[252] and in younger individuals when specifically instructed to use cognitive strategies[253]. Therefore, future research should explore whether cognitive training, as well as cognitive enhancing pharmacological agents, can likewise augment task performance in drug users[254].

6.4 The role of technology

To date, technology in the form of memory prostheses has focused on development of aids to enhance and address shortcomings and deficits in human cognition, action and communication – such as desktop and mobile computing technology mostly applied to work activities and information. Examples of the use of technology to prevent the waste of mental capital in everyday settings by use of cognitive memory prostheses may be divided into two application areas: (i) access to large repositories of personal data and records of personal experience – generally intended for cognitively unimpaired users; and (ii) the provision of information about future commitments and ongoing activities – generally intended for the support of cognitively impaired users as they go about their daily lives[255].

Technologies to aid access to personal data and experience include just-in-time information retrieval agents (desktop and wearable) and "life-logging" (the provision of continuous capture and access to personal experience through the use of wearable and portable computing devices). However, it is unclear to what extent such technologies can support episodic memory.

249 Ball et al. (2002); Barnett and Sahakian (SR-E4) – see Appendix B
250 Willis et al. (2006)
251 Fillit et al. (2002); Salthouse (2006); Deary and Gow (SR-E14) – see Appendix B
252 Logan et al. (2002)
253 Savage et al. (2001)
254 Ersche and Nutt (SR-E13) – see Appendix B
255 Olivier et al. (SR-E25) – see Appendix B

Technology for supporting daily activities includes timed reminders and cognitive support at specified intervals from telephone calls or Personal Digital Assistants, and support for deficits in executive function which manifest as problems in planning, sequencing and attentional control in everyday tasks. Non-technological interventions, such as "stimulus control", relying on associations between actions, or "visual cues" and training, have been used to help in cognitively impaired subjects. An extension of these external memory aids is the "Reality Orientation" approach which presents information on computer screens that are placed in prominent areas of the house. Looking to the future, substantial progress is still needed in developing these technological aids before they become truly integrated and seamless prosthetics.

Through the aggregation of sensory inputs and personalised models of human activity, such environments aim to monitor and reason about our behaviours, goals, and intentions. This can be used to facilitate access to information and communication channels and to control artefacts – through speech recognition, tangible interfaces and display technologies (spoken, haptic and visual) that are ubiquitously embedded in our environments. To realise this vision of "pervasive computing", significant advances are required in the underlying techniques by which the actions and intentions of users in everyday settings are recognised. These depend not only on future sensing technologies, but also on developments in probabilistic reasoning techniques[256] and the modelling and use of context[257]. To date, practical (i.e. deployed) cognitive prostheses have only utilised advances in pervasive computing to the extent that they either are deployed on hand-held devices or utilise wireless telecommunication infrastructure. However, a number of the research prototypes employ wider arrays of sensing and artificial intelligence technologies. This is more than a fortunate confluence, as the vision of pervasive computing is of a world in which the cognitive prosthesis is the very intelligent environment in which impaired and unimpaired people alike reside.

Although the impetus for many of these technological research projects has been to support those with severe cognitive impairment, it seems likely that the coming years will see a growing convergence between the development of multifunctional pervasive computing in support of everyday functions for cognitively normal individuals as well as for those who are impaired. Such a development, based on the principle that good design should be flexible in its application, would seem to have many advantages in promoting optimal mental capital trajectories through life.

6.5 Housing and the built environment

Although at first sight rather far removed from the concept of mental capital, the quality of housing and the built environment can have major effects. These apply across the lifecourse, although there are specific issues that relate to housing for older people, where simple failure of design can often impose premature and unnecessary restrictions on the individual's capacity to maintain independent and productive living.

For individuals, poor housing can lead to psychosocial stress, which in turn has negative effects on mental capital and wellbeing. People can express meaning and identity through their homes and it may be one of the few areas in which they have control. The home is a place for maintaining social relationships and the wider housing environment is important also for facilitating social interaction. For society, poor housing exacerbates the behavioural problems in the community. Poorer quality housing

256 Horvtiz et al. (1998); Pentland (1995)
257 Dey et al. (2001)

negatively impacts upon children's mental development, resulting in higher levels of stress hormones as well as behavioural problems[258].

In view of the importance of housing and the built environment, the present Project has commissioned a detailed study of its effect specifically on wellbeing. This has identified particularly important aspects and future trends[259]. It has also considered possible interventions in the physical environment that have the potential substantially to improve the wellbeing of older people[260].

258 Dunn (SR-E27) – see Appendix B

259 Cooper et al. (DR-2) – see Appendix B

260 See the final Project report for a discussion of interventions in the physical environment; (Appendix B refers)

7 Economic and policy implications

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In this chapter, a number of suggestions for further development and potential policy initiatives are identified. Given the wide-ranging nature of "mental capital through life", these are varied in nature and in disciplinary focus.

7 Economic and policy implications

In this chapter, a number of suggestions for further development and potential policy initiatives are identified. Given the wide-ranging nature of the core subject, mental capital through life, these are varied both in nature and in disciplinary focus. In general, the background work on which this report is based has highlighted that thinking in terms of mental capital and wellbeing has proved to be both challenging and innovative. The challenges come from the intrinsic complexity of an entity as central to an individual's life as mental capital. The innovation derives chiefly from the corresponding impetus that the concept of mental capital has provided, to think in more integrative ways than has generally been the pattern for discipline-based studies.

Underlying the consideration of economic and policy implications is a strong recognition that there are many important areas where the scientific knowledge and evidence base is incomplete; this is particularly the case for issues around ageing and older people, which have been under-researched to date. There is therefore a general implication that significantly more basic research needs to be undertaken across many of the areas of science relevant to the subject of mental capital through life. This will be particularly important where novel interventions are suggested, especially where the analysis of economic costs and benefits is necessary. In many instances, it is reasonably clear that likely gains from many interventions will relate to quality-of-life, the measurement of which is still in its infancy and the valuation of quality-of-life even more so. It is also important to recognise that quality-of-life is highly dependent on perspective: for instance, many older people self-report high quality-of-life in spite of functional limitations and health problems that would lead younger people to assign them a much lower quality-of-life score[261].

7.1 Research to promote basic understanding

These include:

- Longitudinal studies of adolescent alcohol use – there is clear evidence for an association of brain abnormalities with adolescent alcohol use, but the causality and direction of any causal link remain to be established[262].
- Future studies of symptom differences to identify and understand genetic factors and behavioural-neural substrates that predispose youth (or other subsets of the population) to drug and alcohol abuse and their damaging consequences[263].
- Better understanding is needed of processes underlying adolescent behaviour with a view to improving quality of education and pastoral care for young people and reducing their social marginalisation by law and medical professions: in particular, research on motivation and the factors underlying the discounting that leads to anti-social, risk-prone behaviours has significant potential to enhance the mental capital trajectory[264].

261 The present Project has considered measures of wellbeing for different stages of life – the results of this work will be reported in the final Project report.; (Appendix B refers)

262 Paulus and Tapert (SR-E8) – see Appendix B

263 Paulus and Tapert (SR-E8) – see Appendix B

264 Sebastian et al. (SR-E15) – see Appendix B

- Clinical trials are needed to evaluate effects of alcohol and drugs on healthy agers versus younger adults (comparative studies); there is a high level of alcohol abuse among older as well as younger sectors of the population and drug use among older people is likely to increase significantly as generations that have experienced significant drug use become older[265].
- Assessment of change in cognitive ageing needs to be multidisciplinary; to date research on cognitive ageing has been mainly focused on psychological tests of memory and executive functions. In order to understand how cognitive ageing develops and affects mental capital, a wider range of integrated, multidisciplinary studies needs to be undertaken[266].
- Nutrition: epidemiological evidence linking specific nutrients and health – randomised controlled trials on foods and dietary patterns (rather than supplementation) are needed, together with improved standardisation of instruments for testing cognitive function and health to facilitate comparison across studies[267].
- Better understanding of stress susceptibility factors: identification of genetic and environmental factors responsible for variation in susceptibility to stress are needed to allow more targeted approaches for people at risk for stress-related disorders and associated memory impairments[268].
- Research into effects of physical activity on cognition; there has been a rapid recent increase in the capabilities to investigate this potentially important area using physical activity monitors, brain imaging, genetic profiling and by exploring synergies with other lifestyle interventions[269].

7.2 Further work to engage, educate and change behaviour of the public

- How to achieve sustained behaviour change to maintain physical activity – one of the hardest problems is to generate sustained changes in lifestyle. This area needs to be subject to intensive, multidisciplinary study[270].
- Clear and objective information and education of the public about pharmacological cognitive enhancers: while research on PCEs is underway there needs to be a better-informed discussion of the potential for and desirability of such agents[271].
- Greater awareness and treatment of depression: the prevalence of depression at all ages is under-recognised and initiatives to improve awareness and treatment of depression have the potential for major economic and quality-of-life improvements[272].

265 Deary and Gow (SR-E14) – see Appendix B
266 Ibid
267 Packard (SR-E17) – see Appendix B
268 Wolf and Buss (SR-E20) – see Appendix B
269 Hendrickx and van der Ouderaa (SR-E24) – see Appendix B
270 Ibid
271 Morein et al. (SR-E9) – see Appendix B
272 McKeith and Scott (SR-E21) – see Appendix B

7.3 Topics relating to specific classes of interventions

- Cognitive reserve interventions: not only is more work needed to establish more firmly whether or not there is a neurological or psychological basis for 'cognitive reserve', but there then also needs to be a major effort to assess, through appropriate epidemiological studies or (preferably) trials, that interventions can enhance cognitive reserve[273].
- Quantification of changes in brain structure and functions (as well as maturation) related to interventions. There is some evidence that a variety of factors can affect brain development, especially during adolescence. However, most of this evidence derives from post-hoc data analysis, and there needs to be proof-of-principle of the potential to make interventions that can positively affect brain structure and functions[274].
- Prevention/intervention of adolescent substance abuse to treat pre-existing disorders: there is some evidence that substance abuse can exacerbate pre-existing mental disorders (for example, cannabis and schizophrenia) but there is insufficient evidence to show how far interventions can help to mitigate these effects[275].
- Early detection and treatment of Alzheimer's disease (AD). Although there is limited opportunity as yet to treat incipient or full-blown AD, early detection is a priority in order to be able to trial interventions at the earliest stages, when neuroprotection is most likely ultimately to be effective[276].
- More research into anxiety disorder therapeutics to facilitate remission: anxiety imposes a major toll on the mental capital trajectory. Research relating to drug and non-drug interventions are of particular importance[277].
- Development of future-sensing technologies and probabilistic reasoning techniques and modelling and use of context for development of technologies to facilitate/enhance mental capital (memory). Industry is beginning to recognise the potential of these areas of technology. However, there needs to be consideration about how to secure the most effective engagement between inventors and potential users, particularly groups such as older people or those with learning difficulties, who are often excluded from the design processes[278].
- Prospective studies of housing interventions on mental capital and wellbeing: the ways in which housing impacts on the mental capital trajectory appear to be of great importance but are, as yet, poorly understood. Studies are needed to address the impact of housing on executive function, stress biomarkers and socio-emotional wellbeing[279].
- Studies to provide evidence for the benefits of providing stable supportive housing for those with mental illness to reduce homelessness: technological and design opportunities exist in principle, to provide relatively low-cost solutions to providing more successfully supportive housing[280].

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273 Barnett and Sahakian (SR-E4) – see Appendix B
274 Paus (SR-E5) – see Appendix B
275 Paulus and Tapert (SR-E8) – see Appendix B
276 De Rover et al. (SR-E11) – see Appendix B
277 Pine and Leibenluft (SR-E12) – see Appendix B
278 Olivier et al. (SR-E25) – see Appendix B
279 Dunn (SR-E27) – see Appendix B
280 Ibid

7.4 The evaluation of costs and benefits

A crucial policy issue that will affect how successfully interventions can be developed to enhance mental capital through life is the question of how costs and benefits can be measured and accounted for across different agencies and government departments. This may be clearly seen in the context of depression, particularly as it affects older people. As described earlier, depression has high prevalence and imposes significant direct and indirect costs on the health service. It also has an important economic cost in terms of work and productivity lost for those who are still working. In the case of an older person, depression very often leads to social withdrawal and personal neglect (for example, malnutrition), which can result in adverse effects on mental capital and wellbeing and generate a downward spiral into ill-health and high-cost social and medical dependency.

One factor that is reported anecdotally to combat depression among older people is the opportunity to engage either in work or in educational activities, including health-related classes, such as yoga. To date, there appear to be few examples where an integrated economic assessment of the complex interrelationship of these various factors has been done. Such an analysis would, in this example, need to be informed by data on the numbers of students electing to engage in educational activities, the fraction that might be increasingly vulnerable to depression if denied such opportunities, the consequent costs of depression to health and social services, the risk of further exacerbation of health problems through behavioural modification secondary to depression and so on. These are complicated analyses but entirely within the capabilities of skilled teams of modellers who would need to combine expertise in economics, mental health, educational, psychological, health and social services research and biomedicine.

The example of depression is just one instance of the kinds of complex analytical models that will be necessary in order to conduct proper economic assessment of policies aimed at enhancing the mental capital trajectory. In the same way, an intervention aimed at improving motivation of adolescents will need to factor in a series of inter-connected consequences for schools, health and social services, work, policing, and so on. These are not insuperable challenges but they will require cross-departmental and cross-disciplinary collaborations of a kind not often encountered.

The cost-effectiveness of interventions is well illustrated in many contexts and one that is particularly relevant for older people was the introduction in Newcastle in 1991 (at the Royal Victoria Infirmary) of a specialist service for those suffering from unexplained falls[281]. Despite the significant costs of providing such a service, it was found that a considerable overall saving was effected. The Royal Victoria Infirmary was at variance by over 6600 bed days compared with other peer hospitals, and the degree of emergency activity for the relevant diagnoses (Healthcare Resource Groups data) was much less (35% versus 97%). The average length of stay for admitted patients was also shorter for Royal Victoria Infirmary than peers (2.4 versus 8.6 days), and acute length of stay at the Royal Victoria Infirmary was reduced from 10.9 days in 1990 to 2.7 days in 1999[282]. Even in this analysis, the only costs featured were direct health service costs. However, if other benefits had been factored into the analysis (such as work days saved, carer burden reduced, quality of life enhanced, etc.), the cost-benefit ratio could have been even more favourable.

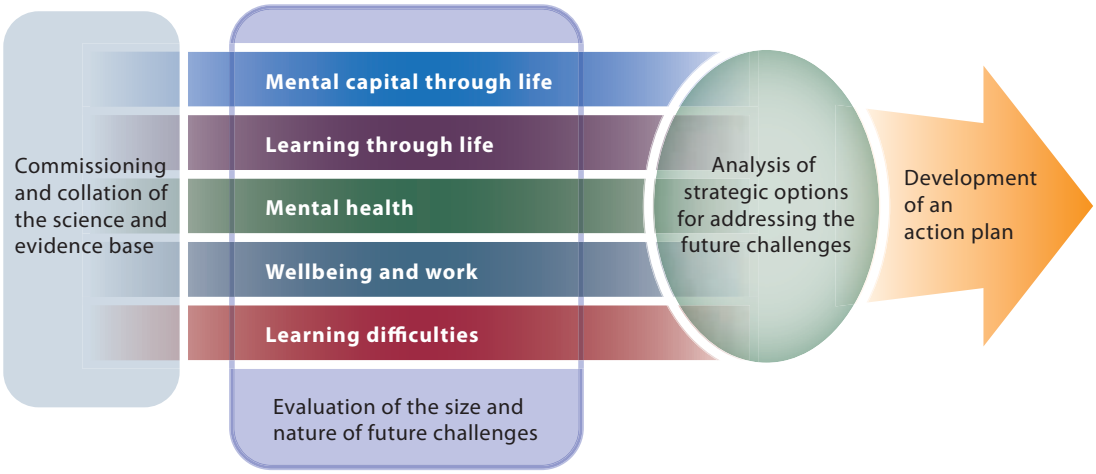
281 Kenny et al. (2002)
282 ICD 10 data

Appendix A: Overview of the work of the Foresight Project on Mental Capital and Wellbeing

The aim of the Project is to advise the Government on how to achieve the best possible mental development and mental wellbeing for everyone in the UK.

The principal parts of the Project are set out in Figure A.1 and are described below. Further information may be found on the Project website (www.foresight.gov.uk). All the Project papers and reports will also be made freely available through this website in October 2008 – either electronically or in hard copy.

Figure A.1: The principal parts of the Project



Analysis of future challenges

The starting point was to generate a vision for the size and nature of future challenges associated with mental capital and wellbeing, and to assess how the situation might change over the next 20 years. This analysis was predicated on the assumption that existing policies and expenditure remain unchanged. To make the analysis tractable, the work was divided into five broad areas, as indicated in Figure A.1. The present report documents the findings from one of these – Mental capital through life. Details of the reports of the five areas are listed in Table A.1 (overleaf).

Table A.1: The challenges ahead – reports of the findings		
Designation	**Title**	**Authors**
CR-E	Mental capital through life: Future challenges	T. Kirkwood J. Bond C. May I. McKeith M. Teh
CR-A	Learning through life: Future challenges	L. Feinstein J. Vorhaus R. Sabates
CR-B	Mental health: Future challenges	R. Jenkins H. Meltzer P. B. Jones T. Brugha P. Bebbington D. Crepaz-Keay M. Knapp
CR-C	Wellbeing and work: Future challenges	P. Dewe M. Kompier
CR-D	Learning difficulties: Future challenges	U. Goswami

The five areas were chosen to map closely onto the interests of important Government Departments, although it was recognised from the outset that the areas were interrelated. Therefore, consideration across the five has also been undertaken – the results of that cross-cutting analysis will be reported in the final Project report.

Supporting evidence and analysis

The above analysis was informed by:

- Consideration of the underpinning science associated with each of the five areas. This was informed by approximately 80 commissioned reviews – these set out the current state-of-the-art of science in diverse fields, and also scientific developments of particular interest (Appendix B provides a full list).
- Reviews of certain socio-economic factors. These were performed when the existing literature was deemed insufficient for the purposes of the Project. In particular, these reviews addressed the relationship of the physical environment to wellbeing, and the evolving use of information and communication technology (see Appendix B).
- Economic analysis. This has taken a broad view of the direct and indirect impacts of important issues – such as specific learning difficulties and mental health problems.
- Systems analysis relating to each of the five areas. An account of the Project systems work is being prepared in a separate Project report (see Appendix B; S1: Systems maps).

- The development of hypothetical future scenarios. These have been used to explore future uncertainty in the five areas (listed in Figure A.1), and to test the robustness of possible interventions. An account of the scenarios and their use within the Project will appear in a separate report (available through www.foresight.gov.uk).

In addition to the above, the work also drew extensively upon the existing literature as well as numerous workshops and meetings with leading stakeholder organisations.

Analysis of strategic options

Having identified important challenges for the future, the Project identified and analysed possible interventions and strategic options for addressing them. Here the analysis of possible costs and benefits has taken a lifecourse approach, recognising that interventions affecting today's children might affect them for the rest of their lives.

Consideration was also given to practicalities affecting the effective realisation of the interventions. For example, these included issues of ethics, governance and public attitudes.

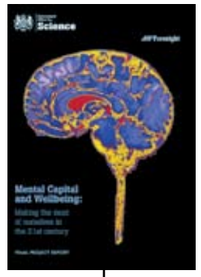
The results from this phase of the Project are presented in the final Project report.

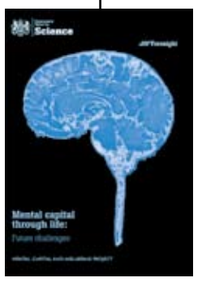
Stakeholder engagement

From the outset, the Project has involved a wide range of leading stakeholders from both the public and private sectors. The intention is to work closely with these to develop a comprehensive plan to take forward the findings of the Project. That plan will be announced at the time of the launch of the final Project report in October 2008.

Appendix B: Structure of the Project reports and supporting papers

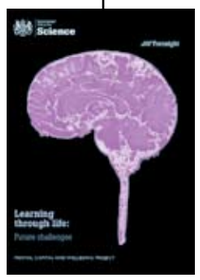
Mental Capital and Wellbeing: Making the most of ourselves in the 21st century
Final Project Report





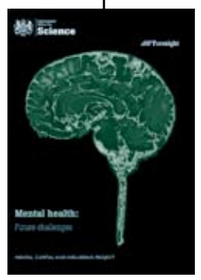
Mental capital through life: Future challenges

- **SR-E1:** *Neuroscience of education*
- **SR-E2:** *Human reward*
- **SR-E3:** *Neuroeconomics*
- **SR-E4:** *Cognitive reserve*
- **SR-E5:** *The adolescent brain*
- **SR-E6:** *Behavioural economics*
- **SR-E7:** *Resilience*
- **SR-E8:** *Adolescent drug users*
- **SR-E9:** *Pharmacological cognitive enhancement*
- **SR-E10:** *Stem cells in neural regeneration and neurogenesis*
- **SR-E11:** *Early detection of mild cognitive impairment and Alzheimer's disease: An example using the CANTAB PAL*
- **SR-E12:** *Anxiety disorders*
- **SR-E13:** *Neurocognition and social cognition in adult drug users*
- **SR-E14:** *Normal cognitive ageing*
- **SR-E15:** *Social cognition in teenagers – inclusion*
- **SR-E16:** *HPA axis, stress, and sleep and mood disturbance*
- **SR-E17:** *Nutrition, cognitive wellbeing and socioeconomic status*
- **SR-E18:** *Nutrition and cognitive health*
- **SR-E20:** *Effect of chronic stress on cognitive function through life*
- **SR-E21:** *Depression and its toll on mental capital*
- **SR-E22:** *Fitness and cognitive training*
- **SR-E24:** *Effects of exercise on cognitive function and mental capital*
- **SR-E25:** *Technology solutions to prevent waste of mental capital*
- **SR-E27:** *Housing as a determinant of mental capital*
- **SR-E29:** *Cognitive neural prosthetics*
- **SR-E31:** *Cellular and molecular logic of neural circuit assembly*



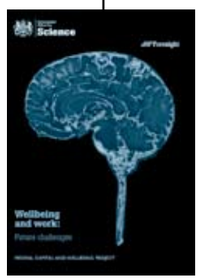
Learning through life: Future challenges

- **SR-A2:** *Learning at work*
- **SR-A3:** *Skills*
- **SR-A4:** *Participation in learning*
- **SR-A5:** *Evidence-informed principles from the Teaching and Learning Research Programme*
- **SR-A7:** *Estimating the effects of learning*
- **SR-A9:** *Self-regulation and executive function*
- **SR-A10:** *Lifelong learning across the world*
- **SR-A11:** *Non-cognitive skills*
- **SR-A12:** *Future technology for learning*



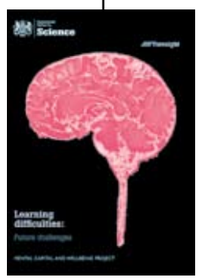
Mental health: Future challenges

- **SR-B1:** *Genetics and social factors*
- **SR-B2:** *Mental health of older people*
- **SR-B3:** *Positive mental health*
- **SR-B4:** *Mental disorders in the young*
- **SR-B5:** *Prisoners*
- **SR-B6:** *The homeless*
- **SR-B7:** *Children in local authority care*
- **SR-B8:** *The costs of mental disorders*
- **SR-B9:** *Serious and enduring mental illness*
- **SR-B10:** *Personality disorders*
- **SR-B11:** *Violence*
- **SR-B12:** *Ageing*
- **SR-B13:** *Migrants*
- **SR-B14:** *Substance abuse*
- **SR-B15:** *Depression*



Wellbeing and work: Future challenges

- **SR-C1:** *Workplace stress*
- **SR-C2:** *Mental wellbeing at work and productivity*
- **SR-C3:** *Management style and mental wellbeing at work*
- **SR-C4:** *Flexible working arrangements and wellbeing*
- **SR-C5:** *New technology and wellbeing at work*
- **SR-C6:** *Stress management and wellbeing*
- **SR-C7:** *Working longer*
- **SR-C8:** *Leisure: the next 25 years*
- **SR-C9:** *Training in the workplace*
- **SR-C10:** *Careers*
- **SR-C11:** *Violence at work*



Learning difficulties: Future challenges

- **SR-D1:** *Specific language impairment*
- **SR-D2:** *Dyslexia*
- **SR-D3:** *Adult learning disabilities*
- **SR-D4:** *Dyscalculia*
- **SR-D5:** *Deafness*
- **SR-D7:** *Genetics and diagnosis of learning difficulty*
- **SR-D8:** *Conduct disorder and anti-social behaviour*
- **SR-D9:** *Social cognition and school exclusion*
- **SR-D10:** *Autism and autism spectrum disorders*
- **SR-D11:** *Attention Deficit Hyperactivity Disorder*
- **SR-D12:** *New technologies and interventions*
- **SR-D13:** *Trajectories of development and learning difficulties*
- **SR-D14:** *Early neural markers of learning difficulty*
- **SR-D15:** *Childhood depression*
- **SR-D16:** *Eating disorders*

Cross-Project papers

- **SR-X2:** *Science of wellbeing*
- **SR-X3:** *Neurobiology of wellbeing*
- **SR-X5:** *Neural circuit assembly*
- **DR-1:** *ICT as a driver of change*
- **DR-2:** *Physical environment and wellbeing*
- **ER-1:** *Ethics*

S1: Systems maps

Note 1: Some reference numbers were assigned to topics; however, the reports/papers were not subsequently commissioned.

Note 2: The Project commissioned some additional "discussion papers" as referred to in the text of the final report.

These will be made available through www.foresight.gov.uk in due course.

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